Proceedings of the Fourth IIASA Task Force Meeting on Input-Output Modeling

Smyshlyaev, A.

IIASA Collaborative Paper
December 1983

Smyshlyaev, A. (1983) Proceedings of the Fourth IIASA Task Force Meeting on Input-Output Modeling. IIASA Collaborative Paper. Copyright © December 1983 by the author(s). http://pure.iiasa.ac.at/2312/

IIASA COLLABORATIVE PROCEEDINGS SERIES

CP-83-S5

PROCEEDINGS OF THE FOURTH IIASA TASK FORCE MEETING ON INPUT-OUTPUT MODELING

IIASA COLLABORATIVE PROCEEDINGS SERIES

CP–81–S1	LARGE-SCALE LINEAR PROGRAMMING Proceedings of an IIASA Workshop G.B. Dantzig, M.A.H. Dempster, and M.J. Kallio, *Editors*
CP–81–S2	THE SHINKANSEN PROGRAM: TRANSPORTATION, RAILWAY, ENVIRONMENTAL, REGIONAL, AND NATIONAL DEVELOPMENT ISSUES A. Straszak, *Editor*
CP–82–S1	HUMAN SETTLEMENT SYSTEMS: SPATIAL PATTERNS AND TRENDS Selected Papers from an IIASA Conference T. Kawashima and P. Korcelli, *Editors*
CP–82–S2	RISK: A SEMINAR SERIES H. Kunreuther, *Editor*
CP–82–S3	THE OPERATION OF MULTIPLE RESERVOIR SYSTEMS Proceedings of an International Workshop, Jodłowy Dwor, Poland Z. Kaczmarek and J. Kindler, *Editors*
CP–82–S4	NONPOINT NITRATE POLLUTION OF MUNICIPAL WATER SUPPLY SOURCES: ISSUES OF ANALYSIS AND CONTROL Proceedings of an IIASA Task Force Meeting K.-H. Zwirnmann, *Editor*
CP–82–S5	MODELING AGRICULTURAL–ENVIRONMENTAL PROCESSES IN CROP PRODUCTION Proceedings of an IIASA Task Force Meeting G. Golubev and I. Shvytov, *Editors*
CP–82–S6	LIQUEFIED ENERGY GASES FACILITY SITING: INTERNATIONAL COMPARISONS H. Kunreuther, J. Linnerooth, and R. Starnes, *Editors*
CP–82–S7	ENVIRONMENTAL ASPECTS IN GLOBAL MODELING Proceedings of the 7th IIASA Symposium on Global Modeling G. Bruckmann, *Editor*
CP–82–S8	PROGRESS IN NONDIFFERENTIABLE OPTIMIZATION E.A. Nurminski, *Editor*
CP–82–S9	INNOVATION POLICY AND COMPANY STRATEGY H. Maier and J. Robinson, *Editors*
CP–82–S10	THE KINKI INTEGRATED REGIONAL DEVELOPMENT PROGRAM Y. Sawaragi and A. Straszak, *Editors*
CP–82–S11	EUROPEAN AND UNITED STATES CASE STUDIES IN APPLICATION OF THE CREAMS MODEL V. Svetlosanov and W.G. Knisel, *Editors*
CP–82–S12	MULTIOBJECTIVE AND STOCHASTIC OPTIMIZATION Proceedings of an IIASA Task Force Meeting M. Grauer, A. Lewandowski, and A.P. Wierzbicki, *Editors*
CP–83–S1	ENVIRONMENTAL MANAGEMENT OF AGRICULTURAL WATERSHEDS A Selection of Papers Presented at a Conference held in Smolenice, CSSR G. Golubev, *Editor*
CP–83–S2	INPUT–OUTPUT MODELING Proceedings of the Third IIASA Task Force Meeting M. Grassini and A. Smyshlyaev, *Editors*
CP–83–S3	EUTROPHICATION OF SHALLOW LAKES: MODELING AND MANAGEMENT. THE LAKE BALATON CASE STUDY Proceedings of an International Workshop L. Somlyódy, S. Herodek, and J. Fischer, *Editors*
CP–83–S4	CONVENTIONAL AND UNCONVENTIONAL WORLD NATURAL GAS RESOURCES Proceedings of the Fifth IIASA Conference on Energy Resources C. Delahaye and M. Grenon, *Editors*
CP–83–S5	PROCEEDINGS OF THE FOURTH IIASA TASK FORCE MEETING ON INPUT–OUTPUT MODELING A. Smyshlyaev, *Editor*

PROCEEDINGS OF THE FOURTH IIASA TASK FORCE MEETING ON INPUT-OUTPUT MODELING

29 September–1 October 1983

Anatoli Smyshlyaev, Editor

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
Laxenburg, Austria
1983

International Standard Book Number 3-7045-0071-2

Volumes in the *IIASA Collaborative Proceedings Series* contain papers offered at IIASA professional meetings, and are designed to be issued promptly, with a minimum of editing and review.

A-2361 Laxenburg, Austria

CONTENTS

INTRODUCTION

Anatoli Smyshlyaev
International Institute for Applied Systems Analysis, Laxenburg, Austria

The 4th Task Force Meeting on Input-Output Modeling, held at Laxenburg 29 September-1 October 1983, reviewed results achieved by IIASA alumni and collaborators in intersectoral modeling (particularly in connection with the INFORUM Project) and also helped to open up new areas for future research with newcomers to the INFORUM-IIASA group. One of the advantages of this series of meetings is that most of the participants have been acquainted for many years, which makes the discussion of rather specialized and advanced research, instead of wide (and necessarily cursory) explanations of the models themselves far easier.

Although input-output modeling is currently less "fashionable" than it was (perhaps in itself a sign of maturity), many research institutes use I/O models as one of the main techniques in studying interindustry interactions. The general framework of the research pursued by IIASA's collaborators has not changed much over the last few years but significant improvements to some models have taken place--involving model closure, semidynamic features, more realistic treatment of price-side and income distribution problems, linkage with macro models, etc. The software for INFORUM (LIFT) has also undergone major development at the University of Maryland.

The most important question at the 1983 Meeting was to what extent I/O modeling efforts allow us to capture the substance of policy issues, for example, energy-conversion problems, changes in consumer behavior patterns, and aspects of foreign trade under new world market conditions. During the Meeting we tried to emphasize lessons derived from our experience of analyses and forecasts based on I/O techniques, so as to concentrate future IIASA research as far as possible on issues of real priority. The "goodness of fit" of models for resolving these problems (both in modeling and in practice) was discussed in some depth.

In all, 33 participants from 19 countries (14 of which have IIASA National Member Organizations) attended the Meeting and 28 papers were presented. Fruitful discussions took place that will greatly assist us in focusing IIASA's research activities in 1984. Discussions at the Task Force Meeting also gave rise to plans for a users' meeting to be held in early 1984: this will concentrate on the practical economic and computing problems associated with models of the INFORUM family. There was also considerable discussion about the problems of moving programs from computer to computer and from country to country. Work at IIASA has begun to solve some of these problems. One potential solution, the transfer of the software to a "universal" microcomputer, received much attention at the meeting but no specific plan of action was agreed upon.

For this proceedings volume we have decided to group the papers into three sections, each consisting of approximately ten papers; these do not necessarily correspond to the original order of presentation. The three sections of the volume may be briefly described as follows.

I. STRUCTURAL CHANGES: RESULTS AND LESSONS FROM MODELING WORK

Clopper Almon, the founder of these activities at IIASA and the leader of the INFORUM team at the University of Maryland, gives an overview of recent developments in the model of the US economy. He and his group view the 78-sector model as a macro model, yet it is also a very sophisticated semi-dynamic model with full price and income-distribution accounting. He gives some examples of the usage of this model and of a disaggregated (425-sector) model for technological assessments and foreign trade issues, as well as devoting some time to questions of improving the software and making it operational on microcomputers. A few empirical results are also given as examples to show the power of the model. *Claire Doblin*'s paper reports preliminary conclusions of an analysis of US data. She considers the experience of 127 industries at the 3-digit SIC level of aggregation over the last two decades to distinguish "winners" and "losers" in terms of rates of growth, analyzing the industries from both the output and the resources sides. Among her findings she points out that the pace and magnitude of structural change make it very desirable to use I/O techniques in future estimates of, for example, energy demand. In some senses her paper is complementary to Almon's modeling overview. *Rolf Pieplow*'s paper gives an overview of the application of I/O models to development policy issues in the GDR. Pieplow describes a macro model consisting of 18 branches and a disaggregated model with about 600 entries, thus showing some similarities with Almon's work. One distinction is that Pieplow finds the method useful for short-run projections while Almon applies a 425-sector model for a 3- to 5-year time horizon. The paper emphasizes the need for disaggregation when considering technological assessment, adaptation to energy interactions on the world market, etc.

Sam Olofin examines methodological problems related to I/O modeling for developing countries. The most important involve the interface between input-output and econometrics, the degree of consistency of data supplied by a variety of economic agents for use within the I/O framework, and the regularity or comparability of compiled I/O data. In Olofin's view, as the data situation improves, I/O econometric models will progressively be of much more use for projections than will macro models.

Douglas Nyhus presents lessons derived from simulations of the Japanese I/O model. His paper considers the sources of structural changes as measured by final demand growth and composition as well as by technology diffusion expressed in terms of changing technical coefficients. The model (which is in fact the new version of the INFORUM model for Japan) is also used for long-term forecasting to illustrate the consequences of expected and observed changes in the areas of final demand and technical coefficients over the last few years. In some respects the paper by *Andor Csepinszky* is related to Nyhus' contribution. It deals with changes in final demand in the Hungarian economy during the 1970s at a rather aggregated level (9 branches). Calculations have been made in both constant and current prices, for which I/O tables are available in Hungary for the period 1970-79.

Anatoli Smyshlyaev and *Georgi Sychev*'s paper deals with the econometric modeling of investment, which is a crucial point in improving the dynamic properties of an I/O model. Studies of a large amount of data on fixed productive capital assets, investments, "unfinished construction", etc., show significant structural changes in USSR investment policy over the last two decades and highlight the difficulties of applying some standard econometric techniques to model it. Predictive power and *ex-post* simulation results are considered as appropriate tests for the investment side of I/O models.

Bernhard Böhm's paper reconsiders traditional ways of modeling consumers' behavior in an I/O framework. His own approach concentrates on the implications arising from maximization of an intertemporal utility function of general functional form. This approach is applied to Austrian data to demonstrate the advantages and disadvantages of different simplified specifications usually introduced in I/O modeling efforts. *Georg Erber* reports some results of statistical analysis of data to be modeled in an I/O framework. Some simple regressions are used to identify the relationships between overall economic growth and the sectoral structure of the labor force and income. These results are obtained from a 51-sector model and Erber emphasizes certain weaknesses inherent in applying a uniform and relatively simple model to many sectors.

The first section closes with a paper by *Maurizio Ciaschini*, which deals with the development of the price side of the Italian model INTIMO. Wages and salaries, which constitute the main difficulty in the estimation of the cost structure, are modeled for 36 sectors. Rather short time-series (1971-80) are used to identify the impact of labor productivity, split into two variables--output and employment growth, on the relative wage rates across sectors. Only a few of the parameters considered are found to be significant in this particular econometric study.

II. INTERNATIONAL TRADE: IMPACT AND POLICY ISSUES

The group of papers in the second section of the volume are tied together by their focus on trade related issues. The first three papers comment on the structure of trade for specific countries: Hungary, Austria, and Italy. The next four contributions are all related by their association with the NordHand model system. The final paper discusses a model of interdependent structural change within the European Communities.

In the first paper, *Andras Simon* develops a set of equations to forecast Hungarian exports and imports on a sectoral basis. The paper first investigates the extent to which sectoral trade is based on comparative costs. Simon concludes that most Hungarian exports are not cost generated but demand generated, subject to production capability. The export equations are broken down into three categories: demand-pull industries, supply-push industries, and demand-pull industries with supply constraints. Hungarian imports are not found to be price sensitive and the overall pattern of trade is not found to have any significant impact on the terms of trade over time. *Josef Richter* then examines the interesting question of the use of import share matrices to link total demand with import demand. Within the context of Austria, he shows that the use of import share matrices sheds considerable light on the behavior of imports by industries that are characterized by high shares of intermediate sales. In the third paper, by *Maurizio Grassini*, the overall patterns of Italian foreign trade are investigated. The increasing importance of foreign trade in the Italian economy is discussed and then a sectoral breakdown of imports and exports as a proportion of domestic demand follows. The paper concludes with a quantitative estimation of sectoral trade equations of the Italian economy. Nearly half of the import equations and about one quarter of the export equations are estimated to be price inelastic.

The papers from the NordHand group of modelers (in Denmark, Finland, Norway, and Sweden) follow a specific sequence. The first paper in the group is a general description of the model system. It is followed by a paper on trade data for the Nordic countries and a brief description of trade among them. The next paper presents the theoretical basis for evaluating a currency devaluation within the NordHand group. The final paper in this group then estimates the effects of a hypothetical Swedish devaluation of 10%. This set of papers is a good example of the fruits of careful international cooperation in model building, especially in linked trade models. Much of the work reported is still in its early stages, but the level of cooperation and consistency shown in these four papers is impressive. The papers show the importance of an *organizational* commitment to a system of linked models.

In the first paper in the NordHand group, *Paal Sand* and *Gunnar Sollie* provide a technical description of the NordHand model system. It is basically a system of four national input-output models carefully linked to each other through a trade sector model. The description of the first version of this trade model is the major contribution of this paper. In the subsequent paper by *Bent Thage* and *Arvid Jakobsen*, the trade data base for 1970-81 used by the NordHand model is explained. They also present a brief survey of the basic characteristics of trade within and outside of the NordHand group. The third paper in this group, by *Sturla Henriksen*, develops a generalized, world trade model based on the assumptions of profit maximization and imperfect competition. This model is then reduced to the current status of the NordHand model systems and a theoretical approach to evaluating a currency devaluation is put forward. That approach is made carefully consistent with the current limitations of the NordHand trade model so that an actual application is possible. Details of this practical application are found in the next paper by *Hans Olsson*, who uses a two-sector commodity grouping for homogenous and heterogenous products to evaluate the impact of a 10% Swedish devaluation. The basic framework of the NordHand model is used to trace through the separate impacts of the devaluation in each of the four countries. The process relies on independent estimates of import and market-share elasticities. The absence of estimates of those elasticities at the 36-sector level prohibited the extension of this approach to the full sectoral level possible within the NordHand system, but it seems likely that extensions of this sort will soon be forthcoming.

The final paper in the section, by *Michael Landesmann*, reports on a very ambitious effort to evaluate a model of *interdependent* structural change within the European communities. The model focuses on the competitive performance of industries and the evolution of world and domestic market shares. The model seeks to explore the pattern of disproportional sectoral growth across economies and uses measurements of the relative supply characteristics to explain market share.

III. INTERINDUSTRY INTERACTIONS AND ENERGY ANALYSIS

The third section of the volume contains ten papers that focus on the empirical analysis of structural change.

The first group of papers deals with changing intermediate coefficients. *Lucja Tomaszewicz* describes the application of a method that combines trend forecasting of important I/O coefficients and the familiar RAS technique. Several measures of the importance of I/O coefficients and alternative trend functions are tested on the basis of time-series data for the Polish economy. *Osmo Forssell* presents the results of some historical studies and points out that changes in input coefficients are caused by three factors: pure technological changes, changes in the product mix of industries, and differences in the unit prices of input factors. Though isolation of those factors is very difficult, a cross-section analysis on the unit level leads to the conclusion that two-thirds of the change investigated can be attributed to changes in product mix. If the most important coefficients are estimated correctly the errors caused by changing I/O coefficients is found to be rather small. Therefore there is a clear need for someone to concentrate on explaining changes in strategic coefficients.

Within the general framework of these arguments *Christian Lager* explains the changes of energy coefficients of some major energy-intensive branches of the Austrian economy in terms of the change of product mix of those branches and other factors expressed by a constant rate of growth of technical progress and alternatively by price elasticities. Besides these empirical results, the paper indicates a technique for estimating more homogenous, commodity-related input coefficients combining aggregate industry statistics and disaggregated commodity data. *Pál Erdősi* has examined the factors mentioned above as potential causes of shifts in the energy coefficient of an economy and he finds that their effects can point in different directions. For the Hungarian economy he shows that product-mix and technology effects cause a fall in energy/ output ratio while shifts away from energy-intensive industries make the energy coefficient rise.

The second group of papers in this section might be characterized as exploring the use of traditional techniques. *Ellen Pløger* subdivides the changes in the energy consumption of Danish industries for the years 1966-79 into a part caused by changes in technology and a part caused by changing final demand. She further analyzes whether the shifts between Danish domestic production and imports influence energy consumption. Finally she illustrates how the results of such an analysis are affected by the methods and concepts used for compiling the I/O tables.

For some specific analytical questions it seems appropriate to disaggregate some sectors of the normal I/O tables and to replace value flows by quantity data. This approach, which was emphasized by Wassily Leontief during a conference on the International Use of I/O Modeling (Dortmund 1982), has been used to construct I/O tables of the energy flows for seven member countries of the European Community for the year 1975. *Heinz Mürdter* begins by giving an overview on this kind of table and elaborates a theoretical framework for I/O energy analysis emphasizing the well-known double-accounting problem. Then he subdivides the primary energy content of final demand for European Community countries into domestic and foreign requirements, before calculating the primary energy content of exports and imports and identifying net consumers and suppliers of energy.

Another approach to the treatment of quantity data is presented by *Christian Lager, Karl Musil,* and *Jiri Skolka.* Data on Austrian energy balances for the period 1955-80 are arranged within a rectangular I/O system containing time series of make and use indices for the energy-conversion sector and matrices of final energy use. With the help of this framework, total primary energy contents of secondary energy carriers are calculated and direct and indirect interactions of energy carriers are analyzed on both an intersectoral and an intertemporal basis.

As an example of how I/O models might be applied to specific long-term economic problems, *David Robison* describes the application of INFORUM-type models for special questions dealing with the long-run profitability of ethanol production. A submodel containing all the necessary information on the sectoral detail for calculating the price at which ethanol production could be profitable is linked to the INFORUM aggregate I/O model (LIFT), which provides consistent information about the observed economic structure. This is a good example of the I/O approach being applied to new technologies.

The last two papers in the volume discuss factors connected with changes in the structure of industrial production. While *Paolo Caravani*, from a theoretical point of view, deals with the problem of choice between rival technologies, *Pavel Karasz* shows, with the help of cluster analysis, that energy and metal consumption is closely related to the mode of production represented by similar row coefficients.

We hope that this short overview of the papers assembled here will give some idea of the usefulness of econometrically backed I/O models both in historical analysis aimed at providing better understanding and as a basis for consistent multisectoral forecasting.

I. Structural Changes: Results and Lessons From Modeling Work

1983 INFORUM MODELING EXPERIENCE: DIVISION OF LABOR AMONG MODELS, LONG-RUN STABILITY, AND THE ANALYSIS OF PROTECTIONISM

Clopper Almon
Department of Economics, University of Maryland, College Park, Maryland, USA

I would like to take this opportunity to share with you, quite informally, some of the most interesting developments at the Inforum project over the last year. These developments fall into three groups. The first concerns how to arrange a profitable division of labor among three models -- an aggregate quarterly model, a 78-sector interindustry macro model with full price and income accounting, and a 425-sector interindustry model which, however, lacks price and income accounting. The second general subject is the dependency of the stability of the 78-sector model on some of its structural equations in ways which were, at first, unexpected. Thirdly comes a brief report on the influence of exports and imports on various industries in the USA. This study considered, of course, not only direct but also indirect effects, so that we could talk about the impact of foreign trade on the demand for, say, electricity. Finally, I want to mention some developments in computing technology that should greatly facilitate international cooperation among input-output model builders and among Inforum's partners in particular.

Division of Labor among Models

As just mentioned, we operate three models of the US economy. No one of them is the most comprehensive or the "best". Rather, each has its capabilities and limitations. One of our concerns has been, therefore, how to combine them so that each contributes what it does best to a forecast that is generally consistent among all three. Since this question of division of labor among models is likely to arise in other countries, our treatment of it may be of some general interest.

The smallest of the models is an aggregate quarterly model with some twenty behavioral equations and about a hundred variables. Its strength, of course, is that it uses quarterly data, and can be easily updated every quarter. Consequently, it is likely to produce the best current year forecasts for the aggregates it deals with. Indeed, several quarters of the current year may already be known. Even for one year ahead, its use of very current data may give this model the advantage in forecasting the aggregates.

The middle-sized model, in terms of industry detail, is a 78-sector annual model known as LIFT (Long-term Interindustry Forecasting Tool). It generates, in addition to final demands and industry outputs, also income by industry. This income is divided among labor income, capital income, and indirect taxes. From the income by industry, complete national income tables are compiled, personal income is calculated, taxes are computed with a very detailed treatment of the federal income tax, and finally disposable income is calculated. Thus, LIFT closes the connection between income and consumption, the link that creates the Keynesian multiplier. Of course, LIFT also makes investment depend upon output, so that it also has the accelerator. Thus LIFT is fully capable of forecasting business cycles.

The third of the companions is the Detailed Output Model, DOM, which is distinguished by having 425 sectors. DOM, however, has no generation of income or prices, and borrows its investment and consumption forecasts from LIFT. The reason DOM lacks these functions is simply that the data do not support more detail in income than was used in LIFT. Indeed, LIFT's income side had only 42 industries because data on the composition of value added do not exist at the level of LIFT's 78 sectors; the 42 industries gave the closest match we could get.

How do the models work together? The quarterly model and LIFT are functionally independent of one another, but the user can employ one to help the other. For example. if a tax cut is scheduled to come in the middle of a calendar year, the quarterly model can express this timing quite precisely. Because of the distributed lags, a ten percent tax cut in the last two quarters has a different effect on annual income from a five percent cut for all four quarters. For forecasting one year ahead, such timing considerations may be quite important. We may, therefore, want to impose income calculated from the quarterly model on LIFT for the current year and one year ahead. Before doing so, however, we would want to be sure that the investment used by the quarterly model is consistent with that generated in LIFT. Thus, there can be several iterations back and forth between the two models. We do not, however, aim for absolute identity in the numbers produced by the two models, only for general agreement about the short-term outlook. If strong measures are necessary to get this general agreement, then something is amiss in one or the other model. For example. last December the quarterly model insisted on much stronger growth in residential construction in 1983 than LIFT had. As a result of comparing the two equations and comparing their results with other forecasts, we concluded that the quarterly model was exaggerating the effect of falling interest rates and that something closer to the LIFT forecast should be our standard. I believe this competition among models within a forecasting group to be healthy self discipline.

The connections between LIFT and DOM are much more formal and automated than those between the quarterly model and LIFT. For example. DOM simply takes the LIFT forecasts for Personal consumption expenditure in household budget categories. These must then be multiplied by a bridge matrix to convert them to input-output industries. This bridge matrix has not been constant in the past and is projected to change in the future. LIFT has equations for projecting these changes and so does DOM. There is, however, no guarantee that the matrix produced by DOM would aggregate to that produced by LIFT. Rather than forcing it to do so, we have taken advantage of the additional information in the DOM matrix and made it the final authority in this matter. That is, we aggregate the DOM bridge matrix to the LIFT sectoral level and use this aggregated matrix in subsequent runs of LIFT. Exactly the same technique is applied to the matrix that converts investment by purchaser to types of equipment and to the matrix that converts construction by type to material requirements. In all of these, LIFT completely determines the totals for the final demand columns while DOM determines their allocation to industries. LIFT can work independently of DOM, but if it is informed that DOM has created matrices for it, it will use them.

The matter is slightly different with exports and imports. DOM has a complete set of import and export equations, so that it could generate the export and import vectors without any knowledge of the corresponding vectors in LIFT. In fact, however, we impose the LIFT vectors on DOM as controls on its export and import vectors. That is, the exports of a group of DOM sectors which aggregate to a single LIFT sector will be constrained to equal the exports found for that sector in LIFT. There are two reasons for this procedure. In the first place, the variables that go into the export forecasts -- prices and foreign demands -- are really at the LIFT level rather than the DOM level, so LIFT is making use of roughly the same information as is DOM. Secondly, this practice makes LIFT consistently the boss of aggregate final demand.

For the input-output coefficient matrix, DOM becomes the boss. We have estimated proportional across-the-row coefficient changes for all of DOM's rows. When DOM gets to, say 1990, it uses its prediction of the input-output A matrix to calculate outputs of its 425 sectors. With these 425 outputs, each of the 425x425 interindustry flows can be calculated and the resulting flow matrix aggregated to the level of LIFT's 78 sectors. From this flow matrix, a coefficient matrix is calculated and used in LIFT on its next run. One of the main reasons for change in input-output coefficients is change in product mix. In so far as that change can be detected in DOM, it can be used to advantage in LIFT forecasts.

It might perhaps seem that we should proceed to estimate investment functions at the DOM level. In a formal sense, we have data on equipment investment by the 4-digit industries, which are generally the DOM industries. At this level of detail, however, the series are so erratic and so much influenced by a few investment projects that statistical analysis of the time series is often unsatisfactory. We have, therefore, left LIFT completely in charge of the final demands.

Cyclical Stability in a Long Term Model

For many years, Inforum models were run with disposable income exogenously chosen to achieve a target level of employment. With such models, we had no occasion to worry about the cyclical sensitivity of the model. Likewise, the builders of quarterly models did not need to worry about stability because, over the period of a three or four year forecast, the asymptotic properties of the model did not really come into play. These models seldom have any explicit connection between labor force, potential GDP and actual GDP. Indeed, in the simple Keynesian analysis taught in countless classrooms around the world, there is no connection between the C + I + G curve and the level of full employment. There is, therefore, no tendency for a model based on this theory to gravitate towards any particular level of employment. Yet one of the striking facts about market economies is that they do seem to "seek" some level of employment, from which they are diverted by various shocks.

In LIFT we have tried to be explicit about this connection, because this model is commonly run over a ten or fifteen year horizon. What are, in fact, the stabilizers that enable the economy to track the labor force over long periods?

The automatic stabilizer most commonly mentioned in text books, unemployment insurance, has relatively little effect. There are two much larger effects. First, when output grows rapidly and unemployment falls, or when unemployment reaches low levels, corporate profits soar. These profits arise partly because the tight labor markets bring about efficient use of labor and high productivity and partly because when firms are unable to hire enough labor to meet the demand for their products at current prices, they raise prices. Of course, they also raise wages, but the net effect is that profits go up. Do the profits stimulate additional demand? In the short run, not much. In the first place, nearly half of them are taxed away. Of what remains of the increase, nearly all will be retained by the firms in the first year. Only gradually will dividends begin to be paid out of the higher level of profits. And in the same year, almost none of the increased profits can go into fixed investment. Consequently, the boom in profits increases prices without a corresponding increase in money being spent. The real level of purchases is reduced, and the economy is stabilized. Profits, by the way, are estimated by subtracting from return to capital several fairly non-cyclical items such as capital consumption allowance, net interest, rental income, and proprietor income. By building into the return to capital equation a dependence on unemployment, we get that dependence in the profits.

The other principal stabilizer is the savings rate. Unemployed people tend to cut their savings, so that spending falls less proportionally than income.

We estimated the return to captial and the savings functions with full awareness of the crucial role they would play in the long-run dynamics. But when we came to run the model, it proved quite unstable. In the first version, unemployment in the current year did not enter the savings function because it had not had a statistically significant coefficient in the estimation of that equation. The result of its omission on the dynamics of the model was that low unemployment in some year, say year 1, would generate a high savings rate in the next year, year 2. That would lead to high unemployment in year 2, low savings and unemployment in year 3, high savings and unemployment in year 4, and so on, in a violent two-year oscillation.

Now the economy plainly does not work that way, whatever the t-statistics may say. The equation was estimated with ordinary least squares, so simultaneous equation bias may account for the insignificance of the coefficient on current year unemployment. In any event, we had to re-estimate the equation with the constraint that current-year and lagged-year unemployment should carry the same weight.

That equation eliminated the biennial oscillation, but other problems appeared. The version of the model used by one researcher tended to explode and produce negative unemployment rates before 1990. What happens in the economy when it moves to the very high employment is that inflation arises and chokes of the purchasing power. Now if the inflation comes by increasing wages and salaries, it also increases personal income. Only if the inflation is particularly strong in profits does it choke of demand. The actual economy has been subject to successive shocks that have kept it well below full employment. Its fundamental structure, however, tends to high employment. But the profit equations, whose business it is to choke of purchasing power have just not had enough "experience" with high employment to know how to behave in its presence. We had to introduce a supplementary, non-estimated equation which gives profits an extra boost at times of very high employment. It is not difficult to introduce such an equation, and with it the behavior of the model improved considerably. It was sad, but perhaps not surprising, that the history of an economy with oil shocks, fluctuations in defense spending, and vacilating monetary policy did not provide information for ascertaining the behavior of profits at the high levels of employment to which the economy tends. It is necessary for the supplementary equation to make only fairly small changes in profits to produce its stabilizing effect; but it is disappointing that the estimated model cannot produce, all by itself, the "equilibrium" level of unemployment.

While these experiments were underway, another researcher was, for reasons unrelated to stability, re-estimating the return to capital equations. The new equations were put into the model without any supplementary equation. To our amazement, they sent the economy into a profound slump with unemployment in the range of 13 percent in the late eighties. It then recovered so vigorously that unemployment went negative in 1992. I should stress that the changes in the equations were made with a view only to improving their fit and the behavior of the model outside the range of past experience. Yet the effect on the dynamic behavior of the model was drastic.

We have not yet reached a resolution on this topic. The lesson that that I can draw so far is only one of warning. It is not necessarily true that equations estimated in isolation will lead to stable model performance. Estimation of the equations by choosing parameters that give a good performance to the entire system in the past is both impractical for so large a system and inadequate for determining the behavior of the model outside the range of past experience. Yet, without shocks, the model may go outside that range. The main point is for modellers to be aware of this problem, for anticipated problems are far more easily handled than unanticipated ones. It is altogether possible that we will eventually get a model which, without any supplementary function, produces reasonable asymtotic behavior. I, however, will be very doubtful about the real significance of the asymptotic unemployment rate and will suspect that it is very sensitive to slight differences in the specification of the equations. Finally, I should add that problems in long term simulations are not unique to input-output models. A number of macro models are also known to break down under some scenarios unless carefully "managed."

The Effects of Protection

The current resurgence of protectionism should sound a clarion call for all good input-output model builders to come to the aid of their country. The allure of protectionism lies precisely in the fact that those who benefit, benefit considerably. It is well worth their while to mount a lobbying campaign even if the chances of success are small. Though they are few, they are politically well organized, and their case is intellectually simple: "We are being hurt by imports; if you want our support in the next election, stop them." Their case is made no more difficult by the desire of politicians to be perceived as responsive to the needs of the voters. Since the positive effects of protection are felt quickly and the adverse effects come slowly, there is a further temptation to protect now and pay later.

By contrast. most groups hurt by protection are hurt only a little. The adverse effects, though greater in total than the beneficial ones, are spread over many industries. And that is exactly where input-output comes in. Over the past year, Inforum has made several analyses of protection which have stirred considerable interest among those who have seen them. We hope to get a version published shortly in a prominent place, and I hope our colleagues in other countries will undertake similar studies.

The preface to these projections is a historical analysis of the direct and indirect effects of foreign trade. For the years from 1962 through 1982, we computed indirect exports by the usual method, except that the input-output coefficients used were for domestic content only. Likewise. we computed the indirect requirements that would have gone into making the imports, had they been made domestically. Again, we used the domestic matrix only. For example, the 1962 US merchandise exports would have contained 43 billion kilowatt hours (kwh) of electricity, had they been made with 1977 technology. Domestic production of our merchandise imports of the same year, always with 1977 technology, would have needed 45 billion kwh. We were running a slight deficit balance on electricity. By contrast, by

1980, the level and structure of our merchandise trade had changed so that we exported 158 billion kwh of embodied electricity and imported 148 billion, for a surplus of 10 billion kwh.

In these calculations we kept the technology -- i.e., the input-output coefficients -- constant at 1977 values. We preferred this calculation to one based on estimates of the coefficients for each year because it makes the change in the indirect requirements depend solely on changes in trade. If we incorporated also some rather shaky estimates of coefficient change, then we would not know how to interprete the changed requirements; they might be either technological changes or shifts in the composition of trade.

Now to return to the example of electricity, we have noted a 10 billion kwh trade surplus in embodied electricity for the USA in 1980, a year in which the dollar was not seriously overvalued. By 1982, the seriously over-valued dollar had turned that surplus into a 15 billion kwh deficit.

That reversal illustrates the power of the mechanism we have used to study the effects of protection in the future. Namely, we have assumed the case most favorable to protection: no retaliation, only an inevitable rise in the dollar if the USA cuts back on its demands for other currencies.

Now it should be pointed out at the outset that we would not expect a long-run change in the total employment as a result of protection. Free trade merely allows us easy access to resources in other countries, but resources do not determine the level of unemployment. If petroleum did not exist and had never existed, we would not therefore have high unemployment rates. We would be poorer, but not less employed. Similarly, we would expect protection to make us poorer, not to affect the aggregate rate of unemployment. Unfortunately, our model is not sufficiently fine to pick up reliably the impoverization that protection imposes. It does, however, show how it rearranges employment among industries. We cannot make a case against protection by arguing that it is a net destroyer of jobs. But we can show the other side of the case of those who would argue that it is a creator of jobs.

In one comparison, for example, the imports of five industries (Apparel, Shoes, Steel, Autos, and TV, radio, and phonographs) were kept at their 1977 level, and the dollar was revalued upward to obtain the same merchandise trade balance in current dollars as in the base run. By 1987 the total employment in the two forecasts was identical. The protected industries, of course, were faring better with protection; their employment was 13 percent above its level in the base case. Apparel was up 8 %; Shoes, 44 %; Steel, 9%; Autos, 13 %; TV and radio, 20%. Most of the unprotected industries had lower employment in the protection scenario; but on average the reduction was only .3%. The biggest single loser was aerospace, with a 6 % loss. Machinery and Agriculture each lost about 2%. Other industries lost only about .1 percent. Nonetheless, it is true that a vote for protection is a vote to move employment from strong and profitable industries -- that pay taxes -- to weak ones that escape taxes and come asking for loan guarantees.

Research Directions in the Next Year

During the coming year I expect to see the completion of two major developments in the Inforum USA model. One, already on the brink of completion, is an integration of a monetary policy model into LIFT and a thorough simulation study of its properties. The second concerns a detailed treatment of the role of government, its taxes and expenditures. The work on taxes already allows the Federal income tax rate structure to be fed into the model exactly as it appears on the tax forms. The model then generates the numbers of taxpayers in each bracket and calculates their taxes. Policy experiments with changing tax rates and their progessiveness are now easily performed. We hope to be soon in a position to handle equally directly experiments with various deductions such as that for interest payment.

We are presently engaged in two other special studies similar in some respects to the one described by David Robison at this conference.

Douglas Nyhus continues active work on the international models; the Office of the U.S. Special Trade Representative is supporting some of the work on the Japanese model. Funding has been found for purchase and processing of up-to-date international trade statistics, so that the goal of models linked by bilateral trade flows has come a little closer in view.

A great need of the US project is a full and fascinating description of the whole system of models as it now stands. That is my job, and it keeps getting pushed aside. I shall try harder.

I would like to add one final word on the subject of our international cooperation. Up until now, a major consideration in finding a national partner was to find an institution with an adequately large computer with lots of free or cheap time. Even if the institution was found, the differences among computers meant that getting a program that worked on one to work on another was a major task.

The past year, however, has seen the appearance of machines costing less than a Volkswagen that are fully capable of executing an Inforum-type model. Not only are the machines cheap, but an amazing and unexpected degree of standardization among these machines has emerged. That standard has been set, for better or worse, by the IBM Personal Computer. Following IBM's stunning performance in grabbing a quarter of the USA micro market, many other manufacturers have begun producing machines based on the same chip, the Intel 8088, and using, or capable of using, the same operating system. There are perhaps two dozen of these machines on the market in the USA and another half dozen in Japan. By the first of November there will be four portables on the US market which, for less than $3000, offer 256K bytes of random access memory, two floppy disks with 640 K bytes or more storage. a 8087 coprocessor for high-speed floating point arithmetic, and a pile of software. I have, in fact, been quoted a price of $2375 for such a system. To it, one would need to attach for easy operation on an Inforum model a hard disk drive with. say, one fixed and one removable 10 megabyte cartridge. The cost would be about $2000 for the hard disk. Thus, for under $5000, one can be equipped with a system that is twice as large. in terms of the size program that can be executed, as was the PDP 11/70 on which Douglas Nyhus and I built models here at IIASA in 1978 - 1980. The mass storage would be several times what we were allowed, and the execution perhaps 10 to 20 times as fast. Nearly all of these machines run, or can run the same operating system, so it really should be possible to mail floppy disks back and forth among partners, stick the US model disk in the Italian partner's computer, press a button, and have it work like it worked back home.

Thus, it appears to me, the technical and financial obstacles which computing requirements have placed in the way of effective cooperation are disappearing. I hope that our cooperation can now move rapidly ahead. Inforum USA will do all that it can through the development of modelling software to make it possible for all of us to take advantage of these developments.

PATTERNS OF INDUSTRIAL CHANGE IN THE USA SINCE 1960

Claire P. Doblin
International Institute for Applied Systems Analysis, Laxenburg, Austria

1. INTRODUCTION

This analysis of industrial changes in the USA is the first in a series of case studies on structural changes since 1960. Generally, this has been a period of economic growth in the USA, but by no means all industries have shared in it to the same extent. Measured by means of index numbers, the growth of total national production represents the national average. Industries with slower growth than that of total industrial production may be viewed as underperformers, and those with faster growth as overperformers. The growth differential is also reflected in the percentage shares held by individual industries in total output (sales values and value added) and capital stock (equipment). The analysis covers 127 US industries at the disaggregated 3-digit SIC level. The major results are that the combined share in total output (sales values at 1972 prices) by the underperformers receded from 61% in 1960 to 50% in 1980; or from 55 to 43% in terms of value added (also at 1972 prices). The most prominent 'losers' are: food (dairy, grain mill, and bakery products); primary metals (steel); transportation equipment (automobiles); and stone, clay, and glass products (cement). With the addition of industries that were still growing faintly in the 1960s, but more slowly than the average in the 1970s, for example, textile mill products, metal fabrications, and others, the combined share of the losers eroded from 78% of total output in 1960 to 67% in 1980 (sales values) or from 73% in 1960 to 62% in 1980 (in terms of value added), whereas the share of the 'winners' moved up from 20% in 1960 to 32% in 1980 (sales values) and from 26% in 1960 to 37% in 1980 (value added). The growth industries include nonelectrical machinery (office and computing machinery; refrigeration and service machinery), electric and electronic equipment (especially electronic equipment and accessories and communication equipment, as well as radio and TV equipment), investments, and chemicals (drugs and pharmaceuticals, soap and toiletries--but not industrial inorganic chemicals). Only one industry, furniture and fixtures, did not change its output share over the period studied.

The age and structure of the stock of capital equipment held by the manufacturing industries also reflected some of the structural changes in output. Primary steel and textile mills were found to have the oldest equipment. But not all of the losers in output were losers in terms of capital stock growth. This reflects the investment activity since the 1970s and may indicate a more promising future for the currently depressed industries that have been retooling, as for example automobiles and, at one time, coal processing.

Overall, the structural changes reflect the decline of the more basic industries using long-established technologies that are both labor- and energy-intensive but low in value added, and the growth of industries with new and more sophisticated technologies based on innovation, which are high in value added. This demonstrates that over the last 20 years US industry has continued on the path towards higher industrialization. The impact on the economy as a whole may be a slowdown in the growth (not an absolute decrease) of energy demand by the industrial sector, if and when a substantial recovery occurs.

2. MANUFACTURING OUTPUT

2.1 Structural Output Changes at the 2-digit SIC Level: An Overview

Between 1960 and 1980, the index for total manufacturing (1970 = 100, with sales values in 1972 prices) increased from 69.1 in 1960 to 131.9 in 1980. The growth of *total manufacturing* may be considered as a national average; deviations from this national average can be viewed as underperformance by industries growing more slowly than the total, or as overperformance by those growing faster than the total. The growth performances of the various industries are also reflected in the shifts in their percentage shares of total manufacturing output.

There was only one industry whose growth was similar to that of total manufacturing, and consequently its share of 1.37% did not change during the 20-year period. This is SIC 25 - furniture and fixtures. The other industries may be subdivided into three groups; for each of these groups, the observed changes in percentage shares reflect different underlying structural changes:

1. Erosion since 1960. These are the industries whose growth was continuously slower than that of the national average, over the period 1960 - 1980. They include SIC 20 - food and beverages; 21 - tobacco products; 23 - apparel; 24 - lumber and products; 29 - petroleum refining and coal products; 31 - leather and products; 32 - stone, clay, glass products; 33 - primary metals; 37 - transportation equipment; and 27 - printing and publishing. The combined share in total manufacturing of these industries eroded from 60.99% in 1960 to 49.66% in 1980.

2. Erosion since 1970. The growth of these industries was only a little faster than the national average in the sixties, followed by a slowdown to less than the national average in the seventies. Industries included are SIC 22 - textile mill products; 26 - paper and allied products; 30 - rubber and plastics; 34 - metal fabrications; and 39 - miscellaneous. The share of these industries in total manufacturing increased from 17.11% in 1960 to 18.76% in 1970, falling subsequently to 17.30% in 1980.

The combined shares of the industries in groups 1 and 2 together eroded from 78.10% in 1960 to 66.96% in 1980.

3. Continued growth since 1960. These are the winners, and they include SIC 28 - chemical and allied products; 35 - machinery (except electrical); 36 - electric and electronics equipment; and 38 - instruments. The share in total output of these industries rose from 20.52% in 1960 to 31.65% in 1980.

2.2. Structural Output Changes at the 3-digit SIC Level

There can be many reasons for an industry's stagnation, decline, or growth. These might be growing affluence and with it a change in tastes and diets (less starchy products), a change in fashion (fewer cigars), and habits (newspapers and books forced out by television), or cheaper imports from abroad, like those that hit the leather and shoe industry, and exacerbated the plight of the automobile and aging steel industries. What were the innovations, and which were the new industries that blossomed in the sixties and particularly in the seventies?

For answers to some of these questions, one has to look at the industries beyond the 2-digit SIC level. Not all industries within the 2-digit group follow the same growth trend; each has its own particular reasons for rising or falling. Some of the main findings are summarized below.

The largest major group, in terms of sales values, is SIC 20 - food and beverages. Its share in total manufacturing fell from 17.84% in 1960 to 14.82% in 1980. Sales at constant 1972 prices grew from $83.4 billion to $123.3 billion, or by 58.6% between 1960 and 1980. Over the same period, population increased 26%. Therefore, food sales, whether or not beverages are included, grew faster than population, but not so fast as total manufacturing. Besides rising affluence, there were changes in tastes and diets, and hence dairy, grain mill (flour), bakery, and sugar products all decreased their share in total manufacturing. The drop was less acute for preserved fruits and vegetables; and a slight increase, possibly at the expense of dairy products, was achieved by fats and oils. At the same time, beverages experienced a strong growth, but not enough to offset the fall in other goods.

Within SIC 22 - textile mill products, the downward movement of cotton and wool that had started long before the 1960s continued through the seventies and eighties. In the sixties, this decrease was somewhat offset by the then still-continuing growth of younger textile industries such as man-made fiber weaving and knitting mills. However, in the seventies, these once "younger" industries also weakened, ceasing to record a strong growth rate. It is likely that they succumbed to competition from abroad. This was also the fate of the much smaller leather and leather goods industry, SIC 31 - leather goods, and especially leather footwear, as well as the rubber and plastics footwear that are part of SIC 30. The relative decrease of SIC 32 - stone, clay, and glass products, was caused by corresponding decreases in SIC 324 - hydraulic cement, SIC 325 - structural clay products, and SIC 327 - concrete, gypsum, and plastic products. These heavy construction materials may well have been replaced by other, lighter materials.

To some extent, the switch to other, lighter materials was also to blame for the severe setback of SIC 33 - primary metals. Their shares in total manufacturing sales dropped from 9% in 1960 to little over 6% in 1980. The fall was steepest for iron and steel (SIC 331 and 332); plagued by overaged equipment and foreign competition, the share dropped from 5.21% in 1960 to 2.95% in 1980. The situation was somewhat different for some of the nonferrous metals; the forthcoming IIASA study on aluminum may throw some light on this phenomenon.

Some part of the decline of the primary metals industry was caused by the changing fortunes of SIC 37 - transportation equipment. The sales values of this industry fell from 13.2% of total manufacturing in 1960 to 10.8% in 1980. From second place (after food) in 1960, it fell to third place in 1980, after food and nonelectrical machinery. Within the transportation equipment industry, the development was uneven. Hardest hit were SIC 371 - motor vehicles and equipment, 372 - aircraft and parts, and 376 - guided missiles and space vehicles. Their combined share in total manufacturing sales tumbled from 12.2% in 1960 to 9.6% in 1980. However, in *absolute* values there was still considerable growth, though it lagged behind that of total manufacturing. The index implicit in the sales values and the FRB production index show that the output of SIC 37 reached its last peak in 1978-79. For SIC 371 - motor vehicles, an all-time peak was reached in 1978 when the 1970 = 100 based indices hit 186.3 (sales values) and 184.1 (FRB). In 1979 came a slight setback--the indices fell to 171.2 (sales values) and 173.2 (FRB). It is indeed remarkable that despite five years of energy crisis, the production of motor vehicles--though limping behind the national average--should still have grown to levels comfortably above those of 1973 and 1970. This growth is consistent with that observed for gasoline consumption, where the 1970 = 100 based index climbed to an all-time record of 126.9 in 1979[1].

However, within the motor vehicles industry, the various components followed different development paths. While the production of large automobiles was seriously depressed by the oil price explosion, the manufacture of smaller models has enjoyed an unprecedented boom since 1967 (when separate indices were first compiled) and through 1978, giving way to mild setbacks in the following year. Some of the relative decline of the transportation industry spilled over into the rubber industries; SIC 301 - tires and inner tubes, with sales values stagnating in the sixties, slipped from 0.68% of total manufacturing in 1970 to 0.60% in 1980.

Now to the growth industries. The share of SIC 28 - chemicals and allied products in total manufacturing sales rose from 5.74% in 1960 to 7.13% in 1970 and 7.97% in 1980. The trend is somewhat different for value added, where the shares in total manufacturing also rose from 5.8% in 1960 to 7.0% in 1970, but subsequently dropped to 6.3% in 1980. The divergence may be due to time lags or the use of different classifications. In any case, in terms of sales values the various chemical industries displayed contrasting growth rates. The sharp increase in the share of total manufacturing of SIC 282 - plastic and synthetic materials, from 0.74% in 1969 to 1.46% in 1980, and SIC 283 - drugs, from 0.66% to 1.36% must be compared with the relative decline of SIC 281 - industrial inorganic chemicals, whose share in sales volume dropped from 0.94% to 0.77% of total manufacturing sales between 1960 and 1980.

It is well known that chemicals and allied products are among the most energy-intensive industries. According to the 1970 census that provided detailed data, this industry took 21% of the total fuels and electricity (in kWh equivalents) *purchased* by the manufacturing sector, more than any other 2-digit SIC industry. The industrial inorganic chemicals industry alone purchased 15% of all the energy sold to the manufacturing sector. Hence the relative decline of industrial inorganic chemicals may have affected the United States' energy consumption at least as much, if not more than, the decline of steel.

The growth of SIC 35 - nonelectrical machinery, is evident from the fact that its share in total sales values moved from 7.51% in 1960 to 11.41% in 1980. This means that nonelectrical machinery moved from fourth place after food, transportation equipment, and primary metals in 1960 to second place after food in 1980. There were of course variations in growth patterns within SIC 35. The strongest growth was achieved by SIC 357 - office and computing machines, with shares in total manufacturing sales rising from 0.53% in 1960 to 1.09% in 1970, and to 3.52% in 1980 (!). Growth was also strong for SIC 358 - refrigeration and service machinery, which moved from 0.59% in 1960 to 0.95% in 1970, before tapering off to 1.04% in 1980.

Reflecting on the slow growth of some of the industries discussed earlier, such as primary metals, it was found that SIC 354 - metal working machinery and SIC 355 - special industry machinery experienced a continuous decline of their shares in manufacturing sales from 1.17% (metal working) and 0.95% (special industry) in 1960 to 1.10% and 0.64%, respectively, in 1980. The growth of other machinery, such as SIC 351 - engines and turbines, and SIC 356 - general machinery, was rather weak from 1960 to 1970, followed by stagnation.

1/ See C. Doblin, *The Growth of Energy Consumption and Prices in the USA, FRG, France and the UK, 1950-1980.* IIASA Research Report, RR-82-18, May 1982.

SIC 36 - electric and electronic equipment, increased its share in total manufacturing sales from 5.45% in 1960 to 7.25% in 1970 and to 9.32% in 1980. The industry's share in manufacturing moved from seventh place in 1960 (after food, transportation, primary metals, nonelectrical machinery, metal fabrications, and chemicals) to fourth position in 1980 (after food, nonelectrical machinery, and transportation). Much of this growth was achieved through innovation in SIC 366 - communication equipment, which increased its share in total manufacturing from 1.42% in 1960 to 2.13% in 1970, and to 2.57% in 1980, and especially in SIC 367 - electronic components and accessories, whose share rose from 0.63% in 1960 to 1.06% in 1970 and to 2.54% in 1980.

Compared to these star performers, the growth of yesteryear's innovation industry, SIC 365 - radio and television, was weak. Its share in total manufacturing rose from 0.34% in 1970 to 0.89% in 1980. At the same time, SIC 363 - electric household appliances, also a former growth industry, showed only weak growth in the sixties, followed by stagnation in the seventies. Weak growth in the sixties, followed by a drop in the seventies occurred in SIC 361 - electric distributing equipment, SIC 362 - electric industrial apparatus, and SIC 364 - lighting and wiring equipment. The combined share of these three industries fell from 1.83% in 1960 to 1.79% in 1980. No doubt their falling fortunes were due to the slack in some of the industries whose shares in total manufacturing sales had themselves decreased.

By way of summarizing the structural changes discussed above, the ranking of the seven industries that command two-thirds of total US manufacturing output (sales values at constant 1972 prices), together with their respective percentage shares, is as follows:

SIC		1960	1980	SIC	
20	Food	17.84	14.82	20	Food
37	Transportation equip.	13.19	11.41	35	Nonelectrical mach.
33	Primary metals	8.95	10.83	37	Transportation equip.
35	Nonelectrical mach.	7.51	9.32	36	Electric & electronic equip.
34	Metal fabrications	6.96	7.97	28	Chemicals
28	Chemicals	5.74	6.36	33	Primary metals
36	Electric & electronic equip.	5.45	6.20	34	Metal fabrications
		65.64%	66.91%		

The change in the place held by an industry between 1960 and 1980 is a clear reflection of the structural changes that have taken place.

3. MANUFACTURING: Capital

3.1 Capital Formation (Gross Fixed Annual Investments)

3.1.1 Growth rates. The average growth rates show that investments in equipment tended to grow at a faster rate than those in structure throughout the period studied (1960-1980). A second observation is that the growth rate was higher in the sixties (7.57% structures and equipment, 8.23% equipment only) than in the seventies (4.15% structures and equipment, 5.41% equipment only). This is consistent with GDP growth rates.

All the same, it is worth noting that in the early seventies (1970-1973) the investment growth rate had slumped to 1.59% for structures and equipment and 3.71% for equipment only. But during the years of rampant inflation (1974-1979), investments perked up considerably: the average annual growth rate was 5.86% for equipment and structures and 6.55% for equipment only.

3.1.2 Selected industries, investments (equipment), and output in the seventies. Investments during the sixties are reflected in the capital stock figures; the following notes relate only to the investments made during the seventies.

Considerable divergence was noted between the growth of investments for the manufacturing sector as a whole and individual industries. Some industries' investment growth trailed behind that of the sector, for example, SIC 20 - food and kindred products, especially if beverages are included, and SIC 33 - primary metals, most notably SIC 331 - blast furnaces and basic steel products. The output of these industries also lagged behind that of the sector.

Following the first oil price explosion, a number of industries stepped up their investments to a higher level, which then remained high throughout the period of severe inflation. These include: SIC 26 - paper and allied products, which may have switched to energy-saving equipment; SIC 29 - petroleum and coal products, whose output slumped in the late seventies; and SIC 37 - transportation equipment, especially SIC 371 - motor vehicles, where output also slumped in the late seventies. The investment surge in the automobile industry started slowly in 1972, and preceded the first oil price explosion: it reflects the industry's changeover to smaller models. Other industries whose investment growth was paralleled by rapidly expanding output are SIC 35 - nonelectrical machinery and SIC 36 - electric and electronic equipment.

3.2 Capital Stock Growth (Equipment)

3.2.1 Total manufacturing sector. The value in 1972 prices of the gross capital stock of equipment used in the manufacturing sector grew from $139 billion in 1960 to $331 billion in 1980. In terms of index numbers (1970 = 100), this was an increase from 65.4 in 1960 to 155.7 in 1980. For total capital stock (equipment and structures), the corresponding increase was from 67.2 in 1960 to 139.4 in 1980.

The growth of capital equipment was faster than that of structures; it was also faster than that of manufacturing output, which rose from 69.1 in 1960 to 137.9 in 1980 (in terms of gross value of sales) or from 61.5 in 1960 to 137.9 in 1980 (as measured by FRB production indices). Obviously, both output and capital grew faster than labor.

3.2.2 Individual industries (equipment only). Only one industry, SIC 25 - furniture and fixtures, showed no change with its share in total manufacturing remaining at about 0.70% throughout the period 1960-1980. The shares of the other industries changed as follows:

1. Industries whose share in the stock of manufacturing equipment decreased continuously from 1960 to 1980. The share of this group in total manufacturing equipment fell from 55.51% in 1960 to 46.15% in 1980. All the industries whose share in capital stock eroded were underperformers in the sense that their production growth trailed the national average. Consequently, their shares in total manufacturing output (sales values and value added) also decreased. These industries are SIC 20 - food and beverages; SIC 21 - tobacco products; SIC 22 - textile mill products; SIC 23 - apparel; SIC 24 - lumber and products; SIC 26 - paper and products; SIC 27 - printing and publishing; SIC 31 - leather and products; SIC 32 - stone, clay, and glass products; SIC 33 - primary metals; and SIC 34 - fabricated metal products.

2. Industries whose share in manufacturing equipment increased continuously from 1960 to 1980. This group includes the four industries whose

share in total manufacturing output rose continuously over the period studied: SIC 28 - chemicals; SIC 35 - nonelectric machinery; SIC 36 - electric and electronic equipment; and SIC 38 - instruments. The increase of the capital stock (equipment) in the chemicals industry is remarkable, though not all of its components shared in this growth: for example, the share of SIC 281 - industrial inorganic chemicals fell from 2.37% in 1960 to 1.69%. Yet total chemicals moved to first place in the 1980 ranking of manufacturing capital (equipment), topping primary metals whose share had dropped from 14.19% in 1960 (first place) to 10.64% in 1980 (second place).

The continued growth of the share in total manufacturing capital stock of SIC 30 - rubber and plastics products, which lasted until 1976, was not matched by a growth in the industry's share in manufacturing output. A backlash from the automobile industry may also be seen in the share of capital stock of SIC 301 - tires and inner tubes, which decreased from 1.19% in 1970 to 0.94% in 1980.

3. Industries whose share in manufacturing equipment decreased in the sixties but increased in the seventies. This group includes SIC 37 - transportation equipment, whose share in total capital stock (equipment) dropped from 8.46% in 1960 to 7.82% in 1980, along with relative sales values. While the share in sales from this industry in total manufacturing was still dropping between 1970 and 1980, there was a growth in the industry's equipment holdings from 7.82% in 1960 to 9% in 1980. This largely reflects the switch to production of smaller cars and the impact of the growth in annual investment since 1972.

For SIC 29 - petroleum and coal products, the share in total manufacturing equipment fell from 3.10% in 1960 to 2.1% in 1966 and 1967. It then rose slightly to 2.4% in 1970, and to 2.9% in 1980. This new growth in the seventies, at the same time that shares of sales values in total manufacturing were falling, may reflect the growth of investment for coal processing.

3.2.3 The age of capital stock. The growth of annual investment in capital stock is reflected in the age structure of the stock (equipment). According to the estimates prepared by the BIE, the industry that in 1980 had the oldest capital stock (equipment), measured in 1972 prices, was SIC 33 - primary metals. As much as 36% of this industry's equipment was 10 years old or older.

Primary metals were followed closely by SIC 22 - textile mill products, where 35% of the equipment was 10 years or more old. Another aging industry is SIC 31 - leather and leather products, with 33% of the capital equipment in the 10 years plus age bracket. All of these industries have been lagging in growth, not only in terms of capital equipment but of output as well - and much of their misery has been due to lack of competitiveness.

On the other hand, some industries with relatively young capital stock (equipment) did not enjoy healthy sales growth over recent years. This is true for example of SIC 29 - petroleum and coal products, where in 1980 barely 19% of the equipment was 10 years old or older, and over 50% was four years old or less. The same is true for SIC 37 - transportation equipment, where 22.2% of the equipment in 1980 was 10 years old or older, whereas 47% was four years old or less. However, these industries may have more potential for a future come-back, and, in the case of automobiles, may be better protected against foreign imports.

Other industries with a relatively young capital equipment stock seem to have good prospects for continued sales growth. This applies to SIC 35 - nonelectric machinery, where in 1980 only 23.7% of the equipment was 10 years old or older, while 47.3% was four years old or even younger. It may also be true for SIC 36 - electrical and electronic equipment, where in 1980 47% of the equipment was four years old or younger and only 22% had reached the age of 10 years or more.

4. OUTLOOK

Much still remains to be done in the analysis of structural changes based on manufacturing output and capital stock (equipment). For example, input-output analysis and the establishment of capital/output ratios have not as yet been tackled from these data. Before going any deeper into this time-consuming task, one might want to consider the results of the admittedly superficial analysis carried out so far. This has demonstrated that over the last 20 years, US industry continued on its way to higher industrialization. This meant moving away from primary industries and those based on long-established technologies, and a shift towards more sophisticated industries and technologies in which the US still has an edge.

The analysis has also identified the long-term losers, whose shares in total manufacturing output and capital have been receding since 1960. Among them steel, basic chemicals, textiles, and leather are prominent examples. Will the 20-year slide continue for these and other industries: for example food, which is affected by changes in taste as well as increasing affluence; or stone, clay, and glass, which suffers from an increasing general preference for lighter materials, as does steel, to some extent? What are the chances for a come-back for transportation equipment and the petroleum and coal products industry? How much more can drugs and pharmaceuticals, office and computing machinery, and electronic equipment expand? Equally important, to what extent can the losses (output and capital) of the losers be compensated by the gains of the winners? This is a question of particular relevance to labor, and it will be reviewed in a forthcoming report.

OBJECTIVES OF INDUSTRIAL STRUCTURAL CHANGES AND SOME CONCLUSIONS ON USING INPUT–OUTPUT MODELS

Rolf Pieplow
University of Economics, Berlin, GDR

In the national economic planning of the GDR, input-output models are used to analyze and to calculate the extent of structural changes within the national economy. Both aggregated and more detailed input-output models are used, depending on the specific application. One of the more aggregated models contains 18 sectors (groups of products) and is used primarily for long-range calculations. A more detailed model containing about 600 entries (partly in physical terms) and 16 ministries is mainly used for one-year calculations (for details, see Köhler et al. 1981).

The structure of these input-output models and their possible applications are well known. Currently, the major uses in the GDR are to facilitate the supply of economic data, the planning of technical coefficients, and the planning of structural changes within sectors. In the field of plan calculations the most important present task is the calculation of the courses of different structural changes with various objectives. The central question remains the planning and forecast of structural changes in industry, which is the leading and largest sector of the national economy. (The share of industrial production in the gross material product of the GDR was 72 percent in 1981 and even more in subsequent years.)

The common goal of the plan calculations is to ensure a steady rate of economic growth in the GDR, as measured by the growth rates of national income or final product, against a background of generally constant or in some cases even declining resource bases. Steady economic growth is the vital precondition for a gradual yet guaranteed increase in the material and cultural living standard of the people. The main way to achieve this end is to harness the latest developments from science and technology, which are the most important determinants of change in the production structure. The need for structural changes is also created by changes in the requirements of the people and the state, changes in the availability of resources within the national economy and on the world market and the consequences of man's interaction with the environment. Finally, changes in the international division of labor and in the structure of world trade also cause significant changes in the domestic production structure of the GDR. All these factors (see Figure 1) act simultaneously and of course interact with one another. The effects on the structure of production differ, both in material consequences and over time.

The objectives deduced from these complexes of causes can differ from one another, but they can also be identical in some cases. For instance, the use of achievements of technological progress is directed toward such ends as saving existing resources, increasing the output of new resources, better satisfying the needs of the people, or increasing the quality of exported goods. The changing requirements of the people demand new articles, services,

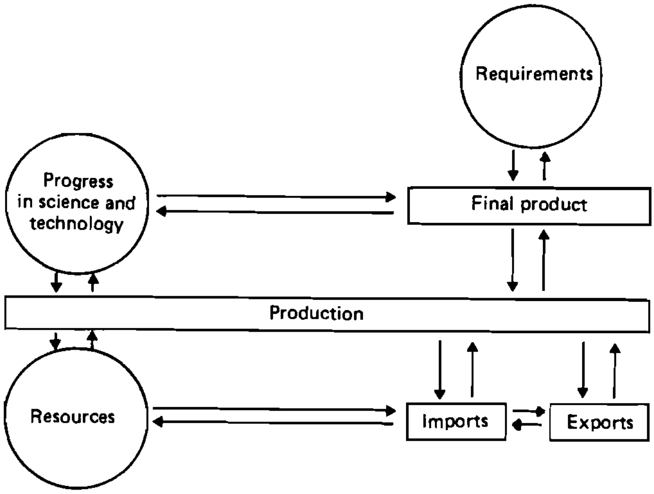


FIGURE 1 Causes of structural changes.

and results from science, and techniques, for instance, to facilitate housework. Changes in the availability of resources evoke processes that can substitute some kinds of energy or raw materials by others or that lead to a higher quality of metals and plastics, thereby reducing the specific consumption of metals in the national economy. Finally, changes in the structure of world trade require new products of a very high technical standard, for example, incorporating a high degree of automation or with very low specific consumption of energy.

In order to meet all these objectives, economic calculations of structural changes are necessary. First of all, it is necessary to calculate all the expenditures implied and the likely results of such structural changes. These calculations are partly performed using input-output models, which have to be adapted to the purpose of the calculation, especially in terms of classification and model structure. For these calculations, input-output models and the use-value and value input-output table with entries in natural units are better suited than others. Many detailed structural changes are not reflected adequately by aggregated input-output models. This does not mean, however, that aggregated input-output models are not used at all for analyzing structural change. In the GDR the influence of structural changes in the requirements of the people on changes in the structure of material consumption and resources has been analyzed using the statistical, 118-sector input-output table. To describe the structural changes in requirements in more detail, the consumption term in the final product was divided into so-called "complexes of needs", such as food, clothing, housing, health, transport, and others. Changes both between and within these complexes of needs have their own particular effects on resources, but there are also common features: for example, they all require more energy. For further information see Heinrichs and Knobloch (1983).

Calculations of structural changes must also take into account that there are no alternatives for a considerable number of these changes, above all in industry; in other words, on the basis of existing conditions, special structural changes *must* be implemented. Examples of this can readily be found:

for instance, the substitution of oil by other kinds of energy (in the GDR, primarily by brown coal), the implementation of basic innovations such as microelectronics, shifts in the overall structure of transport (less transport by road, more by railway and by inland navigation), the higher refining of (especially imported) raw materials, and the adaptation of the structure of export production to changes in the structure of world trade. These structural changes must often be implemented over a relatively short time; they require the concentration of manpower, investment, and resources to achieve the necessary results rapidly. Of course, even in the cases of these absolutely necessary structural changes there exist various routes for their detailed implementation, for example, through changes in the structure of exports or the increased use of microelectronics. With the help of detailed input-output models the best variant can be selected. Many structural changes over recent years have been characterized by their effects in producing a marked reduction in the consumption of energy and materials in industrial production; the summarized data in Table 1 demonstrate this tendency in the GDR since 1975.

TABLE 1 Material and energy consumption in GDR industry per unit value of industrial commodity production (index, 1970 = 100).

Indicator	1975	1980	1982
Empirically important energy and raw materials	87	71	62
Electrical energy	88	75	73
Rolled steel in the metal-working industry	81	60	54

SOURCE: Statistical Pocketbook of the GDR 1983, Berlin, 1983, p.54.

The causes behind the structural changes, however, have themselves an even wider range of dynamic behavior and corresponding "possible" or "necessary" development options. The preconditions for each of these options and their results, both immediate and over the course of time, must be calculated to discover the most effective variants for the national economy. For instance, each of the areas of science and technology listed in Table 2 may produce important structural changes in the national economy. In a relatively small national economy such as that of the GDR, the question frequently arises as to where would the concentration of available scientific potential be most effective, and what results should be expected for the national economy in terms of final product and the structure of production and export. Simultaneously, the further development of the international division of labor, (for the GDR, primarily between the member-countries of the CMEA) must continue to keep pace with rising international standards in science and technology.

If one wishes to explore the main areas of technical progress using input-output models, then these models must be detailed enough to reflect both the preconditions for and the effects of technical development. This requires detailed entries in the use-value and value input-output table. Partial input-output models are also used, for example, in metallurgy, chemistry, engineering, and elsewhere. The most complicated and as yet unresolved problem in this field is the calculation of the influence of scientific and technical innovations on the technical coefficients. For example, it would be very helpful to

TABLE 2 Currently important directions in science and technology.

Microprocessors
Computer science and technology
Control science and technology
Manipulators, robots
NC Machines, computer integrated manufacturing systems
Optoelectronics
Telecommunication systems
Energy technologies
Metal forming techniques
Laser technology
Vacuum engineering
Radiation technology
Cryotechnology
Deep-sea technology
Aeronautical and space engineering
Biotechnology
Gen. engineering
Plastics
Silicates
Composite materials
Environmental protection techniques

calculate the influence of new materials (such as plastics or composite materials) on the consumption coefficients of materials already in use and also on the coefficients in those technologies where the new materials are produced. Precise calculations cannot be made in every case, and expert estimation will remain important in the planning of such technical coefficients for some time to come.

Another phenomenon with important impacts on industrial structure is the development of the export structure in order to meet changes in world trade patterns and the changing demand of foreign trade partners. Clearly, no single national economy can produce the entire assortment of goods produced worldwide. Therefore, the international links of all national economies have been steadily intensified. In many countries the share of machinery and equipment in imports has increased over the years, and this tendency will continue. However, this tendency also calls for a specialization of export structure. This structure is determined by many factors, but one of these has special importance for the national economy of the GDR: the influence of export structure on imports of energy and raw materials. The GDR belongs to that group of countries that find it necessary to import a great amount of energy and raw materials. Therefore, a given export structure gives rise to the use of a given share of imported raw materials for export goods. For this reason, it is essential in the planning of export structure to know exactly how a planned variant of export structure will influence the import of raw materials. The objective is to change the export structure in such a way that imported raw materials are used with a very high efficiency. Consequently the relationship between export and import must be calculated and analyzed, using a detailed input-output model, in order to find the best variant for exports with a correspondingly effective use of imported raw materials. For this it is necessary to subdivide every line of raw material consumption into consumption of inland and imported raw materials. Partly this is already done in the use-value and value input-output table. We were able to analyze the different influences on the total (direct and indirect) expenditures of imported energy and raw materials.

One of the objectives of structural change is to reduce environmental pollution, and in particular to reduce the output of wastes and to promote the recycling of such products. On the one hand this requires us to calculate the output of wastes in the production and consumption processes and determine their possible degree of utilization elsewhere. On the other hand the available volume of secondary raw materials for the production sectors must be determined. From a theoretical point of view it is certainly possible to combine input-output tables with matrices that reflect (a) the output of

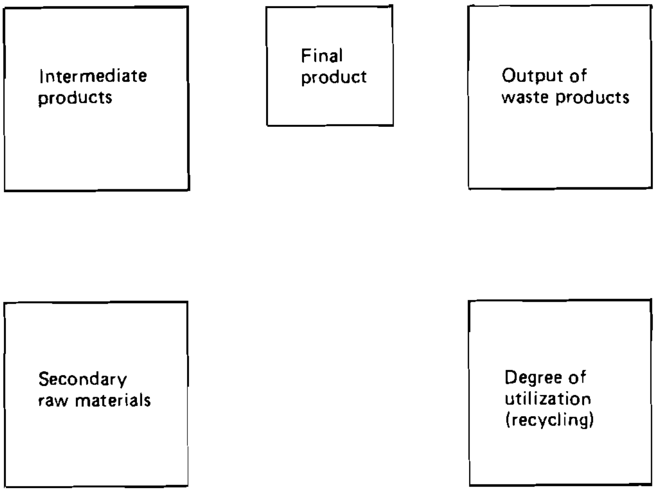


FIGURE 2 Incorporating recycling in macroeconomic input-output models. Source and detailed model: Sagert (1981).

specified waste products per unit of production or consumption, (b) the utilizable secondary raw materials per unit output of waste products, and (c) the use of secondary raw materials per unit of production (a very simplified scheme is shown in Figure 2). The practical implementation of this idea would need extensive and detailed information, and at present we do not have all the necessary data. Moreover, note that the raw material consumption of each raw material entry in the input-output table would have to be subdivided into three shares, corresponding to inland primary, inland secondary, and imported raw materials.

The examples described above show that calculations of structural changes require input-output models with detailed entries in both value and physical units, taking into account the specific purpose of each calculation. Therefore, in the GDR, the continued improvement of the use-value and value input-output table will play a decisive role in the future development of input-output models. New and more detailed entries, as well as a representation of the process of reproduction of capital stock, will be included in future work and optimization tests of the model are currently underway.

REFERENCES

Heinrichs, W. and Knobloch, G. (1983). Konsumtionsmittelproduktion und Übergang zur intensiv erweiterten Reproduktion--theoretische Probleme. Wirtschaftswissenschaft (Berlin), 7:961-983.

Köhler, G., Fülle, H., and Pinkau, K. (1981). Materielle Bilanzierung. Berlin, part 5.

Sagert, J. (1981). Probleme des Zusammenhangs von intensiver Nutzung der natürlichen Ressourcen and Umweltgestaltung. Wissenschaftliche Zeitschrift der Hochschule für Ökonomie 'Bruno Leuschner', Berlin, 3:63-69.

INPUT–OUTPUT ECONOMETRIC MODELING IN DEVELOPING ECONOMIES: SOME METHODOLOGICAL ISSUES

Sam Olofin
Department of Economics and Centre for Econometric and Applied Research (CEAR), University of Ibadan, Ibadan, Nigeria

I. INTRODUCTION

Reliance on primitive methods of rule of thumb for analysis of the economy, becomes increasingly inadequate in developing economies, as their traditional sectors are modernized and the typical economy gets more complex. As these countries develop, formal economy-wide analytical models invariably become a necessity for the average economic policy maker, if he is to succeed in effectively monitoring and influencing the direction and level of economic activity. In most of the developed market economies of the west, large scale macroeconometric models are finding increasing application in the analysis and forecast of short-term aggregate demand. The approach to econometric modeling in these economies is often doctrinaire, emphasizing income determination, forecasting, and policy analysis in the short run. This approach has been found to be unsuitable for most developing economies, Klein (1966) where the overriding concern is on supply side and generation of productive capacity. A study by Mishkin (1979) has shown that standard simulation procedures in these conventional econometric models are capable of misleading policy prescriptions, especially when longer term projections are involved. This is attributable partly to the variability of model coefficients with ordinary time series data. This situation is compounded further in the developing economies in which unstable institutional factors contribute to the quick obsolescence of conventional macroeconometric models. Macroeconomic modeling with supply side emphasis for planning, and longer term projection purposes to meet the needs of developing economies, requires a linkage between final demand spending and sectoral activities in the production sectors. The kind of information that industry studies provide within input-output (I-O) analytical framework have been found to provide a basis for such linkage, and attempts have been made by model builders at incorporating I-O sectors in econometric models of some developed economies, some of which include the U.S., Preston (1975 a, b), Canada (1978) and more recently Germany, Nyhus (1982).

Input-output based econometric modeling appear to have the potential of dealing with two major problems any macro model builder in a developing economy has to contend with, that of finding a suitable theoretical framework free from doctrinaire orthodoxy, and that of finding a suitable framework for longer term studies. However trying to develop input-output econometric models within

---

* The author is Senior Lecturer, Department of Economics and Deputy Director Centre for Econometric and Allied Research, (CEAR) University of Ibadan, Ibadan, Nigeria. Funding support for this research through CEAR by the Ford Foundation, Grant (830-0216) and Rockefeller Foundation, Grant (GA SIE 8114) are hereby acknowledged. Mr. I.D Poloamina a Graduate Assistant at CEAR offered valuable criticism on the original draft of this paper; any shortcomings remain the sole responsibility of the author.

the context of developing economies raises a number of methodological problems some of which are directly linked with the problem of availability of I-0 tables, and their compilation problems, and others which are theoretical in nature. Most of the problems relating to, costs, data, and other resource constraints have been highlighted by Singh (1972) from the perspective of Kenyan experience. One of the major theoretical problems has to do with the problem of inconsistency between I-0 analysis and econometric modeling discussed by Sapir (1976) and Marzouk (1976). Our objective in the present paper is to examine some of these methodological problems further and how they are being tackled within the context of an on-going effort in another developing economy, Nigeria. The rest of the paper is divided into four sections; a section II quickly reviews the I-0 approach to econometric modeling; section three discusses the inconsistency problem. In section IV some of the problems relating to the compilation of I-0 tables are examined and finally in section V a summary is made.

II INPUT-OUTPUT ECONOMETRIC MODELING

The essence of I-0 econometric modeling is to translate gross output into value added by sectors and relate these to final demand categories. The coefficients of the resulting value added equations can then be estimated directly from I-0 tables where the tables are available, or estimated from other national accounts series and given I-0 analysis interpretation. The U.S. model by Preston, the Canadian model by Johnson et. al., and the model for Western Germany by Nyhus, adopted the former approach. In indiviual country models for developing economies where regular I-0 may not be available the approach tends to be the latter, and a few examples include the models of Sudan [Marzouk (1975)], Brazil, [Behrman and Klein (1970)] Mexico [Del Rio and Klein (1974)] and Nigeria [Olofin et al. 1983]. The basic methodology in either approaches may be summarised as follows:

Let,

$A = (a_{ij})$ = matrix of technical coefficients

X_i = production of commodity i

Y_i = final demand for commodity i

Q_i = value added in sector i.

Input-output analysis offers a framework in which, for a given level of output, intermediate input demand can be uniquely detemined from a production relation in which output is made a function of primary inputs only. The basic static I-0 relationships states that

$$X_i = \Sigma^n_{i=1} a_{ij}X_j + Y_i \quad (1)$$

or in matrix notation,

$$X = AX + Y \quad (1)'$$

whereby,

$$(I-A)\ X = Y \quad (2)$$

where, X and Y are n-vectors and A is an (nxn) matrix. Thus relationship (1) states that production of commodity i equals the sum of intermediate input demand and final demands (Y). Also,

$$Q_j = X_j - \Sigma_{i=1}^{n} X_{ij} \qquad (3)$$

We can rewrite (3) as,

$$Q_j = X_j - \Sigma_{i=1}^{n} a_{ij}X_j = [1 - \Sigma_{i=1}^{n} a_{ij}] X_j \qquad (4)$$

or in matrix notation,

$$Q = BX \qquad (4)'$$

where Q is an n-vector and B is an (nxn) matrix whose typical element on the main diagonal is given by,

$$b_{jj} = 1 - \Sigma_{i=1}^{n} a_{ij} \qquad j = 1, \dots, n$$

while all the off diagonal elements are zeros. The relationship (4) defines value added in the jth sector Q_j as the difference between gross output X_j and total intermediate inputs delivered by all sectors to the jth sector. On the production side, this relation transforms gross output into value added by sectors.

Combining eqs. (1)′ and (4)′ we obtain,

$$Q = B(I - A)^{-1}Y \qquad (5)$$

On the demand side, final demand may consist of m components[1], whereby the final demand by the ith sector is given by

$$Y_i = Y_{i1} + Y_{i2} + , \dots, + Y_{im} \qquad (6)$$

The share of the ith sector's final demand deliveries to each final demand category is given by

$$h_{ij} = Y_{ij}/Y_j \quad j = 1, \dots, m \qquad (7)$$

and following Marzouk (1975) these shares can be assumed to be constant.

Combining (6) and (7) we obtain

$$Y_i = \Sigma_{j=1}^{n} h_{ij}Y_j \quad j = 1, \dots, m \qquad (8)$$

or in matrix notation

$$Y = HR \qquad (8)'$$

where Y is an n-vector of final demand deliveries by sectors, H is an (nxm) matrix whose columns sum to unity and show the proportion of each type of final demand delivered by each sector, and R is an m-vector of GNP components. To be able to express value added (Q) as a function of final demand (R) we substitute Y from (8)′ into (5) and we obtain,

$$Q = B\ (I - A)^{-1}\ HR \qquad (9)$$

System (9) is a set of linear equations connecting value addex (Q) with GNP components (R), whose coefficients are to be determined by regression

---

[1] Which typically, includes changes in inventory stock; gross fixed investment; exports; private consumption and public consumption.

analysis, using either data from I-0 tables where these are available, or as approximations of such I-0 based coefficients when other time series data are used.

III. INCONSISTENCY PROBLEM

The inconsistency problem arises when, the coefficients in an I-0 econometric model are estimated from time series other than those derived from industry studies within the framework of I-0 tables. Sapir (op. cit) tries to develop a theory whose results show, that interpretation of ordinary time series based coefficients of valued added functions may be misleading and inconsistent with the usual interpretation of the coefficients of the matrix $B(I - A)^{-1} HR$, when they are obtained directly from I-0 tables. One likely consequence and evidence of such inconsistency would be, an upward bias in the measurement of the impact of fiscial policy measures on GDP, for example long run investment multipliers.

He went further to suggest two possible alternative ways for dealing with the problem. First he suggests the estimation of the $B\ (I - A)^{-1} HR$ matrix directly from I-0 tables, or where they must be obtained from estimation of value added functions, such estimation has to be done simultaneously subject to the restriction, that the coefficients of GNP components in each equation sum up to unity, less the ratio of imports to total value added. It would appear that neither of his two suggested solutions to the problem is feasible within the context of most developing countries. The paucity of data in addition to other compilation problems to be discussed in section IV make the availability of I-0 on a regular basis difficult in most of these countries. Similarly due to data constraints, Marzouk (1976) has shown that any attempt at simultaneous estimation of the value added functions is bound to run into severe multicollinearity problems which may in turn result in exaggerated and possibly meaningless negative coefficients.

Our approach to the development of an I-0 econometric model of the Nigerian economy has been that of a pragmatic approach, which recognises the obvious limitations in trying to relate dynamic coefficients estimates to an essentially static I-0 analytical framework, but accepts the broad I-0 interpretation, which allows the linking of value added with final demand components. The coefficients are estimated without imposing any restrictions, as long as such estimates yield meaningful coefficients. As the data situation improves, not only would compilation of regular I-0 tables become easier but also, the simultaneous estimation of coefficients as suggested by Sapir may become feasible and consequently the problem of inconsistency in I-0 econometric models for developing economies can be tackled.

IV. SOME OTHER METHODOLOGICAL PROBLEMS

There are several methodological problems which are directly related to the compilation of I-0 tables in addition to the interpretation problem dealt with in the section immediately preceeding this. In briefly discussing a number of these problems illustrations will be drawn on how they are being tackled from a developing economy's perspective from CEAR's on going effort to produce I-O tables for the Nigerian economy on a regular basis.

a. Resource constraints and Periodicity.

An I-0 -econometric model that would effectively serve as a framework for long term studies and projections, needs regular I-0 tables which reveal the structural changes that occur within an economy as it grows. One of the most difficult challenges an I-0 analyst in a developing economy would have to contend with is the problem of irregularity of I-0 tables. Given the manpower and other resource requirements of regular production of I-0 tables, producing these tables at regular intervals may be a formidable problem. The nature of these problems and how they render regular compilation of I-0 tables almost impossible in developing countries has been well elborated upon by Singh (op.cit). The result is that for countries which have any I-0 tables at all, such are usually compiled by non-resident experts who compile the table for some particular period and for some specific purpose with no basis for continuity. For example prior to CEAR's project to embark on regular compilation of I-0 tables for the Nigerian economy there were three different attempts by Carter (1966) Clark (1970) and Aboyade et. al (1981) which resulted in three different tables of varying sizes, which were more or less compiled inde pendtly of one another and for different purposes, with no intention whatsoever for continuous compilation. Carter's table involved a 20 x 20 transactions matrix based on Okigbo's (1962) 1950-57 National Accounts of Nigeria. Clark's table had no transactions matrix of its own; instead hypothetical coefficients were used in enlarging Carter's 20 x 20 table to obtain a massive 86 x 86 matrix of technical coefficients. The third table by Aboyade et. al. had a 25 x 25 transactions matrix as an accompaniment of the 1973-75 National Accounts for the Nigerian economy. For all practical purpose it is virtually impossible to link the three tables together by any known methods in any meaningful way for analytical purposes.

It would appear that other than these occasional tables it is difficult to produce I-0 tables regularly because of the absence of any organisation or body committed to doing so. Most developing countries have statiscal gathering agencies which are ill-equiped to undertake such a demanding task on a continuing basis. One of the primary objectives at CEAR in its I-0 project, is to develop a framework that would make for relative ease of compiling regular I-0 tables from industrial survey data and national accounts data, supplemented with data from administrative and other sources. To this end the year 1970 was selected as an experimental year for the feasibility of a regular 50 x 50 transactions flows matrix, [Olayide et. al. (1981)]. Effort is currently in progress to produce regular annual tables begining with 1980.

b. Accounting framework

The accounting framework for I-0 tables described in the United Nations report, A system of National Accounts[2] may be difficult to implement in most developing countries because of data restrictions. In the U.N. framework, presentations of inputs and outputs are done in separate tables, and classification of inputs and outputs is done by commodity. a distinction between industries and commodities is also possible. Despite the obvious advantages of the commodity industry format over the inter-industry square format, the most obvious being the relative ease with which internal consistency checks can be carried out in the former, most developing economies may have to make do with the traditional square inter-industry table in its most simplified form as illustrated in chart 1 below, because of data restrictions. Other methodological and compilations problems yet to be discussed in this section would be discussed in relation to the simplified accounting framework in chart 1.

Refering to chart 1, the V matrix is an (n-1) x (n-1) matrix which is a matrix of the values of intermediate commodity inputs. In this matrix each row shows the distribution by industry of the input of a commodity, while

---

[2] A system of National Accounts, Studies in Methods, Series F, No 2, Rev. 3, United Nations New York, 1968.

each column shows the distribution by commodity of the input of an industry. The F matrix is an (nxm) matrix of the values of commodity inputs of final demand categories. An industry is defined as a group of economic activities brought together under a single category mainly because of their similarity. An nth sector is included as the (r) vector for reason which will be explained shortly under balancing problems. Establishments which come under each industry especially manufacturing, include those employing 10 or more persons only, to the exclusion of small-scale handicraft industries.

c. Aggregation and Disaggregation

Given the paucity of reliable and usable data in most developing countries the temptation is always there, of wanting to construct a highly aggregated table to avoid lots of zero entries. Our approach at CEAR has been that of starting out with a highly dissaggregated table which is then contracted as data constraints dictate the merging of industries. Our belief is that aggretating a large table is often easier than trying to dissaggregate a highly compact table.

While multiple levels of aggregation may be feasible in the manufacturing sectors, depending on the amount of details provided in the industrial survey information, only a single level of aggregation is feasible for sectors which derive from the national accounts statistics, especially the primary producing sectors such as agriculture, mining and quarrying, livestock, fisheries and forestry. Ideally one would expect further disaggregation of primary inputs into categories which may include, wages, salaries, supplementary labour income, indirect taxes and subsidies. This may not be possible for most developing countries again because of unavailability of data, hence the primary inputs matrix may be reduced to a single row vector only.

The level of aggregation of final demand categories will often be dictated by the level of aggregation of these categories in a country's national income accounts. Ordinarily a comprehensive National Accounts for any country would include, the income and expenditure accounts, real domestic product by industry, Financial flow accounts, the balance of payments account as well as the input-output table. Ideally one would expect the final expenditure items in the Income and expenditure accounts to be identical with some items in the I/O sub-system. For most developing countries however such final demand items are highly aggregated, making decomposition into sector demands difficult. Also undervaluation of these items is not unlikely, due to quantification problems of activities in the informal traditional subsistence sector. For a country like Nigeria, expenditure items are disaggregated into private and public sector categories only, and income accruing to primary factors of production and the non-factor costs such as indirect taxes are usually very scanty and unreliable. There is also the lack of data on the valuation and commodity content of inventories, which is consequently treated as a residual final demand vector.

d. Valuation Problems

Ideally an I-0 table should be constructed with valuation done at producers' prices, or what in United Nations SNA terminology is referred to as 'approximate basic values'. Such valuation presupposes the availability of data on the various margins such as retail, wholesale, tax and transport margins which are difficult to come by in most developing economies. It is more likely therefore that valuation of the transactions flows in the I-0 table will be carried out at market or purchasers prices as we are having to do for Nigerian tables.

CHART 1

THE ACCOUNTING FRAMEWORK OF NIGERIAN I/C TABLES

	INDUSTRIES	MISCE	FINAL DEMAND CATEGORIES					TOTAL
			FDHG	INV	CAPF	EXP	Less (IMP)	
INDUSTRIES	V $(n-1 \times n-1)$	r	F $(n \times m)$					q
MISCE	r'							
TOTAL INT. INPUTS IMPORTS TOTAL INPUTS								
PRIMARY INPUTS	y'							
TOTAL GROSS INPUT	q'							

Final Demand Categories

FDHG - Final demand household and govt.
INV - Inventory
CAPF - Capital formation or investment public & private sectors
EXP - Exports
IMP - Imports

Notation

V - is a matrix of the values of intermediate inputs
r - is a vector of unclassified inputs
F - is a matrix of the values of commodity inputs of final demand categories
q - is a vector of the values of total industry output
y - is a vector of primary inputs

Another major problem often arises in compiling the final demand matrix (F) as well as the intermediate use matrix (V), on how to distinguish between imports and domestically produced goods and services. Most firms would hardly make necessary distinction between imports and domestic production of raw materials purchased for further processing. Also final demand transactors such as, households, the government and corporate business do not record the purchase of commodities by their origins, as to whether such commodities are imported or produced domestically. In dealing with this problem what we do is to assume that imports are generally fixed proportions of total supply for each user. By this assumption it is then possible to prorate import values for each commodity over the various users and sectors.

A third major valuation problem has to do with the distinction between current price I-0 tables and constant price I-0 tables. The valuation of I-0 flows at constant prices requires a deflation procedure in which appropriate deflators must be found for each of the n-sectors. For most developing countries like Nigeria, deflators may be obtainable for broad value added categories only. Thus at best constant price I-0 tables would be feasible only at a highly aggregated level. for this reason, our approach in Nigeria is to concentrate on valuation at current market prices pending when the availability of improved data on appropriate deflators would make constant price I-0 table feasible.

e. Commodity Balancing

Another methodological problems arises from the commodity balancing requirement for an I-0 table. Typically any I-0 is constructed on the basis of three key assumptions. These are, (i) that a given economy can be meaningfully segmented into a finite number of sectors each of which produces a single homogenous product. (ii) In all production processes there are no economies of scale nor diseconomies of scale; that is in the absence of technological innovations technological coefficients remain constant. (iii) Thirdly that the level of output in each sector uniquely determines the quantity of each input purchased from other sectors. Given these assumptions, an economy's production processes and their various interrelationships can be specified in terms of balance equations as follows,

$$Q_i = \Sigma^n_{i=o} A_{ij} + Y_i \quad i = 0, 1, 2, \ldots, n \tag{10}$$

where Q and Y are as previously defined and A_{ij} stands for intermediate inputs demand and Q_o stands for the primary commodity.

If we assume the absence of joint production in addition to assuming constant returns to scale, we can write the production function relating output of sector j, Q_j to its input requirements as,

$$Q_j \quad F^j \quad (A_{oj}, A_{1j}, \ldots, A_{nj}; A_{n+1,j}; M_{1j}, \ldots, M_{mj}) \quad j = 1, 2, \ldots, n \tag{11}$$

where M_{ij} is total quantity of various types of inputs purchased by sector j, from outside the geographic boundries of the economy in question, $i = 1, 2, \ldots, m$; $A_{n+1,j}$ is total quantity of homogenous public service purchased by sector j from governmental and quasi-governmental agencies and A_{oj} is total quantity of homogenous labour services purchased by sector j from households. Under the assumption of generalised diminishing returns, the isoquant surfaces derivable form equation (11) have the usual convexity, Dorfman et. al., (1958; p 209), and hence the production function F^j can be written as follows:

$$Q_j = \text{Min } A_{oj}/a_{oj}, \ldots, A_{nj}/a_{nj} ; A_{n+1,j}/a_{n+1,j};$$

$$M_{1j}/b_{1j}, \ldots, M_{mj}/b_{mj}$$

$$j = 1, \ldots n \qquad (12)$$

If it is further assumed that all commodities are non-free or scarce commodities, then the Min Q_j = Max Q_j in (12) and hence eq. (12) is equivalent to equation (11), where the $a_{ijs} > 0$ stand for the technological coefficients and the $b_{ijs} > 0$ for the trade coefficients.

To derive the structural equations, the technological coefficients are needed and are derived as

$$Q_{ij} = A_{ij}/Q_j \qquad (12)$$

whereby,

$$A_{ij} = a_{ij} Q_j; \quad i = 0, 1, \ldots, n \qquad (13)$$

The relationship in (13) states that each input requirement A_{ij} is in fixed proportion to total output Q_j, which is the same as saying that the technological coefficients a_{ijs} are constant. Combining eqs. (10) and (13) we have, for every known quantity of total output Q, the following relation

$$Q_i = \Sigma^n_{i=1} a_{ij}Q_{ij} + Y_i, \quad i = 0, 1, \ldots, n \qquad (14)$$

where, by convention $Y_o = 0$, that is final demand for the non-produced commodity is assumed to be zero. Thus considering a typical column in chart[1], the following should hold:

$$\Sigma^n_{i=1} Q_{ij} + \Sigma^l_{k=1} Y_{kj} = Q_j; \; j = 1, 2, \ldots, n \qquad (15)$$

That is, sector j's total input use Q_j should consist of purchases made from the various sectors of the economy, including itself, plus payments to (l) factors of production. Alternatively looking at the chart row wise, it should be the case that,

$$\Sigma^n_{j=1} Q_{ij} + \Sigma^m_{k=1} Y_{ik} = Q_i; \quad i = 1, \ldots, n \qquad (16)$$

That is, the gross output of industry i, Q_i should equal the sum of the industry's sales to all the n sectors including sales to itself, and its deliveries to each of the m categories of final demand. The balancing requirements is satisfied when sales equals purchases that is,

$$\Sigma^n_{i=1} Q_i = \Sigma^n_{j=1} Q_j = \text{GDP} \qquad (17)$$

To achieve this commodity balance, a uniform valuation of each commodity for all transactors or industries is necessary. This in turn calls for the identification and proper valuation of the margins in trade, transport, taxes, which as earlier pointed are often difficult to quantify in most developing countries. Also there are usually under valuation problems arising from unreported production or disposition, especially in the subsistence sector, miscl assification of production or disposition of output, and wrong valuation or misclassification of imports and exports. Judging from our experience at CEAR on Nigerian I-0 tables, it is often difficult, if not impossible to completely eliminate the resulting imbalances attributable to these various sources. Against conventional practice therefore if commodity balance is to be achieved in the I-0 table, provision must be made for a residual sector, which is designated by the vector (r) in chart 1.

V. CONCLUSION

Some form of formal macroeconomic modeling for effective long term policy analysis and projections is ineviatable as underdeveloped economies develop and become more complex. Input-Output econometric modeling offers one of the likely alternatives to reliance on primitive rule of thumb for such analysis and projections. The most serious methodological obstacles on the path towards realising the former appear to be data related. As data situation improves in these countries such problems can be overcome.

IV. References

Aboyade, O. et. al. (1981). The National Accounts of Nigeria 1973-1975. Federal Ministry of National Planning, Lagos, Nigeria.

Behrman, J. and Klein L.R., (1970). Econometric growth models for the deveoping economy. In Induction, growth and trade, Essays in honour of Sir Ray Harrod. Claredon Press, London.

Del Rio, A.B. and Klein, L.R., (1974). Macroeconometric model building in Latin America: The Mexican case. In N.D. Ruggles (Ed.), The role of computer in economic and social research in Latin America. National Bureau of Economic Research, New York.

Carter, N.G., (1966). An Input-output Analysis of the Nigerian Economy, 1959-60. In Stolper, W.F., Planning without Facts, Lessons in Resource Allocation from Nigeria's Development. Harvard University Press, Cambridge.

Clark, P.B., (1970). Planning Import Substitution: Contribution to Economic Analysis. North-Holland, Amsterdam.

Johnson, W. et. al., (1978). Canadian EXPLOR MODEL (CEM 1), Macro Economic Structural Analysis Group Department of Industry, Trade & Commerce, Ottawa Canada.

Klein, L.R. (1966). What kind of Macroeconomic Model for Developing Economies? The Econometric Annual of the Indian Economic Journal, XII (3).

Marzouk, M.S., (1975). An Econometric Model of Sudan, Simulation experiment with growth prospects. Journal of Development Economics 1975 (1) 337-358.

Marzouk, M.S. (1976). A note on Input-Output Analysis and Macroeconometric Models A comment. Journal of Development Economics. 1976 (3): 385-387

Mishkin, Frederic S., (1979). Simulation Methodology in Macroeconomics: An Innovation Technique. Journal of Political Economy, 87 (4): 816-836.

Nyhus. D.E., (1982). An Econometric Input-Output Model of the West German Economy. WP-82-41. International Institute for Applied Systems Analysis, Analysis, Laxenburg, Austria.

Okigbo, P.D.C., (1962). Nigerian National Accounts 1950-57 Government Printer, Enugu.

Olayide S.O., Olofin, S.O., Iyaniwura J.O. and Adeniyi, J.O., (1981). An Input-Output Model of the Nigerian Economy UIFP-81/002, University of Ibadan Forecasting Programme, University of Ibadan, Ibadan, Nigeria.

Olofin, S., et. al. (1983). The CEAR - FNMP Macroeconomic Model of the Nigerian Economy. DP-83-06
Centre For Econometric and Allied Research, University of Ibadan, Ibadan Nigeria.

Preston, R.S., (1975a). The Input-Output Sector of the Wharton Annual and Industry Forecasting Model. In G. Fromm & L.R. Klein (Ed.), The Brookings Model: Perspective and Recent Developments. North-Holland, Amsterdam.

Preston, R.S., (1975b). The Wharton Long Term Model: Input Output within the context of a macro Forecasting Model. International Economic Review, 16 (1): 3-19.

Sapir, Andre. (1976). A note on Input-Output Analysis and Macroeconometric Models. Journal of Development Economics 1976 (3): 377-383.

Singh, P. (1972). Input-Output Analysis - An appraisal in the context of as yet an unfinished experiment in Kenya. Review of Income and Wealth, 18 (4): 393-398.

OBSERVING STRUCTURAL CHANGE IN THE JAPANESE ECONOMY: AN INPUT–OUTPUT APPROACH

Douglas Nyhus
Department of Economics, University of Maryland, College Park, Maryland, USA

1. INTRODUCTION

The Japanese economy has moved, in the last twenty years, from an agricultural and primitive industrial economy to one of the leading industrial giants of the world. Indeed, there are even those who feel that Japan is leading the world into the post-industrial information oriented society. What can we learn by looking at the structural changes in the Japanese economy over the last twenty years? How important is manufacturing relative to the total economy as compared to fifteen or twenty years ago? How important will manufacturing be twenty years from now? What measure do we use? value added? employment? gross output? What sort of changes may we expect in the future? What are the causes of changes the relative composition of output by industry? Are these causes primarily internal or external? Should we expect past trends to continue or is a "break" to be expected?

Input-Output analysis, because it embodies the very structure of production, consumption, and income generation in the economy, has a decided advantage in shedding light on the questions posed above over that offered by what may be called standard macroeconometric modelling. The dynamics of inter-industrial relationships, the changing composition and overall growth of the different components of final demand and the general effects of changes in relative prices on the real parts of the economy may all be studied using input-output. In addition, the accounting framework of input-output assures us of consistency. A consistency which is often irritating to the model builder but is ultimately a great aid.

The model presented below is of the "standard" INFORUM type. See, for example, Lee (1977), Almon & Nyhus (1980) or Ciaschini (1982). Hence. the description of the equations used is reserved for an appendix since many of them as forms of equations have been presented before. The focus here is upon the changing structure of production. consumption, and some of the causes for the observed changes. The equations were not expressly designed to focus on structural change nor were the data expressly obtained to be viewed from the perspective we will have in this paper but this fact only emphasizes the versatility of input-output as a tool in analyzing structural change. The data for the model were obtained from a timeseries for outputs and final demands in current and constant prices for the years 1955-1978 developed by Prof. Sakuramoto of Keio University in Tokoyo. The series is now being extended by Prof. Kuroda (Tsujimura,Kuroda.Shimada.1981) who is also at Keio University. The data for employment and value added were obtained from the Annual Report on National Accounts published by the Economic Planning Agency of the Government of Japan.

2. SOURCES OF STRUCTURAL CHANGE

Structural change can arise from changes in the relative growth and composition in final demands which in turn are derived from changing incomes, changing relative prices, changing rates of economic growth abroad, changing demands for capital equipment, and finally a changing composition in the products purchased directly by government. Structural change is also a factor of changing technologies of production and of changes in interindustry sales arising from other factors such as relative prices. Let us briefly examine these in turn.

2.1 Private Consumption Expenditures

The structure of private consumption has changed dramatically in Japan in the last twenty years. Food as a share of total expenditure has fallen from 38% in 1960 to 25% in 1980. The amount spent on transportation has grown from less than 1% in 1960 (presumably bicycles) to nearly 3% in 1980. The share spent on house rents has nearly doubled from 8.6% to 15.8% in the period. It is clear that the changing proportions spent on various consumer items has moved Japan in a large and significant manner away from an agriculturally oriented society to a more service oriented society. Indeed the proportion spent on services has grown from 40% in 1960 to 47% in 1980.

The symmetric consumption function which has been widely used in the INFORUM models has again been applied with success to the Japanese case. The symmetric consumption function has the properties: (a) that is homogeneous of degree zero in all prices and income; (b) that commodities should be complements from some goods and substitutes for others; and (c) that the asymptotic consumption pattern depends, as income increases, on relative prices. The form of the equation used may be found in the appendix.

Forecasts using the symmetric consumption function show the share of total expenditures going to food to further decline to 22% by the year 2000. The share spent on transportation equipment to remain at its 1980 level - a reversal of the trend which showed substantial growth historically. The share spent on house rents (which doubled historically) is forecast not to grow but rather to fall slightly. The service share is forecast to continue its upward climb but at a slower pace than that of the historical period. Table 1 shows the proportion of private consumption spent on a selected list of goods and services for the period 1960-2000. In addition, the last line shows total expenditures in trillions of yen in 1975 prices.

TABLE 1 Shares of Total Consumption

	1960	1970	1980	1990	2000
Food	37.5	28.1	25.3	23.3	22.2
Rice	10.3	3.8	2.0	.7	.2
Fish	4.4	2.1	1.2	1.2	1.1
Goods	22.7	26.3	27.6	28.4	28.5
Trans. Equip.	.7	1.5	2.7	2.6	2.7
Textiles	5.9	5.0	2.9	3.2	3.1
Services	39.8	45.6	47.1	48.2	49.4
House Rents	8.6	10.7	15.8	15.2	15.0
Rail Trans.	3.0	1.6	.9	1.0	1.0
Oth. Trans.	2.0	3.5	2.3	2.5	2.5
Restaurants	2.0	5.2	4.8	5.1	5.4
PCE(Tri.of '75 yen)	26.9	63.9	100.5	155.0	230.1

2.2 Exports

Japanese exports have grown tremendously during the historical period. In 1960, total exports were 3.1 trillion yen (1975 prices). By 1980 that figure had grown to 32.4 trillion - an average growth rate of 11.7% per year. There are, however, large differences in growth rates by product. Fabrics grew at an average rate of less than 2% per year while Transportation equipment grew at 17% per year. Indeed the proportion of total exports by product changed dramatically over the period. Fabrics accounted for 15.5% of exports in 1960 but only 2.2% of exports in 1980. Steel's share grew from 5.4% in 1960 to a high of 14.0% in 1975 and back to 8.8% in 1980. Transportation equipment tripled its 1960 share of 8.7 to 25.8% in 1980.

The function relationship chosen to explain the very dramatic growth in Japanese exports is the same as that used in several other models in the INFORUM system. It relates exports by product to domestic conditions in the customer countries for Japanese goods. Relative prices - Japanese to a weighted average of Japan's competitors - were also incorporated. The form of the equation can be found in the appendix.

The forecast period shows some moderation in the past trends and even some reversals. Table 2 shows as the evolving shares of exports as well as the total volume of exports.

TABLE 2 Shares of Total Exports

	1960	1970	1980	1990	2000
Sea Food	1.4	1.0	.5	.6	.6
Chemicals	3.1	5.1	5.0	3.4	2.8
Fabrics	15.6	5.2	2.2	1.8	1.6
Steel	5.6	11.7	8.9	3.2	2.0
Nonelectrical Mach.	6.0	7.8	11.9	16.8	16.7
Trans. Equipment	8.7	15.9	25.8	33.3	34.5
Services	16.4	19.8	14.9	15.2	14.9
Exports (tril.'75 yen)	3.1	12.7	32.4	40.3	58.9

2.3 Imports

Like the two previous components of final demand, imports have grown tremendously. The volumn of imports has grown more slowly - 8.0% vs. 11.7% - than that for exports. The composition of imports has not changed as much as that for exports. Primary materials remain at the heart of Japanese imports. In fact, primary materials have increased as a share of total imports from 34.7% in 1960 to 38.9% in 1980. Other non-food manufactures have falled from 28.5% to 26.8% over the period. Crude oil has remained the largest single commodity import as its share increased from 18.6% to 28.6% in 1980. The next largest share in 1960 was for Vegetable related agricultural products whose share fell from 13.5% to 8.2% over the same period. Machinery imports started the period with a 4.1% share and ended with a 5.2% share.

As with the export equation, imports are a function of domestic demands (output plus imports less exports) and relative foreign to domestic prices. The exact form of the equation can be found in the appendix.

Table 3 shows the evolution of the shares of total imports evaluated in

1975 prices.

TABLE 3 Shares of Total Imports

	1960	1970	1980	1990	2000
Primary goods	34.7	39.3	38.9	31.9	30.9
Crude oil	18.6	27.6	28.6	24.4	24.3
Raw agr. products	15.8	11.3	9.8	7.3	5.5
Manufactured food	12.5	9.1	8.3	6.9	5.8
Machinery	4.1	5.0	5.2	12.4	12.5
Other manufactures	24.4	23.2	21.6	24.7	28.2
Services	5.0	5.6	10.7	11.5	11.7
Imports (tr.'75 yen)	5.1	17.8	25.4	42.0	62.8

2.4 Investment in Structures and Equipment

The focus here is on the goods and services purchased. Hence here we observe machinery as an investment good and not investment by the machinery industry. Construction as a share of private investment has remained the largest proportion but that share has fallen substantially from its 1960 share of 69.2% to 58.1% in 1980. The mirror of construction's loss has been Electrical machinery's gain from 3.9% to 9.7% in 1980. Other products with gains have been Furniture. Fabrics, and Miscellaneous Manufacturing. Transportation equipment and Nonelectrical machinery shares have remained significant but without any substantial change historically.

The approach to modelling changes in the shares of private investment is to compute what would have been the sales of a particulary good, say Electrical machinery, if the 1975 share of investment had remained constant. The actual sales are then compared to the constant share calculated sales. If the ratio of the two (actual/calculated) is rising we have evidence of a rising share of Electrical machinery in private investment. The exact form of the equation can be found in the appendix. The table below shows the evolution of some major categories of private investment.

TABLE 4 Shares of Private Investment

	1960	1970	1980	1990	2000
Construction	69.2	56.3	58.1	54.3	51.8
Nonel. Mach	14.1	17.2	14.0	14.0	13.8
Elect. Mach	3.9	6.7	9.7	12.9	15.4
Furniture	.4	1.1	1.0	1.1	1.2
Trade margins	5.2	7.2	7.0	7.4	7.6
Trans. margins	.5	.7	.7	.7	.7
Invest(tr.'75 yen)	7.4	29.7	42.7	68.6	105.4

2.5 Input-Output Coefficient Change

Changes in the input-output coefficients are a very essential part of the study of structural change. In fact, it it just these changes that are meant by many who speak of structural change. Changes in input output coefficients can arise from a changing mix of technologies in a given industry as it modernizes. Such changes can occur even when no new techology asserts itself, but merely be in response to changes in the relative prices of various inputs.

The method used to predict coefficient change is identical to the method used for the shares of investment described above. The appendix has the exact formulation of the equation. Just as with the investment shares, we calculated what would have ben the intermediate sales of a product if the input-output matrix had not changed. The actual sales were then compared to the constant coefficient sales and the ratio explained using a logistic curve. Some of the ratios have had dramatic movements. The ratio for primary steel was 1.47 in 1960 - meaning that the overall average of the coefficients were 47% higher in 1960 than in 1975 - and .94 in 1980. The ratio grew from .79 to 1.03 over the period for Communication services. Likewise the ratio for Chemicals grewfrom .60 to 1.05. On the other hand, the ratio for Fabrics fell from 1.42 to .92 as did the ratio for Railroads which dropped from 2.56 in 1960 to .82 twenty years later. The table below shows the movement in the ratios for a selected group of industries together with their forecast out to the year 2000.

Table 5 Ratios of Acutal to Calculated Intermediate Use (1975 = 1.00)

	1960	1970	1980	1990	2000
Veg.Agr.Prod.	1.28	1.10	.94	.85	.77
Fabrics	1.42	1.27	.92	.79	.70
Chemicals	.60	1.07	1.05	1.11	1.13
Pet. Refining	.83	1.12	.78a	.68a	.65a
Prim. Steel	1.47	1.26	.94	.85	.80
Metal Products	.63	1.04	1.09	1.18	1.21
Railroad Trans.	2.56	1.23	.82	.61	.49
Oth. Trans.	.67	.97	1.09	1.25	1.36
Communication Serv.	.79	.80	1.03	1.09	1.14

a Exogenously assumed

3. CHANGES IN OUTPUT AND EMPLOYMENT

To a significant extent output and employment change the results of the underlying changes we observed in Section 2. Output and employment are, however, the significant variables when looking at different policies.

3.1 Output

The result of all the changes observed in section 2 can be felt in changes in output. The model has sixty-seven producing sectors. Table 6 show the results for an aggregate list of twenty-four industries. To avoid double counting (e.g. counting iron ore goining into steel and counting it again as the steel goes into machinery) value added weights are used. Thus we can talk meaningfully of a Non-durable manufacturing industry etc. From Table 6 the share decline in the importance of primary industries and of government services industry stands out. Primary industry alone fell from a 14.2% share of total output to a 4.5% share over the 1960-1980 period. Including the forecast period we see the slow decline in the importance of Non-durable manufacturing, the rise and retreat of Durable manufacturing and

TABLE 6 Structure of Gross Output (% of total)

	(HISTOR)	(HISTOR)	(FORCST)	(FORCST)	(FORCST)
	1960	1970	1980	1990	2000
Primary Industry	14.23	6.99	4.47	3.83	3.46
1 Agr.,Forestry&Fishery	13.40	6.34	3.89	3.30	2.94
2 Mining	0.83	0.64	0.58	0.53	0.53
Non-durable Manufacturing	9.82	9.27	8.05	7.53	7.21
3 Food and Beverages	4.84	3.26	2.71	2.51	2.36
4 Textiles	2.34	1.74	1.06	0.95	0.81
5 Pulp,Paper&Related Products	0.73	1.03	0.97	0.98	0.97
6 Chemicals	1.32	2.23	2.38	2.31	2.32
7 Petroleum & Coal	0.58	1.00	0.93	0.79	0.75
Durable Manufacturing	14.37	21.54	22.33	21.18	21.28
8 Stone,Clay,Glass	1.01	1.46	1.26	1.30	1.31
9 Basic Metals	2.48	3.49	3.01	2.24	1.99
10 Fabricated Metals	0.87	1.67	1.73	1.87	1.88
11 Machinery(non-elect)	1.88	3.23	3.32	3.40	3.43
12 Electrical Machinery	1.41	2.82	3.59	2.96	3.39
13 Transportation Equipment	2.24	3.61	4.56	4.70	4.74
14 Precision Instruments	0.28	0.49	0.65	0.64	0.65
15 Other Manufacturing	4.21	4.78	4.22	4.08	3.90
Services	45.61	51.67	55.87	58.02	58.57
16 Construction	8.42	9.03	8.97	8.99	8.82
17 Utilities(Private)	1.40	1.78	1.98	2.07	2.17
18 Trade	9.94	13.47	14.40	15.48	15.94
19 Finance & Insurance	5.03	5.06	5.23	5.43	5.48
20 Real Estate	4.91	5.34	8.76	9.16	9.36
21 Transp. & Communication	5.68	6.28	5.97	6.09	6.18
22 Other Services	10.23	10.71	10.56	10.80	10.63
Government & NP Inst.	15.98	10.54	9.27	9.44	9.47
23 Government	14.16	9.05	7.95	7.87	7.74
24 Non-Profit Institutions	1.82	1.48	1.32	1.57	1.73

the steady increase in the importance of the Service economy.

3.2 Employment

In many respects the shifting relative importance of industries weighted by jobs the patterns set by outputs. Clearly, if Primary industry's share of output has been cut three quarters we should see a similiar slicing of its importance in the employment market. The difference between output and employment changes can be explained by difference in relative rates of productivity growth and in changes in the average hours worked per month. Since productivity has been increasing generally faster in manufacturing and in agriculture than in services the picture of the structure of jobs has changed somewhat more than that for output.

The equation for employment is quite simple. Historically, the labor required per year for a given output is first calculated as the number of jobs times the average hours worked per month. This labor requirement is then converted to a per unit of output basis and related to trends and changes in output. The average hours worked per month has been steadily declining in Japan but is still higher than in the west. For example, in 1981, the average hours worked per month varied from a high of 189.3 in Construction to a low of 160.9 in Finance. Those numbers are the equilivent of 44.0 hours and 37.4 hours per week. A simple logistic curve with an asymptote of 152 hours (35.3 per week) was estimated . The form of the equations estimated can be found in the appendix.

Table 7 shows some of the principle changes in the structure of employment from 1960 to 1980. It may seem hard to believe that in 1960 over one third of all Japanese workers were in the Agricultural and Mining sectors. Even by 1980 that proportion was still 12.8%. As a proportion of employment both Non-durable and Durable manufacturing peaked around 1970. The decline is forecasted to continue through the end of the century. All of services, except Trade, are forecast to grow as shares. Indeed, during the 1970's, Services (including Construction) began to employ over half of the working population in Japan. In approximately twenty years that proportion may rise to over 60%.

4. CONCLUSIONS

Clearly, there have been substantial changes in the structure of employment and output in the Japanese economy during the last twenty years. The model shows a continuation of past trends. No "breaks" have been observed in the past and none are forecast. Certainly some trends have slowed or have even been reversed. For example the historical increase in Durable manufacturing relative to the rest of the economy has clearly come to an end and that sector is falling in relative importance. Substantial changes have occurred internally through changing consumption patterns and changing input-output coefficients. The structure of exports has changed and has had its impact on the domestic economy. The structure of imports has not changed greatly, however, imports may have more effect in the future then in the past. On balance, we may tentatively conclude that internal changes in demand patterns outweigh changes in external patterns in the shaping of the overall Japanese economy.

REFERENCES

Almon, C. and Nyhus, D. (1980) An International System of I-O Models - Status Report: December 1980. INFORUM, University

TABLE 7 Employment Shares (% of Total)

	(HISTOR) 1960	(HISTOR) 1970	(FORCST) 1980	(FORCST) 1990	(FORCST) 2000
Primary Industry	33.66	20.08	13.03	10.50	9.52
1Agr.,Forestry&Fishery	32.43	19.60	12.79	10.35	9.42
2 Mining	1.23	0.47	0.24	0.15	0.10
Non-durable Manufacturing	7.40	7.62	6.20	5.00	4.27
3Food and Beverages	2.43	2.49	2.28	1.89	1.71
4 Textiles	3.19	3.28	2.32	1.99	1.72
5 Pulp,Paper&Related Products	0.64	0.66	0.53	0.43	0.33
6 Chemicals	1.06	1.09	0.94	0.59	0.39
7 Petroleum & Coal	0.09	0.10	0.12	0.10	0.11
Durable Manufacturing	14.62	19.12	18.55	16.86	15.73
8Stone,Clay,Glass	1.09	1.24	1.36	1.78	2.22
9 Basic Metals	1.08	1.22	1.02	0.51	0.33
10Fabricated Metals	1.36	2.25	2.07	1.26	0.85
11Machinery(non-elect)	2.17	2.88	2.60	2.04	1.50
12Electrical Machinery	1.52	2.71	2.68	1.70	1.30
13Transportation Equipment	1.66	2.41	2.62	2.62	2.30
14Precision Instruments	0.41	0.57	0.60	0.48	0.35
15Other Manufacturing	5.33	5.85	5.60	6.48	6.87
Services	37.87	46.00	53.79	58.42	60.65
16Construction	6.43	8.09	10.05	11.34	12.69
17Utilities(Private)	0.51	0.53	0.56	0.64	0.67
18Trade	13.04	16.18	17.29	16.57	14.79
19Finance & Insurance	1.77	2.51	2.87	3.08	3.24
20Real Estate	0.19	0.56	0.94	0.71	0.58
21Transp. & Communication	4.65	5.54	5.89	6.92	7.64
22Other Services	11.28	12.59	16.19	19.16	21.04
Government	6.45	7.19	8.43	9.22	9.83
23Government	5.69	5.79	6.57	7.23	7.71
24Non-Profit Institutions	0.76	1.40	1.86	1.99	2.13

of Maryland, College Park, Maryland.

Ciaschini, M. (1982) The Estimation of the Investment Functions for the Italian Model. In A. Smyshlyaev (Ed.) Proceeding of Task Force Meeting on Input-Output Modeling. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Lee, Y. (1977) An Econometric Interindustry Forecasting Model of the French Economy. INFORUM Research Report No. 20. College Park, Maryland.

Nyhus, D. (1975) The Trade Model of a Dynamic World I/O Forecasting System. INFORUM Research Report No. 14. College Park, Maryland.

Tsujimura. K. Kuroda, M. and Shimada, H. (1981). Economic Policy and General Interdependence. Kogakusha Ltd. Tokoyo

5. APPENDIX

5.1 Personal Consumption Equations

The form of the equation for good i in group G (e.g. transportation) and subgroup S (e.g. public or private) is:

$$C_i = [b_{1i} + b_{2i}t + b_{3i}(y/\bar{p}) + b_{4i}A(y/\bar{p})]$$

$$(p_i/p_S)^{-\lambda_S} \quad (p_i/p_G)^{-\lambda_G} \quad (p_i/\bar{p})^{-\lambda_0}$$

where

C_i = consumption per capita in constant prices of good i in year t

y = disposable income per capita in current prices in year t

p_i = the price index of good i in year t.

$$p_S = (\prod_{j \in S} p_j^{s_j})^{1/s_S} \quad , \quad p_G = (\prod_{j \in G} p_j^{s_j})^{1/s_G}$$

$$\bar{p} = \prod_{\text{all } j} p_j^{s_j}$$

where s_j is the budget share of commodity j in the base year, and

$$s_S = \sum_{j \in S} s_j \;;\; s_G = \sum_{j \in G} s_j \;;\; \sum_{\text{all } j} s_j = 1$$

and b's and λ's are parameters to be estimated statistically.

5.2 Imports

The equation form for each commodity (dropping commodity and time subscripts) is.:

$$M = (a + bU)p^n$$

where

M is the volume of imports of the commodity
U is the domestic demand = output + imports - exports
P is the price term

$$P_t = \sum_{i=0}^{5} w_i \, (P_f/P_d)_{t-i}$$

where

$$P_f = \sum_{m=1}^{9} s_m \, P_{dm} \, E_m = \text{foreign price}$$

where

P_{dm} is the domestic price index in country m

s_m is the share of imports from country m of total imports of the commodity

E_m is an index of the price of m's currency in yen

P_d is the domestic price index of the commodity in Japan

m = Canada, U.S.A., Belgium, France, Germany, Italy, Netherlands, U.K., and the Rest of the World

w's are weights for lagged prices. The weights are derived from Nyhus (1975).

5.3 Exports

The form of the equation is identical to that for imports but the meaning of the variables is different.

$$X = (a + bD)P^n$$

where
X is the volume of exports of a commodity
D is an index of foreign demands defined by

$$D = \sum_{m=1}^{9} v_m \, I_m$$

where
I_m is the industrial production index of country m and

v_m is the share of the total exports foing to country m

m is Canada, U.S.A., Belgium, France, Germany, Italy, Netherlands, U.K., and the Rest of the World.

$$P = \sum_{i=0}^{5} w_i \, (P_d/P_f)_{t-1}$$

where

P_d is the domestic price index in Japan

P_f is an index of competitors prices defined by:

$$P_f = \sum_{m=0}^{10} u_m E_m$$

where

P_{dm} is the domestic price index of the country in country m

E_m is the price of m's currency

u_m is the share of world exports of the commodity by country m.

5.4 Coefficient Change

Changes in input-output coefficients are crucial to any meaningful study of structural change in an economy. The method chosen here is designed to account for wide-spread, pervasive coefficient change in a rather simple manner.

A logistic curve defined by the differential equation

$$1/c\ dc/dt = b(a - c)$$

is used. "c" denotes the coefficient, "a" its asymptote and "b" a constant. Thus, the rate of change of the coefficient slows as the coefficient approaches its "saturation" or as it nears its minimum use point.

The soluton of this differential equation is

$$c_t = a/(1 + Ae^{-bat})$$

where A is a constant of integration.

To apply ordinary least squares, the equation is re-arranged as follows:

$$\ln (a/c_t - 1) = \ln A - bat \text{ if } a/c_t \geq 1$$

or

$$\ln (1 - a/c_t) = \ln (-A) - bat \text{ if } a/c_t < 1.$$

The first is used for rising coefficients; the second for declining ones.

The application of the above equations to the data presents some problems. Time series on individual coefficients do exist, but because they were not derived from basic data but rather from a form of the RAS method, we feel that the estimates based on the movements of individual cells of the matrix are probably not meaningful. Therefore, we introduce a new C_{it} referring to the entire row i as follows:

$$U_{it} = X_{it} - F_{it} - a_{ii}\, X_{it}$$

$$V_{it} = \sum_{\substack{j \neq i \\ j=1}}^{67} a_{ij}\, X_{jt}$$

$$C_{it} = U_{it}/V_{it} \quad , \qquad i=1,\ldots,50.$$

where

U_{it} = actual intermediate use of commodity i

X_{it} = domestic output of commodity i

V_{it} = indicated use if coefficients have remained constant over the entire period

a_{ij} = the mtrix of direct coefficients for 1975

c_{it} = index for the movement of all the coefficients in the i^{th} row.

5.5 Employment Equations

For each of 24 industries, let

$$L = H \cdot J$$

where
H = average hours worked per month
J = number of jobs in industry
L = labor requirement

The labor requirement equation then becomes

$$\ln(L/Q) = b_o + b_1 CON2 + b_2 time1 + b_3 time2 + b_4 PCQ + b_5 PCH$$

where
Q is gross output measured in constant 1975 prices
time1 has values 55 in 1955, to 80 in 1980
time2 equals time1 for 1955-1969 and zero otherwise
PCQ is the percentage change in output
PCH is the percentage change in monthly hours
CON2 has a value of 1 in 1955-1969 and zero otherwise

5.6 Average Monthly Hours Equation

$$R = A/H$$

where
A = asymptotic value of hours (always 152≈35.4 hrs/wk)
H = average monthly hours

The estimated equation is then

$$\ln(1.-R) = b_o + b_1 time + b_2 PCQ.$$

STRUCTURAL DEVELOPMENT IN THE FINAL DEMAND OF THE HUNGARIAN ECONOMY, 1970–1979

Andor Csepinszky
Central Statistical Office, Keleti Károly u. 5/7, 1525 Budapest, Hungary

The paper deals with some structural development characteristics of final demand: consumption, gross capital formation and exports of the Hungarian economy during the time period of the seventies. As a suitable measure to represent industry contributions value added in each of them were to be chosen. In order to separate quantity and price effects from each other measures were calculated both on current and on constant prices. Hereby price movements during the time period were also given. Moreover with a view to particular character of price building mechanism in socialist countries value added in each industry were estimated on so-called costs proportinate level too. Data comprised in input-output table series of Hungary 1970-1979 on current and on constant producer's prices served as an empirical background for investigations. Industry breakdown in them were as follows:

1/ Exploitation of sources of power /with electricity production/
2/ Machinery /with metallurgy/
3/ Chemicals
4/ Light industry and other manufacturing
5/ Food production
6/ Construction /with building materials/
7/ Agriculture, Forestry and Water management
8/ Transportation, Communication and Trade
9/ Non material services.

Economic measures

In order to find a formula adequate for investigations value added in each industry has been defined on final demand sectors:

$$P^{/VA/} = \hat{A}^{/VA/} /I-A/^{-1} Y \qquad /1/$$

Where $\hat{A}^{/VA/}$ is a diagonal matrix of specific value added in each industry. Characteristic element of it $X_j^{/VA/}/$ $/X_j$; $X_j^{/VA/}$ value added in industry j, X_j gross output of industy j.

TABLE 1. Structure of Consumption 1970-1979 /on current prices/

in per cent

Industries \ Years	1970.	1971.	1972.	1973.	1974.	1975.	1976.	1977.	1978.	1979.
Manufacturing	17,7	16,7	17,6	17,4	17,4	18,0	18,3	17,9	18,2	18,8
Construction	3,2	3,2	3,6	3,5	3,3	3,2	3,3	3,4	3,8	3,8
Foods	21,7	21,2	20,9	22,2	19,2	17,6	18,6	18,1	16,3	15,2
Goods	42,6	41,1	42,1	43,1	39,9	38,8	40,2	39,4	38,3	37,8
Services	35,3	35,0	35,9	35,4	35,4	34,1	33,7	34,3	34,3	34,9
Industry's contributions	77,9	76,1	78,0	78,5	75,2	72,9	73,9	73,7	72,6	72,7
Imports	23,0	24,9	22,8	23,7	30,3	31,4	26,9	28,3	28,7	28,7
Consumption	100,9	101,0	100,8	102,2	105,5	104,3	100,8	102,0	101,3	101,4
Some corrections in price level	-0,9	-1,0	-0,8	-2,2	-5,5	-4,3	-0,8	-2,0	-1,3	-1,4

TABLE 2. Consumption Development 1970-1979. /Index 1970=100,0/

on constant prices

Measures of Development \ Years	1970.	1971.	1972.	1973.	1974.	1975.	1976.	1977.	1978.	1979.
Nomianl value	100,0	110,3	116,4	125,5	138,4	153,6	168,3	180,4	197,6	209,8
Real value	100,0	106,3	109,5	112,5	120,3	125,9	130,3	134,8	140,6	144,6
rate of returns effects	100,0	106,7	109,7	113,6	115,5	117,4	118,3	120,3	121,0	124,8
relativ price effects	100,0	99,1	98,9	97,7	102,2	104,7	107,0	108,5	111,9	111,1
Price movement	100,0	103,7	106,3	111,6	115,0	122,0	129,2	133,8	140,5	145,1
Price movement /modified/	100,0	111,3	117,7	128,5	135,4	146,7	157,3	166,3	176,6	188,8

Y is a matrix of final demand sectors: industries' outputs to consumption, gross capital formation and exports.

$$\bar{p}^{/VA/} = \hat{A}^{/VA/}/I-\bar{A}/^{-1} \qquad /2/$$

Where: $\hat{A}^{/VA/}$ is a diagonal matrix composed in the same way as it has been done in formula /1/ however in this case the size of matrix has been widened by two sectors: imports and depreciations.

Having made imports as a vektor: outputs have been given by empirical data as they could be found in input-output tables; input elements have been determined by $/X^{/I/}/X^{/E/}/.\ X_i^{/E/}$; $X^{/I/}$ is import sum, $X^{/E/}_i$ is output of industry i to exports.

Having made depreciations as a vector: outputs have been given gathering them as empirical data from input-output tables; input elements could be defined by $\{\alpha X_{i2}/X_2 + /1-\alpha/\ X_{i6}/X_6\}$; α is X_2/X_6 and the signs 2 and 6 refer to machinery and construction.

$$p^{/M/} = \hat{A}^{/M/}/I-A/^{-1} \qquad /3/$$

a price transformation relation which gives price multipliers in each industry to get a price for them proportionate one to production costs.

Here $\hat{A}^{/M/}$ is a diagonal matrix containing value added in each industry, however not on its empirical level, but on a calculated one determined it according to general returns rate in the economy as a whole.

Structural relations.

a/ Consumption

In the seventies ratios between goods and services produced at home and imported ones for purposes of consumption measured on constant prices demonstrate a very high level of stability. Contributions of home industries expressed in value added give both at the begining and in the last year of the seventies nearly the same ratios: there-quarters to one. Having compiled the measures on current prices there is a considerable shift in favour of imports. Its share rises from 23 % to 29 % during the same time period. Reason for it lies in change of crude oil world price level movement as it could be seen in table 1./ where in row: imports takes place a great jump between 1973 and 1974. Having transformed price levels, would have taken them proportionate with production costs in each industry the situation will be very similar to it already has been get on constant prices. Goods and services producing industries are divided in respect to their contributions nearly half and half between each other.

TABLE 3. Structure of Gross Capital Formation 1970-1979 /on current prices/

Industries / Year	1970.	1971.	1972.	1973.	1974.	1975.	1976.	1977.	1978.	1979.
Manufacturing	25,4	24,5	21,0	20,7	21,0	22,1	20,8	19,5	20,3	20,3
Construction	26,4	24,8	28,3	29,4	26,2	24,8	25,6	26,2	23,7	27,6
Foods	5,9	6,9	6,8	6,0	5,2	5,0	4,8	4,0	4,3	4,0
Goods	57,7	56,2	56,1	56,1	52,4	51,9	51,2	49,7	48,3	51,9
Services	11,3	10,9	11,9	12,4	11,1	10,9	11,1	10,3	9,9	9,6
Industry's contributions	69,0	67,1	68,0	68,5	63,5	62,8	62,3	60,0	58,2	61,5
Imports	29,9	32,6	31,3	31,5	37,8	38,4	36,8	39,6	41,2	38,0
Gross Capital Formation	98,9	99,7	99,3	100,0	101,3	101,2	99,1	99,6	99,4	99,5
Some corrections in price level	1,1	0,3	0,7	0,0	-1,3	-1,2	0,9	0,4	0,6	0,5

TABLE 4. Development of Gross Capital Formation 1970-1979. /Index 1970=100/

on constant prices

Measures of Development / Years	1970.	1971.	1972.	1973.	1974.	1975.	1976.	1977.	1978.	1979.
Nominal value	100,0	121,1	109,8	112,6	142,3	161,5	170,4	193,0	231,7	209,4
Real value	100,0	121,5	104,9	105,5	130,7	144,5	149,0	163,3	192,1	165,2
rate of returns effects	100,0	106,5	108,5	111,6	114,0	117,0	120,7	121,4	121,5	124,9
relative price effects	100,0	100,2	100,4	100,7	100,9	101,1	101,3	101,5	101,8	102,0
Real value /modified/	100,0	113,9	96,2	93,9	113,6	122,2	121,9	132,5	155,3	129,7
Price movement	100,0	99,7	104,7	106,7	108,9	112,8	114,4	118,2	120,6	126,8
Price movement /modified/	100,0	106,3	113,4	119,9	125,3	132,2	139,8	145,7	149,2	161,4

As regards dynamics of consumption: a very rapid increase could be seen measured it in value terms on current prices and a moderate one expressed it in real terms on constant prices. Rate of growth in the first case is 8,5 % and later one is only 4,2 %. Price index number during the same decade: 145,1 which is equivalent a rate 4,3 % every year. However the meaning of rate of growth in real terms is not quite clear. Having investigated rate of returns within consumptions valuated on constant prices it is running up in a considerable high degree every year: in 1970 it has a value 41 % and in 1979 it comes to 51 %; with a rate of growth 2,5 % in each year. There is no reason to believe that an the increase could be originated solely from an improvement of productivity level in economy. Much rater it could be assigned to some mistake in making of price index number or to some changes in product mix. Then secondly relative price levels in socialist countries compared them production costs are too high in manufacturing and too low in food production, agriculture and in services. This fact makes growth rate to be higher a half per cent every year. Having summarized all the results factors of modification and the modified dynamics of consumption expressed in real terms could be given in table 2.

b/ Gross Capital Formation

In this field of final demand a considerable shift could be discovered in shares between home industry contributions and imports in favour of the later one measured them either on current or on constant prices. Having valuated industry contributions on an average costs and returns level of economy, picture will be very similar to it. Nevertheless only one difference could be observed among them, and that is extent of change registered on measures of contributions in current prices is larger than that defined on contributions in constant or in production costs proportionate prices. In 1970 the share of imports on constant price accounting system is 33,8 % and on production costs proportionate one the same. Whereas in 1979 they run to 39,5 % and 38,5 %. The share of industry contributions in sphere of services has been stabilized around 10 % all over the whole decade.

Dynamics of gross capital formation in the seventies were faster than those of consumption. Rate of growth was nearly the same valuated both consumption and gross capital formation measures on current prices: 8,6 %. However price index level of gross capital formation was with 40 % lower than that in consumption. Therefore gross capital formation gained a rate of growth 5,7 % every year in average over that of consumption 4,2 %. Having discounted the above mentioned rate of growth by returns rate index number and relativ price modification factor a modified quantity index could be presented: 2,7 % in each year of the decade, which is 2.5 times higher than that of consumption.

TABLE 5. Structure of Exports 1970-1979. /on current prices/

in per cent

Year Industries	1970.	1971.	1972.	1973.	1974.	1975.	1976.	1977.	1978.	1979.
Manufacturing	43,0	41,0	41,5	40,6	41,0	41,3	42,0	41,1	41,0	41,9
Construction	2,3	2,2	2,5	2,7	2,7	2,7	2,3	2,3	2,3	2,4
Foods	16,3	18,3	17,8	20,4	18,6	16,7	14,8	15,7	14,5	13,5
Goods	61,6	61,5	61,8	63,7	62,3	60,7	59,1	59,1	57,8	57,8
Services	12,7	12,6	12,7	12,5	13,0	12,6	11,8	12,2	12,6	11,9
Industry's contributions	74,3	74,1	74,5	76,2	75,3	73,3	70,9	71,3	70,4	69,7
Imports	25,2	25,9	25,0	24,8	30,4	30,9	28,3	29,2	29,3	30,6
Exports	99,5	100,0	99,5	101,0	105,7	104,2	99,2	100,5	99,7	100,3
Some corrections in price level	0,5	0,0	0,5	-1,0	-5,7	-4,2	0,8	-0,5	0,3	-0,3

TABLE 6. Development of Exports /1970-1979/ /Index 1970 = 100/

on constant prices

Years Measures of development	1970.	1971.	1972.	1973.	1974.	1975.	1976.	1977.	1978.	1979.
Nominal value	100,0	108,4	133,1	163,5	186,4	197,7	201,1	237,7	240,5	278,5
Real value	100,0	107,2	127,8	146,5	151,6	158,0	168,5	192,7	196,1	217,8
rate of returns effects	100,0	106,5	110,2	113,9	115,9	118,2	121,5	122,9	124,0	129,1
relative price effects	100,0	100,6	101,2	101,8	102,4	103,1	103,7	104,3	104,9	105,6
Real value /modified/	100,0	100,1	114,6	126,3	127,7	129,7	133,7	150,3	150,8	159,8
Price movement	100,0	101,1	104,1	111,6	123,0	125,1	119,3	123,4	122,6	127,9
Price movement /modified/	100,0	108,3	116,1	129,5	146,0	152,4	150,4	158,2	159,5	174,3

c/ Exports

Industry contributions of national economy and imports play the same role in satisfying export demand as they done it in consumption. Shares of home industry contributions were moving around 70 % valuated them both in a constant price system and in a production costs proportionate one. According to it imports rate has a 30 % level and they proved to be very stable over the whole investigated time period. The role of services in exports as it could be anticipated much more smaller than that was in consumption, it has nearly the same one as in gross capital formation: 15-17 % determined it on constant prices. From exports of a value 100 forint contains home industry contributions of 70 forints and imports consumed in a value of 30 forints. An increase of import shares from 25,2 % in 1970 up to 30,6 % in 1979 was only a consequence of crude oil price level movement between 1973 and 1974 and it did not mean that the role of imports was growing in Hungarian economy really.

In spite of exports had the most rapid increase level among final demand sectors of hungarian economy in the seventies; international financial balance of it was going from bad to worse. This process stopped only for the early eighties and it has been resulted to some economic arrangements of restrictiring charackter. Increment rates on a yearly average reached at a level of 12,1 %, measured it on current prices. And that valuated on constant prices had a considerable high level: 9 % Having taken into account returns rate level and production costs proporcionate effects growth rates expressed in real terms are sinking down; it has a value of only 5,3 % in each year.

References

Ágazati Kapcsolatok Mérlege 1970-1979. Statisztikai Kiadó Vállalat Budapest, 1981.

Ágazati Kapcsolatok Mérlege 1970-1979. 1976. évi változatlan áron. Statisztikai Kiadó Vállalat. Budapest, 1982.

Ágazati Kapcsolatok Mérlege, 1976. Statisztikai Kiadó Vállalat Budapest, 1979. p. 6-16.

J.Schumann: Input-Output Analyse Springer Verlag Berlin 1968.

Morishima: Value, Exploitation and Growth. Mc Graw-Hill. London 1978.

INVESTMENT FUNCTIONS IN AN INPUT–OUTPUT MODEL OF THE USSR ECONOMY

Anatoli Smyshlyaev[1] and Georgi Sychev[2]
[1] *International Institute for Applied Systems Analysis, Laxenburg, Austria;*
[2] *CEMI, Moscow, USSR*

The econometric modeling of investment behavior is a difficult task, both on the macro and on the industry level. Sometimes this problem can be "avoided" at the macro level by assuming investment to be an exogenous variable. To oversimplify the structure of a macromodel somewhat, one can estimate the system of simultaneous equations using time series data:

$$\begin{cases} C_t = \alpha + \beta Y_t + \varepsilon_t \\ Y_t = C_t + I_t \end{cases}$$

where

C_t = consumption,
Y_t = income,
I_t = investment,
ε_t = an error term.

If income is considered as an exogenous variable then the equality written above is not a proper model in terms of goodness of fit with respect to investment time series. It is easy to show that even though the goodness of fit for the first equation, expressed in terms of R^2 t-values, exceeds any given level of significance, it is still possible to obtain a very poor fit for investment.

Fortunately investments can be modeled in a different way, for example in terms of a distributed lag structure for income or industrial output (value added). Again, oversimplifying the model, one can write an equation:

$$I_t = \sum_{i=0}^{n} \beta_i * Q_{t-i}$$

where Q_{t-i} denotes output in period t-i and some restrictions are imposed on the parameters of the lag structure, i.e. the β_i are estimated under certain constraints, both on the length of the distributed lag structure (n) and on the scale of β_i.

An approach widely applied in the INFORUM family of input-output models specifies investment roughly in this way. One additional assumption is made on replacement policy, namely:

$$W_t = r*k*\tilde{Q}_t$$

where

W_t = replacement in period t,
r = replacement rate (constant),
k = capital/output ratio (constant),
$\tilde{Q}_t$ = smoothed output in period t.

If

$$\Delta F_+^t = k * \sum_{i=0}^{n} w_i * \Delta Q_{t-i}$$

where

ΔF = fixed productive assets expansion,
w_i = parameters of distributed lag structure under the condition $\Sigma w_i = 1$, $w_i \geq 0$,

then the following equation might be estimated

$$\Delta F_t = k*(z*\tilde{Q}_t+\Delta Q_{t-2}) + k*w_0(\Delta Q_t - \Delta Q_{t-2}) + k*w_1(\Delta Q_{t-1}-\Delta Q_t)$$

under the assumption that n = 2, for any given value of r.

However we have found this formulation to be of only limited use for the USSR data on investments. The USSR statistics provide a variety of data on fixed productive assets, investment, unfinished construction, and the "technological" structure of investments. Therefore there is no need to artificially simplify real processes that are taking place in investment policy. To make clear the sources of various data we introduce the following notation, which will be used extensively below:

$$\Delta F_t = V_t - W_t$$

$$\Delta F_t = F_t - F_{t-1}$$

$$V_t = I_t - \Delta N_t$$

$$N_t = N_{t-1} + I_t - V_t$$

where

F_t = fixed productive assets at the end of year t,
V_t = investments realized during this year, i.e. being used in a production process,
N_t = unfinished construction (including some equipment to be completed in future periods $V_{t+\tau}$).

It is easy to understand these balances in terms of an econometric model of the relationship between V_t and I_t:

$$V_t = \sum_{i=0}^{\infty} \beta_i * I_{t-i}$$

The relationship between *future* (expected) outputs and the increase in fixed productive assets can also be expressed by either

$$\Delta F_t = \sum_{i=0}^{\infty} \alpha_i * \Delta Q_{t+i}$$

or

$$\Delta Q_t = \sum_{i=0}^{\infty} \gamma_i * \Delta F_{t-i}$$

where ΔQ_t might be considered as an "expected" increase and be denoted $\Delta\tilde{Q}_t$.

Direct observations on W_t show that it will be simpler to assume that

$$W_t = r * F_t$$

or

$$W_t = w * I_t$$

because both W_t/F_t and W_t/I_t are rather unstable over time.

Let us now turn to some of the estimation difficulties arising from the data themselves. We begin by examining changes in the average annual growth rates in the USSR, as shown in Table 1.

TABLE 1 Average annual growth rates (%) in the USSR, 1961-1980[a].

Index	1961-65	1966-70	1971-75	1976-80
Net material product	6.4	7.7	5.7	4.2
Investment	7.7	7.4	7.2	5.2
Fixed productive capital assets	9.3	8.2	8.7	7.3

[a] These values are estimated as "geometrical means" of growth rates for every five-year period from ref. [3], pp.37,41.

It should be noted that the index changes are highly synchronized. This leads to correspondingly steady changes in the industrial structure of investment. Over the last two decades, the share in investment of aggregated branches of the economy have not changed very much; for example, the share of agriculture has remained practically constant over the last 10 years (see Table 2).

Within the mining and manufacturing industries, the highest rates of investment growth have been in machinery and oil and gas production, while coal and ferrous metals show a more modest increase in investment. Generally there is a correspondence with lagged rates of production growth but this

TABLE 2 Structure of Soviet industrial investment: industry shares (%), 1961-1980[a].

Industry	1961-65	1966-70	1971-75	1976-80
Mining and manufacturing	36.5	35.2	35.0	35.2
Agriculture	15.5	17.2	20.1	20.3
Transportation and communications	10.1	9.6	10.8	12.0
Construction	4.0	3.8	3.4	2.7
Others, including residential	33.9	34.2	30.7	29.8

[a] Calculated as the share of each industry in total investment in the Soviet economy. Values for both individual industries and the economy as a whole are given in absolute units in ref. [3], pp.336,337.

cannot be considered as a justification for a "demand"-based model of investment behavior.

Our first major observation is that we see a very steady growth in most of the indicators described above. There are no obvious business cycles or short-run effects that allow us to identify a distributed lag structure for any of the models (see Table 2 and Figure 2). Because the growth of investment and its distribution between industries is regarded as an important tool in achieving the long-term goals of the USSR economy, there is no significantly direct relationship between the "profitability" of industries in the past and growth of investment in the near future. Therefore, the model used in the INFORUM family seems to be inappropriate for USSR investment patterns. Moreover, in many cases the annual growth of investment (disregarding fixed productive assets) is much more stable than the growth of output (see Tables 3 and 4).

Many excellent theoretical ideas on the distributed lag structures either between V_t and I_t or between ΔF_t and ΔQ_t fail to be proved when econometric procedures are applied, as illustrated by specific examples for a number of industries.

Thus, the growth rate of investment in the coal industry dropped from 4.1% in 1966-1970 to 2.9% in 1971-1975 and 1976-1980 while the growth rate of production increased from 1.6% in 1966-1970 to 2.4% in 1971-1975 before dropping back to 0.4% in 1976-1980. Though the growth rate of oil and gas production decreased from 8.2% in 1966-1970 to 5.6% in 1976-1980, the growth rate of investment in this industry was increasing throughout the period. The same situation can be seen for ferrous metals, chemicals, and food and beverages (see Tables 3 and 4). This phenomenon is brought about by the interindustrial investment distribution mechanism of the Soviet economy, in which individual industry investment shares are defined by the importance of the industry concerned for the whole national economy and not by the profitability of the industry as is usually the case in market economies. It can be seen from Table 5 that a number of industries consistently get high priority in the investment distribution mechanism more or less regardless of their production growth rates: these include oil and gas, machinery, agriculture, and transportation and communications.

Great inertia in investment growth trends can also be captured by using an autoregressive model, but once again this is of only limited use. A more flexible approach must be developed to catch the most important changes in investment policy over the last twenty years. This means, however, that a

TABLE 3 Average annual rates of investment growth (%) in the USSR, 1966-1980[a].

Industry	1966-70	1971-75	1976-80
Productive sphere	7.6	8.4	5.7
Mining and manufacturing	6.6	7.1	5.4
Coal	4.1	2.9	2.9
Oil and gas	8.5	8.4	9.5
Electricity	5.6	4.4	2.4
Ferrous metals	4.1	5.4	3.0
Machinery	10.2	10.7	7.5
Chemicals	4.8	7.3	7.3
Wood and paper	3.7	5.3	3.3
Building materials	6.7	6.0	0.5
Textiles, apparel	11.1	5.9	3.7
Food and beverages	7.0	4.3	3.5
Construction	12.3	9.7	6.4
Agriculture	9.6	10.7	5.3
Transportation and communications	6.3	9.7	7.3

[a] All values are taken from ref. [4], p.71.

TABLE 4 Average annual rates of production growth (%) in the USSR, 1966-1980[a].

Industry	1966-70	1971-75	1976-80
Productive sphere	7.4	6.3	4.2
Mining and manufacturing	8.5	7.4	4.4
Coal	1.6	2.4	0.4
Oil and gas	8.2	7.3	5.6
Electricity	9.0	7.1	5.0
Ferrous metals	5.7	5.0	1.9
Machinery	11.5	11.6	8.2
Chemicals	11.9	10.5	5.7
Wood and paper	5.3	5.2	1.5
Building materials	8.2	7.1	1.8
Textiles, apparel	9.7	4.6	3.4
Food and beverages	5.9	5.4	1.5
Construction	7.1	6.8	2.8
Agriculture	4.3	0.6	1.3
Transportation and communications	-		

[a] These values (excluding those for coal, oil and gas, and agriculture) are taken directly from ref. [7], pp.63-66. The remaining values are calculated as follows: for coal on the basis of absolute values taken from ref. [3], p. 157, for oil and gas on the basis of absolute values in terms of conventional units taken from ref. [3], p.156, and for agriculture on the basis of annual growth rates taken from ref. [3], pp.37,41.

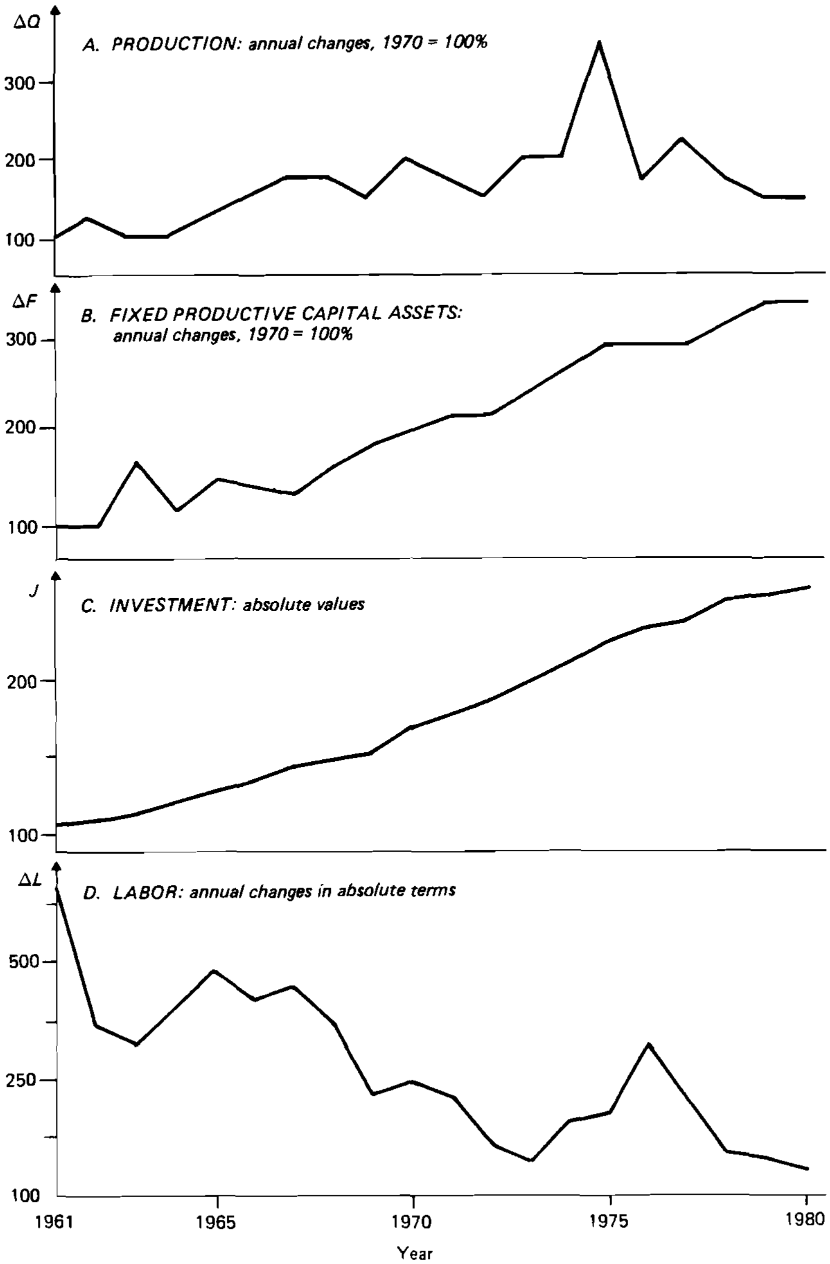


FIGURE 1 Growth of Soviet manufacturing industry, 1961-1980. Sources of data are as follows: *A*, for all years from ref. [3], pp.126,127. *B*, for 1972 calculated on the basis of the USSR capital assets input-output table in ref. [6], pp.62-81; for all other years calculated using the capital assets growth rates in ref. [3] , pp.37,41. *C*, for 1961-1965 from ref. [5], p.550; for 1966-1980 from ref. [3], pp.336,337. *D*, for 1960-1965 from refs. [6], p.188, and [7], p.126; for 1966-1980 from ref. [3], p.134.

TABLE 5 Elasticities of the investment growth of various Soviet industries with respect to total investment in the productive sphere, 1960-1980[a].

Industry	1966-70	1971-75	1976-80
Mining and Manufacturing	0.85	0.85	0.95
Coal	0.60	0.35	0.50
Oil and gas	1.10	1.00	1.65
Electricity	0.70	0.50	0.40
Ferrous metals	0.55	0.65	0.55
Machinery	1.35	1.25	1.30
Chemicals	0.60	0.85	1.25
Wood and paper	0.45	0.65	0.60
Building materials	0.85	0.70	0.10
Textiles, apparel	1.40	0.70	0.65
Food and beverages	0.90	0.50	0.60
Construction	1.55	1.15	1.10
Agriculture	1.25	1.25	0.95
Transportation and communications	0.80	1.15	1.25

[a] All values are from ref. [4], p.71

coherent set of equations needs to be estimated for the same time interval under the specific assumptions made regarding the residual terms, so as to avoid bias in the sum of investments produced by the system of equations.

A few words should be said about the goodness of fit for these variables when strong trends exist both in investments and in the annual changes of outputs of particular industries. On the basis of purely statistical criteria one can hardly distinguish between, for example, the model

$$V_t = \alpha I_t + \beta V_{t-1} + \varepsilon_t$$

and

$$V_t = \gamma_1 I_t + \gamma_2 I_{t-1} + \varepsilon_t$$

A priori knowledge based on cross-section data gives us some restrictions on the parameters of different models but unfortunately these parameters may vary over time.

We give below a few examples of the models for V and I, estimated under different assumptions, but the most difficult questions still concern models of the relationship between I and ΔQ. In the estimation results given below for "Machinery", V, I, N, and L are measured in value terms, while Q, ΔQ, F, and ΔF are expressed as index numbers related to the base year. In each case, R^2 is the coefficient of determination and DW is the Durbin-Watson statistic.

"Machinery" [8, p.87,89] (estimated by OLS):

$$V_t = 0.579\ I_t + 0.370\ I_{t-1}$$

$$R^2 = 0.990,$$

$$DW = 1.8$$

$$I_t = 0.584\ V_t + 0.168\ V_{t+1} + 0.133\ V_{t+2} + 0.118\ V_{t+3}$$

$$R^2 = 0.998,$$

$$DW = 2.9$$

"Machinery" [9, p.134] (estimated by two-stage least squares):

$$\begin{cases} I_t = -25.4 + 0.555\ V_t + 0.4963\ V_{t+1} \\ V_t = 0.5104\ I_t + 0.5421\ N_t \end{cases}$$

The parameters of the last equation have some important properties because the volume of unfinished construction explicitly influences investment decisions.

The exponential distributed-lag structure:

$$V_t = \alpha I_t + \beta V_{t-1} + \varepsilon_t$$

gives the following results for "machinery" [8, p.112]:

$$V_t = 0.510\ I_t + 0.480\ V_{t-1}\ .$$

All these results show that the same proportion of the share of investments made in the current year (between 50% and 60%) will appear in the same year as an expansion of fixed productive assets. Therefore, at least 40% of this expansion clearly originates from previous investments, and due to variance in W_t and ΔN_t (they are not linear functions of I_t), the relationship between I_{t-1} and ΔQ_t is still rather weak*.

$$\Delta Q_t = \underset{(6.4)}{0.236}\ F_t + \underset{(0.6)}{0.483}\ \Delta F_t$$

$$R^2 = 0.84,$$

$$DW = 0.91$$

for example

$$\Delta Q_t = \underset{(2.8)}{2.07} + \underset{(13.8)}{0.138}\ I_t$$

$$R^2 = 0.91,$$

$$DW = 0.6$$

---

* The time series for *investment* (I_t) is taken directly for 1961-1965 from ref. [5], p.550 and for 1966-1980 from ref. [3], p.338. The time series for *capital assets* (F_t) is calculated on the basis of the USSR capital assets input-output table given in ref. [6], pp.62-81. The absolute value for 1972 is calculated on the basis of this table and the absolute values for the other years are calculated using the capital assets growth rates given in refs. [3], p.141, and [5], p.235. The time series for *production* (Q_t) consists of percentages of the base-year (1970) value. Values for all years, including 1970, are taken from ref. [3], pp. 126, 127.

but

$$\Delta Q_t = \underset{(2.3)}{1.7} + \underset{(2.8)}{0.27}\ I_t - \underset{(1.4)}{0.14}\ I_{t-1}$$

$$R^2 = 0.91,$$

$$DW = 0.85$$

Machinery, 1962-1980:

$$\Delta Q_t = \underset{(t=1.16)}{1.106} - \underset{(0.03)}{0.120} * I_t + \underset{(3.54)}{0.954} * \Delta Q_{t-1}$$

$$R^2 = 0.95,$$

$$DW = 1.38$$

$$\Delta Q_t = \underset{(1.70)}{1.06419} - \underset{(1.50)}{0.070} * \Delta F_t + \underset{(6.75)}{1.20061}\ \Delta Q_{t-1}$$

$$R^2 = 0.95,$$

$$DW = 1.89$$

$$\Delta Q_t = \underset{(9.47)}{1.16717} - \underset{(1.32)}{0.071} * \Delta F_t - \underset{(0.04)}{0.268} * \Delta L_t + \underset{(6.49)}{1.202} * \Delta Q_{t-1}$$

$$R^2 = 0.94,$$

$$DW = 1.90$$

More sophisticated models that include relative prices and labor inputs, wages, etc., cannot work efficiently on this problem due to the long-term stability in prices and the very gradual growth of wages. Moreover, there are many indications of another lag phenomenon that might be called the "efficient use of new fixed productive assets" which is reflected by the very weak relationship between the annual growth of investment and increase of production.

These factors act as data "supply" limitations on econometric modeling. Another "demand"-side limitation is the following: requirements concerning the goodness of fit and the prediction results are much higher than those relating to any other variables of the input-output model. The forecast that provides the volume of total investment as the sum of investments "expected" (or required) by individual industries will be of limited use because rather rigid limits are imposed (again through the above-mentioned lags related to the growth of the construction, building materials, and equipment-producing industries). This illustrates again one of the main differences between the USSR input-output model and other INFORUM models.

$$J_t^k / \Sigma J_t^k = f_k(t) + \varepsilon_t^k$$

where J^k denotes investment in the kth industry, but this can be justified in the case of a few specific branches, such as agriculture and allied industries (see Table 2).

FIGURE 2 Investment indicators for the ferrous metals industry, 1961-1985. Sources of data are as follows: ref.[3], pp. 126,127,135-137,141,338; ref. [6], pp. 62-81,196,197,526.

Smoothed k (1960-1980):

$$k = \underset{(140.89)}{0.42} - \underset{(30.59)}{0.0073}\, t$$

$$R^2 = 0.98, \quad DW = 1.08.$$

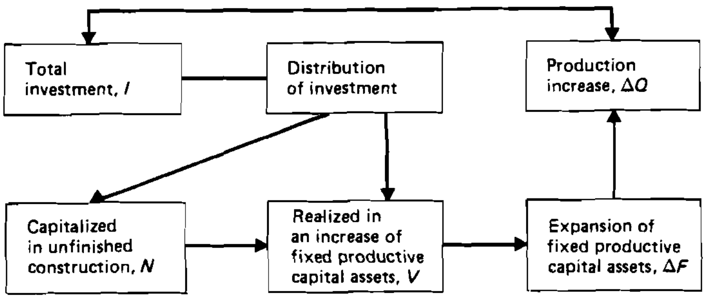


FIGURE 3 A sequence of models developed to simulate investments.

One can see from Tables 3-5 that investments are characterized by a strongly inertial pattern in many sectors of the Soviet economy, so that it is impossible to distinguish the impact of lagged investments on the growth of industrial production. It seems at first appropriate to use a "capital/output" ratio that itself exhibits inertia, but unfortunately the resulting estimates of required investments vary within intervals that are wider than expected. For example, in the case of ferrous metals (see Figure 2) predicted for the year 1985, the value of output/fixed productive assets will vary from 0.20 to 0.18 according to the specific function of time selected. Under the primitive assumption that annual increases in production will be the same in 1981-85 as in 1976-80, we find a difference in fixed productive assets of the order of 10% that, with the given rate of replacement and growth of the share of unfinished construction, will lead to a variance of 50% in required investments. This sequential calculation may be shown more simply as follows:

$$\{\mathrm{var}(k) = 10\%\} \rightarrow \{\mathrm{var}(F_{1985}) = 10\%\} \rightarrow \{\mathrm{var}(\Delta F = F_{1985} - F_{1980}) = 30\%\}$$

$$\rightarrow \{\mathrm{var}(W_t \text{ and } V_t) = 40\%\} \rightarrow \{\mathrm{var}(I_t \text{ and } \Delta N_t) = 50\%\}$$

Perhaps we are exaggerating the problems of investment modeling, but at least it is clear that, despite the availability of data and proper econometric results for some of the stages depicted in Figure 3, the main task of constructing a semi-dynamic input-output model is far from completion. As the model of interindustry interactions can both predict and test the consistency of a set of outputs for a number of industries, but leaves open the investment consistency question, we still need a coherent system of equations describing investment patterns. Bearing in mind the demand for "accuracy" in investment forecasts, a model constructed in the spirit of both a "consumer expenditure system" and a "distributed lag structure" is definitely required.

REFERENCES

[1] Yaremenko, Y.V. Structurnye izmenenia v socialisticheskoj economieke (Structural changes in a socialist economy, in Russian). Moscow, Mysl, 1981.

[2] Almon, Clopper,Jr. 1985:Industry Forecasts of the American Economy. Lexington, Mass. Lexington Books, 1974.

[3] Narodnoe khoziajstvo SSSR v 1980 godu (Statistical Yearbook:USSR Economy in 1980, in Russian). Moscow, Financy i statistika, 1981.

[4] Rutkovskaya, E.A. and A.S. Smyshlyaev. Investitshionnye pokazately v narodnokho-ziajstvennom prognoze (Investment Indices in Economic Forecasting, in Russian). Izvestiya Akademii Nauk SSSR, seriya ekonomicheskaya, 1982, N2.

[5] Narodnoe khoziajstvo SSSR v 1973 godu (Statistical Yearbook:USSR Economy in 1973, in Russian). Moscow, Statistika, 1974.

[6] Narodnoe khoziajstvo SSSR v 1974 godu (Statistical Yearbook:USSR Economy in 1974, in Russian). Moscow, Statistika, 1975.

[7] Statistichesky ejegodnik stran-chlenov Soveta Ekonomicheskoy Vzaimopomotshy (Statistical Yearbook of the CMEA countries: 1981, in Russian). Moscow, Financy i Statistika, 1981.

[8] Rutkovskaya, E.A. Problemy i metody othenky raspredelennogo laga v kapitalnom stroitelstve. (Problems and Methods of Distribution Lag Estimation in Construction, in Russian. In: Modeling of Investment Processes). Moscow, CEMI, Akademii Nauk, SSSR, 1979, pp. 83-117.

[9] Smyshlyaev, A.S. Alternativnye modely raspredelen nyh zapazdyvanyi v kapitalnom stroitelstve. (Alternative Distributed Lag Models in Construction, in Russian. In: Modeling of Investment Processes). Moscow, CEMI, Akademii Nauk SSSR, 1979, pp. 118-137.

DEMAND SYSTEMS BASED ON INTERTEMPORAL CONSUMER DECISIONS – THEIR USEFULNESS FOR INPUT–OUTPUT MODELING

Bernhard Böhm
Institute for Advanced Studies, Vienna, Austria

1. INTRODUCTION

Systems of consumer demand equations evidently contain a lot of structural information. Several ways are possible to specify a demand system. It may be proposed directly or derived from some underlying assumptions of utility maximization. The latter may give rise to a number of qualitative properties which take the form of restrictions on price and income parameters. Taking them into account could simplify the specification and increase efficiency of the estimates provided there is sufficient reason for their validity.

Most models used to explain final consumer demand in the context of an input-output system are kept simple. The present paper attempts to shed some light on the underlying framework of demand models which incorporate detailed structural information and which could lead to the formulation of simpler models once certain basic assumptions can be taken for granted. The approach differs from the usual static utility maximization but rather concentrates on the implications derived from the maximization of an intertemporal utility function of general functional form.

The link between the present and the future in the model is performed by the introduction of money and assets which provide purchasing power for the future. As a result the demand system derived from this intertemporal utility maximization also includes demand function for money and assets. It thus constitutes an opportunity for linking with the financial subsystem of the economy, taking account of the interdependence between real and monetary side in consumer choice behavior.

The properties of such a demand system are briefly reviewed and related to conditions on the underlying theory. These concern in particular functional properties of the utility function and price expectations.

To demonstrate applicability of the indirect approach as well as to assess the relevance of certain restrictions a practical example is given. The demand system is applied to Austrian data for the period 1954 to 1977 following the very general approach of the "Rotterdam-School". Testing the constraints within this framework could give rise to even more restrictive model specifications (e.g. specific functional forms like LES etc.) and thus economizing on parameters. It could then guide the selection of models to explain final consumer demand within the input-output framework.

2. THE INTERTEMPORAL APPROACH

The idea of the model follows an approach by Grandmont (1974) where intertemporal utility only depends on commodity demand. Given the intertemporal utility function $U(x_t,x_{t+1})$, referring to period t as the present and to period t+1 as the future, and x the n-vector of quantities of commodities, we write the constraint the consumer faces in the future as

(1) $p'_{t+1}x_{t+1} = Y_{w,t+1} + M_t + (1+r_t)A_t = L_{t+1}$.

We assume for simplicity that terminal stocks of money and assets are zero. Notation is as follows:

p	commodity price vector (nx1)
M	nominal stock of money
A	market value of assets
A^+	nominal value of assets. $A^+ = (1+r)A$
r	interest rate
p_a	price of assets (i.e. $p_a = 1/(1+r)$)
Y_w	labour income
L	total resources

The constraint for the present period is

(2) $p'_t x_t + M_t + p_a A^+_t = L_t = Y_{w,t} + \bar{M} + (1+\bar{r})\bar{A}$

where we assume the initial stocks of nominal money and assets to be given. For simplicity we shall also treat labour income as given and the same in each period.

Using a dynamic programming procedure the consumer is assumed first to solve the maximization problem for the period t+1, the future, for given prices and income, conditionally on his present consumption vector, money and assets. His demand system for the future period is then substituted into the utility function. This gives then the semi-indirect utility function $u^+(x_t, M_t, A^+_t, p_{t+1})$. Assuming a price expectation function of the general form $p_{t+1} = \psi(p_t)$ one arrives at the utility function $u(x_t, M_t, A^+_t, p_t)$ whose properties depend on the future demand system, the price expectation function, and the direct utility function U. This utility function is now maximized w.r.t. x_t, M_t and A^+_t subject to the constraint for the present period, given prices and initial resources. Thus money and assets are attributed indirect utility and one has the problem to face prices explicitly in the utility function.

We are interested in the properties of the demand system resulting from the maximization of $u(x, M, A^+, p)$ w.r.t. x, M and A^+ subject to $p'x + M + p_a A^+ = L$. (Time subscripts are deleted for convenience). Problems of this type have been examined by Kalman and Intriligator (1973). To facilitate notation the following column vectors of dimension (n+2x1) are defined: $q = (x', M, A^+)'$, $\pi = (p', 1, p_a)'$. Then the problem may be restated as

(3) $\max u(q,p)$ w.r.t. q subject to $\pi' q = L$

with given prices and total resources.

Assuming $u(q,p)$ to be concave in q, the sufficient conditions for maximization fulfilled, one solves the necessary conditions for the demand system:

(4) $q = q(p', p_a, L)$

$\lambda = \lambda(p', p_a, L)$

where λ is the Lagrange multiplier.

An investigation of the comparative static properties of this demand system leads to the following observations:

1. In analogy to traditional demand systems (i.e. from static utility maximization without money and assets) the Engel aggregation conditions (Summation) holds:

(5) $\pi' q_L = 1$ where $q_L = (\partial q/\partial L)$

2. The homogeneity property of the demand system depends on the homogeneity properties of the utility function. This problem is discussed in detail in Dusansky and Kalman (1974) and (1978) where necessary and sufficient conditions are given for homogeneity to prevail. Also Grandmont (1974) discusses this aspect. He showed that a linear homogeneous price expectation function will provide a utility function homogeneous of degree zero in nominal money holdings and current prices. This contains the assumption of static expectations. Thus if we assume the utility function to be homogeneous of some degree in M, A^+, and p then we shall obtain commodity demand functions being homogeneous of degree zero in commodity prices and resources, but not in the asset price. The demand functions for nominal money and asset demand will then be homogeneous of degree one in p and L.

3. For the symmetry property it is important to remember that prices are treated as given parameters in the maximization problem while in the comparative static analysis they are perturbed to find out their effect on the optimal levels of commodities, money and assets. Thus the presence of prices in the maximizing function becomes important for the derivation of income (resource) compensated commodity price changes. They may be written as the system of generalized Slutsky equations:

(6) $$(\partial q/\partial p) + q_L x' = (\partial q/\partial p)\Big|_{u\ \text{const.}} + (1/\lambda) q_L (\partial u/\partial p)' \equiv K_p$$

The compensated asset price effects are of the traditional kind.

(7) $$(\partial q/\partial p_a) + q_L A^+ \equiv K_{p_a}$$

The complete substitution matrix may be written in partitioned form

(8) $$K = [K_p \ \vdots \ K_{p_a}] \quad \text{of dimension } (n+2)\text{x}(n+1).$$

Matrix K does obviously not possess the symmetry property.

However, it has been shown by Dusansky and Kalman (1972) that the (nxn) submatrix of generalized commodity price effects i.e.

(9) $$(\partial x/\partial p) + x_L x' = K_{xp},$$

is symmetric and negative semidefinite if the utility function is restricted to belong to the general class of functions:

(10) $$u(x,M,A^+,p) = \alpha(p'x + M + A^+) + g(x,M,A^+) + h(p),$$

where α is any constant, g and h are real valued functions sufficiently differentiable. This requirement is a bit weaker than to demand separability of all quantities with respect to commodity prices. However it requires additive separability of the financial quantities M and A^+ with respect to all commodity prices.

To sum up: In its full generality the present demand system derived from an intertemporal consideration only fulfills the summation condition. However, if one is prepared to make specific assumptions e.g. on the nature of the price expectation function, such as to imply an utility function homogeneous of some degree then homogeneity of the demand system prevails. Furthermore, a specific assumption of the form of the utility function will generate symmetric compensated commodity price effects for commodity demand. The same holds for negativity. The validity of such specific assumptions may be tested for in applied models.

In the next section the demand system is transformed into an applicable version.

3. AN APPLICATION

To achieve a model version which is sufficiently general and can be empirically implemented we adopt the framework of the "Rotterdam-model" (cf. Barten (1967, 1977), Theil (1975, 1976)).

Starting from the differenced demand system $dq=(\partial q/\partial p)dp+(\partial q/\partial p_a)dp_a+q_L dL$ and considering the (generalized) Slutzky equation (6,7,8) we obtain

$$(11)\quad dq = K_p dp + K_{pa} dp_a + q_L(dL - x'dp - A^+ dp_a).$$

Applying the logarithmic transformation, noting that

$dp = \hat{p}$ dlog p, "^" denotes a diagonal matrix,

premultiplying the system by $\hat{\pi}$ and dividing by L we get:

$$(12)\quad \frac{\hat{\pi}\hat{q}}{L}\,\mathrm{dlog}\,q = \frac{\hat{\pi}K_p\hat{p}}{L}\,\mathrm{dlog}\,p + \frac{\hat{\pi}K_{p_a}p_a}{L}\,\mathrm{dlog}\,p_a +$$

$$+\ \hat{\pi}q_L\left(\mathrm{dlog}L - \frac{x'\hat{p}}{L}\,\mathrm{dlog}\,p - \frac{A^+p_a}{L}\,\mathrm{dlog}\,p_a\right).$$

Defining

$\frac{\hat{\pi}\hat{q}}{L} = \hat{w}$, the resource shares, $w' = (w_1,\ldots,w_n,w_M,w_A)$,

$\hat{\pi}q_L = B$, the marginal resource shares,

$\frac{\hat{\pi}K_p\hat{p}}{L} = S_p$, a (n+2 x n) matrix

$\frac{\hat{\pi}K_{p_a}p_a}{L} = S_{p_a}$, a (n+2 x 1) vector,

$\mathrm{dlog}L^+ = \mathrm{dlog}L - \sum_{j=1}^{n} w_j\,\mathrm{dlog}p_j - w_A\mathrm{dlog}\,p_a$, the growth rate of real resources (in view of the price of money being the numeraire),

we can write in simpler notation

$$(14)\quad \hat{w}\,\mathrm{dlog}\,q = S_p\,\mathrm{dlog}\,p + S_{p_a}\,\mathrm{dlog}\,p_a + B\,\mathrm{dlog}\,L^+.$$

From the fact that $d\log L^{+} = w' d\log q$ follows directly that

(15) $\iota' B = 1$ and $\iota' S = 0$, where ι is the summation vector and $S = (S_p \vdots S_{p_a})$.

Generally no restriction for homogeneity holds unless there is reason to believe in the homogeneity property of the underlying utility function. In such a case it follows from the implied homogeneity properties of the demand functions that

$\sum_{j=1}^{n} S_{ij} = - B_i(w_M+w_A)$ for i=1,...,n; i.e. all commodity demand equations,

(16) $\sum_{j=1}^{n} S_{Mj} = - B_M(w_M+w_A)+w_M$ for the (nominal) money demand equation, and

$\sum_{j=1}^{n} S_{Aj} = - B_A(w_M+w_A)+w_A$ for the (nominal) asset demand equation.

Considering the commodity demand subsystem

(17) $w_i d\log x_i = \sum_{j=1}^{n} S_{ij}\, d\log p_j + S_{iA}\, d\log p_a + B_i d\log L^{+}$ $(i=1,\ldots,n)$

the symmetry condition

(18) $S_{ij} = S_{ji}$ for $i,j = 1,\ldots,n$

may also be imposed if one is prepared to assume the type of utility function mentioned above (10). This follows directly from the symmetry of K_{xp} under this assumption.

Additionally, if one restricts the utility function still further by specifying $\alpha=0$, then also $S_{iA}=S_{Ai}$ for i=1,...,n holds.

From the negative semidefinitness of K_{xp} under the specific utility hypothesis (10) follows the negativity of the S_{ii} elements for i=1,...,n. As the asset price effects are of the traditional kind it implies that the compensated asset price effect on asset demand must be negative, thus $S_{AA}<0$.

If one is prepared to assume the elements of B and S to be constant, system (14) may be estimated by linear methods.

4. AN EMPIRICAL EXAMPLE

The theoretical form of the model (14) is approximated using finite differences (following e.g. Theil (1975)). Also a constant term is included. For the error terms (e_{it}) the standard classical assumptions are made (homoscedasticity and absence of intertemporal correlation). As the summation condition implies $\sum_{i=1}^{n+2} e_{it}=0$ for all t=1,...,T, the variance covariance matrix of the errors will be singular. To avoid this, one equation of the system may be deleted arbitrarily (due to our assumption of no autocorrelation).

The system applied to unrestricted and restricted estimation is given by

$$(19)\quad w_{it}\Delta\log q_{it}=d_i+B_i\Delta\log L^{+}+\sum_{k=1}^{n}S_{ik}\Delta\log p_k+S_{iA}\Delta\log p_a+e_{it}$$

for $i=1,\dots,n+2$ and $t=1,\dots,T$.

The model is estimated by ordinary and generalized least squares (Aitken) as well as by maximum likelihood methods (ML).

Homogeneity and symmetry conditions may be imposed on the constant parameters. The nonlinearity in the homogeneity condition (16) is removed by an approximation using sample means for w_A and w_M. Inequality restrictions are not imposed but may be checked.

The validity of these linear (or linearized) restrictions is tested using three test criteria: The Wald test (WT), the Likelihood Ratio test (LR) and the Lagrange Multiplier test (LM). We take into account that they all are asymptotically equivalent but numerical differences appear in our application. Possible conflicts in the test results are indicated.

We are using annual time series data on Austrian consumer expenditures disaggregated into three categories: food and beverages (x_1), other nondurables and services (x_2), and durable goods (x_3). These series at constant prices of 1964 are obtained by deflating the respective nominal series with their implicit price indexes (p_i). A general commodity price index is constructed by using the shares of the real consumption expenditure groups. The nominal money stock (M) consists of currency holdings outside banks and demand deposits of private public. The nominal stock of assets (A^+) contains time- and savings deposits of the private public plus their bond holdings. The available material does not permit a splitting between private firms and households. The market value (A) is obtained by discounting the nominal stock using a weighted average of the effective rate on savings deposits and the effective yield on new bond issues for the rate of interest, which defines implicitly the price of assets (p_a). Data on total resouces (L,L^+) are computed from the "uses-side" of the balance equation. All quantities are divided by population to get per-capita variables. A list of the data used may be obtained from the author on demand. The observation period is from 1954 to 1977.

A selection of estimation results is given in table 1. Starting with the unconstrained estimates we notice the insignificance of the marginal resource shares for the first two commodity groups. Among the price coefficients only those for the nondurable equation are reliable. The imposition of symmetry on the commodity price coefficients changes their values to a large extent and turns them all significant. Also, all marginal resource shares show much lower standard errors. The own price effect for assets is positive but insignificant. The asset price effect on money demand shows the wrong sign too but is also not significant. The only significant effect of the asset price appears in the durables equation where it is positive as expected.

It can be seen from inspection of table 2 which contains a summary of the test results that imposition of symmetry on the commodity price submatrix is compatible with the sample information. Thus the restriction on the type of utility function does not seem to be serious. The cost of returning to the familiar symmetry restriction (at least partially) is rather easy to bear.

The case is different for the homogeneity condition. Testing for this property produced conflicting results. This remains so even when the symmetry conditions are added. Thus homogeneous price expectations and utility (though only a sufficient condition for homogeneous demand) do not seem to be reflected in actual demand behavior beyond doubt.

TABLE 1 Empirical results

categories	B_i	S_{ij}				d_i	DW
		unconstrained					
food and beverages	.111	-.099	-.062	.037	-.257	.001	1.907
	(.092)	(.070)	(.094)	(.100)	(.403)	(.007)	
other nondurables and services	.089	.146	-.398	.232	-.667	.013	1.782
	(.080)	(.061)	(.082)	(.087)	(.350)	(.006)	
durable goods	.156	-.046	-.003	-.016	.389	-.005	2.050
	(.051)	(.039)	(.053)	(.056)	(.225)	(.004)	
money	.263	.005	.023	-.106	-.368	-.008	2.187
	(.081)	(.062)	(.083)	(.089)	(.356)	(.006)	
assets	.381	-.006	.439	-.146	.903	-.001	2.017
	(.147)	(.112)	(.151)	(.161)	(.645)	(.011)	
	homogeneity and symmetry (of commodity equations) constrained (ML-estimation)						
food and beverages	.193	-.126	.103	-.065	.040	-.009	
	(.086)	(.044)	(.035)	(.028)	(.437)	(.006)	
other nondurables and services	.169		-.245	.066	-.480	.005	
	(.077)		(.042)	(.029)	(.378)	(.005)	
durable goods	.186			-.085	.480	-.008	
	(.051)			(.033)	(.229)	(.004)	
money	.221	.051	-.061	.071	-.369	-.007	
	(.090)	(.062)	(.084)	(.076)	(.400)	(.007)	
assets	.230	.036	.137	.013	.329	.018	
	(.152)	(.067)	(.088)	(.077)	(.743)	(.011)	

TABLE 2 Testing restrictions$^{1)}$

version	estim. method	$\log\mathcal{L}$	WT	LR	LM	crit.val. 95%	remarks
unconstrained	OLS	286.34	-	-	-	-	-
Symmetry of commodity price coeff.	Aitken	283.54	5.602		4.279	7.81	Ho passes
	ML	283.905	5.610	4.871	4.279	-"-	-"-
Homogeneity	OLS	280.09	12.502		7.204	9.49	conflicting inference
	ML	281.655	12.502	9.371	7.204	-"-	
Symmetry of commodity price coeffic. and homogeneity	Aitken	276.765	19.151		11.963	14.07	confl.inf.
	ML	278.87	19.190	14.945	11.920	-"-	-"-

---

[1] Tests calculated with factor T-K

It should be noted that the presented application is only a tentative one. Using the approach on a larger scale (data permitting) will certainly reveal more of the structural information contained in price and resource parameters.

For its use in estimating the disaggregated consumption component of final demand the Rotterdam model may not be used straight forwardly. Its estimated price, income and resource parameters should first be converted into (variable) elasticities. They may be calculated e.g. using the average resource shares or the most recent ones available. Their estimated value could subsequently be inserted into the following equation for the i-th sector:

$$(20)\quad x_{i_t} = x_{i_{t-1}} (L_t/L_{t-1})^{\eta_i} \prod_{j=1}^{n} (p_{jt}/p_{jt-1})^{\sigma_{ij}} (p_{at}/p_{at-1})^{\sigma_{ia}} \qquad i=1,\ldots,n$$

where $\eta_i = B_i/\bar{w}_i$, $\sigma_{ij} = S_{ij}/\bar{w}_i$, $\sigma_{ia} = S_{ia}/\bar{w}_i$ are the respective elasticities calculated using average resource shares.

On the other hand other well known demand models, like the linear expenditure system and others, may be used as well. One should note, however, that the assumption of a specific functional form of the underlying utility function already implies specific assumptions concerning price expectations and the interaction between monetary and real items. It would certainly not be wise to choose a particular functional form whose implications were rejected by a more general (e.g. the Rotterdam) model.

5. CONCLUSIONS

This paper attempted to present a demand model based on intertemporal consumer decisions. Its theoretical and empirical implications have been discussed and subsequently tentatively applied to Austrian data. In doing so all theoretical assumptions were kept at a rather general level and no specific functional forms had to be used. Obviously a number of issues were not given attention to keep the model relatively simple. Among further improvements of this model due consideration should be given to an explicit treatment of consumer credit and the role of durable goods. For the present exposition it might be sufficient to mention the possibility to treat assets as net assets, provided they remain positive which is likely the case for the aggregate household sector. Considering consumption of durables would further require detailed data on stocks and durability. Reliable data are generally found only on expenditures.

Finally, the attention brought to the interplay of real and monetary magnitudes by focusing on the intertemporal aspect of consumer decisions should promote thoughts and attempts to integrate monetary aspects within input-output modelling.

REFERENCES

Barten, A.P. (1967). Evidence on the Slutsky Conditions for Demand Equations Review of Economics and Statistics 49, 77-84.

Barten, A.P. (1977). The Systems of Consumer Demand Functions Approach: A Review. Econometrica 45, 23-51.

Dusansky, R., Kalman, P.J. (1972). The real-balance effect and the traditional theory of consumer behavior: a reconciliation. Journal of Economic Theory 5, 336-47. Erratum, Journal of Economic Theory 6 (1973), 102.

Dusansky, R., Kalman, P.J. (1974). The Foundations of Money Illusion in a Neoclassical Micro-Monetary Model. American Economic Review 64, 115-122.

Dusansky, R., Kalman, P.J. (1978). Illusion-Free Demand Behavior in a Monetary Economy: The General Conditions. In: Some Aspects of the Foundations of General Equilibrium Theory. Springer Lecture Notes.

Kalman, P.J., Intriligator M.D. (1973). Generalized Comparative Statics with Applications to Consumer Theory and Producer Theory. International Economic Review. Vol.14, No.2, June 1973, 473-486.

Grandmont, J.-M. (1974). On the Short Run Equilibrium in a Monetary Economy. In J. Dreze (Ed.), Allocation under Uncertainty. Macmillan, London.

Theil, H. (1975,1976). Theory and Measurement of Consumer Demand. Vol.I, II. Amsterdam.

ANALYSIS OF SECTORAL EMPLOYMENT AND WAGE PATTERNS IN THE FRG

Georg Erber
*Deutsches Institut für Wirtschaftsforschung, Königin-Luise Strasse 5,
D-1000 Berlin 33 (West)*

Introduction.

The following paper gives some results of a preparatory data analysis for the development of sectoral employment and sectoral wages and salaries, which are now available for the disaggregated econometric model at the DIW. The FIND-Project (Forecasting Interindustrial Development), which will be accomplished in cooperation with the SFB 21 (Sonderforschungsbereich - Special Research Section) of the Bonn University, started at the beginning of this year and is supported by the DFG (Deutsche Forschungsgemeinschaft - German Research Community). Its main targets are published in the research plan presented at a meeting of the DFG in Bonn in July 1982 (KRELLE, ERBER, KIY (1982)).

The paper stresses the necessity of preparatory data analysis as a step in the beginning of a development of a large sectoral disaggregated econometric model. A thorough knowledge of what kind of story the data tell us is important to use an adequate theoretical framework later on. Analytic tools are necessary in this situation, because the overwhelming amount of information contained in thousands of sectoral time series makes an immediate understanding of the informational content impossible. The current available literature (cf. e.g. MOSTELLER, TUKEY (1977), TUKEY (1977)) gives some advice, but there is still a necessity for further development of methods for the econometrics of sectoral changes and structural pattern dynamics.

Income and Employment in the Federal Republic of Germany.

The development of the employment and income situation in different industries of the Federal Republic of Germany is characterized by the major trends, which are observed in other highly industrialized countries. The tertiary sectors are absorbing more and more people from the primary and secondary sectors. Especially the government sector, which is by far the largest single sector in the 51 sector classification, increased its percentage share of the total employees from 10.45 % in 1960 to 17.07 % in 1980. Correspondingly the income situation for the tertiary sectors are changing relatively to the primary and secondary sectors. For the government sector this over proportional increase in the incomes earned in this sector is expressed by the growth of its percentage share of the total wages and salaries from 14.28 % in 1960 to 19.36 % in 1980. On the other hand this development should not be interpreted as a widening gap in the per capita income situation between the government sector and the other sectors. The per capita income for the government sector increased from 9,742 DM in 1960 to 41,569 DM in 1980 compared to the total income increase in wages and salaries from 7,131 DM in 1960 to 36,651 DM in 1980. This implies a closing of the per capita income gap from 136.6 % in 1960 to 113.4 % in 1980 of the earnings of government workers in relation to the general income development. The income situation in the government sector is still favorable compared to the total development, but with the growth of this sector its comparative advantages diminishes. Despite this major trends there are other developments, which are more specific for Germany and should be analysed in further detail.

The Data.

The time period under investigation is the period from 1960 to 1980. The data used are in part from the Federal Statistical Office (STATISTISCHES BUNDESAMT (1982)) and also based on own computations at the DIW. The following sectors from the Federal Statistical Office are split up at the DIW by using further information:

Federal Statistical Office	51 Sector Classification
75 electricity, gas, water supply	2 electricity and long-distance generating station 3 gas supply 4 water supply
115 wholesale and retailing	40 wholesale 41 retailing
119 remaining traffic	43 shipping, waterways and harbours 44 road traffic (incl. other transport)
124 rented dwellings,services n.e.s.	48 rented dwellings 49 services n.e.s.

All data are consistent with the published data if the Federal Statistical Office. The data are disaggregated by a 51 sector classification of the production sectors, which is given by the table opposite.

The Prelimenary Data Analysis.

One problem, which has to be solved, consists of finding adequate methods to get an overall picture of the development of the multisectoral time series.

The traditional approach is to look at the annual or average growth rates or the percentage share changes in comparison to the aggregate development and to interprete these relative changes. This approach could be an easy way to find structural stabilities on that level, but it overlooks other more hidden stable relations in the data.

Another way to tackle the problem is to use correlation and regression analysis, not in the fashion to get an estimation for an already formulated economic relationship like labour demand or wage functions, but as a descriptive tool for compressing information contained in the

	Classification of the production sectors
1	agriculture, forestry and fishing
2	electricity and long-distance generating station
3	gas supply
4	water supply
5	coal mining
6	remaining mining
7	chemical industry, prod. and proc. of nuclear fuel
8	mineral oil refining
9	plastics manufactures
10	rubber and asbestos manufactures
11	industry of building materials
12	fine ceramic industry
13	production and processing of glass
14	iron and steel industry
15	industry of non-ferrous metals
16	foundries
17	steel drawing and cold rolling mills, steel forging
18	constructional steel
19	machinery construction
20	office equipment, computers
21	vehicle construction
22	shipbuilding
23	aerospace industry
24	electrical equipment
25	precision engeneering, optical industry, and watches
26	industry of hardware, and metal goods
27	musical instruments, toys, jewelry, and sport articles
28	saw-mills and timber processing
29	timber manufactures
30	cellulose and paper processing
31	paper and board manufactures
32	printing and duplicating
33	textile industry
34	leather industry
35	cloathing industry
36	food and drinks manufacturing
37	tobacco industry
38	building and road construction
39	completion of construction
40	wholsale
41	retailing
42	railway
43	shipping, waterways and harbours
44	road traffic (incl. other transport)
45	communications (Federal Post)
46	credit institutes
47	insurance
48	rented dwellings
49	services n.e.s.
50	public sector (incl. social insurance)
51	private households and non-profit organizations

data. This way of looking at the data does not make the traditional approach obsolete, but it gives additional help for making decisions about the adequate formulation of an econometric model. Should a top-down specification chosen or a bottom-up procedure selected ? These decision are not easily to be made on a priori considerations, because from a theoretical point of view it may be very sensible to choose a bottom-up procedure as well as a top-down approach. The data analysis can give hints, which kind of specification strategy would be more appropriate.

With top-down specification we label a way of formulating a model, which seperates the macroeconomic behavioral relation from the sectoral behavioral relations. Therefore these models have a dichotomy between the explanation of the level of the macroeconomic activity and the sectoral level of explanation. This kind of theoretical formulation could be based on a microeconomic decision model with two separable decisions (cf.e.g. SONO (1961), STROTZ (1957), BLACKORBY, PRIMONT, RUSSEL (1978)) or could use very different explanatory theories, which are independent from another. Consistency is the only condition which is necessary. Since the sectoral development cannot be explained as a single decision maker problem of allocating resources, because there are usually a number of different decision makers, we are bound to use the metaphor of the representative enterprise or ommit it at all.

With bottom-up specification we label a procedure, which explains the different sectors without giving an explanation for the aggregate. The aggregate variable could be regarded as an accounting variable without an economic explanation. It only summarizes the sectoral development and the sectoral explanation for the purpose of compressing information, but there are no macroeconomic decision problems. This approach seems to be better suited to take account of institutional factors, because there are no a priori restrictions to guarantee consistency between the two levels. This greater flexibility of sectoral modelling seems to be very attractive, but there might be circumstances where they represent an unnecessary complication. If the sectoral data are highly multicollinear, there is no need to give a specific sectoral explanation. To the contrary very heterogenuous developments in single sectors would indicate that bottom-up procedures are useful and top-down would fail.

As a first step of applying regression and correlation analysis the following models are used:

1. Intercorrelation matrices of the sectoral and aggregate time series.
2. Time trend regressions of the sectoral time series (linear and logarithmic linear).
3. Regressions of the sectoral time series with the aggregate variable as the explanatory variable (linear and logarithmic linear).

The intercorrelation matrix of the sectoral data makes the linear dependencies of all series obvious. This is a useful information to discover blocks with strong linear dependencies which should be treated differently than blocks which are independent. That these structures occur in sectoral time series data are shown by the intercorrelation matrices for employment and the wage and salary data (cf. the table 1 and 2 of the appendix*).

If it is possible to identify typical patterns in the intercorrelation matrix, we get useful information where top-down or bottom-up approaches are more adequate. Some sectors might move in a strong linear dependent way with another and it would be impossible to find other

---

*For reasons of space the appendix is not reproduced here. It is, however, available on microfiche from the Publications Department, IIASA, A-2361 Laxenburg, Austria, on request.

significant interactions between them. Even if the theoretical preferences would like to use a sector specific approach, it will not work with the available data. On the other hand the top-down approach will fail, if there is no dependency, which guarantees a strong relation.

Looking at the intercorrelation matrix of the employment (cf. table 1 of the appendix*)we see that the sectors 2,4,9,21,23,25,39,41 and 44 - 50 are all strong positively correlated. These are all industry sectors with an increasing employment over the period 1960 - 1980. With these the sectors 1,5,6,11,12,14,16,18,22,27,29,33,34,35,37,42,43 are negatively correlated. These sectors are characterized as decreasing employment sectors. The remaining sectors 3,7,8,10,13,15,17,19,20,24,26, 28,30,31,32,36,38,40,51 do not have such a clear cut relationship. We find a reasonably strong positive relation between the pairs of sectors 28,29 and 31,32. Since 28 (saw-mills and timber processing) and 29 (timber manufactures) are linked by their production processes this is not surprising. The same is true for 31 (paper and board manufactures) and 32 (printing and duplicating). The first view shows that 15 sectors are sectors with increasing employment, 17 are sectors with decreasing employment and 19 sectors do not have a clear cut relationship and need further investigations.

The picture shown by the intercorrelation matrix for wages and salaries is very different. There are high posetive correlations between all sectoral variables (cf. table 2 of the appendix*). The elements of the correlation matrix are nearly everwhere approximately one. At the first sight this might be a surprising result, because the sectoral annual growth rates and percentage shares show considerable differences over the time period from 1960 - 1980. Therefore we get an extremely homogeneous pattern compared to the correlation matrix of the empolyees. Any attempt to give more specific explanation, which assumes implicitly a greater heterogeneous diversity in the sectoral development and want to identify more specific effects, would fail under these circumstances. We will resume this problem.

The next step of our analysis investigates the trend component in the sectoral data. Since linear and logarithmic linear regressions were computed, we get information, if a continuous linear/exponential growth/decline governs the development or different patterns are present.

The tables for the regression analysis are organized as follows:

1. The name of the regressed variable and its scaling dimension.

2. The equation spefication using the following labels:

LF(i,t) - sectoral employees of sector i
LF(t) - total employees
W(i,t) - wages and salaries of sector i
W(t) - total wages and salaries
u(t) - error term for sector i
t - trend variable (t = 1,...,21)

---

*For reasons of space the appendix is not reproduced here. It is, however, available on microfiche from the Publications Department, IIASA, A-2361 Laxenburg, Austria, on request.

Employment (in 1000)

$LF(i,t) = a(i) + b(i) * t + u(t)$

i	sector	a	t(a)	b	t(b)	DW	R2
1	Landw	448.100	186.5	-12.41170	64.9	0.211	0.8870
2	Elektrw	158.419	151.3	3.20000	38.4	0.202	0.9354
3	Gas	18.638	35.4	-0.03636	0.9	0.611	0.0284
4	Wass	21.633	57.2	0.34935	11.6	1.074	0.9103
5	Kohlenbb	460.233	185.8	-13.80910	70.0	0.232	0.8958
6	übr.Bb	51.019	57.7	-1.88052	26.7	0.240	0.9075
7	Chemie	561.319	262.5	4.27403	25.1	0.466	0.5973
8	Minöl	46.610	44.3	-0.33247	4.0	0.385	0.1332
9	Kunststv	98.838	67.4	5.78961	49.5	0.580	0.9247
10	Gummi	126.390	90.6	0.00779	0.1	0.484	0.0000
11	Steinerd	317.152	218.2	-4.58961	39.7	0.770	0.8892
12	Feinker	84.357	135.8	-1.38312	28.0	1.212	0.9562
13	Glas	94.800	90.4	-0.38441	4.6	0.461	0.1721
14	Eisensch	507.733	273.8	-10.40000	70.4	0.609	0.9395
15	NE-Met	97.814	77.1	-0.63247	6.3	0.241	0.2080
16	Giesser	179.267	139.0	-3.06753	29.9	1.127	0.8525
17	Zieherei	272.686	224.4	-1.03636	10.7	1.527	0.4558
18	Stahlbau	235.591	160.3	-3.17922	27.2	1.129	0.7864
19	Maschbau	1081.670	345.5	2.84806	11.4	0.507	0.1254
20	BM,ADV	74.805	45.7	0.78831	6.0	0.282	0.1282
21	Strfzbau	574.643	190.2	17.31820	72.0	0.519	0.8595
22	Schiffb	90.100	109.6	-1.37273	21.0	0.439	0.8751
23	Luftfzb	23.576	32.0	1.31558	22.4	0.806	0.9085
24	Eltechn	1007.110	283.0	7.58312	26.8	0.605	0.3787
25	Feinmech	162.848	163.2	2.47272	31.1	1.447	0.9129
26	EBM	404.986	224.6	-2.95974	20.6	0.688	0.5848
27	Mus,Splw	99.057	114.2	-0.62857	9.1	0.587	0.5427
28	Holzbear	91.590	137.5	-1.84156	34.7	1.298	0.9669
29	Holzver	382.071	249.0	-3.51298	28.7	0.600	0.7909
30	Zellst	92.229	114.4	-1.85195	28.8	0.536	0.9323
31	Papierv	149.986	105.2	-0.73896	6.5	0.362	0.1836
32	Druck	259.467	140.7	-1.81299	12.3	0.246	0.3259
33	Textil	728.286	363.9	-19.38960	121.6	0.707	0.9755
34	Leder	232.510	175.1	-6.40130	60.5	0.443	0.9573
35	Bekleid	520.219	218.1	-10.49610	55.3	0.382	0.8526
36	Ernährung	727.024	329.8	2.62985	15.0	0.283	0.3323
37	Tabakver	70.905	68.8	-2.53247	30.8	0.193	0.9060
38	Bauh.gew	1716.450	341.2	-23.08830	57.6	0.412	0.5859
39	Ausbau	466.819	246.7	7.20260	47.8	0.697	0.8731
40	Grosshd	1062.340	381.4	2.61818	11.8	0.471	0.1621
41	Einzelhd	1191.700	473.9	24.05320	120.1	0.553	0.9609
42	Eisenbahn	517.229	256.9	-7.21559	45.0	0.313	0.8433
43	Schiffrt	103.543	153.3	-1.47792	27.5	0.604	0.9468
44	übr.Verk	324.400	213.5	5.49609	45.4	0.456	0.9059
45	Bupost	406.181	251.8	4.29091	33.4	0.431	0.8220
46	Kreditin	254.795	152.5	13.85840	104.2	0.263	0.9767
47	Versich	130.710	85.8	4.22987	34.9	0.151	0.8495
48	Wohnverm	47.371	98.1	2.52467	65.7	0.777	0.9950
49	sonst.Die	1101.100	447.3	37.77410	192.7	0.329	0.9851
50	Staat	2051.100	643.4	90.62730	356.9	0.476	0.9927
51	Priv.HH	659.143	227.9	3.44156	14.9	0.244	0.2235
52	Summe	20586.600	2162.3	106.23000	140.1	0.611	0.7000

Employment (in 1000)

$\ln LF(i,t) = a(i) + b(i) * t + u(t)$

i	sector	a	t(a)	b	t(b)	DW	R2
1	Landw	6.134	49.8	-0.03850	3.9	0.241	0.9160
2	Elektrw	5.073	61.8	0.01702	2.6	0.180	0.9159
3	Gas	2.926	24.1	-0.00226	0.2	0.613	0.0383
4	Wass	3.081	40.9	0.01390	2.3	0.982	0.9102
5	Kohlenbb	6.170	51.5	-0.04331	4.5	0.368	0.9394
6	übr.Bb	4.009	31.6	-0.06089	6.0	0.438	0.9606
7	Chemie	6.330	72.4	0.00722	1.0	0.457	0.6023
8	Minöl	3.850	24.0	-0.00875	0.7	0.396	0.1712
9	Kunststv	4.647	37.1	0.03781	3.8	0.393	0.9079
10	Gummi	4.837	39.3	0.00004	0.0	0.508	0.0000
11	Steinerd	5.772	63.6	-0.01745	2.4	0.732	0.8849
12	Feinker	4.449	59.6	-0.02003	3.4	1.246	0.9562
13	Glas	4.553	41.5	-0.00446	0.5	0.470	0.1885
14	Eisensch	6.252	71.9	-0.02641	3.8	0.723	0.9537
15	NE-Met	4.588	34.7	-0.00752	0.7	0.229	0.2380
16	Giesser	5.201	49.2	-0.02096	2.5	1.140	0.8566
17	Zieherei	5.609	74.8	-0.00397	0.7	1.531	0.4568
18	Stahlbau	5.467	52.8	-0.01557	1.9	1.318	0.7830
19	Maschbau	6.985	74.8	0.00260	0.3	0.522	0.1309
20	BM,ADV	4.299	24.2	0.01027	0.7	0.266	0.1525
21	Strfzbau	6.367	54.6	0.02371	2.6	0.434	0.8382
22	Schiffb	4.513	47.2	-0.01844	2.4	0.436	0.8732
23	Luftfzb	3.203	21.8	0.03712	3.2	0.637	0.8342
24	Eltechn	6.914	64.3	0.00713	0.8	0.625	0.3938
25	Feinmech	5.101	72.4	0.01295	2.3	1.491	0.9208
26	EBM	6.008	63.5	-0.00814	1.1	0.678	0.5841
27	Mus,Splw	4.598	50.5	-0.00691	1.0	0.579	0.5427
28	Holzbear	4.541	57.4	-0.02607	4.1	1.276	0.9671
29	Holzver	5.948	71.8	-0.01011	1.5	0.634	0.7878
30	Zellst	4.554	44.9	-0.02661	3.3	0.422	0.9193
31	Papierv	5.013	41.9	-0.00551	0.6	0.354	0.2012
32	Druck	5.564	46.3	-0.00805	0.8	0.245	0.3457
33	Textil	6.647	64.5	-0.03921	4.8	0.389	0.9587
34	Leder	5.511	48.0	-0.04131	4.5	0.342	0.9435
35	Bekleid	6.288	50.8	-0.02732	2.8	0.316	0.8437
36	Ernährung	6.588	81.1	0.00359	0.6	0.285	0.3330
37	Tabakver	4.331	38.2	-0.05757	6.4	0.366	0.9715
38	Bauh.gew	7.461	56.0	-0.01648	1.6	0.394	0.5954
39	Ausbau	6.153	76.2	0.01324	2.1	0.671	0.8755
40	Grosshd	6.968	83.0	0.00243	0.4	0.474	0.1672
41	Einzelhd	7.098	114.1	0.01643	3.3	0.662	0.9677
42	Eisenbahn	6.258	64.2	-0.01655	2.1	0.321	0.8371
43	Schiffrt	4.649	67.4	-0.01684	3.1	0.728	0.9552
44	Übr.Verk	5.793	77.0	0.01415	2.4	0.461	0.9158
45	Bupost	6.009	78.9	0.00958	1.6	0.417	0.8252
46	Kreditin	5.598	59.7	0.03534	4.7	0.189	0.9648
47	Versich	4.882	39.2	0.02557	2.6	0.144	0.8216
48	Wohnverm	3.916	50.2	0.03469	5.6	0.277	0.9822
49	sonst.Die	7.038	134.2	0.02496	6.0	0.576	0.9927
50	Staat	7.671	110.5	0.03037	5.5	0.360	0.9856
51	Priv.HH	6.491	59.6	0.00487	0.6	0.244	0.2226
52	Summe	9.933	153.3	0.00492	1.0	0.609	0.7098

For the linear equations:

a(i) - parameter of the constant term for sector i
b(i) - parameter of the explanatory variable for sector i

For the logarithmic linear equations:

a(i) - natural logarithm of the scaling parameter for the sector
b(i) - parameter of the sectoral elasticity of sector i

3. The estimated values:

a - column label for a(i)
b - column label for b(i)
t(a) - estimated t-value of parameter a
t(b) - estimated t-value of parameter b
DW - Durbin-Watson statistic
R2 - coefficient of determination

The theoretical t-value for the 1 % significance level is 2.861 and for the 5 % level is 2.093 with 19 degrees of freedom.

4. The estimation method is always ordinary least squares (OLS).

5. The estimation period is everywhere 1960 - 1980.

For the development of the sectoral employees described by the trend models (cf. p.90) we find, that the sectors 1,2,4,5,6,9,11,12,14,16,21, 22,23,25,28,30,33,34,37,39,41 - 50 have high coefficients of determination. Their parameters are all significant at the 1 % level. The sign of the parameters b(i) show an increasing trend for the sectors 2,4,9,21,23,25,39,41,44 - 50, and a decreasing trend in 1,5,6,11,12,14, 16,22,28,30,33,34,35,37,42,43. In comparison to the linear time trend model the logarithmic model gets higher coefficients of determination for the sectors 1,5,6,14,16,25,28,37,43,44,45,49, but the growth rate is only statistically significant for the sectors 5,6 and 37. These are all declining industries with respect to employment. This could be interpreted as a situation, where the mining sectors (5,6) and the tobacco industry (37) reached some kind of saturation level at the end of the seventies. The current crisis in the coal mining industry shows, that the process could well be an intermediate stabilization of a shrinking process, which stopped during the two oil crisis, but started again with the stablilization of the oil prices in the beginning eighties. When minor superiorities of an exponential trend with respect to the coefficient of determination occur in other sectors, but the growth rate does not pass the significance test at the 5 % or 1 % level a clear cut decision in favour for an exponential growth/decline assumption cannot be made. Since for predictive purposes an exponential growth/decline assumption seems more riskier than a linear, we prefer the more conservative approach of linear trends with significant coefficients.

Looking at the results of the time trend analysis for the development of the sectoral wages and salaries (cf. p.92), we notice that with the exeception of the sector for remaining mining (6) all others have coefficients of determination larger than 80 % and significant parameters. All incomes grow. Only the sector road traffic (incl. other trans-

Wages and Salaries in mill.DM

W(i,t) = a(i) + b(i) * t + u(t)

i	sector	a	t(a)	b	t(b)	DW	R2
1	Landw	1901.330	187.1	188.10400	232.4	0.170	0.8493
2	Elektrw	-643.949	48.3	544.81800	512.7	0.111	0.9409
3	Gas	-17.000	3.7	43.88310	118.9	0.271	0.8763
4	Wass	-25.571	6.3	53.88310	165.6	0.152	0.9466
5	Kohlenbb	3387.140	252.5	281.42900	263.4	0.283	0.8060
6	übr.Bb	430.857	111.4	16.80520	54.6	0.287	0.6823
7	Chemie	266.764	13.8	1350.00000	874.7	0.214	0.9564
8	Minöl	213.810	40.1	96.10390	226.5	0.689	0.9512
9	Kunststv	-553.428	52.5	317.32500	378.2	0.268	0.9328
10	Gummi	360.715	57.5	185.26000	370.6	0.568	0.9741
11	Steinerd	1524.860	161.2	332.41600	441.2	0.494	0.9591
12	Feinker	302.953	71.8	67.22080	199.9	0.406	0.9602
13	Glas	266.000	48.9	121.79200	281.2	0.465	0.9665
14	Eisensch	3184.950	256.5	450.54500	455.7	0.423	0.9355
15	NE-Met	331.667	63.4	135.90900	326.0	0.595	0.9766
16	Giesser	877.382	114.0	168.37700	274.6	0.485	0.9320
17	Zieherei	800.762	81.7	342.96100	439.2	0.339	0.9558
18	Stahlbau	984.430	105.3	251.93500	338.4	0.534	0.9338
19	Maschbau	1513.200	66.4	1952.09000	1075.9	0.247	0.9600
20	BM,ADV	-189.857	25.6	218.42900	369.8	0.567	0.9640
21	Strfzbau	-2010.050	82.2	1706.20000	876.5	0.193	0.9327
22	Schiffb	369.429	62.8	103.68800	221.4	0.487	0.9385
23	Luftfzb	-318.286	43.7	118.80500	204.6	0.189	0.8946
24	Eltechn	329.957	14.4	1891.78000	1039.9	0.224	0.9572
25	Feinmech	-183.381	16.6	317.23400	361.4	0.165	0.9205
26	EBM	1151.950	105.2	474.58400	544.4	0.382	0.9638
27	Mus,Splw	248.238	50.9	89.07790	229.5	0.238	0.9598
28	Holzbear	386.524	96.2	69.88310	218.3	0.527	0.9695
29	Holzver	1149.340	99.9	392.18200	428.2	0.208	0.9373
30	Zellst	512.429	116.7	80.42860	229.9	0.699	0.9672
31	Papierv	321.144	53.3	172.49300	359.4	0.520	0.9746
32	Druck	818.479	105.3	329.14300	531.8	0.405	0.9806
33	Textil	3385.050	396.8	300.23400	441.9	0.537	0.9666
34	Leder	1249.480	302.4	58.66240	178.3	0.851	0.9525
35	Bekleid	1893.480	305.7	228.68800	463.7	0.927	0.9837
36	Ernährung	2298.950	163.3	930.05200	829.3	0.175	0.9739
37	Tabakver	256.524	72.4	32.74030	116.1	0.185	0.9205
38	Bauh.gew	7739.480	337.1	1662.56000	909.3	0.602	0.9442
39	Ausbau	214.286	13.8	786.88300	638.2	0.194	0.9482
40	Grosshd	1706.010	83.8	1573.87000	971.0	0.249	0.9608
41	Einzelhd	-1475.050	57.3	2040.81000	995.0	0.120	0.9415
42	Eisenbahn	2690.760	186.3	610.88300	531.2	0.275	0.9358
43	Schiffrt	625.238	108.8	82.72730	180.8	0.192	0.9144
44	übr.Verk	1.432	0.1	775.45400	626.7	0.155	0.9460
45	Bupost	336.811	22.8	825.05200	701.3	0.198	0.9604
46	Kreditin	-1587.000	84.6	1097.65000	734.6	0.148	0.9429
47	Versich	-502.429	43.3	475.93500	514.5	0.148	0.9548
48	Wohnverm	-140.667	24.9	104.13000	231.8	0.121	0.9479
49	sonst.Die	-1473.140	52.3	2170.81000	968.3	0.105	0.9273
50	Staat	-6178.960	130.0	7380.47000	1949.0	0.133	0.9477
51	Priv.HH	490.951	25.6	1021.69000	668.4	0.126	0.9289
52	Summe	29224.000	295.9	35024.10000	4452.4	0.155	0.9563

Wages and Salaries in mill.DM

ln W(i,t) = a(i) + b(i) * t + u(t)

i	sector	a	t(a)	b	t(b)	DW	R2
1	Landw	7.749	57.0	0.04497	4.2	0.257	0.9099
2	Elektrw	7.121	70.2	0.11288	14.0	0.359	0.9951
3	Gas	4.916	38.0	0.09575	9.3	0.512	0.9824
4	Wass	5.005	42.7	0.10406	11.1	0.384	0.9898
5	Kohlenbb	8.285	51.7	0.04108	3.2	0.359	0.8136
6	übr.Bb	6.123	40.0	0.02557	2.1	0.340	0.6684
7	Chemie	8.389	80.7	0.09717	11.7	0.803	0.9928
8	Minöl	6.073	37.5	0.08585	6.7	0.277	0.9480
9	Kunststv	6.356	51.3	0.12441	12.6	0.586	0.9911
10	Gummi	6.729	52.8	0.08439	8.3	0.788	0.9787
11	Steinerd	7.731	63.8	0.06718	7.0	0.682	0.9727
12	Feinker	6.137	60.6	0.06651	8.2	0.891	0.9862
13	Glas	6.364	52.9	0.08172	8.5	0.669	0.9819
14	Eisensch	8.332	67.7	0.05574	5.7	0.705	0.9585
15	NE-Met	6.507	53.8	0.08070	8.4	0.607	0.9810
16	Giesser	7.149	52.5	0.06252	5.8	0.895	0.9508
17	Zieherei	7.453	69.1	0.07851	9.1	1.110	0.9873
18	Stahlbau	7.389	57.4	0.06852	6.7	0.873	0.9669
19	Maschbau	8.885	76.1	0.09171	9.9	0.728	0.9872
20	BM,ADV	6.140	34.4	0.12017	8.5	0.350	0.9603
21	Strfzbau	8.261	71.5	0.11312	12.3	0.904	9.9919
22	Schiffb	6.425	47.2	0.07250	6.7	0.543	0.9629
23	Luftfzb	5.041	36.5	0.13899	12.6	0.968	0.9890
24	Eltechn	8.714	70.6	0.09786	10.0	0.657	0.9860
25	Feinmech	6.802	65.3	0.10138	12.2	0.619	0.9933
26	EBM	7.780	75.3	0.07891	9.6	0.990	0.9893
27	Mus,Splw	6.173	76.8	0.07604	11.9	1.218	0.9957
28	Holzbear	6.285	58.1	0.06316	7.3	0.703	0.9802
29	Holzver	7.701	71.6	0.07316	8.5	0.552	0.9856
30	Zellst	6.524	63.6	0.05940	7.3	1.110	0.9819
31	Papierv	6.642	54.5	0.08507	8.8	0.581	0.9824
32	Druck	7.391	60.5	0.08110	8.3	0.359	0.9805
33	Textil	8.254	74.6	0.04673	5.3	0.526	0.9613
34	Leder	7.179	71.1	0.03175	3.9	0.735	0.9427
35	Bekleid	7.733	68.4	0.05489	6.1	0.678	0.9690
36	Ernährung	8.455	93.3	0.07913	11.0	0.588	0.9937
37	Tabakver	5.798	48.6	0.05209	5.5	0.273	0.9579
38	Bauh.gew	9.312	61.0	0.06965	5.7	0.496	0.9381
39	Ausbau	7.874	75.7	0.09582	11.6	0.827	0.9926
40	Grosshd	8.734	83.4	0.08896	10.7	0.616	0.9911
41	Einzelhd	8.579	85.9	0.10666	13.4	0.552	0.9949
42	Eisenbahn	8.302	58.3	0.06902	6.1	0.304	0.9518
43	Schiffrt	6.698	51.5	0.05297	5.1	0.331	0.9431
44	übr.Verk	7.805	83.8	0.09791	13.2	0.628	0.9954
45	Bupost	7.929	64.8	0.09616	9.9	0.323	0.9860
46	Kreditin	7.719	62.6	0.11805	12.0	0.282	0.9904
47	Versich	6.989	61.7	0.11384	12.6	0.396	0.9926
48	Wohnverm	5.377	47.7	0.11812	13.1	0.435	0.9932
49	sonst.Die	8.681	91.9	0.10393	13.8	0.455	0.9956
50	Staat	9.817	84.3	0.10910	11.8	0.341	0.9910
51	Priv.HH	8.222	64.2	0.09055	8.9	0.241	0.9811
52	Summe	11.794	113.8	0.09043	11.0	0.481	0.9918

port) has an insignificant coefficient for the absolute term. Comparing the linear trend model with the logarithmic linear trend we find that nearly all fits are better than the linear approach. The following sectors deviate from this general trend: 8,20,32,33,34,35,38. The result, that the development of sectoral incomes follows a growth trend over the last 21 years is not very surprising, but the degree of homogenity of a continuous growth for all sectors is not self evident from the prima vista of changing sectoral shares and different growth rates. The argument, that trade unions and organizations of entrepreneurs are bargaining with another on the basis of leader and follower relationships for the different industries and therefore the decision of one sector is carried over by the other, does not fit at this situation. Trade unions and entrepreneurs bargain on wage rates not on a whole income position of the sectoral employees. Even, if working hours would be fairly constant over time, which was not the case in FRG, the number of employed people is not fixed by contract.

Turning now to the estimates, where the sectoral variables are related to the aggregate. We notice, that for the sectoral employees the use of the aggregate employment variable does not give a good explanation for the sectoral development (cf. p.94). Only the sectors 2,9,21 and 45 have high R2 and significant coefficients. The first three of them get better results by using the linear logarithmic approach. The aggregate variable for the employees is therefore a much weaker explanatory variable than the time trend. In its the aggregate so many different developments are mixed up, that it is does not fit into any sectoral development very well. The significance of time trends in the sectoral variables shows us on the other hand, that this is not a cause of fairly instable employment movements in the single sectors. The main reason for the discrepancy between time trend and total aggregate variable lies in the fact, that the number of employed people did not increase very much and not very steadily as well. In 1960 we had 20.073 million employees and in 1980 22.909 million. During this period we had a small recession in 1967 with a drop of employment from 21.626 million in 1966 to 20.908 in 1967 and an increase over the level of 1966 in 1970 to 22.138 million For the first decade we had therefore a small increase in employment in the first half and a slight decrease with slow recovery, which needed three years. A similar development is oberserved for the second decade, where the first oil crisis stopped a continuous growth. Starting in 1970 with 22.138 million the growth stopped in 1973 with 22.833 million and passed this level only in 1980 with 22.909 million.

Looking now at the results for the wages and salaries (cf. p.95), we notice that here the aggregate variable is a nearly perfect explanatory variable for all sectors. In the average performance the logarithmic linear approach outperformes the linear and the trend model. The differences are in most cases not very dramatic, only the sector 6 improves considerably by the aggregate variable model. The rest is very close to each other.The aggregate income seems to be better suited to tackle the two recessions in the FRG, which we already mentioned. It gets therefore a slight advantage over the trend model. A better discrimination between both would only be possible, if the economic development in this variable would be disturbed, so that the collinearity between both would not prevail.

From the economists point of view it seems justified to prefer the aggregate variable model. This poses the question, if there exists an

Employment (in 1000)

LF(i,t) = a(i) + b(i) * LF(t) + u(t)

i	sector	a	t(a)	b	t(b)	DW	R2
1	Landw	2214.890	53.4	-0.08749	45.9	0.593	0.7105
2	Elektrw	-314.012	16.6	0.02333	26.8	0.605	0.8018
3	Gas	24.139	3.4	-0.00027	0.8	0.638	0.0255
4	Wass	-26.448	3.7	0.00239	7.4	0.658	0.6849
5	Kohlenbb	2418.960	55.5	-0.09702	48.4	0.612	0.7128
6	Übr.Bb	323.053	20.8	-0.01346	18.9	0.624	0.7489
7	Chemie	-208.911	8.0	0.03757	31.4	0.500	0.7439
8	Minöl	33.873	2.3	0.00042	0.6	0.326	0.0034
9	Kunststv	-802.212	35.2	0.04435	42.4	0.511	0.8745
10	Gummi	18.064	1.0	0.00498	6.0	0.411	0.1799
11	Steinerd	788.817	26.0	-0.02400	17.2	0.470	0.3920
12	Feinker	254.899	17.2	-0.00854	12.5	0.624	0.5874
13	Glas	83.068	5.5	0.00034	0.5	0.370	0.0022
14	Eisensch	1856.380	46.7	-0.06725	36.8	0.604	0.6333
15	NE-Met	120.031	6.6	-0.00134	1.6	0.212	0.0151
16	Giesser	519.852	21.1	-0.01721	15.2	0.689	0.4324
17	Zieherei	334.714	17.7	-0.00338	3.9	1.092	0.0779
18	Stahlbau	634.729	25.6	-0.01995	17.5	0.877	0.4994
19	Maschbau	187.987	4.9	0.04252	24.3	0.462	0.4506
20	BM,ADV	-150.013	7.3	0.01073	11.4	0.306	0.3832
21	Strfzbau	-2287.050	61.9	0.14030	82.6	0.582	0.9094
22	Schiffb	282.605	19.9	-0.00954	14.6	0.519	0.6818
23	Luftfzb	-162.898	12.2	0.00924	15.1	0.628	0.7219
24	Eltechn	-758.544	19.9	0.08499	48.7	0.566	0.7669
25	Feinmech	-186.167	10.2	0.01729	20.6	0.491	0.7198
26	EBM	605.982	20.4	-0.01074	7.9	0.484	0.1240
27	Mus,Splw	163.492	12.2	-0.00328	5.3	0.539	0.2382
28	Holzbear	318.183	18.7	-0.01135	14.5	0.551	0.5917
29	Holzver	810.720	30.8	-0.02148	17.7	0.619	0.4766
30	Zellst	310.380	17.3	-0.01096	13.3	0.410	0.5268
31	Papierv	128.009	6.3	0.00064	0.7	0.280	0.0022
32	Druck	332.533	12.1	-0.00428	3.4	0.206	0.0292
33	Textil	3094.380	55.9	-0.11856	46.6	0.455	0.5880
34	Leder	1016.510	31.7	-0.03927	26.6	0.409	0.5809
35	Bekleid	1612.520	34.6	-0.05552	26.0	0.345	0.3845
36	Ernährung	141.289	5.4	0.02825	23.5	0.376	0.6183
37	Tabakver	430.729	23.4	-0.01782	21.0	0.590	0.7231
38	Bauh.gew	3239.110	39.0	-0.08167	21.4	0.323	0.1182
39	Ausbau	-598.146	19.6	0.05259	37.4	0.374	0.7505
40	Grosshd	198.152	6.4	0.04105	29.1	0.383	0.6424
41	Einzelhd	-2061.430	36.1	0.16170	61.6	0.349	0.7000
42	Eisenbahn	1416.940	39.1	-0.04500	27.1	0.400	0.5288
43	Schiffrt	289.503	19.0	-0.00930	13.3	0.544	0.6038
44	Übr.Verk	-431.356	15.3	0.03752	29.0	0.336	0.6805
45	Bupost	-312.629	16.1	0.03521	39.4	1.102	0.8923
46	Kreditin	-1695.090	41.7	0.09664	51.8	0.510	0.7656
47	Versich	-517.920	22.7	0.03195	30.5	0.622	0.7815
48	Wohnverm	-284.030	15.3	0.01651	19.4	0.450	0.6859
49	sonst.Die	-3757.560	50.9	0.24243	71.6	0.355	0.6541
50	Staat	-10115.700	93.0	0.60508	121.1	0.440	0.7133
51	Priv.HH	465.011	11.2	0.01066	5.6	0.220	0.0346

Employment (in 1000)

ln LF(i,t) = a(i) + b(i) * ln LF(t) + u(t)

i	sector	a	t(a)	b	t(b)	DW	R2
1	Landw	63.471	2.7	-5.78354	2.5	0.586	0.7053
2	Elektrw	-22.143	1.6	2.74390	2.0	0.639	0.8127
3	Gas	6.768	0.4	-0.38720	0.2	0.649	0.0383
4	Wass	-17.745	1.3	2.10061	1.5	0.677	0.7094
5	Kohlenbb	70.578	2.9	-6.49695	2.7	0.619	0.7215
6	Übr.Bb	94.866	3.4	-9.16463	3.3	0.583	0.7425
7	Chemie	-7.536	0.7	1.39634	1.3	0.571	0.7677
8	Minöl	3.721	0.2	0.00305	0.0	0.328	0.0000
9	Kunststv	-58.908	3.2	6.40549	3.5	0.545	0.8890
10	Gummi	-3.627	0.2	0.84756	0.5	0.435	0.1817
11	Steinerd	25.401	1.4	-1.98476	1.1	0.458	0.3908
12	Feinker	30.810	1.7	-2.66159	1.5	0.601	0.5761
13	Glas	4.047	0.3	0.04573	0.0	0.376	0.0007
14	Eisensch	42.834	2.1	-3.69207	1.8	0.584	0.6358
15	NE-Met	8.555	0.4	-0.40549	0.2	0.202	0.0236
16	Giesser	29.999	1.5	-2.50610	1.2	0.664	0.4178
17	Zieherei	8.336	0.7	-0.27744	0.2	1.089	0.0763
18	Stahlbau	26.488	1.5	-2.12195	1.2	0.949	0.4959
19	Maschbau	-1.329	0.1	0.83537	0.7	0.474	0.4624
20	BM,ADV	-24.453	1.1	2.89024	1.3	0.306	0.4124
21	Strfzbau	-33.695	2.6	4.23780	3.1	0.606	0.9140
22	Schiffb	31.866	1.9	-2.75915	1.6	0.480	0.6674
23	Luftfzb	-56.311	2.5	6.00000	2.7	0.717	0.7438
24	Eltechn	-10.181	0.9	1.71951	1.5	0.590	0.7808
25	Feinmech	-14.578	1.1	1.98476	1.5	0.496	0.7381
26	EBM	12.403	0.8	-0.64939	0.4	0.481	0.1269
27	Mus,Splw	12.347	0.9	-0.78354	0.6	0.534	0.2379
28	Holzbear	38.539	1.9	-3.43293	1.7	0.510	0.5722
29	Holzver	19.325	1.4	-1.35061	1.0	0.635	0.4802
30	Zellst	37.937	1.7	-3.37195	1.5	0.376	0.5037
31	Papierv	4.404	0.3	0.05488	0.0	0.274	0.0007
32	Druck	10.012	0.6	-0.45427	0.3	0.206	0.0375
33	Textil	56.851	2.2	-5.07012	2.0	0.389	0.5471
34	Leder	58.949	2.2	-5.39634	2.0	0.366	0.5493
35	Bekleid	37.106	1.6	-3.11585	1.3	0.316	0.3744
36	Ernährung	-1.715	0.2	0.83537	0.9	0.383	0.6136
37	Tabakver	87.765	3.2	-8.41768	3.0	0.572	0.7088
38	Bauh.gew	20.129	0.9	-1.28659	0.6	0.312	0.1238
39	Ausbau	-15.045	1.2	2.13720	1.7	0.408	0.7783
40	Grosshd	-1.227	0.1	0.82317	0.9	0.385	0.6556
41	Einzelhd	-17.080	1.2	2.43902	1.7	0.385	0.7278
42	Eisenbahn	28.455	1.6	-2.24085	1.3	0.388	0.5237
43	Schiffrt	27.391	1.7	-2.29573	1.4	0.539	0.6058
44	Übr.Verk	-15.030	1.1	2.10061	1.5	0.352	0.6889
45	Bupost	-10.936	1.2	1.70732	1.9	1.133	0.8935
46	Kreditin	-48.851	2.4	5.49085	2.7	0.577	0.7949
47	Versich	-37.433	2.1	4.26524	2.4	0.608	0.7803
48	Wohnverm	-46.733	2.2	5.10976	2.4	0.519	0.7273
49	sonst.Die	-28.433	1.5	3.57927	1.9	0.415	0.6965
50	Staat	-37.301	1.9	4.53659	2.3	0.507	0.7507
51	Priv.HH	3.500	0.2	0.30488	0.2	0.219	0.0298

Wages and Salaries in mill.DM

$W(i,t) = a(i) + b(i) * W(t) + u(t)$

i	sector	a	t(a)	b	t(b)	DW	R2
1	Landw	1672.750	204.7	0.00554	317.3	0.215	0.9462
2	Elektrw	-1140.260	168.1	0.01566	1079.5	0.456	0.9966
3	Gas	-66.523	18.6	0.00128	167.8	0.514	0.9624
4	Wass	-71.339	27.2	0.00154	275.2	0.799	0.9923
5	Kohlenbb	2984.270	275.9	0.00044	365.0	0.504	0.9299
6	Übr.Bb	399.270	118.8	0.00052	72.7	0.427	0.8451
7	Chemie	-833.738	79.8	0.03848	1722.7	1.557	0.9969
8	Minöl	170.171	28.2	0.00266	206.2	0.397	0.9317
9	Kunststv	-840.202	115.4	0.00911	585.4	0.518	0.9869
10	Gummi	241.419	43.2	0.00520	435.3	0.580	0.9860
11	Steinerd	1283.110	167.0	0.00941	572.6	0.681	0.9848
12	Feinker	250.164	99.8	0.00191	356.7	1.531	0.9958
13	Glas	183.106	39.3	0.00343	344.3	0.534	0.9845
14	Eisensch	2785.360	321.6	0.01292	698.0	1.220	0.9870
15	NE-Met	248.331	49.7	0.00381	356.4	0.580	0.9834
16	Giesser	725.432	134.0	0.00484	417.8	1.371	0.9858
17	Zieherei	520.077	97.8	0.00978	860.0	1.718	0.9967
18	Stahlbau	758.893	116.2	0.00723	517.9	1.913	0.9865
19	Maschbau	-44.359	3.8	0.05556	2241.2	1.018	0.9977
20	BM,ADV	-325.356	44.9	0.00612	395.1	0.451	0.9719
21	Strfzbau	-3568.080	217.8	0.04904	1400.3	0.347	0.9884
22	Schiffb	297.800	53.4	0.00292	245.5	0.551	0.9577
23	Luftfzb	-443.717	80.6	0.00346	293.7	0.377	0.9708
24	Eltechn	-1222.010	118.7	0.05395	2452.0	1.102	0.9985
25	Feinmech	-498.040	70.2	0.00918	605.5	0.308	0.9884
26	EBM	804.355	98.8	0.01343	772.3	0.884	0.9906
27	Mus,Spiw	183.047	47.3	0.00252	304.7	0.454	0.9863
28	Holzbear	340.094	96.9	0.00197	262.1	0.667	0.9849
29	Holzver	790.798	115.8	0.01127	772.3	0.709	0.9933
30	Zellst	457.512	123.1	0.00227	285.4	0.999	0.9857
31	Papierv	208.079	40.5	0.00485	441.5	0.530	0.9885
32	Druck	625.626	79.7	0.00920	548.4	0.303	0.9827
33	Textil	3249.690	325.2	0.00829	388.3	0.252	0.9463
34	Leder	1229.260	247.4	0.00161	151.2	0.447	0.9153
35	Bekleid	1790.600	226.2	0.00632	373.3	0.412	0.9629
36	Ernährung	1639.220	192.3	0.02627	1442.2	0.498	0.9970
37	Tabakver	223.160	110.5	0.00095	219.8	0.548	0.9928
38	Bauh.gew	6838.320	280.2	0.04630	887.4	0.389	0.9391
39	Ausbau	-458.198	50.8	0.02251	1167.5	0.581	0.9949
40	Grosshd	453.510	46.0	0.04479	2126.0	1.131	0.9982
41	Einzelhd	-3314.110	236.3	0.05860	1954.3	0.362	0.9956
42	Eisenbahn	2302.300	160.0	0.01715	557.6	0.237	0.9460
43	Schiffrt	539.222	152.9	0.00240	318.8	0.575	0.9896
44	Übr.Verk	-681.383	86.6	0.02223	1321.5	0.456	0.9970
45	Bupost	-308.080	34.7	0.02345	1231.9	0.456	0.9955
46	Kreditin	-2577.580	284.9	0.03152	1629.7	0.792	0.9974
47	Versich	-897.305	155.3	0.01358	1099.4	1.169	0.9976
48	Wohnverm	-228.758	64.8	0.00298	394.2	0.570	0.9932
49	sonst.Die	-3545.180	195.9	0.06261	1618.8	0.214	0.9894
50	Staat	-12628.100	549.0	0.21143	4300.1	0.693	0.9976
51	Priv.HH	-501.249	46.4	0.02951	1278.8	0.443	0.9939

Wages and Salaries in mill.DM

$\ln W(i,t) = a(i) + b(i) * \ln W(t) + u(t)$

i	sector	a	t(a)	b	t(b)	DW	R2
1	Landw	1.924	1.2	0.49415	4.1	0.190	0.9060
2	Elektrw	-7.561	8.6	1.24500	18.0	1.045	0.9983
3	Gas	-7.509	5.1	1.05385	9.1	0.427	0.9812
4	Wass	-8.556	8.5	1.14984	14.6	0.848	0.9965
5	Kohlenbb	2.874	1.7	0.45849	3.4	0.318	0.8357
6	Übr.Bb	2.746	1.6	0.28601	2.2	0.312	0.6893
7	Chemie	-4.265	5.0	1.07295	16.2	1.105	0.9980
8	Minöl	-5.136	3.0	0.95026	7.0	0.297	0.9577
9	Kunststv	-9.802	7.1	1.37045	12.8	0.312	0.9917
10	Gummi	-4.284	3.4	0.93371	9.6	0.776	0.9880
11	Steinerd	-1.079	1.0	0.74664	9.2	0.865	0.9907
12	Feinker	-2.549	3.3	0.73637	12.1	1.517	0.9969
13	Glas	-4.291	3.6	0.90338	9.8	0.543	0.9895
14	Eisensch	1.017	0.9	0.61992	6.7	0.755	0.9777
15	NE-Met	-4.012	3.3	0.89197	9.4	0.585	0.9882
16	Giesser	-1.066	0.8	0.69612	6.7	1.011	0.9720
17	Zieherei	-2.793	3.2	0.86860	12.7	1.645	0.9965
18	Stahlbau	-1.591	1.3	0.76105	8.0	1.225	0.9836
19	Maschbau	-3.088	3.4	1.01507	14.5	1.011	0.9971
20	BM,ADV	-9.563	5.2	1.33118	9.3	0.286	0.9717
21	Strfzbau	-6.449	5.5	1.24743	13.6	0.576	0.9945
22	Schiffb	-3.085	2.4	0.80592	8.0	0.725	0.9812
23	Luftfzb	-12.978	7.9	1.52852	11.9	0.714	0.9863
24	Eltechn	-4.077	4.9	1.08431	16.7	1.089	0.9981
25	Feinmech	-6.369	5.7	1.11709	12.9	0.374	0.9945
26	EBM	-2.494	2.5	0.87120	11.3	0.916	0.9944
27	Mus,Spiw	-3.667	3.2	0.83479	9.5	0.393	0.9896
28	Holzbear	-1.981	2.2	0.70059	10.2	1.174	0.9945
29	Holzver	-1.831	1.8	0.80829	9.9	0.458	0.9919
30	Zellst	-1.221	1.2	0.65671	8.4	1.207	0.9896
31	Papierv	-4.460	3.9	0.94123	10.6	0.420	0.9916
32	Druck	-3.189	2.7	0.89699	9.7	0.339	0.9890
33	Textil	2.115	2.1	0.52014	6.5	0.507	0.9821
34	Leder	3.058	2.7	0.34950	3.9	0.557	0.9421
35	Bekleid	0.571	0.5	0.60725	6.7	0.592	0.9781
36	Ernährung	-1.839	2.2	0.87294	13.4	0.533	0.9973
37	Tabakver	-0.997	0.8	0.57613	5.8	0.208	0.9662
38	Bauh.gew	0.146	0.1	0.77662	6.5	0.465	0.9616
39	Ausbau	-4.590	4.6	1.05703	13.6	0.625	0.9960
40	Grosshd	-2.856	3.3	0.98282	14.7	1.428	0.9976
41	Einzelhd	-5.286	5.5	1.17589	15.5	0.569	0.9972
42	Eisenbahn	-0.804	0.6	0.77135	7.7	0.305	0.9802
43	Schiffrt	-0.244	0.2	0.58840	5.6	0.283	0.9595
44	Übr.Verk	-4.920	5.3	1.07921	14.9	0.632	0.9972
45	Bupost	-4.631	4.9	1.06485	14.6	0.696	0.9969
46	Kreditin	-7.670	8.0	1.30481	17.4	0.905	0.9977
47	Versich	-7.805	6.5	1.25462	13.4	0.678	0.9942
48	Wohnverm	-9.924	6.9	1.29795	11.6	0.552	0.9889
49	sonst.Die	-4.811	4.4	1.14439	13.4	0.430	0.9953
50	Staat	-4.405	5.1	1.20592	17.8	0.904	0.9983
51	Priv.HH	-3.580	2.8	1.00066	10.0	0.422	0.9880

economic explanation for the persistence of a strong logarithmic linear relationship, with some deviations in favour of the linear model ? An immediate reference to an economic theory seems not to be at hand, but in some way there is a relation to a wage fund interpretation of this finding. If the nominal wages and salaries of the sectors are following some fairly stable time paths, then the relation between aggregate income and sectoral income could only be constant, if the adjustments taking place between different sectors, is realized by adjustments of the wage rate and the labour force. The interpretation suggests, that there is an independent determination of the structure of the sectoral incomes, which is only influenced by the general economic conditions, which determine the level of the aggregate income. Only through this channel the market forces influence sectoral wage funds. The parametric structure instead is given by technological and institutional conditions, which neglect, to a great extent, market signals.

So far this is not an affirmative statement, because there is a lack of an explicit model, which could show the mechanism at work and show the basic assumptions to get the result. But it might be a fruitful way for further theorizing. The answer for this problem will not be presented in this paper, which started to demonstrate the usefulness of preliminatory data analysis. If we end here to ask new questions without having them in mind when we started the analysis, this shows the success of this approach. The relation to economic theory is still not explained. The question, of how to relate this way of analysis to standard models in econometric work cannot be answered yet as well. Up to now it is a way to look at the modelling problem from a different perspective, when probably orthodox models have failed. To use the information in the data effectively to avoid false modelling concepts, which would tell the wrong story with the data, which are differently related, is the target of further research. This is only a beginning.

The table on the next page summerizes the results of our regression analysis:

T,W,LF - estimates of t,W,LF give a good fit (R2 > 0.80)
(+/-) - increasing/decreasing with good fit
W > ln T - linear wages fitted better than logarithmic trend

Summary.

The paper presents a first step to apply data analytic techniques to sectoral disaggregated economic time series. It uses two examples to demonstrate, that quite different observations could be made.

The analysis of the employment data show some simple time trend relations, which are not directly related to the aggregate development of total employees. There remains a large number of sectors, which do not fit well in the four simple models used. Therefore thorough investigation for the specific developments in these sectors is necessary and a strategy for using the bottom-up concept seems promising.

The analysis of the wages and salaries data show a very different pattern. All sectoral time series are highly correlated with each other. Therefore little extraordinary sectoral developments can be discovered, which are not summerized in the linear or logarithmic linear model with

		EMPLOYMENT			WAGES AND SALARIES.		
		t		LF	t		W .
1	Landw	T(-)	>	ln L(+)	ln T(+)	<	W(+)
2	Elektrw	T(+)			ln T(+)	<	ln W(+)
3	Gas				ln T(+)	>	ln W(+)
4	Wass	T(+)			ln T(+)	<	ln W(+)
5	Kohlenbb	ln T(-)			ln T(+)	<	ln W(+)
6	Übr.Bb	ln T(-)					W(+)
7	Chemie				ln T(+)	<	ln W(+)
8	Minöl				T(+)	>	ln W(+)
9	Kunststv	T(+)	>	ln L(+)	ln T(+)	<	ln W(+)
10	Gummi				ln T(+)	<	ln W(+)
11	Steinerd	T(-)			ln T(+)	<	ln W(+)
12	Feinker	T(-)			ln T(+)	<	ln W(+)
13	Glas				ln T(+)	<	ln W(+)
14	Eisensch	T(-)			ln T(+)	<	W(+)
15	NE-Met				ln T(+)	<	W(+)
16	Giesser	T(-)			ln T(+)	<	W(+)
17	Zieherei				ln T(+)	<	W(+)
18	Stahlbau				ln T(+)	<	W(+)
19	Maschbau				ln T(+)	<	W(+)
20	BM,ADV				T(+)	<	W(+)
21	Strfzbau	T(+)	>	ln L(+)	ln T(+)	<	ln W(+)
22	Schiffb	T(-)			ln T(+)	<	ln W(+)
23	Luftfzb	T(+)			ln T(+)	>	ln W(+)
24	Eltechn				ln T(+)	<	W(+)
25	Feinmech	T(+)			ln T(+)	<	ln W(+)
26	EBM				ln T(+)	<	ln W(+)
27	Mus,Splw				ln T(+)	<	ln W(+)
28	Holzbear	T(-)			ln T(+)	>	ln W(+)
29	Holzver				ln T(+)	<	W(+)
30	Zellst	T(-)			ln T(+)	<	ln W(+)
31	Papierv				T(+)	<	ln W(+)
32	Druck				T(+)	<	ln W(+)
33	Textil	T(-)			T(+)	>	ln W(+)
34	Leder	T(-)			T(+)	>	ln W(+)
35	Bekleid				T(+)	<	ln W(+)
36	Ernährung				ln T(+)	<	ln W(+)
37	Tabakver	T(-)			ln T(+)	<	W(+)
38	Bauh.gew				T(+)	<	ln W(+)
39	Ausbau	T(+)			ln T(+)	<	ln W(+)
40	Grosshd				ln T(+)	<	W(+)
41	Einzelhd	T(+)			ln T(+)	<	ln W(+)
42	Eisenbahn	T(-)			ln T(+)	<	ln W(+)
43	Schiffrt	T(-)			ln T(+)	<	ln W(+)
44	Übr.Verk	T(+)			ln T(+)	<	ln W(+)
45	Bupost	T(+)	>	L(+)	ln T(+)	<	ln W(+)
46	Kreditin	T(+)			ln T(+)	<	ln W(+)
47	Versich	T(+)			ln T(+)	<	W(+)
48	Wohnverm	T(+)			ln T(+)	<	W(+)
49	sonst.Die	T(+)			ln T(+)	>	ln W(+)
50	Staat	T(+)			ln T(+)	<	ln W(+)
51	Priv.HH				ln T(+)	<	W(+)

the aggregate variable as the only explanatory factor. Instead of giving further incentives to take a closer look at the structure of the sectoral data, these results need further economic interpretation to find a reasonable answers, why this relation exists.

The analysis of the data should not stop here. There are further aspects to take notice of, like the concentration of the labour force in a smaller number of sectors during the last 21 years in the FRG. The sectors 19,21,24,40,41,49,50,51 had a percentage share of 41.08 % in 1960 of all employed people, this share increased to 55.02 % in 1980. But structural change not only occurs in the intersectoral movements but in the sectors themselves. If single sectors grow too large in the chosen classification there is the danger of loosing important information, because of the intrasectoral change cannot analyzed. For long-run analysis of structural change this development should be anticipated to the extent, that probable growth areas should be seperated from the rest. If a restructuring of the whole sector classification is necessary needs further discussions, but that the current classification is not the optimal one for analyzing the future developments in the fields of microeletronics, robotics, environmental industries, telecommunications seems quite obvious. Since the current debate concentrates very much on high-technology developments, which shows a deficit of information, this is a problem, which have to be solved in the near future. Modelbuilders should have this in mind, when starting to develop a large model, because much effort could be spoiled, if we produce information where it is are not most needed and the effects on the remaining part of the model cannot be neglected.

As Leontief (1971) stressed in his presidential address to the American Economic Association, we need more reliable data, and we need, in my opinion, better methods to identify structural pattern before we start to formulate our theoretical assumptions. Accepting Kalmans thesis (1982), "...uncertain data implies an uncertain model ... it follows that any statistical procedure which gives unique answers (mathetical special cases aside) must be pervaded by prejudice. The technical problem is to ascertain what specific assumptions, usually well hidden, constitute the prejudice. I venture to guess that tracking down the prejudices will turn out to be an extraordinary rewarding enterprise..."(163) There is much to do...

<u>References.</u>

BLACKORBY, C., PRIMONT, D., RUSSELL, R.R. (1978): Duality, Separability, and Functional Structure: Theory and Applications, Amsterdam, 1978.

KALMAN, R.E. (1982): Foundations of Identification, in: Current Developments in the Interface: Economics, Econometrics, Mathematics, ed. by Hazewinkel & Rinnooy Kan, Dordrecht, Boston, London, 1982, p.161-196.

KRELLE, W., ERBER, G., KIY, M. (1982): Forschungsplan für die Entwicklung eines disaggregierten Modells 2 (research plan).

LEONTIEF, W. (1971): Theoretical Assumptions and Unobserved Facts, American Economic Review, Vol.61, 1971, p.1-7.

MOSTELLER, F., TUKEY J.W. (1977): Data Analysis and Regression, Reading Massachusetts, 1977.

SONO, M. (1961): The Effect of Price Changes on the Demand and Supply of Separable Goods, in: International Economic Review, Vol. 2, 1961, p.239-271.

STATISTISCHES BUNDESAMT (1982): Volkswirtschaftliche Gesamtrechnung, Fachserie 18, Reihe 8.5., Revidierte Ergebnisse 1960 bis 1980, Stuttgart-Mainz, S.170-171,306-307.

STROTZ, R.H. (1957): The Empirical Implications of the Utility Tree, in: Econometrica, Vol.25, 1957, p.269-280.

TUKEY, J.W. (1977): Explanatory Data Analysis, Reading, Massachusetts, 1977.

THE ESTIMATION OF THE SECTORAL WAGE EQUATIONS FOR THE ITALIAN MODEL

Maurizio Ciaschini
Department of Economics, University of Urbino, Via Saffi 15, 61029 Urbino, Italy

1. INTRODUCTION

Many of the changes in the structure of economic variables are driven by the relative price vector--either the production or the consumers' price vector. Therefore, a description of the price formation process is needed in order to explain the complete effects on the real variables that originate from shocks on the nominal side (prices and costs). In this paper we deal with the construction of the price side and the estimation of the wage equations for the dynamic econometric interindustry forecasting model, which is part of the INTIMO model of the Italian economy. The INTIMO model is itself part of the INFORUM international input-output forecasting system. In Section 2, the structure of the real side of the model is briefly described, while Section 3 deals with the price side and the wage equation.

2. STRUCTURE AND SOLUTION PROCEDURE

Any model is based on a description of the economy studied. Macro models rely on the summary descriptions provided by the tables of national accounts; input-output models rest on the expansion of these accounts to distinguish types of products and the users of each product.

Figure 1 shows schematically the table used for the real side of the Italian model. The output of the economy is divided into 44 branches or products. The sales of each of these branches in a particular year are shown across a specific row of the table in Figure 1, in columns corresponding to each buyer. There are a total of 114 of these buyer columns. The elements to the right of the double line in Figure 1 represent final demands. The sum of all the final demands is the gross domestic product.

If the demand relationships explaining the components of GDP are disaggregated into a highly detailed set, the flows of income towards the expenditure flows must be generated. In this process a major role is played by the relative price vector. The simulation of the real side can be run under specific assumptions regarding relative prices. But we can also make such prices endogenous and calculate them simultaneously with the real side.

For such purposes it is convenient to explain the whole set of prices on the basis of the costs in individual sectors, according to the equation

$$p = pA(t) + v \tag{1}$$

where A is the coefficient matrix, p the price vector, and v the unit value

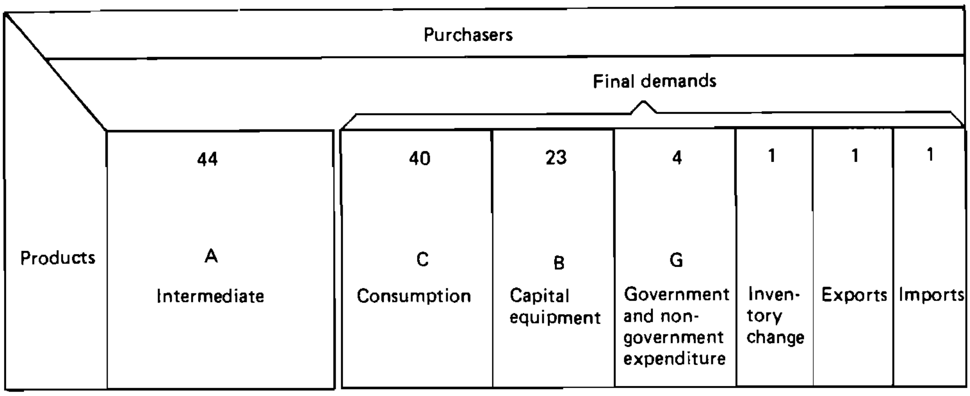


FIGURE 1 The real side of INTIMO.

added in current prices. Matrix A(t) can be split into two parts, a domestic part D(t) and an imported part M(t), so that eqn.(1) can be rewritten as

$$p = pD(t) + fM(t) + v \tag{2}$$

where f is the price vector of imports. For the base year, the matrix M is available in Italian national input-output accounts so that the problem is to find a method to update such a matrix for the following years, given the fact that a simple criterion that updates the components of matrix M proportionally to the change of total imports is not adequate. A rule is needed that assigns the highest percentage increases to cells that initially had low import penetration and recognizes that zero initial penetration probably meant that imports were not feasible for such cells. Such a rule is given by the formula

$$m_{ijt} = m_{ij0} / (m_{ij0} + k_i(1-m_{ij0}))$$

with k_i determined such that

$$m_{ijt}\, x_{ijt} = y_{it}$$

where y_{it} is the forecast of total imports of product i at time t from the real side of the model, x_{ijt} is a forecast of input-output flows, and m_{ij0} is the base-year import share. The relation between the base-year and revised values of m_{ij} is shown in Figure 2, for various values of k.

The unit value added in current prices is given by:

$$v_i = V_i/q_i \tag{3}$$

where V_i is the level of value added by product in current prices in sector i

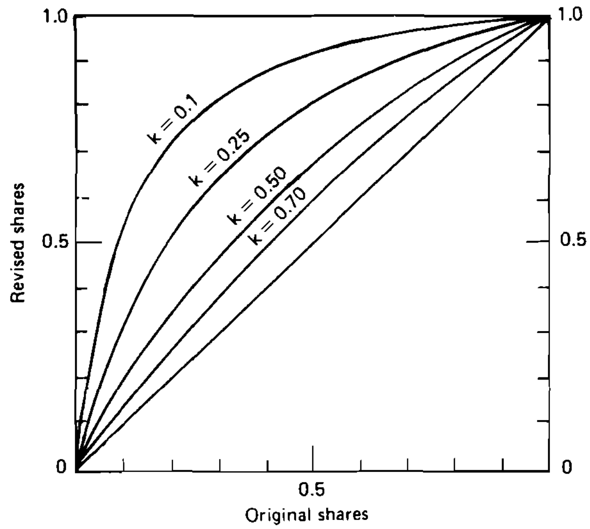


FIGURE 2 Share revision function.

and q_i represents the current sectoral output in base-year prices. The sectoral value added by product, V, is determined starting from the base-year value added matrix. Such a matrix, which is given in Italian accounts for 44 sectors and seven value added categories, is determined on the basis of the establishment.

First, we reconstructed the production transfers matrix in order to correct the value added matrix by product. During the simulation this matrix is updated year by year according to the rate of change of the corresponding sectoral output. The value added in current prices is then determined, imparting to each component of the matrix the rate of change forecast by the behavioral equation of the corresponding value added component. Schematically, the price side of INTIMO is shown in Figure 3.

Prices	Intermediate costs	Wages and salaries	Benefits	Capital allowance	Other incomes	Valued-added tax	Subsidies

FIGURE 3 The price side of INTIMO.

3. THE WAGE EQUATION

The econometric part of the nominal side deals with the specification and estimation of the value added components of the behavioral equations. In this paragraph we shall refer specifically to the results obtained for the wage equation. A manufacturing wage equation was first estimated to represent the wage rate toward which sectoral wage tends in the long run. The wage rates in each industry are then estimated relative to the manufacturing wage and only transient factors, such as the rate of change of output, are allowed to affect these ratios.

The manufacturing wage equation is as follows:

$$\log (WM/EM) = a_1 \log PRODM (t) + a_2 \log PRODM (t-1) + a_3 \log P(t) + a_4 \log P(t-1) \qquad (4)$$

where WM represents the manufacturing wage index, EM the manufacturing employment index, PRODM the labor productivity, and P the consumers' price index.

The relative wage equation was specified as

$$\frac{W_i/\ell_i}{(WM/EM)} = a_0 + a_1(\Delta q_i(t)/q(t)) + a_2(\Delta e_i(t)/e_i) + a_3 t \qquad (5)$$

where W_i represents the ith-sector wage index, e_i the ith-sector employment index, $(\Delta q_i(t)/q_i(t))$the percentage change in constant price output of sector i, and $(\Delta e_i(t)/e_i)$ the percentage change in employment of the ith-sector. Regressions were run on the basis of data on wages in current prices from 1971 to 1980 for 40 input-output sectors, employment, and constant-price outputs. For the manufacturing wage equation the data for the 20 manufacturing sectors were aggregated out of the 44 input-output sectors. The results obtained are shown in Table 1. Wage sector 36 is the result of the aggregation of input-output sectors 36-41.

The goodness of fit, as expressed by R^2 corrected, is greater than 0.70 in 14 equations while in 10 wage equations it is less than 0.50. In the majority of sectors (28), the intercept appears sensible in terms of Student's t-statistic. The effect of the rate of change in employment on sectoral wage appears negative in 15 sectors out of the 36, but for only five of them was the Student's t greater than 2. The effect of the rate of change in output is negative in 22 sectors but the t-test is greater than 2 in only eight cases. A very low time effect was detected. Table 2 shows a detailed result of the regression for some wage sectors.

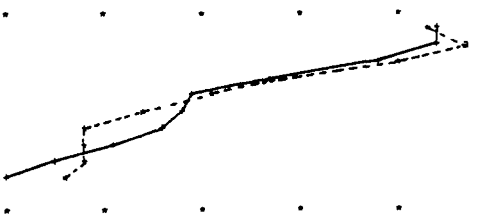
A simulation of the entire model was performed using the coefficient shown in Table 1. The results obtained for the relative wage indexes are shown in Table 3. Finally, an aggregated summary of the results obtained for the real and price sides is shown in Table 4.

TABLE 1 Summary of estimation results for the sectoral wage equations.

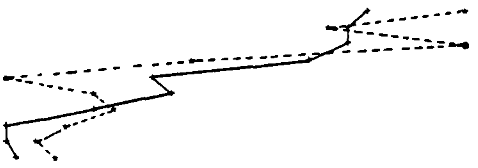
S E C T O R	intercept	output %	employm.%	time	r-barsq	dw
1 - Agriculture,for,fishery	- 1.92	- 0.44	- 0.09	- 0.03	0.90	0.85
	(- 5.76)	(- 0.58)	(- 0.28)	(8.60)		
2 - Coal	1.03	- 0.86	- 0.07	- 0.00	0.04	2.04
	(2.53)	(- 1.63)	(- 0.64)	(- 0.12)		
3 - Coke	2.46	0.42	- 0.03	- 0.01	0.42	2.26
	(4.98)	(1.90)	(- 0.13)	(- 3.06)		
4 - Petroleum,gas,refining	1.12	0.26	0.32	- 0.00	0.46	2.45
	(2.89)	(0.21)	(2.92)	(- 0.59)		
5 - Eletricity,gas,water	4.48	- 1.44	0.15	- 0.46	0.90	0.97
	(7.97)	(- 1.41)	(0.38)	(- 6.36)		
7 - Non Ferrous ores	2.28	0.04	- 0.02	- 0.01	0.94	1.95
	(19.39)	(0.23)	(- 0.73)	(-11.14)		
8 - Non metal min,min prod.	0.21	0.42	- 0.20	0.01	0.70	1.59
	(1.18)	(0.88)	(- 1. 51)	(4.23)		
9 - Chemical products	1.41	- 0.13	- 0.01	- 0.00	0.03	1.58
	(3.58)	(- 0.17)	(- 0.05)	(- 1.18)		
10 - Metal products	1.66	0.01	0.11	0.00	0.60	1.52
	(7.77)	(0.02)	(0.73)	(- 3.03)		
11 - Agricul and indus. machinery	1.43	- 0.18	0.04	- 0.00		
	(8.84)	(- 0.43)	(0.44)	(- 2.68)		
12 - Office,precis,opt. instruments	0.63	- 0.21	- 0.09	0.00	0.31	1.23
	(4.12)	(- 0.92)	(- 1.78)	(2.34)		
13 - Electrical goods	1.99	- 0.95	0.31	- 0.01	0.32	1.05
	(10.97)	(- 2.53)	(2.71)	(- 5.40)		
14 - Motor vehicles	2.91	0.68	- 0.14	- 0.02	0.87	1.72
	(12.02)	(1.60)	(- 0.62)	(- 7.02)		
15 - Other transport equipment	2.26	- 0.52	0.16	- 0.01	0.88	1.71
	(15.38)	(- 2.29)	(3.03)	(- 8.50)		
16 - Meat	0.10	0.25	- 0.41	0.01	0.62	2.20
	(0.39)	(0.29)	(- 1.44)	(3.37)		
17 - Mill	0.25	2.93	- 0.63	0.00	0.68	1.96
	(0.90)	(2.32)	(- 3.27)	(2.44)		
18 - Other foods	- 1.08	- 2.62	0.20	0.02	0.70	1.17
	(- 2.57)	(- 1.09)	(0.06)	(4.81)		
19 - Non alcohol,alcoh.beverages	- 0.38	- 2.20	- 0.09	0.01	0.53	2.63
	(- 0.97)	(- 1.43)	(- 0.55)	(3.37)		
20 - Tobacco	3.70	- 0.28	0.00	- 0.03	0.81	2.27
	(3.24)	(- 0.57)	(- 0.03)	(- 2.40)		
21 - Textiles and clothing	0.50	- 0.16	0.04	0.00	0.53	2.75
	(3.47)	(- 0.37)	(0.66)	(3.56)		
22 - Leather and shoe	- 0.76	0.57	- 0.14	0.02	0.93	2.06
	(- 3.67)	(0.61)	(- 1.59)	(8.64)		
23 - Wood and forniture	0.45	0.62	- 0.11	0.00	0.48	2.79
	(1.59)	(0.59)	(- 1.03)	(2.10)		
24 - Paper and printing prod.	1.77	0.63	- 0.01	- 0.01	0.82	1.68
	(10.61)	(1.17)	(- 0.31)	(- 4.70)		
25 - Rubber and plastic prod.	0.41	1.48	0.04	0.00	0.51	2.25
	(0.95)	(2.79)	(0.62)	(1.43)		
26 - Other manufact prod.	1.05	- 0.32	- 0.02	- 0.00	- 0.28	1.29
	(3.53)	(- 0.85)	(- 0.26)	(- 0.17)		
27 - Construction	1.37	0.73	- 0.17	- 0.00	0.10	1.99
	(5.29)	(1.62)	(- 1.20)	(- 1.53)		
28 - Recovery and repair serv.	0.70	- 0.07	- 0.60	0.00	0.39	2.05
	(4.26)	(- 0.39)	(- 2.54)	(1.60)		
29 - Trade	0.75	0.38	0.22	0.00	0.43	2.78
	(6.34)	(1.41)	(- 1.25)	(1.81)		
30 - Hotels and restaurants	- 0.51	0.76	- 0.08	0.01	0.92	1.77
	(- 3.30)	(2.06)	(- 0.35)	(9.53)		
31 - Inland transport	2.88	- 1.91	- 0.59	- 0.02	0.61	1.72
	(5.88)	(- 0.79)	(- 0.75)	(- 3.83)		
32 - Sea and air transport	5.41	0.57	- 0.96	- 0.05	0.98	3.15
	(31.52)	(1.16)	(- 3.56)	(-25.83)		
33 - Transport services	1.12	0.60	- 0.92	- 0.00	0.61	2.02
	(7.82)	(1.69)	(- 3.82)	(- 0.94)		
34 - Communication	3.81	0.26	1.53	- 0.03	0.75	2.81
	(3.93)	(0.17)	(1.90)	(- 3.04)		
35 - Public Services	4.38	0.81	0.36	- 0.04	0.96	1.83
	(16.03)	(1.05)	(0.54)	(-13.93)		
36 - Other Services	3.54	1.22	2.60	- 0.30	0.80	0.80
	(3.02)	(0.13)	(0.99)	(- 2.66)		

TABLE 2 Regression results for sectoral wages.

```
   sector 5  electricity, gas, water

      see =      0.0401   rsqr = 0.9334   rbarsqr = 0.9001
rho = 0.512 dw = 0.976 aape =    3.41
 variable                 regros-coef      std.error           t-value          mean
 intercept                  4.485771        0.562196            7.9790          1.0000
 vpemp                     -1.446955        1.023243           -1.4141          0.0109
 vpq                        0.157728        0.405885            0.3286          0.0811
 time                      -0.046007        0.007227           -6.3659         75.5000
 wagr5                        dependent variable - - - - - - - - -              1.00919


date  actual   predic    miss
       is *     is +   is a-p *
 71    1.21     1.22    -0.01
 72    1.25     1.21     0.04
 73    1.17     1.16     0.01
 74    1.06     1.06     0.00
 75    1.00     0.98     0.02
 76    0.93     0.97    -0.04
 77    0.88     0.95    -0.07
 78    0.87     0.91    -0.03
 79    0.87     0.85     0.03
 80    0.85     0.79     0.06
date  actual   predic    miss
       is *     is +   is a-p *
                          0.791     0.887      0.983     1.079
```



```
   sector 10  metal products

      see =      0.0180   rsqr = 0.7336   rbarsqr = 0.6004
rho = 0.239 dw = 1.523 aape =    1.41
 variable                 regres-coef      std.error           t-value          mean
 intercept                  1.667255        0.214518            7.7721          1.0000
 vpemp                      0.017507        0.614577            0.0285          0.0071
 vpq                        0.117833        0.161315            0.7305          0.0618
 time                      -0.008469        0.002794           -3.0308         75.5000
 wagr10                       dependent variable - - - - - - - - -              1.03524


date  actual   predic    miss
       is *     is +   is a-p *
 71    1.09     1.07     0.02
 72    1.06     1.07    -0.00
 73    1.09     1.07     0.02
 74    1.04     1.06    -0.02
 75    1.00     1.03    -0.03
 76    1.02     1.03    -0.02
 77    1.02     1.02     0.00
 78    1.01     1.00     0.01
 79    1.01     1.00     0.01
 80    1.01     1.00     0.01
date  actual   predic    miss
       is *     is +   is a-p *
                          0.999     1.019      1.038     1.058
```



```
   sector 4 petroleum, gee, refining

      see =      0.0306 · rsqr = 0.6463   rbarsqr = 0.4695
 rho =-0.230 dw = 2.459 aape =    2.32
 variable                 regres-coef      std.error           t-value          mean
 intercept                  1.122839        0.388089            2.8933          1.0000
 vpemp                      0.262403        1.193701            0.2199          0.0188
 vpq                        0.325908        0.111391            2.9253         -0.0174
 time                      -0.002978        0.004977           -0.5983         75.5000
 wagr4                        dependent variable - - - - - - - - -              0.89728


date  actual   predic    miss
       is *     is +   is a-p *
 71    0.92     0.93    -0.01
 72    0.93     0.94    -0.00
 73    0.88     0.92    -0.04
 74    0.82     0.82     0.00
 75    1.00     0.93     0.07
 76    0.91     0.93    -0.02
 77    0.91     0.88     0.04
 78    0.89     0.91    -0.02
 79    0.87     0.89    -0.02
 80    0.84     0.84    -0.01
date  actual   predic    miss
       is *     is +   is a-p *
                          0.815     0.854      0.892     0.931
```

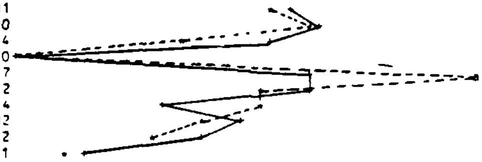
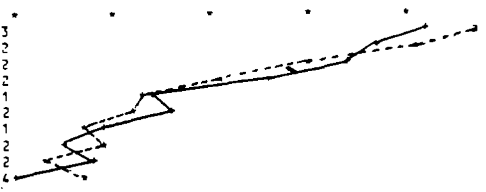
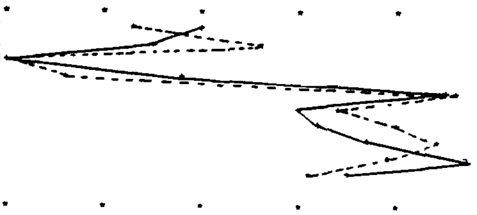


TABLE 2 (continued).

```
   sector  14  motor vehicles
      see =     0.0230   rsqr = 0.9151   rbarsqr = 0.8726
rho = 0.136 dw = 1.728 aape =    1.96
 variable                 regres-coef     std.error          t-value          mean
 intercept                  2.910903       0.242105          12.0233         1.0000
 vpemp                      0.689380       0.429081           1.6066         0.0153
 vpq                       -0.149926       0.238906          -0.6275         0.0438
 time                      -0.024951       0.003190          -7.3210        75.5000
 wagr14                       dependent variable - - - - - - - - -            1.03110


oate  actual   predic    miss
        is *     is +   is a-p *
 71     1.18     1.15     0.03
 72     1.14     1.12     0.02
 73     1.09     1.11    -0.02
 74     1.04     1.07    -0.02
 75     1.00     1.01    -0.01
 76     1.00     1.02    -0.02
 77     0.97     0.98    -0.01
 78     0.98     0.96     0.02
 79     0.95     0.97    -0.02
 80     0.97     0.93     0.04
date  actual   predic    miss
```



```
   secotr 17  mill

      see =     0.0270   rsqr = 0.7901   rbarsqr = 0.6852
rho = 0.019 dw = 1.961 aape =    2.41
 variable                 regres-coef     std.error          t-value          mean
 intercept                  0.259515       0.287592           0.9024         1.0000
 vpemp                      2.936034       1.263619           2.3235         0.0032
 vpq                       -0.634656       0.193914          -3.2729         0.0554
 time                       0.009263       0.003790           2.4441        75.5000
 wacr17                       dependent variable - - - - - - - - -            0.93328


date  actual   predic    miss
        is *     is +   is a-p *
 71     0.88     0.91    -0.02
 72     0.92     0.89     0.04
 73     0.83     0.83    -0.00
 74     0.85     0.90    -0.04
 75     1.00     0.99     0.01
 76     0.96     0.94     0.01
 77     0.98     0.95     0.03
 78     0.99     0.96     0.03
 79     0.97     1.00    -0.03
 80     0.94     0.96    -0.01
date  actual   prodic    miss
        is *     is +   is a-p *
```



```
sector 19 beverages
      see =     0.0305   rsqr = 0.6906   rbarsqr = 0.5359
rho =-0.317 dw = 2.633 aape =    2.41
 variable                 regres-coef     std.error          t-value          mean
 intercept                 -0.382516       0.393727          -0.9715         1.0000
 vpemp                     -2.206362       1.535674          -1.4367        -0.0017
 vpq                       -0.098234       0.176795          -0.5556         0.0679
 time                       0.017439       0.005160           3.3796        75.5000
 wagr19                       dependent variable - - - - - - - - -            0.93130


date  actual   predic    miss
        is *     is +   is a-p *
 71     0.85     0.88    -0.03
 72     0.87     0.86     0.01
 73     0.89     0.87     0.02
 74     0.87     0.91    -0.04
 75     1.00     0.93     0.07
 76     0.97     0.96     0.01
 77     0.97     0.98    -0.02
 78     0.98     0.97     0.01
 79     0.97     0.97    -0.00
 80     0.94     0.96    -0.02
date  actual   predic    miss
        is *     is +   is a-p *
```

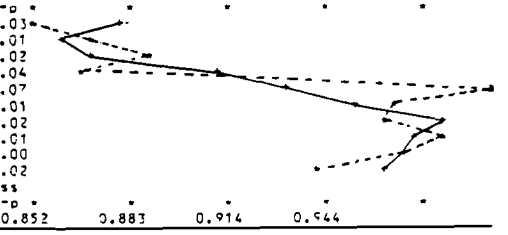
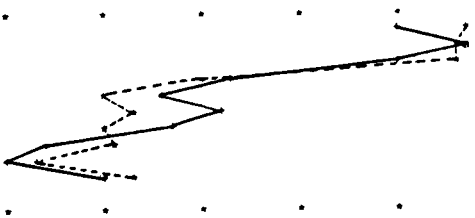


TABLE 2 (continued).

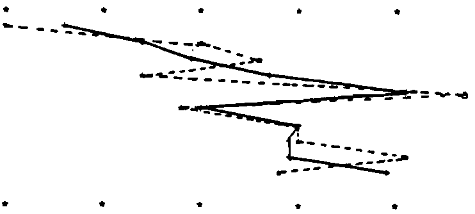
```
  sector 23 electrical goods

      see =    0.0110   rsqr = 0.8304   rbarsqr = 0.8206
rho = [illegible] dw = 1.292 aape =   0.95
 variable                regres-coef     std.error         t-value        mean
 intercept                1.990422       0.181489          10.9700       1.0000
 vpemp                   -0.958299       0.378322          -2.5330       0.0165
 vpq                      0.318775       0.117388           2.7156       0.0821
 time                    -0.012977       0.002402          -5.4024      75.5000
 wagr13                     dependent variable - - - - - - - - -          1.02149
```

```
date  actual   predic    miss
       is *     is +   is a-p *
 71    1.07     1.05     0.01
 72    1.07     1.07    -0.00
 73    1.07     1.06     0.01
 74    1.01     1.02    -0.01
 75    1.00     1.01    -0.01
 76    1.01     1.02    -0.02
 77    1.00     1.01    -0.01
 78    1.00     0.99     0.01
 79    0.99     0.98     0.01
 80    1.01     1.00     0.01
date  actual   predic    miss
       is *     is +   is a-p *
```



```
  sector 29  trade

      see =    0.0109   rsqr = 0.6234   rbarsqr = 0.4350
rho =-0.394 dw = 2.787 aape =   0.88
 variable                regres-coef     std.error         t-value        mean
 intercept                0.754008       0.118927           6.3401       1.0000
 vpemp                    0.381723       0.269889           1.4144       0.0132
 vpq                     -0.223578       0.178621          -1.2517       0.0371
 time                     0.002922       0.001606           1.8191      75.5000
 wagr29                     dependent variable - - - - - - - - -          0.97132
```

```
date  actual   predic    miss
       is *     is +   is a-p *
 71    0.94     0.95    -0.01
 72    0.96     0.96     0.01
 73    0.97     0.96     0.01
 74    0.96     0.97    -0.02
 75    1.00     0.99     0.01
 76    0.96     0.96    -0.00
 77    0.98     0.98     0.00
 78    0.98     0.98     0.00
 79    0.99     0.98     0.02
 80    0.97     0.99    -0.01
date  actual   predic    miss
       is *     is +   is a-p *
```



```
  sector  31 inland transport

      see =    0.0405   rsqr = 0.7421   rbarsqr = 0.6131
rho = 0.138 dw = 1.723 aape =   3.36
 variable                regres-coef     std.error         t-value        mean
 intercept                2.883208       0.490270           5.8809       1.0000
 vpemp                   -1.919690       2.411754          -0.7960       0.0165
 vpq                     -0.599441       0.791122          -0.7577       0.0353
 time                    -0.023975       0.006255          -3.8329      75.5000
 wagr31                     dependent variable - - - - - - - - -          1.02032
```

```
date  actual   predic    miss
       is *     is +   is a-p *
 71    1.17     1.14     0.02
 72    1.13     1.10     0.02
 73    1.02     1.04    -0.02
 74    1.09     1.05     0.04
 75    1.00     1.05    -0.05
 76    0.97     0.97     0.00
 77    0.93     0.99    -0.05
 78    0.94     0.98    -0.05
 79    0.97     0.96     0.02
 80    0.99     0.92     0.06
date  actual   predic    miss
       is *     is +   is a-p *
```

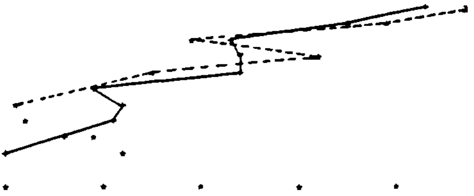


TABLE 3 Simulation results for sectoral wage index.

	PREVISIONE:		ITALIA 17 DEC 1981				SERIES		INDICI DEI SALA		
	BRANCHE DI O	1975	1976	1977	1978	1979	1980	1981	1983	1985	1990
1	AGRICOLTURA, SILV, PES	1.00	1.26	1.64	1.91	2.31	2.90	3.57	5.26	7.95	20.26
2	CARBONE, LIGNITE, AGGL	1.00	1.30	1.62	1.76	2.03	2.47	3.12	4.18	5.70	13.07
3	PROD. COKEFAZIONE	1.00	1.06	1.48	1.60	1.94	2.39	2.34	3.34	4.71	8.99
4	PETROLIO, GAS N, PR. RA	1.00	1.13	1.44	1.62	1.87	2.19	2.39	3.46	4.91	10.69
5	ELETTRICITA, GAS, ACQU	1.00	1.15	1.39	1.59	1.87	2.22	2.17	2.62	3.13	4.55
7	MIN. METAL. FER. E NON	1.00	1.20	1.52	1.72	1.98	2.42	2.64	3.61	4.93	9.92
8	MIN. E PROD. NON METAL	1.00	1.25	1.62	1.87	2.15	2.62	2.90	4.21	6.19	14.25
9	PROD CHIMICI E FARMA	1.00	1.22	1.51	1.74	2.01	2.37	2.73	3.86	5.44	11.83
10	PROD. IN METALLO	1.00	1.26	1.62	1.85	2.16	2.64	2.87	4.09	5.79	12.33
11	MACCH. AGRIC. E INDUST	1.00	1.23	1.56	1.78	2.12	2.62	2.70	3.82	5.38	11.62
12	MACCH. UFF, PRECIS, OTT	1.00	1.24	1.57	1.83	2.09	2.59	2.82	4.04	5.74	13.17
13	MATER. FORNITURE ELET	1.00	1.24	1.58	1.83	2.12	2.63	2.85	4.04	5.68	12.14
14	AUTOVEICOLI E MOTORI	1.00	1.23	1.53	1.78	2.04	2.53	2.53	3.59	4.90	9.16
15	ALTRI MEZZI DI TRASP	1.00	1.26	1.55	1.80	2.09	2.60	3.00	3.88	5.19	10.84
16	CARNI FRESCHE&CONSER	1.00	1.19	1.60	1.92	2.24	2.65	3.02	4.38	6.37	15.03
17	LATTE&PROD. DERIVATI	1.00	1.18	1.54	1.81	2.09	2.47	1.74	3.43	5.28	12.36
18	ALTRI PROD. ALIMENTAR	1.00	1.26	1.62	1.90	2.21	2.62	3.68	4.96	7.23	17.84
19	BEVANDE ALCOLICHE&NO	1.00	1.20	1.53	1.79	2.09	2.47	3.44	4.75	6.98	16.86
20	TABACCHI LAVORATI	1.00	1.18	1.36	1.63	1.91	2.27	2.42	3.15	4.06	6.65
21	PROD. TESSILI&ABBIGL.	1.00	1.26	1.64	1.87	2.27	2.77	3.16	4.53	6.53	15.04
22	CUOIO E CALZATURE	1.00	1.25	1.65	1.93	2.38	2.93	3.20	4.71	6.95	16.99
23	LEGNO&MOBILI IN LEGN	1.00	1.25	1.66	1.93	2.29	2.81	3.10	4.47	6.48	15.09
24	CARTA, CARTOTECN, EDIT	1.00	1.21	1.56	1.80	2.11	2.53	2.56	3.76	5.30	11.07
25	GOMMA&MAT. PLASTICHE	1.00	1.30	1.67	1.94	2.28	2.78	3.15	4.60	6.73	14.95
26	ALTRE INDUSTR. MANIF	1.00	1.18	1.53	1.77	2.21	2.69	2.96	4.27	6.07	13.86
27	COSTRUZIONI E OO. PP.	1.00	1.18	1.53	1.79	2.09	2.52	2.81	3.95	5.70	12.07
28	BENI RECUPERO, RIPARA	1.00	1.23	1.54	1.76	2.05	2.53	2.84	3.97	5.63	12.84
29	COMMERCIO	1.00	1.19	1.55	1.78	2.13	2.55	2.86	4.09	5.87	13.28
30	ALBERGHI, PUBBL. ESERC	1.00	1.23	1.58	1.88	2.32	2.75	3.14	4.67	6.88	16.66
31	TRASPORTI INTERNI	1.00	1.20	1.48	1.71	2.09	2.58	2.67	3.34	4.28	8.31
32	TRASP. MARITTIMI&AERE	1.00	1.08	1.32	1.45	1.67	1.94	1.76	1.95	2.06	0.81
33	ATTIVITA CONN. TRASPO	1.00	1.19	1.46	1.69	2.08	2.54	2.73	3.80	5.36	11.87
34	COMUNICAZIONI	1.00	1.15	1.38	1.61	2.12	2.50	1.65	2.72	3.52	5.04
35	CREDITO E ASSICURAZI	1.00	1.13	1.31	1.47	1.67	2.00	2.03	2.54	3.14	3.82
36	SERVIZI ALLE IMPRESE	1.00	1.16	1.43	1.66	1.96	2.42	2.26	3.16	4.09	6.65
37	LOCAZIONE DI FABBRIC	1.00	1.16	1.43	1.66	1.96	2.42	2.26	3.16	4.09	6.65
38	SERV. INSEGNAM. DS. VE.	1.00	1.16	1.43	1.66	1.96	2.42	2.26	3.16	4.09	6.65
39	SERVIZI SANIT. DS. VE	1.00	1.16	1.43	1.66	1.96	2.42	2.26	3.16	4.09	6.65
40	SERV. RICR. &CULT DS. V	1.00	1.16	1.43	1.66	1.96	2.42	2.26	3.16	4.09	6.65
41	SERV. GENERALI P. A.	1.00	1.16	1.43	1.66	1.96	2.42	2.26	3.16	4.09	6.65
42	SERV. INSEGNAM. NDS. VE	1.00	1.16	1.43	1.66	1.96	2.42	2.26	3.16	4.09	6.65
43	SERV. SANITARI NDS. VE	1.00	1.16	1.43	1.66	1.96	2.42	2.26	3.16	4.09	6.65
44	SERV. DOMESTICI&ALTRI	1.00	1.16	1.43	1.66	1.96	2.42	2.26	3.16	4.09	6.65
45	SALARI PUBBL. AMMIN.	1.00	1.16	1.43	1.66	1.96	2.42	2.26	3.16	4.09	6.65

TABLE 4 Summary aggregated results of a simulation: (a) real side GDP sectors, (b) nominal side value added components.

(a)

PREVISIONE:	ITALIA 17 DEC					TASSI DI CRESCITA:		RISULTATI AGGREG		
SETTORE:	75-76	76-77	77-78	78-79	79-80	80-81	81-83	83-85	85-90	75-90
PRODOTTO INT. LORDO	3.34	4.64	1.53	6.16	2.59	-2.53	2.43	4.16	2.83	2.87
RISORSE DISPONIBILI	3.47	5.35	1.57	6.80	2.63	-3.14	2.37	4.40	2.71	2.92
AMMINISTRAZIONE	3.64	2.00	0.50	0.05	1.09	0.40	3.80	3.53	3.11	2.52
SERVIZI NDEST. VENDIT	3.64	2.00	0.50	0.05	1.09	2.79	2.82	2.67	3.38	2.53
SERVIZI SANITARI	3.64	1.67	0.83	0.05	1.09	0.41	2.14	4.03	2.33	2.11
CONSUMI COLL. PRIVATI	3.64	2.00	0.50	0.05	1.09	0.41	2.27	2.59	3.25	2.24
CONSUMI DELLE FAMIGL	3.37	2.20	2.97	5.20	4.28	0.43	3.19	2.82	2.93	3.01
ESPORTAZIONI	11.91	9.88	2.17	7.04	-1.12	-6.23	1.47	5.52	2.50	3.34
IMPORTAZIONI	13.09	0.12	2.90	7.31	3.16	-2.18	2.10	3.64	2.66	3.28
VARIAZIONI DELLE SCO	0.00	65.97	-25.83	69.46	-31.85	0.00	0.00	55.18	-6.31	0.00
INVESTIMENTI FISSI L	1.32	0.47	-0.21	10.47	5.55	-3.18	-1.72	5.42	2.90	2.42
OCCUPAZIONE INTERNA	0.50	0.53	0.71	0.86	0.89	-3.19	-1.25	1.33	0.54	0.21

(b)

PREVISIONE:	ITALIA 17 DEC					TASSI DI CRESCITA;		CONTI NAZIONALI		
BRANCHE DI O	75-76	76-77	77-78	78-79	79-80	80-81	81-83	83-85	85-90	75-90
REDDITO NAZIONALE	17.35	18.77	13.86	18.34	18.05	7.09	15.66	17.50	15.14	15.70
SALARI & STIPENDI L	19.31	24.26	15.38	18.16	21.07	1.33	16.09	17.76	14.37	15.94
ONERI SOCIALI	26.37	16.73	18.36	24.43	21.69	16.32	19.18	21.45	17.93	19.66
ALTRI REDDITI	14.71	16.31	14.18	18.22	14.81	10.26	14.46	15.62	14.68	14.80
AMMORTAMENTI	3.71	5.78	2.46	6.72	2.77	-2.82	2.56	4.40	2.70	3.07
IMPOSTE INDIRETTE	15.41	17.66	-1.56	12.71	13.60	11.34	15.03	15.97	14.94	13.72
IVA SULLA PRODUZION	15.96	16.47	13.37	19.11	15.45	11.11	15.07	16.33	15.16	15.34
CONTRIBUTI ALLA PRO	15.49	17.21	14.39	18.60	14.78	8.30	14.53	15.89	14.75	14.89

II. International Trade: Impact and Policy Issues

THE TREATMENT OF FOREIGN TRADE IN THE HUNGARIAN INFORUM MODEL

Andras Simon
Institute for Economic and Market Research, Dorottya u. 6, 1051 Budapest, Hungary

1 INTRODUCTION

This paper is one of a series describing the various blocks of an input-output model of the Hungarian economy that is being built as part of the INFORUM international system of models[1]

One of the aims of the foreign-trade model block is to capture those determinants of Hungarian exports and imports that are likely to shape the future development of Hungarian foreign trade and to set up econometric equations for forecasting trade. Another objective is to analyze past developments in the structure of Hungarian foreign trade to discover whether, and in what ways, this structure has responded to changes in world market or domestic economic conditions

Hungary's foreign trade involves both the ruble area and the convertible-currency area, but economic conditions differ so much between the two that there are hardly any common features to study. Here we will confine our investigations to trade with the convertible-currency area; ruble-area trade will be mentioned only when it has some direct connection to non-ruble trade.

2. COMPARATIVE COSTS AND HUNGARIAN FOREIGN TRADE

2.1. Two ways of revealing comparative advantages in empirical models

According to international trade theory, trade is based on comparative differences in the conditions of production of various goods in various countries. In pure theory comparative advantages of a country in producing a given good cannot be revealed by an international price or cost comparison since prices and costs are equalized on the international market by competition. This line of thought leads to the conclusion, that comparative advantages are manifested only in the international trade structure

Depending on how information on prices is utilized in the explanation of trade patterns empirical studies on international trade may be divided into two categories. In the first category prices and costs are not explicitly included

---

[1] About the INFORUM - Project see Almon - Nyhus (1977)

into the models. Comparative advantages are revealed by the trade structure and the explanation of the patterns of trade is provided by the Hekscher-Ohlin theory: since the relative requirements of capital and labor in the productive precess is assumed to vary among products but not among countries, the primary explanation of international trade is to be found in inter-country differences in relative endowments of capital and labor.[2]

In studies belonging to the second category prices or costs are explanatory variables of the models explaining trade patterns. In these models there is no need for an assumption of the Heckscher-Ohlin type but much more is demanded from the statistical data.

In these models[3] the validity of the one good-one price theorem is questioned on the ground, that in empirical models goods are defined as aggregates of commodities being substitutes to some degree but not necessarily perfect substitutes. In a model covering the whole trade of a country, trade is divided into a limited number of commodity classes Regardless how many commodity classes are distinguished, this division can never be fine enough to result in a set of homogenous goods. If the commodity classes are not homogenous goods price differences may arise within a class. Prices of commodities produced in various countries are measured by price indexes. In statistics the weights used in the indexes are trade or production volumes, different weights for each index. These weights do not necessarily produce price indexes suitable to indicate the relative competitive positions of different countries in a commodity class. To find the criteria for proper weights in this respect is quite complicated.[4] We confine ourselves here to some intuitive arguments. Let us assume that two price indexes have to be compared: a "world market price" index calculated by using weights of world trade and a Hungarian export price index calculated by using weights of Hungarian exports The difference between the two price indexes shows relative competitiveness, if the goods included into the world market index are substitutable with those included into the Hungarian export price index. In addition it is desirable that demand for the commodities included into a commodity class have roughly the same price elasticities. Let us see an example where a price index comparison is meaningless. Agricultural goods are an aggregate of nearly-homogenous goods which cannot be or can hardly be differentiated by countries of origin. Here differences in the price indexes of various countries show only the different structure of their exports. If corn predominates Hungarian exports, the export price compared to the world market prices of agricultural goods in general will hardly say anything about the competitive position of Hungarian exports. In other commodity classes goods of different countries within a subgroup may be non-perfect substitutes and substitutability across subgroups may be considerable too. In the case of steel products for example it is clear that however far we go to a fine commodity classification containing such subgroups as rolled bars or sheets it would be found that qualitative differences among

---

[2] For a deeper understanding of this approach and lists of the rich bibliography on the topic see the pioneering works of Balassa (1965, 1979).

[3] Such a trade model was developed first by Armington (1969a, 1969b)

[4] See Leamer and Stern (1970), pp. 41-48. for a precise discussion of the problem.

the products produced by various countries within the subgroup still prevent these products to be considered as perfects substitutes. On the other hand, substitutability between subgroups as rolled bars and rolled sheet is substantial, nearly as large as that among products of different countries within a subgroup. This assures that differences in the price indexes indicate changes in the relative competitive positions rather than being simply results of differing product mixes.

2.2. Prices, costs and the Hungarian trade structure

In this paper we take the second approach described in Section 2.2 when examining the development of the Hungarian trade structure as a result of the changing pattern of comparative advantages.

This approach assumes that exports of an industry are determined by the following general relationships:

$$e = f\ (pe/pe_w,\ dw)$$

$$e = f\ (pe/c)$$

where

e = exports
pe= export price index
pe_w = price index of competitors on the world market
dw = world demand indicator
c = index of costs of the exported goods.

The first equation may be defined as a demand equation, the second as a supply equation, and _e_ and _pe_ are endogenous variables of the system. Unfortunately, we have not statistics on _pe_ and _pe_ separately. Thus the relationship investigated in this paper is the following reduced form:

$$e = f\ (pe_w,\ c,\ dw) \qquad (1)$$

Supply of imports is considered infinitely elastic and imports are assumed to be determined by demand:

$$m = f\ (pm,\ c,\ dd) \qquad (2)$$

where

m = imports
pm = price index of imports
c = index of costs of import substitutes
dd= domestic demand indicator.

69 inputoutput sectors are distinguished in the model, 35 of the sectors are industries producing internationally traded goods.

Equations (1) and (2) could have been used as prototype equations to be estimated sector by sector to set up the trade bloc of the input-output model. Instead of doing so, we first calculated some synthetic indicators for total exports, imports and total trade to see if the pattern of these variables showed any sign of response on price-cost developments. Then a sector-by-sector comparison follows between comparative costs and trade dynamics.

International Price Data. Unfortunately, our information on prices is partly related to $\underline{pe}$, partly to $\underline{pe}_w$. Export and import price indexes are available for a nine industry breakdown and producer's price indexes are available for several countries of the INFORUM system in a more detailed breakdown. It would be simple to consider the average of the producer's price indexes of our main trading partners as international prices of our competitors. In this case, however, we had the problem that the structure of Hungarian exports within a sector differs too much from that of output in the trading partner countries. Therefore we rather considered Hungarian export price indexes as an approximation of the prices of competitors. Ratios of producer's prices of the trading partners were used only in the further breakdown of prices in the nine industry aggregates, where no other information was available. A similar approach was adopted in the construction of the import price indexes.

Domestic Cost Calculations . It would be very straightforward if we were able to use Hungarian producers' prices as an indicator of costs; unfortunately, however, the Hungarian price system is not suitable for this purpose. It has altered frequently over the past 20 years, but in most cases this was the result not of changing real costs but of changes in the tax and subsidy system.

To examine the development of costs over time, a calculated price system was set up. This price system is based on two primary cost factors: labor and capital. Labor costs are evaluated at a wage rate moving along the trend value of total real consumption. Connecting wages to consumption in this way ensures that the price level will remain nearly constant. Using trends instead of actual values excludes the effects of short-run fluctuations in income policy on costs and makes it easier to concentrate on long-term developments of the cost structure.

There are several ways in which capital costs could be taken into consideration. We could, for example, have set average calculated prices equal for every year assuming some weighting scheme, and then calculated a profit rate that is uniform by sectors but that changes from year to year. However, the method actually adopted was to calculate a uniform profit rate for the base year (1972) such that the average of calculated prices of traded goods equals that of world market prices, and then to keep this profit rate constant for every subsequent year. This allows some changes in the price level but makes the interpetation of changes in costs easier.

In the calculated price system the intermediate inputs of so-called competitive goods (those that could be sold or purchased on the world market) are valued at foreign trade prices. In our input-output model we have to assume that industries are homogeneous in the sense that, in those sectors where exports and imports are nonzero, all goods are assumed to be competitive.

As our objective was a relative price-cost comparison, we multiplied world market prices by a calculated exchange rate index that keeps world and calculated price levels equal.

With these principles in mind, the following calculations were carried out. For the base year (1972) the following equation system was solved for the profit rate (v) and the calculated prices (pc_i), with the calculated exchange rate index (r) set equal to one:

$$pc_i = \sum_{j \; T} (pw_j/r) \; . \; a_{ij} + \sum_{J \; NT} pc_j \; . \; a_{ij} + v \; . \; cap_i + w . emp_i \qquad (3)$$

$$r = \sum_{i=1}^{79} pc_i \; (exp_i + imp_i) \; / \sum_{i=1}^{79} (pe_i \; . \; exp_i + pm_i \; . \; imp_i) \qquad (4)$$

$$pw_i = (pe_i \; . \; exp_i + pm_i \; . \; imp_i) \; / \; (exp_i + imp_i) \qquad (5)$$

where

i = 1, 2, ..., 79 denotes the sectors,
pc_i = calculated prices,
exp_i = exports at constant domestic prices,
imp_i = imports at constant domestic prices,
pe_i = export price index, 1972 = 1 measured in forints,
pm_i = import price index, 1972 = 1 measured in forints,
pw_i = average world market price index,
a_{ij} = input-output coefficients,
T = index-set of the trading industries,
NT = index set of the nontrading industries,
cap_i = fixed capital stock/output at constant prices,
v = profit rate,
emp_i = employees/output,
w_i = wage rate, and
r = calculated exchange rate index, 1972 = 1.

The solution obtained for the profit rate (v) was 0.20 . At first glance this may seem too high, but it can be fairly easily explained. First, it includes depreciation costs. Second, owing to peculiarities of the price system used to measure wages via total consumption, the share of wages in value added is relatively low. Further refinements could certainly be made in the weighting of cost factors, but we feel they would probably not significantly alter the results of our analysis.

Having fixed the profit rate on the basis of 1972, we proceeded with calculations for the other years. As explained above, for years other than the base year v is kept constant (=0.2) and the system is solved for pc_i and r.

2.3. Terms of Trade

Let us consider the following expression as an indicator of changes in the total terms of trade:

$$\frac{\frac{1}{r}\cdot\frac{\sum_i pe_i\cdot exp_i}{\sum_i exp_i} \Big/ \frac{\sum_i pc_i\cdot exp_i}{\sum_i exp_i}}{\frac{1}{r}\cdot\frac{\sum_i pm_i\cdot imp_i}{\sum_i imp_i} \Big/ \frac{\sum_i pc_i\cdot imp_i}{\sum_i imp_i}}$$

The variables used have been derived in Section 2.2. Calculated price indexes are deflated to be equal to 1 in 1972. In general, the higher this indicator the more favorable are the contributions of international price and domestic cost developments to the gains from international trade. The index does not show, however, the absolute level of gains from trade.

Before going on to evaluate the results, we must make some remarks on the limitations of the method used.

The most unrealistic assumption of the input-output model is that of the homogeneity of sectors. If we were to accept this assumption fully we could not explain the existence of both exports and imports within a given sector. One refinement would be to assume that exports, goods for domestic use, and imports, within the same industry are substitutable and that their prices are related to their rates of substitution. This would mean that costs per unit of output would be roughly the same for exports and import substitutes. In fact, this formulation is particularly inappropriate for the Hungarian input-output table, where goods for domestic use, exports, and imports are valued at prices almost totally unrelated to their rates of substitution.

To minimize the effects on our indicator of different cost/output levels arising from distortions in the measurement of output, calculated prices were all deflated to a 1972 basis. This procedure excludes any effects of differences in the cost levels of various industries on the dynamics of trading gains. (Shifts of the overall export or import structure toward sectors with different cost levels may have such effects.)

The indicator can be usefully reformulated as follows:

$$\underset{\text{price terms of trade}}{\frac{\frac{1}{r}\cdot\frac{\sum_i pe_i\cdot exp_i}{\sum_i exp_i}}{\frac{1}{r}\cdot\frac{\sum_i pm_i\cdot imp_i}{\sum_i imp_i}}} \quad x \quad \underset{\text{cost terms of trade}}{\frac{\frac{\sum_i pc_i\cdot imp_i}{\sum_i imp_i}}{\frac{\sum_i pc_i\cdot exp_i}{\sum_i exp_i}}}$$

This emphasizes the fact that terms of trade in a broader sense depend both on the price terms of trade-what we normally imply when we speak of terms of trade-and on the corresponding cost terms of trade. In theory, each of these would consist of the price (or cost) effect proper and a structural effect. In practice, however, owing to the limitations of our input-output method, the cost effect in the second term is not measurable, and we are only àble to capture the effect on costs of changes in trade structure. Changes are regarded as favorable if exports have shifted to industries with low cost dynamics and imports to industries with high domestic cost dynamics.

Table 1 shows the dynamics of the various components of the terms of trade indicator between 1965 and 1979.

As the data show, the total terms of trade improved gradually in the late sixties and early seventies, before deteriorating sharply after the oil price rises of 1973. The overall development of the terms of trade has been dominated by the price component (7) throughout the period studied; the cost component (8) has improved slightly between 1965 and 1979, but its maximum variance has not exceeded 3 %.

Let us now examine how changes in the trade structure have contributed to the development of the terms of trade. For example, it would be interesting to know whether the economy reacted to price conditions by reducing the trade shares of goods whose relative prices changed unfavorably and increasing trade for industries whose terms of trade became more favorable. Before embarking on a sector-by-sector analysis, we will first review some aggregate results obtained using a short-cut method.

Laspeyres and Paasche chain indexes were calculated for relative export and import prices. Relative prices were defined, sector-by-sector, as the ratio of the international price to the domestic cost. Aggregating the chain indexes of these prices using trade in the base year as weights, we arrive at the Laspeyres index of prices. The Paasche index, which uses the current year's trade as weights, will be higher than the Laspeyres index, if trade has shifted to industries with increasing prices. The sign of the difference between the two (Laspeyres index - Paasche index) for each year gives information about the correlation of changes in sectoral prices and trade. Table 2 shows the indexes for exports and imports.

The fourth and seventh columns of the table show the sign of the differences for exports and imports, respectively. A positive sign for exports means a favorable change in export structure, whereas a positive sign for imports represents an unfavorable change in import structure.

The randomness of the signs signifies that there is no indication of any adaptation of the economy to changing price terms. The same conclusion was drawn from an alternative calculation procedure, which can be briefly described as follows. Base indexes of relative prices were calculated using both the 1965 and the 1979 trade values as weights. The differences between the two indexes for both exports and imports lay within a range of 0.5 %, showing that over the last 15 years the structure of trade has had practically no effect on the terms of trade. The detailed results of this calculation are not reproduced here.

2.4. Sectoral Analysis

We will now describe the results of a sector-by-sector analysis of the relation between export or import shares and relative prices.

TABLE 1 Components of Hungarian terms of trade, 1965-1979.

Year	1 Export price	2 Import price	3 Calculated export price	4 Calculated import price	5 Relative export price 1/3	6 Relative import price 2/4	7 Price terms of trade 1/2	8 Cost terms of trade 4/3	9 Total terms of trade 7 x 8
1965	1.112	1.256	1.175	1.157	0.546	1.086	0.585	0.985	0.871
1966	1.000	1.157	1.066	1.057	0.938	1.094	0.864	0.992	0.856
1967	1.029	1.172	1.088	1.058	0.545	1.116	0.678	0.965	0.847
1968	0.051	1.086	1.017	1.020	0.935	1.058	0.876	1.008	0.884
1969	1.105	1.233	1.165	1.126	0.957	1.098	0.896	0.973	0.872
1970	1.146	1.008	1.164	1.114	0.985	1.046	0.975	0.961	0.940
1971	1.006	1.041	1. 029	1.03o	0.979	1.008	0.976	0.005	0.971
1972	1.001	1.000	1.000	1.000	1.001	1.000	1.001	1.000	1.001
1973	0.909	0.960	1.072	0.940	0.987	1.001	1.000	0.976	0.850
1974	0.896	1.046	1.001	0.886	0.595	1.054	0.854	0.995	0.800
1975	0.808	0.983	0.921	0.931	0.878	1.056	0.822	1.011	0.831
1976	0.898	1.045	1.001	1.825	0.897	1.820	0.850	1.024	0.850
1977	0.899	1.008	1.962	1.004	0.915	1.004	0.552	1.022	0.912
1978	0.927	0.999	0.988	1.015	0.929	0.924	0.929	1.017	0.944
1979	0.832	0.910	0.008	0.919	0.916	0.990	0.915	1.012	0.920

We set up a series of regression equations for both exports and imports. The dependent variable was in each case the share of sectoral exports or imports in the total, while the explanatory variable was the ratio of the foreign trade price to domestic costs.

For exports, a positive sign for the coefficient of the explanatory variable indicates that the industry concerned behaved well from the point of view of comparative cost theory, expanding its export share when domestic costs decreased in relation to international prices. For imports, a negative sign indicates similarly "good" behavior. However, the results for imports should be treated very cautiously; while the domestic costs of exports are more or less measurable, the meaning of the costs of import substitution is more questionable.

TABLE 2 Laspeyres and Paasche indexes of relative prices

Year	Exports			Imports		
	Laspeyres	Paasche	sign. of difference	Laspeyres	Paasche	sign. of difference
1966	1.012	1.005	-	1.016	1.012	-
1967	0.987	0.984	-	1.026	1.020	-
1968	0.990	0.988	-	0.956	0.946	-
1969	1.053	1.053	0	1.065	1.054	-
1970	1.015	1.015	0	0.956	0.952	-
1971	1.033	1.045	+	0.968	0.968	0
1972	1.036	1.024	-	0.998	0.999	+
1973	0.989	0.987	-	1.006	1.002	-
1974	0.916	0.908	-	1.072	1.052	-
1975	1.012	1.023	+	1.013	1.023	+
1976	1.016	1.036	+	1.000	0.997	-
1977	1.025	1.026	+	0.996	0.993	-
1978	1.022	1.022	0	0.987	0.989	+
1979	0.978	0.982	+	0.998	0.998	0

For exports, seven industries have equations where the price variable has significantly the appropriate sign. The majority of the textile industry belongs to this group; here increasing comparative costs and a decreasing share in total exports prevail. In the pharmaceutical industry, an expansion is coupled with improving comparative costs.

Fifteen industries have equations with a significantly wrong sign for the price variable. Machine industries show the most conspicuous results. Here the rapid expansion of exports has taken place at the same time as a marked deterioration in the price/cost ratio. The clear difference between the directions of the two trends shows that the expansion of exports was not a result of the improving competitiveness of Hungarian goods on the world market. On the contrary, it actually took place against the background of a widening gap between Hungarian technology and world market standards.

When drawing conclusions we should of course not forget the limitations of our method. We cannot, for instance, differentiate between the costs of production for exports and those for goods for domestic use. But as the share of exports in the total gross output of the machine industries is no more than about 20 %, the development of the costs of "export industries" may differ from that of "domestic industries". However, even if these cost dynamics do differ, the data clearly show a relative deterioration in the international competitive position of the machine industry as a whole.

The equation results suggest that comparative costs play hardly any role in the determination of the structure of Hungarian exports. Machinery is a dynamic sector in strong world demand, whereas the demand for textiles is growing much more slowly. The shrinking share of textiles and the growing importance of machinery in Hungarian exports indicate that demand is more important in explaining exports. To put it very simply, it seems that anything that can be sold abroad is exported, more or less irrespective of its costs of production.

For imports, fifteen industries out of 53 importing sectors have an equation where the price variable has significantly the appropriate sign. All the machine industries belong to this group. The shares of both exports and imports of machine products are increasing, indicating that the probable reasons for trade in machinery are not comparative cost differentials but product differentiation and economies of scale.

Oil represents one sector where increasing prices actually played a role– in cutting imports during the late seventies.

Ferrous metals show an appropriate reaction to prices for both exports and imports. This may demonstrate pricesensitive behavior. There is not much reason to think that domestic use changed markedly as a function of world market prices but it is possible that trade with the ruble area was shifted from year to year to achieve gains from the price differences between the two markets.

In other industries, even where we obtain significant coefficients for prices (such as pharmaceuticals, rubber), the explanation of imports may not lie in comparative costs, but elsewhere. There are two principal non-cost reasons for importing goods. First, some goods may not be produced domestically because of the lack of production capacity, know-how, or the reguired natural conditions. Most machine imports, chemicals, and some foodstuffs (e.g., coffee) belong to this category. Their import is dependent on the development of domestic production in the case of intermediate products, and of final use in the case of finished products. Second, some imports fill transitory gaps between domestic (and ruble-area originated) supply and demand. Unforeseen changes in demand or interruptions in supply may cause such imports. This type of situation is probably responsible for most of the seemingly rather volatile time series of light industry and some of the food industries (e.g., sugar).

3. TRADE EQUATIONS FOR THE MODEL

In Section 2 we saw that comparative cost theory does not seem to be either practically applicable or adequate in explaining the development of Hungarian foreign trade over the last 15 years. When setting up a forecasting model this must of course be taken into account. The main determinants of exports should be foreign demand and the availability of exportable goods, while imports are generally considered as noncompetitive and depending mainly on domestic activities. When applying the model for practical forecasts, it must also be remembered that the time horizon of the forecast is expected to be about ten years, in other words, not much less than the observation period. The economic system of Hungary changed greatly during the observation period and there is good reason to suppose that it may change even more in the coming years. For this reason it is highly probable that in some cases we will have to set aside behavioral equations that were valid for the past and introduce into the model relationships and parameters whose existence and value cannot yet be empirically predicted or tested.

It is possible, for example, that the cost calculations of Section 2 may become a basis for a price forecasting model and that prices may still enter into foreign trade as explanatory variables. Since 1980 domestic prices have already been behaving according to the calculated price model of Section 2. Their effect on trade decisions is still very doubtful at present, and it is an open question whether, in any future economic framework, relative sectoral prices will have an effect on the sectoral structure of trade. Research experience in other countries may throw some light on this area.

3.1. Export Equations

For exports, three categories of industries were distinguished.

Demand-Pull Industries. In these industries exports have a considerable share in total output. Production capacities are not fully utilized so there are no supply constraints for exports. The goods produced are usually diversified, with the consequence that market shares cannot be easily expanded by undercutting competitors' prices. For this reason world market demand is the explanatory variable for the equations describing these industries. Most of the light industries, as well as ferrous metals, belong to this group. For the ferrous metals industry a relative price variable is also included in the equation.

Supply-Push Industries. In these sectors domestic output is the only explanatory variable. Two types of industries are included here. Firstly, there are the machine industries. These are the most diversified sectors and the aggregate approach of our model is probably least suited to explain their development. We decided to consider the development of these industries as related to domestic output rather than demand, on the basis of regression results and not a priori theory. Secondly, there are the other supply-determined export industries. These are usually industries of simple raw materials and/or they tend to export simple and homogeneous goods. Because of the homogeneity of these goods they can usually be sold on the world market without any disastrous sacrifices in prices and therefore production capacity utilization is high. The share of exports in total output is sufficiently high that changes in domestic demand do not show up in export performance. Food and agricultural industries as well as some chemical sectors (e.g., fertilizers, synthetics, oil refining, rubber) belong to this group. Additional explanatory variables are included in two cases: relative prices in the equation for oil refining and foreign demand in the equation for the rubber industry.

Demand-Pull Industries With Supply Constraints. These industries mainly supply the domestic market, but they also have a non-negligible proportion of export trade. Although exports from these industries follow world market trends, their exports, exhibit rather large fluctuations, presumably because they partly serve the purpose of draining the fluctuating surpluses of the domestic market. In the equations, world market demand captures the long-term developments in these industries and changes in the sum of domestic output and imports reflect short-term demand shocks.

Data on World Demand. The series of models in the international INFORUM system would ideally seem to be the best source of data for the foreign demand variable of the Hungarian model. However, at the present early stage of both the Hungarian model and the INFORUM system it seemed simpler to use UN statistics. Output indexes in a 13-industry breakdown for Western Europe were considered as indicators of demand in Hungary's main export markets. As exports are treated in more detail in the model than in the UN output statistics, the same index value was used within groups of industries in the model.

3.3. Import Equations

As our investigation has shown, imports do not seem to depend on prices. It is assumed in the model that domestic sales act as an indicator of demand to explain the development of imports over time.

REFERENCES

Almon, C. and Nyhus, D. (1977). The INFORUM international system of input-output models and bilateral trade flows. INFORUM Research Report No. 21. Department of Economics, University of Maryland, College Park, Maryland.

Armington, P. (1969 a). A Theory of Demand for Products Distingnished by Place of Production. IMF Staff Papers, 16. pp. 159-177.

Armington, P. (1968). The Geographic Pattern of Trade and the Effects of Price Changes. IMF Staff Papers, 16, pp. 179-197.

Balassa, B. (1965). Trade Liberalization and Revealed Comparative Advantage. Manchester School, 33, No.1, pp. 99-123.

Balassa, B. (1979). The changing Pattern of Comparative Advantage in Manufactured Goods. Review of Economics and Statistics, 59, No 2, pp. 259-266.

Leamer, E.E. and Stern, R.M. (1970). Quantitative International Economics. Allyn and Bacon, Boston.

STRUCTURAL ASPECTS OF IMPORT DEMAND IN AUSTRIA: LESSONS FROM INPUT–OUTPUT STUDIES

Josef Richter
Federal Economic Chamber, Vienna, Austria

1. INTRODUCTION

Changes in demand for imported commodity i are the result of changes in the total demand for commodity i (imported and domestically produced) and changes in the market share of imports. Changes in total demand for commodity i can be attributed to changes in final demand and to changes in technology.

Input-output models provide almost ideal instruments to quantify the relationships between final demand, technology and the total demand for a given commodity. However, in the context of an econometric input-output model the decision has to be taken whether a global import share is sufficient to link import demand to total demand or whether a computationally more inconvenient approach of complete import share matrices should be chosen.

The more or less standard specification of an import equation in an INFORUM type model (see for example Almon (1979) or Nyhus (1982)) is:

$$m_{it} = (a_i + b_i\ u_i)\ (pf_{it}/pd_{it})^{\ n_i} \qquad (1)$$

where

m_{it} are the imports of commodity i in year t

u_{it} is the domestic use of good i in year t

pf_{it} is the foreign price for commodity i and

pd_{it} is the domestic price for commodity i.

This specification which also may be found - with some modifications - in many other econometric input-output models (see for example Barker (1976)) assumes identical import shares for all the users of commodity i. Statistical data which is available in many countries indicate that this basic assumption is highly unrealistic in many cases. Due to a lack of homogeneity in the composition of the imported and domestically produced goods of the same category the shares vary significantly across receiving industries and final demand categories. The application of global market shares to total domestic demand - neglecting the composition of total demand - leads to biases if rapid structural change is going on in the economy under consideration.

The findings reported in the following paragraphs are the result of an attempt to estimate the order of magnitude of the structural aspect of import demand. This investigation of the role of changing composition of total demand was carried out within the data framework of the Austrian 48 sector INFORUM model. As in many other examples of empirical exercises the design of the study was to a large extent influenced by the availability or absence of data.

The whole ex-post analysis covers the period 1970 to 1981. All computations were done in constant prices.

2. IMPORT DEMAND UNDER THE ASSUMPTIONS OF CONSTANT (DEMAND DIFFERENTIATED) IMPORT SHARES AND CONSTANT TECHNOLOGY

2.1 Basic relationships

Total imports M^t of year t may be viewed as the sum of imports used for domestic production MM^t and imports directly channeled to final demand (MF^t).

$$M^t = MM^t + MF^t \tag{2}$$

Demand for final demand imports results from the level and composition of total final demand Y^t and the market specific import shares

$$MF^t = Y^t - YD^t \tag{3}$$

Y^t is the matrix of total final demand (of domestic and imported origin, dimension i x k) of year t. YD^t is the matrix of final demand of domestic origin. An element yd^t_{ik} of this matrix can be calculated by

$$yd^t_{ik} = y^t_{ik} \cdot (1-mfs^t_{ik}) \tag{4}$$

mfs^t_{ik} is an element of the import share matrix of final demand MFS^t of year t. Intermediate imports are determined by total output and the market shares of imports in intermediate transactions, MMS^t denoting the import share matrix of intermediate transactions. Total output X^t is of course a function of technology (as represented by matrix A), final demand and the market shares of imports in both final demand and intermediate deliveries.

$$MM^t = MC^t \cdot X^t \tag{5}$$

An element of MC^t, the matrix of import coefficients of year t, can be seen as the product of the input coefficient a^t_{ij} and the specific import share:

$$mc^t_{ij} = a^t_{ij} \cdot mms^t_{ij} \tag{6}$$

2.2 Data

A set of comparable input-output tables at constant prices with full import matrices would be an almost ideal basis for a profound attempt to decompose total change in the global import share into its market share aspect and into its structural aspect. At least a set of comparable input-output tables should be available in order to isolate the effects of changing technology.

The Austrian data situation is much less favorable. In the absence of complete input-output tables at constant prices the investigation had to be based on final demand estimates in constant prices of different statistical reliability.

Private consumer expenditures in sufficient detail were obtainable from national accounts. Own calculations on the 6 digit level of the Brussels nomenclature led to imports and exports at constant prices. Since Austrian national accounts do not provide investment by type of commodity a bridge matrix with constant coefficients had to be used to convert investment by type of investment (construction, equipment, vehicles) into investment by input-output categories. The same unsatisfying approach had to be applied for public consumption.

Total output figures at constant prices were again available from national accounts. All additional disaggregation which was essential for this study had to be based on own estimates. These estimates are of somewhat reduced statistical reliability.

2.3 Calculating structural factors

The general approach of the study was to calculate hypothetical imports under the assumption of constant import shares and to compare these hypothetical imports with the observed ones. Any deviation of the calculated from the observed import value can then be interpreted as the contribution of changing market shares to total import demand. Vice versa the extent to which changing import demand can be explained by applying constant shares to changing demand patterns can be considered as the "structural factor" of import demand.

Within the limitations given by the Austrian data situation the elements of the matrix of hypothetical final demand imports MF^{t*} (the superscript * stands for the "hypothetical character") were calculated by

$$mf_{ik}^{t*} = y_{ik}^{t} \cdot mfs_{ik}^{b} \tag{7}$$

The superscript b denotes the use of base year relationships. Equation (7) leads immediately to an estimate of domestic final demand YD^{t*} which could be used to calculate a hypothetical vector of total output and then to compute intermediate imports. It is obvious that the calculation of output should be based on

$$X^{t*} = (I - AD^{t*})^{-1} \cdot YD^{t*} \tag{8}$$

where AD^{t*} is the matrix of input coefficients of domestic origin defined as

$$ad_{ij}^{t*} = a_{ij}^{t} \cdot (1 - mms_{ij}^{b}) \tag{9}$$

Unfortunately matrix A is not available for other years than the base year, so that the element specific import share of the base year cannot be applied to technical coefficients of year t. As a very unsatisfying proxy a vector of total output X^{t**} had to be computed using

$$X^{t**} = (I - AD^{b})^{-1} \cdot YD^{t*} \tag{10}$$

The calculation of intermediate imports MM^{t**} thus relies not only on the assumption of unchanged element specific import shares but also on the hypothesis of constant technology.

$$MM^{t**} = MC^{b} \cdot X^{t**} \tag{11}$$

2.4. Results

The contribution of the broadly defined structural factor to the growth of imports is considerable on the overall economic level. In constant prices merchandise imports grew by 83,3 % in the period 1970 to 1981, the application of constant import share matrices explains about 70 % of this increase. The growth of imports is of course also due to the development of overall economic demand. Therefore the share of imports in total demand for comparable commodities seems to offer more insight into the role of structural aspects. In the period 1970 to 1981 this global import share rose from 26,4 % to 35,4 %. More than 40 % of this increase can be attributed to the changing pattern of domestic demand. Part of this changing pattern of total demand is taken into account by any input-output model, i.e. the changing demand for different groups of commodities. Even an 40 % explanation therefore cannot be taken as an argument in favor or against demand differentiated import shares. Such an analysis has to be based on a sectoral level. Table 1 compares the observed imports by groups of commodities (corresponding to input-output sectors) with estimates for imports obtained by applying constant import share matrices as discribed in equations (7) to (11).

TABLE 1 Observed and hypothetical imports 1970 and 1981 in millions of AS, prices 1976

Sector	1970		1981	
	Obs.	Hyp.	Obs.	Hyp.
Agriculture	8644	8838	12287	11212
Mining	8731	5281	6732	8007
Crude oil & refinery	12780	13775	20645	21514
Non-metallic minerals	2022	2369	3471	3162
Cement	36	37	58	49
Glass	802	1028	1637	1422
Meat	1868	1582	2378	2196
Mills	312	363	286	371
Bakery	169	308	500	350
Sugar	42	80	91	103
Dairy products	202	366	501	449
Other food	3213	4050	7349	6848
Beverages	206	448	469	574
Tabacco	76	72	84	93
Textiles	7954	8498	16128	14900
Apparel	2340	4774	9384	8195
Leather products	1932	3259	4750	4396
Chemicals	17130	18890	38231	32961
Iron & steel	5682	4980	8794	7748
Machinery	18123	17569	30909	28691
Ships & locomotives	375	509	506	791
Foundries	712	310	615	474
Nonferrous metals	5131	4901	6195	7503
Metal products	5827	6736	11138	9188
Optical equipment, etc.	2361	3385	5808	5293
Electric motors	1629	1695	2739	2842
Electric wires	148	266	744	427
Other electric equipment	5676	7469	13176	11982
Radio & TV	4707	2898	6904	5485
Vehicles	11073	13261	22604	21705
Sawmills	596	840	2102	1420
Veneer & plywood	100	135	330	241
Wood products	1839	2819	5922	4879
Paper & pulp	1155	1479	2557	2512
Paper products	963	1434	2787	2085
Printing & publishing	2201	2783	4652	3661

In general the use of the 1976 import share matrices leads to an overestimation of the imports in 1970 and to an underestimation of the 1981 imports. Quite a number of factors can be made responsible for the increase in global import shares which can be observed for most of the sectors:

- a general tendency towards increased international division of labor
- the effects of liberalization of world trade
- limits in domestic production capacities
- the role of multinational enterprises
- changes in the competitive position of Austria versus its major trading partners, etc..

In the context of the alternative global import shares versus demand differentiated import shares it seems to be advisable to have a look at the part of change in the (commodity specific) global import share that can be explained by the changing composition of demand.

The analysis of commodity specific import shares was limited by the fact, that total output figures at constant prices are not available at the same level of disaggregation as foreign trade data. The investigation was therefore concentrating on commodity groups with high import shares.

TABLE 2 Observed and hypothetical commodity specific import shares[a]

Selected sectors	1970 Obs.	1970 Hyp.	1981 Obs.	1981 Hyp.	Share of the structural factor[b]
Agriculture	15,13	15,47	18,84	17,19	45,3
Crude oil & refinery	28,85	31,10	38,34	39,95	86,8
Textiles	33,47	35,76	60,50	55,89	70,0
Apparel	20,29	38,15	52,71	46,96	14,5
Chemicals	40,56	44,73	53,60	46,21	10,3
Iron & steel	21,39	18,74	47,78	42,09	100,9
Machinery	37,68	41,37	45,64	42,24	9,5
Paper & pulp	14,51	18,58	20,03	19,68	15,5

[a] imports i/ (total output i + imports i - exports i)

[b] percentage share of change in global import share attributable to changed composition in demand

As might be seen from table 2 the explanatory power of differentiated import shares differs from sector to sector quite significantly. In some sectors like agriculture, crude oil and refinery, textiles and especially iron and steel the contribution of the structural factor is remarkably high. All these commodity groups can be characterized by a high share of intermediate sales. The base year market share matrix of imported goods shows that for all these sectors the market shares of imported goods vary significantly across receiving industries.

On the other side there are some groups of commodities for which the "full import share matrix approach" is of little value. These groups have in common that a high proportion of their sales is delivered to one or few industries or final demand categories. As in the case of apparel (more than 60 % of total supply going to private consumption, more than 30 % to exports) there is not much room for structural effects. On the other hand relative prices, fashion etc. play a dominant role.

3. IMPORT DEMAND UNDER SLIGHTLY MODIFIED ASSUMPTIONS

The calculations described in chapter 2 were based on the assumption of constant technology. Because of the lack of a set of comparable input-output tables in constant prices this hypothesis was chosen although it is obvious that changes in technology have their implications on the demand of imports. It is also clear that any comparison of imports calculated under the "constant technology assumption" with observed imports does not isolate the structural effect but is the result of structural changes and technological evolutions.

In a second set of calculations it was attempted to incorporate at least the information available on total output at constant prices. In order to make use of the observed development of total output by industries equation (11) had to be modified to

$$MM^{t***} = MC^{b} \cdot X^{t} \qquad (12)$$

This specification has the advantage that some of the effects of changing technology can be taken into account. On the other hand MC^b is obviously inconsistent with X^t since it is based on the hypotheses of both constant technological relationships and constant element specific import shares. Any aggregation of hypothetical intermediate imports MM^{t***} and hypothetical final demand imports MF^{t*} also implies inconsistency.

Because of these shortcomings and the involved difficulties to interpret the results, only a few figures of the second set of computations shall be reported in table 3.

TABLE 3 Observed and hypothetical commodity specific import shares[a]

Selected sectors	1970 Obs.	1970 Hyp.	1981 Obs.	1981 Hyp.	Share of the structural factor[b]
Agriculture	15,13	15,95	18,84	17,01	27,2
Crude oil & refinery	28,85	33,97	38,34	35,09	8,0
Textiles	33,47	43,70	60,50	48,67	14,1
Apparel	20,29	39,54	52,71	46,15	.
Chemicals	40,56	47,24	53,60	44,06	.
Iron & steel	21,39	21,23	47,78	38,33	65,3
Machinery	37,68	43,08	45,64	42,67	.
Paper & pulp	14,51	20,68	20,03	18,64	.

[a] imports i/ (total output i + imports i - exports i)

[b] percentage share of change in global import share attributable to changed composition in demand

The poor performance of the modified model is not too surprising. Since imports are a function of total output and vice versa the "incorporated inconsistency" plays an important role. In the set of computations described in chapter 2 - and fortunately also in the world of input-output models - any underestimation of final demand imports leads to an overestimation of intermediate imports, any overestimation of final demand imports to an underestimation of intermediate imports. This is especially the case with big main diagonal coefficients associated with remarkable import shares in these coefficients. If instead of hypothetical (and consistent) total output figures observed (and inconsistent) output figures are used to compute intermediate imports, such compensating effects are excluded.

4. CONCLUSION

The results reported in the preceeding paragraphs should not be overemphasized. They are based on insufficient empirical material and reflect- at least to a certain extent - specific Austrian circumstances. Some of the results are also considerably influenced by the level of aggregation that had to be chosen.

Nevertheless they seem to provide some arguments in favor of the use of complete import matrices for determining the demand for imports. The empirical analysis indicates that structural factors play an important role for a number of imported commodities, although the change in element specific import shares still has to be explaind by other means.

For all those well elaborated models which also have a price side (for which an import matrix is essential) the incorporation of complete import matrices on the real side might help to achieve more consistency in the overall model.

The following annex gives the FORTRAN statements for a simultaneous calculation of imports and output using complete import share matrices. The program was written by Doug Nyhus as part of the software for the Austrian model.

5. REFERENCES

Almon, C. (1979). The Inforum-IIASA International System of Input-Output Models. WP -79-22. International Institut for Applied Systems Analysis, Laxenburg, Austria.

Barker, T.S. (1976). Imports. In T.S. Barker (Ed.), Economic Structure and Policy. Chapman and Hall, London.

Bjerkholt, O., Longva, S. (1980). Modis IV A Model for Economic Analysis and National Planning. Central Bureau of Statistics of Norway, Oslo.

Nyhus, D.E. (1982). An Econometric Input-Output Model of the West German Economy. In A. Smyshlyaev (Ed.), Proceedings of Task Force Meeting on Input-Output Modeling (1981) CP-82-32. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Skolka, J.V. (1977). Input-Output Anatomy of Import Elasticities. Empirical Economics 2 (3): 123-136.

ANNEX[1]

```
C       *** BEGIN THE ITERATIVE SEIDEL PROCESS ***
    19 KOUNT=0
C
C       BEGIN OF SEIDL LOOP
C
   90  DIFMAX=0.
C
C       DO LOOP FOR ALL COLUMNS
C
       DO 40 N = 1,NCA
       I = ITRIAN(N)
       SUM = FD(I)
       DO 21 J = 1,NCA
       IF(J.EQ.I) GO TO 21
       SUM = SUM + A(I,J)*Q(J)
    21 CONTINUE
C       CALCULATE INVENTORY CHANGE
       IF(NYR.GT.LASYR(NGOV+4)) GOTO 28
       GOTO 25
  28   CONTINUE
       IF(NT.GT.1) VEN(I) = VENEQ(I,1)
C       CHECK FOR A FIX ON INVENTORY
       M = MODFIO(I,2) + 1
C SKIP FIXING FOR FIXES EXACTLY EQUAL TO ZERO
       IF(FIXV(I).EQ.0.) GO TO 25
       GO TO (25,24,23,22),M
C      GO TO 25 FOR NO FIX, 24 FOR OVERRIDE,
C      23 FOR ADDITION, 22 FOR MULTIPLICATION
C      EITHER FIX OR NO GROWTH FOR INVENTORY
C
    22 VEN(I) = FIXV(I)*VEN(I)
       GO TO 25
    23 VEN(I) = VEN(I) + FIXV(I)
       GO TO 25
    24 VEN(I) = FIXV(I)
    25 SUM = SUM + VEN(I)
C RECORD INVENTORY IN HE MATRIX
       HE(I,7) = VEN(I)
C       COMPUTE IMPORTS
       IF(NYR.LE.LASYR(NGOV+3)) GO TO 345
C CALCULATE IMPORTS
       YM = 0.
C COMPUTE INTERMEDIATE IMPORTS
       DO 3001 K = 1,NCA
       IF(Q(K).LE.0.) GO TO 3001
C SKIP THE DIAGONAL DEMAND FOR IMPORTS
       IF(I.EQ.K) GO TO 3001
       YM = YM + A(I,K)*AM(I,K)*Q(K)
  3001 CONTINUE
C ADD IN FINAL DEMAND IMPORTS
       DO 3002 K = 1,8
       KP = K + NCA
  3002 YM = YM + AM(I,KP)*HE(I,K)
```

---

[1] This program was written by Doug Nyhus.

```
C ADD IN DIANGONAL IMPORT DEMANDS
C    IMPORTS AND OUTPUT MUST(!!!) BE SOLVED SIMULTANEOUSLY
C     IMPORTS = YM + DIANGONAL IMPORTS DEMAND
C     IMPORTS = YM + A(I,I)*AM(I,I)*QNEW
C     SINCE QNEW = SUM + A(I,I)*QNEW - IMPORTS
C    THEN
C      QNEW = SUM + A(I,I)*QNEW - (YM +(A(I,I)*AM(I,I)*QNEW))
C    OR   QNEW = (SUM - YM)/(1.-A(I,I) + A(I,I)*AM(I,I))
C     THEREFORE  LET
       PART = (SUM -YM)/(1. -A(I,I) +A(I,I)*AM(I,I))
       YMP(I) = YM + A(I,I)*AM(I,I)*PART
C      CHECK FOR A FIX ON IMPORTS
      M = MODFIO(I,1) + 1
C SKIP ZERO FIXES
      IF(FIXIMP(I).EQ.0.) GO TO 35
      GO TO (35,34,33,32),M
C
C     GO TO 35 FOR NO FIX, 34 FOR OVERRIDE
C
   32 YMP(I) = FIXIMP(I)*YMP(I)
      GO TO 345
   33 YMP(I) = FIXIMP(I) + YMP(I)
      GO TO 345
   34 YMP(I) = FIXIMP(I)
C ALLOW SOLUTION FOR FIXES
  345 QNEW = SUM + A(I,I)*Q(I) - YMP(I)
      GO TO 351
C NORMAL SOLUTION
   35 QNEW = (SUM - YM) / (1. -A(I,I) + A(I,I)*AM(I,I) )
  351 DIF = QNEW - Q(I)
C     IF(I.EQ.3) WRITE(6,3551) KOUNT,I,Q(I),QNEW,DIF
 3551 FORMAT(' KOUNT,I,QOLD,QNEW,DIF=',2I5,3F10.2)
      Q(I) = QNEW
      DIF = ABS(DIF)
      IF(DIF.LT.DIFMAX)  GO TO 40
      IMAX = I
      DIFMAX=DIF
   40 CONTINUE
C
C     COLUMN LOOP FINISHED
C
      KOUNT = KOUNT + 1
      WRITE(6,1789) NYR,ITREL,KOUNT,IMAX,DIFMAX
 1789 FORMAT(' SEIDEL ITER:NYP,ITREL,KOUNT,IMAX,DIFMAX=',
     & 4I5,F12.2)
      IF(KOUNT.GT.21)  STOP
      IF(DIFMAX.GT.TOLER) GO TO 90
C
C     LOOP OF SEIDL FINISHED
C
      IF(KMP.EQ.1) GO TO 622
C CHECK AND DO GROUPS ON IMPORTS AND INVENTORY CHANGE
      KMP = 1
      DO 615 I = 1,NCA
      FIXIMP(I) = YMP(I)
```

STRUCTURAL CHANGES IN ITALIAN FOREIGN TRADE

Maurizio Grassini
Faculty of Political Science, Florence, Italy

1. INTRODUCTION

One way to investigate structural changes in a given economy is to consider the evolution of various economic aggregates. If we compare consumption and investment in two periods and find that in the earlier one investments were negligible while in the more recent period they showed a much higher relative level, we can say that a structural change in the economy has taken place. From a stationary economy we have moved towards one with a very high level of accumulation; this might, for example, describe the case of an underdeveloped country undergoing industrialization, and we conclude that the structure of the economy in the two periods is different.

Structural changes can also be investigated within a given economic aggregate. The same (relative) level of, e.g. investments can be obtained by different degrees of accumulation in different sectors; their quality--that is to say, the content of technological innovation in the sectoral investment process--leads to different merceological patterns in the demand of investment goods, which in turn stimulates, to a variable degree, the output level of the respective producing sectors. Thus, the quality of the investment process, in other words, the quality of a final demand component, represents an important factor driving the relative composition of the producing sectors in the economy.

Therefore, when studying the structural changes in an economy over a period of two or three decades, it is vital to analyze the main economic aggregates and to look for their determinants at a more disaggregated level. This can be done by utilizing input-output modeling and taking the implied sectoral classification as a disaggregation criterion, which has the property of preserving accounting consistency with the more traditional macro models.

Here, we present a contribution on Italian foreign trade. The work reported is part of a project for building a multisectoral model of the Italian economy. The general structure of this model, known as the Interindustry Italian Model (INTIMO), is described in Grassini (1982a, 1982b). INTIMO is a member of the INFORUM family, and therefore its structure reflects the prototype designed by Almon (Almon et al., 1974), which is described in many papers concerning the construction of national models; among them we can mention those for the FRG (Nyhus, 1982), Bulgaria (Dimitrov, 1982), France (Lee and Almon, 1978), Hungary (Fink and Simon, 1982), Belgium (Vanwynsberghe et al., 1977; Vanwynsberghe, 1982), and the United Kingdom (Bell, 1982). INFORUM-type models following the same framework can be conveniently linked by means of import-export trade matrices for each sector considered in the national models. These matrices, which represent import-export flows between importing countries (columns) and exporting countries (rows), form the basic framework of a dynamic world trade model first proposed by Nyhus (1974) for interlinking a group of national input-output models (Nyhus and Almon, 1983; Nyhus, 1983).

National INFORUM models must adhere as far as possible to the international linking structure, but can and should be specific as regards domestic structural equations, such as those for consumption, investment, labor productivity, etc. Anyone contemplating the construction and international linking of an input-output model within the INFORUM "family" must undertake a careful formulation of the statistical data used for modeling the foreign block of the model, in order to make clear the merceological content of import and export equations.

In Section 2, the production of import and export data for the Italian model is described; in Section 3 a brief analysis of the changes in composition of Italian trade in commodities is presented; Section 4 is devoted to the import-export equations which will be inserted in the Italian model in the course of the updating process; and Section 5 presents the estimation results and some general conclusions.

2. THE DATA

The data have been produced by using statistics on trade in commodities published by the UN following the Standard International Trade Code, SITC. As is known, the items classification for both exports and imports is available in 4-digit detail up to 1970 and in 5-digit detail from 1971 up to the present. Furthermore, two modifications of the code took place during the sample period 1963-1980; the first--a slight revision of the code at the same time as the adoption of the 5th digit--was introduced in 1971; the second revision--a significant change in the coding of commodities with less relevant items being grouped together and others that are growing in importance in international trade being split--defines the commodities trade data from 1978 to the present. An item-by-item investigation has led to the definition of a bridge between the two series--before 1977 and after 1978--so that it is possible to make the data homogeneous for the construction of time series.

The 4-digit classification is considered to be sufficiently detailed for the investigation of Italian imports and exports, and it is available at that level in both quantity and value terms for all the items considered. The aggregation of the data has been done according to the I-O table of the Italian economy; in the table, sectors are distinguished following the NACE/CLIO classification, which makes the I-O tables of the European Community countries comparable. The bridge between SITC and NACE/CLIO codes only partially follows the proposals given by ISPE (1981): (a) for the level of detail adopted (4-digit for all the items) and the reassignment of many commodities; (b) for the specific bridge linking pre-1977 and post-1978 periods. The bridge matrices between the NACE-CLIO and SITC classifications are reported in the Appendix. Furthermore, the proposed classification has been checked with the time series on imports and exports at the I-O level presently produced, unfortunately only for the most recent years, by ISTAT (Italian Statistical Bureau); that is to say with the original source of the data we are dealing with. More precisely, the construction of the time series has been compared with the "true" data before their transmission to the UN Statistical Office, their classification in SITC code and conversion into dollars and, finally, their reconversion back into national currency, which is the first step of the data collection described here. Comparison of ISTAT data and the data produced for the present study has shown negligible discrepancies with respect to the expected departures from the official data due to imperfect transmission,etc.

3. THE STRUCTURAL CHANGES

Italian foreign trade is firstly analyzed considering the economic aggregates of the national accounts; then some insights into the data described in the previous section are given. The intertemporal comparison is based upon data relating to four equally spaced years: 1965-1970-1975-1980. The choice of the time interval is arbitrary and the world and national economic cycles might have suggested different points in time; for example, 1975 was the year of the big world depression following the first shock in the world raw material market, but the years immediately before and after were not much better, from the standpoint of being "representative"; 1974 showed the destabilizing effect of the fast rise of oil prices and, internally, the effect of a sudden growth of the inflation rate to levels never recorded in the recent past; 1976 registered a remarkable expansion of the Italian economy with a good export performance but with a worsening of the balance of payments which led to a restrictive economic policy and the subsequent recession in 1977. In general, the sixties and seventies are not easily subdivided into periods for intertemporal comparison; therefore, given the length of the sample period, four equally spaced years were considered.

In Table 1 the macroaggregates of foreign trade and GNP are presented. It can be seen that the structure of final demand, which is equal to GNP plus imports, has markedly changed because of the faster growth of exports. This has implied a constant positive trend in the opening of the Italian economy. This process cannot be ascribed to the impact of the European Common Market, which produced its main effect in the sixties; rather, it is due to the spread of international economic integration particularly noticeable among Western European countries.

TABLE 1 Imports, exports, and GNP in real terms (index numbers, 1965=100).

Indicator	1965	1970	1975	1980
GNP	100	135	152	184
Imports	100	204	238	365
Exports	100	166	235	326
GNP + Imports	100	142	161	202
Exports/GNP	0.13	0.16	0.20	0.23

Changes in the structure of Italian international trade in commodities can be analyzed in Tables 2 and 3. On the imports side, agricultural products and oil represented 57% of the imports in 1965; at the end of the period considered their share was reduced to 26%. Consequently, many items tended to record increasing shares during the period; among the most noticeable are the fast growth of machinery, electric goods, and motor vehicles which taken together increased their global share from 8 to 23%. These items are mainly investment goods, so that one can argue that if the dependence on raw materials were reduced, imported technology could play a crucial role in the restructuring of production processes.

Exports display a similar reduction in the importance of agricultural goods and an expansion of machinery, electric goods, and motor vehicles from 26 to 33%, an expansion less than that recorded for imports but equally important, if one also considers the increase in exports of metal products. These records throw some light on the competitiveness of Italian mechanical industries, while the textile, clothing, and leather and shoes industries tend to preserve--but not expand--their shares in Italian exports.

TABLE 2 Composition of imports (constant prices, base year 1975).

Sector	1965	1970	1975	1980
Agriculture	16.90	13.18	12.26	9.90
Coal	2.13	1.98	1.89	1.71
Coke	0.09	0.05	0.04	0.02
Oil	40.57	24.88	23.82	16.56
Electricity, water	0.00	0.01	0.94	0.87
Nuclear fuels	0.01	1.25	0.06	0.12
Ferrous/nonferrous ores	8.70	10.62	8.48	9.83
Nonmetal, mineral products	1.49	2.02	1.79	2.13
Chemical products	4.79	8.19	8.88	9.68
Metal products	1.10	1.46	1.61	1.72
Agric. & indust. machinery	3.57	6.52	6.66	5.70
Office, Precis. Opt. Instr.	1.22	2.30	2.61	5.01
Electrical goods	1.98	4.00	4.88	5.34
Motor vehicles	1.37	4.12	4.53	7.19
Other transp. equipment	1.42	1.21	1.64	1.85
Meat	3.60	3.93	4.66	3.71
Milk, dairy	1.84	1.47	2.21	2.19
Other foods	1.99	2.84	3.13	2.75
Nonalcoh. and alcoh. beverages	0.14	0.33	0.46	0.41
Tobacco	0.08	0.10	0.58	0.50
Textiles & clothing	2.36	3.14	3.18	4.79
Leather & shoe	0.22	0.49	0.56	0.80
Wood & furniture	1.38	1.62	1.46	1.72
Paper & printing products	2.21	2.87	2.03	2.89
Rubber & plastic products	0.35	0.81	1.08	1.63
Other manufact. products	0.52	0.60	0.56	0.98
Total	100.00	100.00	100.00	100.00

Using input-output data, it is possible to consider the evolution over time of the ratio of sectoral imports to (sectoral domestic) demand. This ratio gives a kind of average propensity to import with respect to the domestic demand (consumption, investment, and public consumption). But such ratios can only encompass the usual economic meaning of a global propensity, and they disregard the structural changes of the economy which hide two main demands for imports: raw and intermediate materials and investment goods rerequired by the production sectors on one side and final goods needed by the final demand (including exports) on the other side. Anyway, these ratios--presented in Table 4--show, for example, that the decreasing importance of imports of agricultural products was determined by the (relative) reductions in domestic demand, while office machinery and precision and optical instruments faced strong international penetration, making the ratio of imports to domestic demand grow from 37% in 1965 to 62% in 1980. In contrast, the food industries and the traditional textile, clothing, leather, shoe, and furniture sectors showed low ratios throughout the period. The faster growth of imports with respect to GNP, as shown in Table 1, is here reflected in the general trend of the ratios.

TABLE 3 Composition of exports (constant prices, base year 1975).

Sector	1965	1970	1975	1980
Agriculture	8.20	4.97	4.57	3.22
Coal	0.00	0.01	0.00	0.00
Coke	0.08	0.16	0.20	0.16
Oil	8.78	8.56	5.57	4.05
Electricity, water	0.05	0.06	0.21	0.10
Nuclear fuels	0.00	0.01	0.02	0.15
Ferrous/nonferrous ores	5.38	3.56	6.86	4.81
Nonmetal, mineral products	2.70	3.43	3.32	4.53
Chemical products	8.61	8.44	8.71	7.30
Metal products	5.65	4.61	6.18	10.11
Agric. & indust. machinery	13.27	17.61	15.79	16.02
Office, precis. opt. instr.	1.87	2.94	2.50	4.59
Electrical goods	5.56	5.89	7.37	5.82
Motor vehicles	5.76	9.17	9.29	6.74
Other transp. equipment	2.96	1.94	1.97	2.14
Meat	0.39	0.31	0.33	0.52
Milk, dairy	0.95	0.31	0.24	0.18
Other foods	3.00	2.57	2.83	2.97
Nonalcoh. & alcoh. beverages	0.22	0.28	0.46	0.45
Tobacco	0.00	0.00	0.00	0.00
Textiles & clothing	11.97	11.42	10.08	10.92
Leather & shoe	6.93	6.05	5.68	4.75
Wood & furniture	1.69	1.42	1.71	2.78
Paper & printing products	1.35	1.81	1.51	1.91
Rubber & plastic products	2.36	2.21	2.43	2.06
Other manufact. products	2.26	2.28	2.16	3.73
Total	100.00	100.00	100.00	100.00

4. QUANTITATIVE ANALYSIS OF IMPORTS AND EXPORTS

In order to evaluate the explanatory power of some economic variables regarding imports and exports we establish relationships among the variables; that is to say, we rely upon models. These relationships must be designed in such a way as to permit their statistical estimation and evaluation and, at the same time, they should be considered a part of a larger model useful in predicting expected structural changes according to given scenarios.

4.1. The Model

The import equations have the following structure

$$M = (a+bD)p^n \qquad (1)$$

where

M is the volume of imports of a given good;

D is the domestic demand defined as total output (or production) plus total imports minus exports;

p is a price term;

TABLE 4 Ratios of imports to domestic demand.

Sector	1965	1970	1975	1980
Agriculture	0.22	0.20	0.19	0.20
Coal	0.91	0.92	0.98	0.98
Coke	0.05	0.02	0.02	0.01
Oil	0.60	0.39	0.41	0.44
Electricity, water	-	-	0.04	0.05
Nuclear fuels	-	-	-	-
Ferrous/nonferrous ores	0.27	0.27	0.24	0.29
Nonmetal, mineral products	0.08	0.10	0.09	0.13
Chemical products	0.17	0.22	0.22	0.24
Metal products	0.05	0.05	0.08	0.13
Agric. & indust. machinery	0.17	0.26	0.30	0.36
Office, precis. opt. instr.	0.37	0.50	0.51	0.62
Electrical goods	0.12	0.18	0.24	0.27
Motor vehicles	0.08	0.20	0.27	0.38
Other transp. equipment	0.28	0.18	0.21	0.22
Meat	0.15	0.18	0.19	0.18
Milk, dairy	0.22	0.18	0.23	0.25
Other foods	0.06	0.08	0.08	0.08
Nonalcoh. & alcoh. beverages	0.03	0.07	0.10	0.10
Tobacco	0.01	0.02	0.10	0.11
Textiles & clothing	0.05	0.07	0.08	0.14
Leather & shoe	0.04	0.07	0.07	0.14
Wood & furniture	0.08	0.08	0.08	0.09
Paper & printing products	0.12	0.12	0.10	0.15
Rubber & plastic products	0.04	0.08	0.10	0.17
Other manufact. products	0.20	0.17	0.15	0.28

a, b, and n are parameters (to be estimated).

All the variables and parameters in practice carry an index i denoting the ith good; furthermore, the variables M, D, and p have an index t denoting time, an observation index in the time series available. The price term, p, is a function of import prices, p^m, in national currency (for goods of type i) and of domestic (producers') prices, p^d. For the ith good, the price term is defined as

$$p_t = \Sigma_{r=0}^{R} w_r(p_{t-r}^m/p_{t-r}^d)$$

where the w_r denote weights defining for each good the lag structure of the past (relative) prices for the explanation of imports at time t. R is the maximum time lag.

Export equations have a similar analytical structure. For each good i we have

$$E = (a+bF)p^n$$

where

E is the volume of exports of a given good (for exports the current value is deflated with home producers' prices);

F is an index of foreign demand;
p is a price term;
a, b, and n are, as before, parameters.

The price term is a function of export price, p^E, and the price in the world market, p^w, so it is effectively a competitive index for the Italian producers. The price term is

$$p_t = \Sigma^R_{r=0} w_r (p^E_{t-r}/p^w_{t-r})$$

where the w_r denote weights defining the lag structure of the price term in the export equations.

When the fitting of these equations is not considered satisfactory, a time trend is proposed. Its form is

$$\log M = a + bt + cp$$
$$\log E = a + bt + cp$$

where a, b, and c are parameters, t is time, and p is the price term defined as before. When the estimated c parameter does not turn out to be negative as expected, the price term is dropped.

The variables p^w and F, as well as p^E for the forecast, are obtained from Nyhus (1975).

Once the lag structure of the price terms is assumed as given, the analytical form of the equations suggests an easy scanning estimation procedure. Since we were dealing with a re-estimation of the trade block of the input-output model we relied upon the old price elasticities presented in Alessandroni (1982) as prior information to be used as initial values in the scanning process. These values were used in an estimation procedure based on the maximization for each equation of a utility function defined as follows

$$U = R^2 - 05 \parallel n - np \parallel / \parallel np \parallel$$

where np is the previous (or a priori) price elasticity.

We found that the old elasticities were sometimes rejected.

5. RESULTS AND CONCLUDING REMARKS

The estimation results for the import and export equations are presented in Tables 5 and 6, respectively.

Import equations are not reported for all the commodities considered; some of them have been excluded under the criterion that, if imports account for more than 90% of domestic demand, the imports are considered simply proportional to domestic demand.

Export equations are not considered when the amount of exports or the world demand for the Italian goods in question are negligible.

The aggregate import demand elasticity for the 1975 import structure was 1.24 and the aggregate price elasticity was equal to -0.46. The aggregate elasticities for exports in 1975 were equal to 1.4 with respect to foreign demand and -0.96 with respect to the relative price term.

Among the import equations nine commodities are not price-elastic, while among the export equations only five commodities are insensitive to the price term. This could mean that Italian productive structure is mainly oriented to transform raw materials and intermediate goods to satisfy a final goods demand; then, if the final goods market involves Italian producers in a

TABLE 5 Summary import regression results (T coefficients in parentheses).

SECTOR	PRICE ELASTICITIES		CONSTANT(A)	DEMAND(B)	DEMAND ELASTICITY	RBARSQ	80 IMPORTS
	ESTIMATE	A PRIORI					
1AGRICULTURE,FOR.FISHERY	-0.50	-0.50	598.1 (0.80)	0.250 (5.55)	1.14	0.603	7609.
4OIL AND REFINING	-0.30	-0.20	387.6 (0.19)	0.489 (3.72)	1.06	0.532	21935.
7FERROUS NON FERROUS ORES	0.0	2.00	278.7 (1.19)	0.258 (10.74)	0.92	0.871	7821.
8NON METAL MIN.MIN PROD	0.0	2.00	421.6 (4.62)	0.196 (10.48)	1.52	0.865	1720.
9CHEMICAL PRODUCTS	-1.00	-2.00	1122.1 (9.01)	0.340 (20.07)	1.27	0.969	7577.
11AGRIC.& INDUS.MACHINERY	0.0	2.00	1354.8 (2.54)	0.536 (5.62)	1.66	0.642	4916.
12OFFICE,PRECIS,OPT INSTR.	0.20	-2.00	-219.8 (-5.08)	0.690 (25.03)	1.11	0.770	3118.
13ELECTRICAL GOODS	0.0	2.00	1116.7 (4.52)	0.433 (9.46)	1.50	0.839	3955.
14MOTOR VEHICLES	-1.00	-1.00	2095.8 (7.98)	0.668 (12.46)	1.71	0.881	6991.
15OTHER TRANSPORT EQUIPMENT	0.0	-2.00	5.8 (0.09)	0.216 (6.14)	0.99	0.683	1359.
16MEAT	-0.35	0.50	-511.8 (-4.89)	0.202 (16.19)	1.29	0.890	2747.
17MILK AND DAIRY	-0.50	-0.50	-152.2 (-2.22)	0.329 (11.79)	1.16	0.883	1474.
18OTHER FOODS	-0.55	0.75	428.6 (-5.62)	0.129 (16.51)	1.34	0.928	2104.
19NON ALCOHOL,ALCOH.BEVERAGES	-0.90	-1.00	-188.5 (-10.18)	0.252 (16.64)	1.88	0.923	391.
20TOBACCO	0.0	-1.00	-535.9 (-5.37)	0.406 (6.24)	4.05	0.691	425.
21TEXTILES & CLOTHING	-1.70	-1.50	-2125.3 (-3.53)	0.279 (5.15)	2.32	0.702	3694.
22LEATHER & SHOE	-1.50	1.50	98.8 (-1.76)	0.147 (4.82)	1.41	0.725	754.
23WOOD & FURNITURE	0.10	-1.00	20.4 (0.53)	0.084 (11.65)	0.97	0.883	1776.
24PAPER & PRINTING PROD.	0.0	1.00	-153.7 (-1.90)	0.157 (11.16)	1.15	0.879	1838.
25RUBBER & PLASTIC PROD.	-1.00	-1.00	-328.0 (6.51)	0.237 (12.88)	1.57	0.911	1287.
26OTHER MANUFACT. PROD.	0.0	-1.50	14.8 (0.28)	0.193 (3.58)	0.95	0.410	875.

SUMMARY OF TIME EQUATIONS LN(IMPORTS) = A + B*TIME + C*RELATIVE PRICE

SECTOR	PRICE ELASTICITIES	CONSTANT(A)	TIME(B)	RBARSQ	IMPORTS
3COKE	-1.10	6.9 (3.55)	-0.043 (1.04)	0.622	15.
10METAL PRODUCTS	0.0	3.6 (5.47)	0.034 (3.65)	0.420	1193.

TABLE 6 Summary export regression results (T coefficients in parentheses).

SECTOR	PRICE ELASTICITIES ESTIMATE	A PRIORI	CONSTANT(A)	DEMAND(B)	DEMAND ELASTICITY	RBARSQ	1980 EXPORTS
1AGRICULTURE.FOR.FISHERY	0.50	0.50	27.1 (-0.12)	9.170 (3.79)	1.027	0.469	2102.
3COKE	1.50	0.75	26.2 (-2.06)	0.537 (4.51)	1.401	0.684	80.
4OIL AND REFINING	0.0	2.00	235.4 (0.73)	10.640 (3.40)	0.868	0.384	3576.
7FERROUS NON FERROUS ORES	0.0	-2.00	818.2 (-1.87)	17.767 (4.04)	1.678	0.474	3248.
8NON METAL MIN,MIN PROD.	0.0	-2.00	-1118.1 (-8.02)	19.350 (13.46)	1.086	0.914	3132.
9CHEMICAL PRODUCTS	-0.40	-2.00	-101.4 (-1.09)	19.534 (19.65)	1.043	0.965	4411.
10METAL PRODUCTS	2.00	-2.00	-69.8 (-0.38)	15.773 (8.06)	1.037	0.961	4471.
11AGRIC.& INDUS.MACHINERY	2.00	2.00	-2448.1 (-11.21)	58.954 (24.96)	1.503	0.963	10173.
12OFFICE,PRECIS.OPT INSTR.	0.40	2.00	-430.1 (-3.34)	10.798 (7.81)	1.447	0.817	2348.
13ELECTRICAL GOODS	0.80	-2.00	-914.1 (-4.62)	22.787 (10.10)	1.496	0.885	3421.
14MOTOR VEHICLES	2.00	2.00	-329.4 (-1.91)	21.458 (12.13)	1.141	0.942	4793.
15OTHER TRANSPORT EQUIPMENT	0.20	-2.00	-219.2 (-2.35)	7.526 (7.51)	1.321	0.793	1418.
16MEAT	-0.50	-0.50	-168.4 (5.23)	2.602 (7.50)	2.398	0.757	341.
18OTHER FOODS	-0.65	-0.75	-477.8 (-3.67)	11.908 (8.56)	1.551	0.835	1703.
19NON ALCOHOL,ALCOH.BEVERAGES	-1.00	-1.00	-119.5 (-8.10)	2.043 (12.93)	1.907	0.896	277.
21TEXTILES & CLOTHING	0.0	-1.50	-4309.4 (-6.21)	63.844 (9.25)	2.337	0.833	7547.
23WOOD & FURNITURE	0.0	-1.00	550.9 (-3.08)	10.312 (5.40)	1.840	0.623	2044.
24PAPER & PRINTING PROD.	-1.00	-1.00	-466.2 (7.00)	8.524 (12.19)	1.838	0.889	1143.
25RUBBER & PLASTIC PROD.	-1.00	-1.00	199.7 (-2.71)	7.312 (9.34)	1.280	0.844	1305.

SUMMARY OF TIME EQUATIONS LN(EXPORTS) = A + B*TIME + C*RELATIVE PRICE

SECTOR	PRICE ELASTICITIES	CONSTANT(A)	TIME(B)	RBARSQ	EXPORTS
22LEATHER & SHOE	-2.42	0.5 (0.27)	0.123 (3.12)	0.657	4125.

competition measured through relative prices, the supply of the final goods implies a certain consumption of intermediate goods which are purchased mainly with respect to technological requirements. This hypothesis is supported by the aggregate value of the price elasticities presented above; in fact, while the relative prices in the import equations show a price elasticity of -0.46, exports turn out to be more price-elastic with a value of -0.96.

Furthermore, it should be noticed that the domestic demand in the import equations is defined as output less exports plus imports. Now, it could be the case that for some sectors imports might quite rationally depend upon exports of the same product group; in fact, the sequence import-processing-export can be developed within the same commodity classification. Then, the demand component in the export equations might require redefinition in order to produce the model specification implied by this sequence (Tahon and Vanwynsberghe, 1983).

In further research on the import and export equations of the multi-sectoral Italian model, we plan to test the redefinition of the demand term for imports already adopted for the Belgian model, and we hope to investigate various peculiarities among the intermediate, investment, and final goods which in general make up the imports and exports of each sector.

REFERENCES

Alessandroni, A. (1982) Le equazioni del commercio con l'estero nel modello INTIMO-INFORUM. Rapporto INTIMO n.4.

Almon, C., Buckler, M., Horwitz, L., and Reinbold, T. (1974) 1985: Interindustry Forecasts of the American Economy. Lexington, Mass.

Bell, D. (1982) Infouk - An Interindustry Forecasting Model for the U.K. In A. Smyshlyaev (Ed.), Proceedings of the Task Force Meeting on Input-Output Modeling (1981). CP-82-32. IIASA, Laxenburg, Austria.

Dimitrov, A. (1982) E.I. Inforum Model for Bulgaria - Adjustment Problems and some Results. In A. Smyshlyaev (Ed.), Proceedings of the Task Force Meeting on Input-Output Modeling (1981). CP-82-32. IIASA, Laxenburg, Austria.

Fink, G. and Simon A. (1982) Outlines of an Econometric Input-Output Model of the Hungarian Economy. In A. Smyshlyaev (Ed.), Proceedings of the Task Force Meeting on Input-Output Modeling (1981). CP-82-32. IIASA, Laxenburg, Austria.

Grassini, M. (1982a) Un modello macroeconometrico di analisi e previsioni intersettoriali. Atti della XXXI Riunione scientifica - Società Italiana di Statistica, Torino, 5-7 aprile.

Grassini, M. (1982b) A National Scenario for a Regional Model. WP-82-131. IIASA, Laxenburg, Austria.

ISPE (1981) Costruzione di serie storiche relative al commercio con l'estero secondo la classificazione NACE-CLIO adottata nelle tavole intersettoriali dei paesi della CEE. Roma.

Lee, Y.S. and Almon C. (1978) An Input-Output Forecasting Model of the French Economy. Inforum Research Report no.20. University of Maryland, College Park, Maryland.

Nyhus, D.E. (1975) The Trade Model of a Dynamic World Input-Output Forecasting System. INFORUM Research Report no.14. Department of Economics, University of Maryland, College Park, Maryland.

Nyhus, D.E. (1982) An Econometric Input-output Model of the West German Economy. In A. Smyshlyaev (Ed.), Proceedings of the Task Force Meeting on Input-Output Modeling (1981). CP-82-32. IIASA, Laxenburg, Austria.

Nyhus, D.E. and Almon, C. (1983) Linked input-output models for France, Federal Republic of Germany, and Belgium. In B.G. Hickman (Ed.), Global International Economic Models. North Holland, Amsterdam.

Nyhus, D.E. (1983) Linking Seven Input-Output Models of the Inforum System. In M. Grassini and A. Smyshlyaev (Eds.), Input-Output Modeling. CP-83-S2. IIASA, Laxenburg, Austria.

Olsson, H. and Sundberg, L. (1983) A Trade Model for the Nordic Countries. In M. Grassini and A. Smyshlyaev (Eds.), Input-Output Modeling. CP-83-S2. IIASA, Laxenburg, Austria.

Tahon, H. and Vanwynsberghe, D. (1983) The international part of the Belgian Inforum Model. In M. Grassini and A. Smyshlyaev (Eds.), Input-Output Modeling. CP-83-S2. IIASA, Laxenburg, Austria.

UN (1975) Standard International Trade Classification. Revision 2. Statistical Papers, Series M N, 34/Rev. 2. United Nations, New York.

Vanwynsberghe, D., Nyhus, D.E., and Almon C. (1977) An Input-Output Model for Belgium. INFORUM Research Report n. 22. Department of Economics, University of Maryland, College Park, Maryland.

Vanwynsberghe, D. (1982) A description of the Belgian Inforum Model. In A. Smyshlyaev (Ed.), Proceedings of the Task Force Meeting on Input-Output Modeling (1981). CP-82-32. IIASA, Laxenburg, Austria.

APPENDIX

Bridge between NACE-CLIO and SITC classifications before 1977.

NACE CLIO	SITC																			
1	11	12	13	14	15	19	251	252	341	342	343	344	350	360	371	372	411	412	421	422
	430	440	451	452	459	571	572	573	574	575	576	577	579	541	542	544	545	546	548	721
	751	752	1211	1212	1213	2111	2112	2114	2116	2117	2119	2120	2221	2231	2232	2222	2234	2223	2235	2224
	2225	2226	2238	2239	2320	2471	2472	2479	2460	2681	2682	2683	2685	2686	2687	2911	2919	2922	2923	2924
	2925	2926	2927	2929	9410															
2	3221	3222	3231	3223	3224															
3	3232	3222																		
4	3343	3351	3330	3344	3341	3342	3345	3353	3354											
5	3510	3415	3413	3414																
6	5241	3415																		
7	2815	6750	6760	6770	6781	6785	6783	6784	6782	2816	2814	2820	2871	2872	2873	2874	2875	2876	2877	2879
	2890	2860	2881	2882	6712	6713	6716	6724	6725	6727	6731	6732	6733	6741	6744	6745	6746	6749	6747	6794
	6793	6811	6812	6821	6822	6831	6832	6841	6842	6851	6852	6861	6863	6871	6872	6880	6891	6899		
8	2731	2732	2733	2734	2741	2742	2771	2782	2783	2784	2785	2786	2789	2772	6611	6612	6613	6618	6623	6624
	6631	6632	6633	6635	6637	6638	6639	6641	6642	6643	6644	6645	6646	6647	6648	6649	6651	6652	6658	6664
	6665	6666	6671	6672	6673	6674														
9	2331	5821	5822	5823	5824	5825	5826	5827	5828	5829	5841	5842	5843	5849	5851	5852	3352	2665	2666	2667
	2671	2672	2711	2712	2713	2714	5111	5112	5113	5114	5121	5122	5123	5161	5162	5137	5138	5139	5163	5145
	5146	5147	5148	5154	5155	5156	5157	5169	5221	5222	5223	5224	5225	5231	5232	5233	5237	5249	5311	5312
	5322	5323	5331	5332	5334	5335	5411	5413	5414	5415	5416	5417	5419	5513	5514	5530	5543	5541	5542	5621
	5622	5623	5629	5721	5722	5723	5911	5912	5913	5914	5921	5922	5981	5982	5983	5989	6516	6517	6518	6531
	6532	6534	6539	6535	6536	6538	8821	8822												
10	8951	6911	6912	6924	6931	6932	6940	6951	6953	6954	8121	8124	6960	6999	6991	6992	6997	6993	6996	6994
	6921	6998	6935	6978	6973	6974	6975													
11	7111	7112	7119	7126	7129	7131	7144	7148	7149	7132	7133	7138	7139	7187	7188	7211	7212	7213	7223	7221
	7219	7371	7372	7373	7244	7245	7246	7247	7248	7243	7251	7252	7259	7263	7269	7264	7267	7268	7271	7361
	7362	7367	7233	7234	7239	7284	7272	7283	7281	7368	7369	7451	7753	7452	7411	7412	7413	7414	7415	7416
	7491	7492	7493	7499	7431	7432	7433	7434	7435	7436	7439	7421	7422	7423	7428	7429	7442	7449	7441	
12	7511	8811	7512	7521	7522	7523	7524	7525	7528	7518	7591	7599	8841	8842	8710	8813	8720	8740	8732	8731
	8812	8741	8742	8743	8744	8745	8749	8851	8852											
13	7161	7711	7712	7162	7163	7169	7721	7722	7723	7731	7732	7611	7612	7621	7622	7628	7648	7641	7642	7643
	7751	7752	7754	7757	7758	7741	7742	7781	7782	7761	7762	7763	7764	7768	7783	7788	7784	7631	7638	8933
	8981	8982	8989																	
14	7831	7821	7822	7841	7842	7849	7810													
15	7912	7911	7913	7914	7915	7860	7861	7919	7832	7851	7852	7853	8941	7921	7922	7923	7924	7928	7929	7931
	7932	7933	7938																	
16	111	112	113	114	115	116	118	121	129	141	142	149	811	1111	4113					
17	224	223	230	240																
18	460	470	481	482	483	484	488	582	583	586	589	561	564	565	611	612	615	616	617	619
	711	712	722	723	730	741	742	811	812	813	819	913	914	980	4232	4233	4234	4235	4236	4239
	4241	4242	4243	4244	4245	4249	4311	4312	4313	4314										
19	585	1110	1121	1122	1123	1124														
20	1221	1222	1223																	
21	2614	2613	2631	2632	2633	2634	2640	2651	2652	2654	2655	2659	2690	6130	6542	6543	6545	6551	6552	6546
	6541	6544	6549	6560	6571	6572	6573	6574	6575	6576	6577	6579	6581	6582	6583	6584	6591	6592	6593	6594
	6595	6596	6589	6577	8421	8422	8423	8424	8429	8441	8442	8443	8431	8432	8433	8434	8435	8439	8465	8471
	8481	6553	8451	8452	8459	8461	8462	8463	8464	8472	8484	8483	6511	6512	6513	6514	6515	6519	6521	6522
22	6112	6113	6114	6115	6116	6118	6121	6122	6123	6129	8310	8510								
23	2450	2481	2482	2483	2440	6341	6342	6343	6344	6349	6352	6351	6353	6354	6359	6330	8211	8212	8219	
24	2511	2512	2519	2516	2517	2518	6411	6412	6413	6415	6416	6417	6418	6419	6421	6422	6423	6424	6428	8921
	8922	8928	8924																	
25	5831	5832	5833	5834	5835	5836	5837	5838	5839	2332	6210	6251	6252	6253	6254	6259	6281	6282	6289	8482
26	8946	8931	8932	8933	8935	8939	8122	8830	8942	8947	8952	8959	8960	8973	8974	8972	8997	8993	8994	8998
	8996	8999	9110	9610	9710															

Bridge between NACE-CLIO and SITC classifications after 1978.

NACE CLIO	SITC																			
1	11	12	13	14	15	19	250	311	312	313	320	410	421	422	430	440	451	452	459	511
	512	513	514	515	517	541	519	542	544	545	546	548	721	751	752	1210	2111	2112	2114	2116
	2117	2119	2120	2211	2212	2213	2214	2215	2216	2217	2218	2219	2311	2421	2422	2423	2424	2429	2621	2622
	2623	2625	2626	2627	2628	2629	2911	2919	2921	2922	2923	2924	2925	2926	2927	2929	9410			
2	3214	3215	3216	3217																
3	3218	3215																		
4	3324	3318	3321	3322	3323	3325	3326	3329												
5	3412	3510	3411																	
6	5151	5153																		
7	2813	6750	6761	6762	6770	6781	6782	6783	6784	6785	2814	2820	2831	2832	2833	2834	2835	2836	2837	2839
	2840	2850	2860	6711	6712	6713	6714	6715	6721	6723	6725	6727	6729	6731	6732	6734	6735	6741	6742	6743
	6747	6748	6791	6792	6793	6811	6812	6821	6822	6831	6832	6841	6842	6851	6852	6861	6862	6871	6872	6880
	6893	6894	6895																	
8	2731	2732	2733	2734	2741	2742	2751	2752	2761	2762	2763	2764	2765	2766	2769	6611	6612	6613	6618	6623
	6624	6631	6632	6634	6635	6636	6637	6638	6639	6641	6642	6643	6644	6645	6646	6647	6648	6649	6651	6652
	6658	6664	6665	6666	6671	6672	6673	6674												
9	5152	5813	5819	6516	5811	5211	5214	2312	2662	2663	2664	2711	5714	2712	2713	2714	5121	5122	5123	5124
	5125	5126	5127	5128	5129	5131	5132	5133	5134	5135	5136	5141	5142	5143	5149	5213	5310	5321	5323	5324
	5325	5331	5332	5333	5411	5413	5414	5415	5416	5417	5419	5511	5512	5530	5541	5542	5543	5611	5612	5613
	5619	5711	5712	5713	5992	5995	5996	5997	5999	6517	6535	6536	8623	8624						
10	8951	6911	9510	6912	6913	6921	6922	6923	6931	6932	6933	6934	6941	6942	6951	6952	6960	6971	6972	6979
	6981	6982	6983	6984	6985	6986	6988	6989	8121	8123	8124									
11	7111	7112	7113	7114	7115	7116	7117	7118	7121	7122	7123	7125	7129	7151	7152	7171	7172	7173	7181	7182
	7183	7184	7185	7191	7192	7193	7195	7196	7197	7198	7199									
12	7141	7142	7143	7149	8611	8612	8613	8614	8615	8616	8617	8618	8619	8641	8642					
13	7221	7194	7222	7231	7232	7241	7242	7249	7250	7261	7262	7291	7292	7293	7294	7295	7296	7297	7299	8911
	8912	8914	8918	8919																
14	7321	7322	7323	7324	7326	7327	7328													
15	7311	7312	7313	7314	7315	7316	7317	7325	7329	7331	7333	7334	7341	7349	7351	7353	7358	7359	8941	
16	111	112	113	114	115	116	118	121	129	133	134	138	814	4111	4113					
17	221	222	223	230	240															
18	460	470	481	482	483	484	488	520	532	533	536	539	551	554	555	611	612	615	616	619
	620	711	713	722	723	730	741	742	811	812	813	819	913	914	990	4212	4213	4214	4215	4216
	4217	4221	4222	4223	4224	4225	4229	4311	4312	4313	4314									
19	1110	535	1121	1122	1123	1124														
20	1221	1222	1223																	
21	2611	2612	2613	2631	2632	2633	2634	2640	2651	2652	2653	2654	2655	2658	2670	6130	6511	6512	6513	6514
	6515	6518	6519	6521	6522	6531	6532	6533	6534	6537	6538	6539	6540	6551	6554	6555	6556	6557	6558	6559
	6561	6562	6566	6569	6574	6575	6576	6577	6578	8411	8412	8413	8414	8415	8420					
22	2118	6112	6113	6114	6119	6121	6122	6123	6129	8310	8510									
23	2411	2412	2431	2432	2433	2440	6311	6312	6314	6318	6321	6322	6324	6327	6328	6330	8210			
24	2511	2512	2515	2516	2517	2518	2519	6411	6412	6413	6414	6415	6416	6417	6419	6421	6422	6423	6429	8921
	8922	8923	8924	8929																
25	2313	5812	2314	6210	6291	6293	6294	6299	8416	8930										
26	8122	8630	8942	8944	8945	8952	8959	8943	8960	8971	8972	8991	8992	8993	8994	8995	8996	8999	9110	9610

TECHNICAL DESCRIPTION OF THE NORDHAND MODEL SYSTEM

Paal Sand and Gunnar Sollie
Central Bureau of Statistics, Oslo, Norway

1. INTRODUCTION

This paper primarily provides a technical description of the NORDHAND model system (section 3). First, however, information is provided on the incitaments for establishing the model system (section 2). The paper also provides a brief description of some of the supposed areas of application for the model system and of some lines along which the model system is supposed to be further developed (section 4).

2. BACKGROUND

The economies of the Nordic countries are small and open$^{1)}$ and, as a consequence, very sensitive to fluctuations in the world trade. In the seventies, a period characterized by uncertainty in the world economy, forecasts of future developments of exports and imports, as well as of other macroeconomic variables, have, to some extent, failed$^{2)}$. This is partly due to incorrect assumptions about the future developments of the economies of major trading partners. The need for improved treatment of foreign trade in the macroeconomic planning models is thus strongly felt by the planning authorities.

At a meeting in February 1982, government and research institutions$^{3)}$ in four Nordic countries (Denmark, Finland, Norway and Sweden) decided to establish the NORDHAND model system, a model system focusing on links, through trade, between the four countries. The NORDHAND model system is related to

---

1) The Nordic share in the world trade is about 5 per cent, while the shares of exports/imports in GDP varies from about 30 per cent for Swedish exports/imports to about 50 per cent for Norwegian exports.

2) Figures, for the Norwegian economy, showing the discrepancies between forecasted and observed values for exports, imports and other macroeconomic variables are presented in O. Bjerkholt and P. Sand: The use of a Nordic Inforum System of Input-Output Models in Norwegian Economic Planning. Paper presented to the Task Force Meeting on Input-Output Models, IIASA, Laxenburg, Austria, September 23-25, 1982.

3) The institutions are: Danmarks Statistik (Denmark), University of Oulu (Finland), Central Bureau of Statistics (Norway) and National Industrial Board (Sweden).

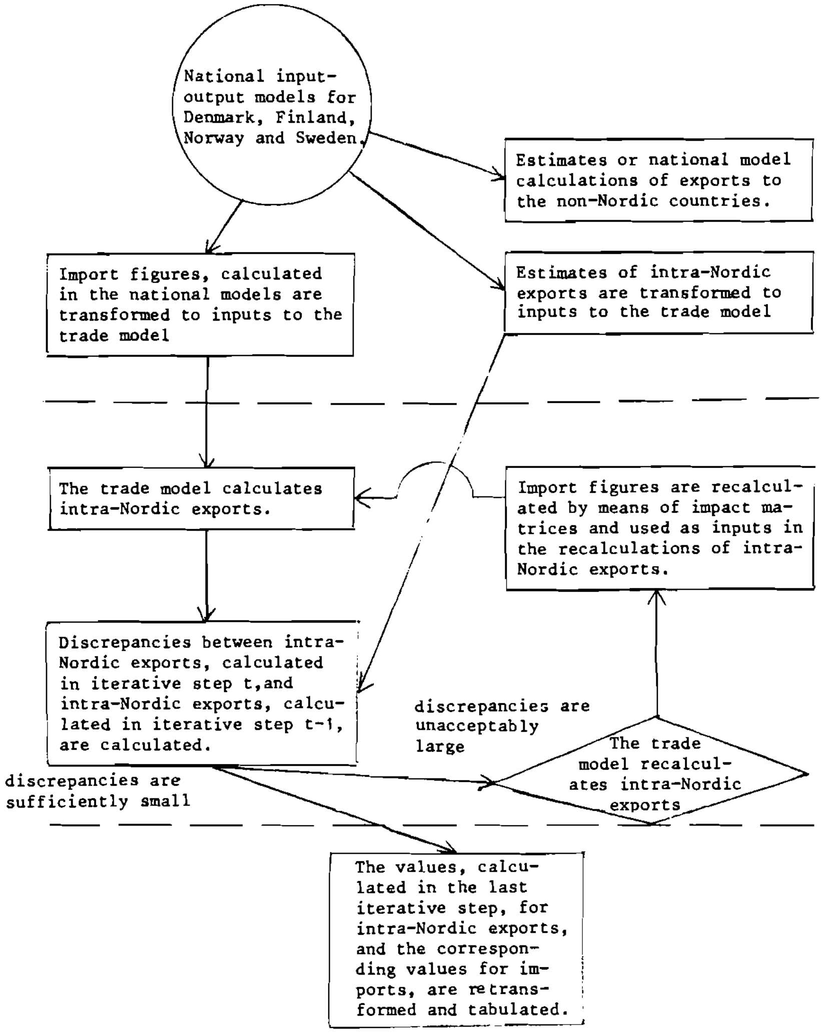
a more comprehensive model system established during the last 5-6 years on the basis of an initiative made by IIASA (International Institute for Applied Systems Analysis, Austria) and INFORUM (International Forecasting project, University of Maryland, USA).

Financially supported by Nordisk Økonomisk Forskningsråd, a first version of the NORDHAND model system is now established. In the paper at hand, a technical description of the first version is provided.

3. TECHNICAL DESCRIPTION OF THE NORDHAND MODEL SYSTEM

3.1. A brief outline of the model system

The NORDHAND model system consists of four national input-output models - one for each of the Nordic countries (excl. Iceland) - and a trade model linking these together. The figure below, and the comments attached to it,



describes, in a simple way, how the various parts of the model system are related to each other.

The trade model is represented by the area between the two dotted lines, while the areas outside these lines represent the national models. The transformations and retransformations mentioned are necessary for two reasons:

- The commodity classifications of the national models do not coincide with the commodity classification of the trade model.
- The currency used in the trade model is different from the currencies used in the national models.

The iterative process that takes place within the trade model starts from import figures calculated in the national models, transformed to satisfy the requirements of the trade model. The figures resulting from the calculations, in the trade model, of each Nordic country's intra-Nordic exports are compared to the corresponding estimates used in the national models, transformed to satisfy the requirements of the trade model. If the discrepancies are regarded to be sufficiently small, the iterative process is concluded. On the other hand, if the discrepancies are regarded to be unacceptably large, the iterative process continues by recalculations, in the trade model, of each Nordic country's intra-Nordic exports. The necessary inputs of import figures in these recalculations are estimated by means of impact matrices, derived from the national models. The iterative process, as described above, continues until the discrepancies mentioned above are regarded to be sufficiently small.

3.2. The equation system of the trade model

The trade model presented below is a simple quantity model and should be regarded as the first step towards a more elaborate trade model.

The basic relation in the trade model is the relation for country k's[1] intra-Nordic exports:

$$(1) \quad X^{k} = \Gamma^{k} \circ \sum_{l \neq k} (M^{kl} \circ \Lambda^{kl} \circ B^{l})$$ [2]

where

---

[1] In this paper, except where it is explicitly stated not to be the case, k, l = D, F, N, S where D, F, N and S denote Denmark, Finland, Norway and Sweden, respectively.

[2] The symbol o means element by element multiplication of vectors (or matrices) and requires that the vectors (or matrices) involved are of the same order: $Z = X \circ Y$, where X and Y are vectors (of the same order) means that $Z_i = X_i \cdot Y_i$ for all i.

X^k = vector1) of intra-Nordic exports of NORDHAND-commodities2) from country k; constant (1980-) prices; US$.

Γ^k = vector of correction parameters for intra-Nordic exports of NORDHAND-commodities from country k;

$M^{kl}(k \neq l)$ = vector of market shares by (NORDHAND-) commodity of country k in country l's imports3).

$\Lambda^{kl}(k \neq l)$ = vector of parameters for exogenous adjustments of the market shares by (NORDHAND-) commodity of country k in country l's imports;

B^l = vector of imports of NORDHAND-commodities to country l; constant (1980-) prices; US$.

The parameters for exogenous adjustments, the elements of $\Lambda^{kl}(k \neq l)$, are initially given by

(2) $\Lambda^{kl} = e$4) $\qquad k \neq l$

and is introduced to be able, in a simple way, to adjust the intra-Nordic market shares. Instead of adjusting the elements of $M^{kl}(k \neq l)$ directly, we substitute the initial values of the elements of $\Lambda^{kl}(k \neq l)$ by alternative values, different from 15).

Given the particular role of $\Lambda^{kl}(k \neq l)$, (1) could be expressed in the following way: Country k's intra-Nordic exports of NORDHAND-commodities is equal to the other Nordic countries imports of NORDHAND-commodities from country k, corrected (by means of Γ^k) to account for cif-fob factors and other sources of deviations between figures reported by exporting countries and figures reported by importing countries.

Before the iterative process, briefly described in section 3.1, is started, the correction parameters, the elements of Γ^k, are calculated on the basis of actual figures for 1980, for country k's intra-Nordic exports of NORDHAND-commodities and for the other Nordic countries' imports of NORDHAND-commodities:

---

1) The number of commodities classified according to the commodity classification of the trade model is 36, and in this paper, except where it is explicity stated not to be the case, all vectors are of order $(36 \cdot 1)$.

2) The term NORDHAND-commodities is used to denote the commodities of the trade model.

3) These market shares are calculated on the basis of actual figures, from OECD's trade statistics, for 1980.

4) e is a column vector with all elements equal to 1.

5) Analyses of the effects of policy measures affecting the intra-Nordic market shares can thereby be linked to the trade model through $\Lambda^{kl}(k \neq l)$.

$$(3)\quad \Gamma^k = X^k(T{=}0) \circ \mathrm{INV} \sum_{l \neq k} \left(M^{kl} \circ \Lambda^{kl} \circ B^l(T{=}0)\right)$$ [1]

where $X^k(T{=}0)$ and $B^l(T{=}0)$ are identical to X^k and B^l, respectively, except for the fact that their elements are actual figures for 1980[2].

Country k's intra-Nordic exports and country k's imports are calculated in an iterative process. In each iterative step, country k's intra-Nordic exports of NORDHAND-commodities are calculated on the basis of figures, calculated in the preceding iterative step, for the other Nordic countries' imports of NORDHAND-commodities. Formally, this procedure is described by

$$(4)\quad X^k_t = \Gamma^k \circ \sum_{l \neq k} \left(M^{kl} \circ \Lambda^{kl} \circ B^l_{t-1}\right)$$

where, compared to (1), the subscripts t and t-1, denoting iterative steps, have been added.

In each iterative step, rates of change of country k's intra-Nordic exports of NORDHAND-commodities are calculated:

$$(5)\quad \dot{X}^k_t = \widehat{X^k_{t-1}}^{\,-1} \cdot \left(X^k_t - X^k_{t-1}\right)$$ [3]

The iterative process continues until the following condition is satisfied:

$$(6)\quad |\dot{X}^k_t| \leqq \varepsilon \cdot e$$ [4]

where ε is the acceptability limit for the values of the elements of $|\dot{X}^k_t|$.

As long as the iterative process continues, new values for the elements of X^k are calculated as described by (4). Through the relations in the national models, the new values for the elements of X^k generate new values for the elements of B^k. This fact is accounted for by means of the following relation:

$$(7)\quad B^k_t = \left(V^k \cdot \dot{X}^k_t + e\right) \circ B^k_{t-1}$$

where the subscripts t and t-1 denote iterative steps. V^k is the impact matrix (cfr. section 3.1) derived from the national model of country k.

1) The symbol INV attached to a vector (or a matrix) means that each element of the vector (or the matrix) is substituted by its inverse: $Y = \mathrm{INV}\ X$, where X is a vector, means that $Y_i = 1/X_i$ for all i.

2) These figures are figures from OECD's trade statistics.

3) The symbol ^ attached to a vector means a diagonal matrix with the elements of the vector along the main diagonal. The symbols t and t-1 denote iterative steps.

4) The symbol | | attached to a vector means that each element of the vector is substituted by its numerical value.

The j'th element of the i'th row of V^k [1], represents the percentage impact on country k's imports of NORDHAND-commodity i of a one percentage increase in country k's intra-Nordic exports of NORDHAND-commodity j. In this context it should be noted that the use of impact matrices is a simplification compared to ordinary calculations in the national models, and that the main reason for using impact matrices is to make the model system easier manageable.

The iterative process, formally described above, is started by setting

$$X^k_{t-1} = X^k_o \qquad (8)$$
$$B^k_{t-1} = B^k_o$$

where

X^k_o = vector of intra-Nordic exports of NORDHAND-commodities from country k, transformed from estimates used in the national model of country k; constant (1980-) prices; US$.

B^k_o = vector of imports of NORDHAND-commodities to country k, transformed from figures calculated in the national model of country k; constant (1980-) prices; US$.

The values of country k's intra-Nordic exports of NORDHAND-commodities (the values of the elements of X^k), calculated in the last iterative step, and the corresponding values of country k's imports of NORDHAND-commodities (the values of the elements of B^k) are the outputs of the trade model.

3.3. Construction of impact matrices used in the trade model

The construction of the impact matrices used in the trade model necessarily involves (cfr. the definition of V^k in section 3.2) the problems of transformation and retransformation mentioned in section 3.1[2].

The links between the commodity classification of the national model of country k and the commodity classification of the trade model are given by two value transformation matrices, T_{Ak} and T_{Mk}. The typical element of T_{Ak}, t^{Ak}_{ij}, represents exports of those micro-commodities[3] that simultaneously belong[4] to commodity i of the national model of country k and NORDHAND-

---

[1] The matrix V^k is of order $(36 \cdot 36)$.

[2] It should be noted, however, that the fact that the currency used in the trade model is different from the currencies used in the national models represents no problem in the construction of the impact matrices used in the trade model, since the elements of these matrices represent the percentage impacts on imports of percentage increases in intra-Nordic exports.

[3] The term "micro-commodities" is used to denote the one-, two- and three-digit SITC-commodities of which the NORDHAND-commodities are aggregates.

[4] The value transformation matrices are constructed on the basis of actual figures for 1980, expressed in the national currency of the country in question.

commodity j. The value transformation matrices are formally (and implicitly) defined by (9)-(12):

$$(9) \quad T_{Ak} \cdot e = \tilde{A}^k_N$$

where

$\tilde{A}^k_N$ = exports, from country k, of those components of the commodities of the national model of country k that are classifiable in terms of SITC-commodities1); actual figures for 1980; national currency of country k; vector of order $(n^k \cdot 1)$2).

$$(10) \quad T'_{Ak} \cdot e = A^k$$

where

A^k = vector of exports of NORDHAND-commodities from country k; actual figures for 1980; national currency of country k.

$$(11) \quad T_{Mk} \cdot e = \tilde{M}^k_N$$

where

$\tilde{M}^k_N$ = imports, to country k, of those components of the commodities of the national model of country k that are classifiable in terms of SITC-commodities; actual figures for 1980; national currency of country k; vector of order $(n^k \cdot 1)$.

$$(12) \quad T'_{Mk} \cdot e = M^k$$

where

M^k = vector of imports of NORDHAND-commodities to country k; actual figures for 1980; national currency of country k.

From the definitions of the matrices T_{Ak} and T_{Mk} it follows that they are both of order $(n^k \cdot 36)$.

The impact matrix is defined by:

$$(13) \quad V^k = W^k \cdot \widehat{\bar{A}^k} \cdot \widehat{A^k}^{-1}$$

where

$\bar{A}^k$ = vector of intra-Nordic exports of NORDHAND-commodities from country k; actual figures for 1980; national currency of country k.

and where W^k is a matrix3), the typical element of which, w^k_{ij}, representing

---

1) In this context it should be noted that the commodities of the national models also contain components that are not classifiable in terms of SITC-commodities.

2) n^k is the number of commodities of the national model of country k.

3) The matrix W^k is of order $(36 \cdot 36)$.

the percentage impact on country k's imports of NORDHAND-commodity i of a one percentage increase in country k's exports of NORDHAND-commodity j. (13) implies that each element of V^k is proportional to the corresponding element of W^k, with the share of intra-Nordic exports in total exports as the proportionality factor.

In the following it is shown how the matrix W^k is constructed:

i. The matrix Z^k [1], the typical element of which, z_{ij}^k, representing the percentage increase in country k's exports of commodity i of the national model of country k that correspond to a one percentage increase in country k's exports of NORDHAND-commodity j, is constructed. The following relation applies:

$$(14) \quad Z^k = 0{,}01 \cdot \widehat{A_N^k}^{-1} \cdot T_{Ak}$$

where

A_N^k = exports, from country k, of the commodities of the national model of country k; actual figures for 1980; national currency of country k; vector of order $(n^k \cdot 1)$.

ii. The columns of Z^k are used as inputs in impact calculations in the national model of country k. The output from these calculations is a matrix U^k [2], the typical element of which, u_{ij}^k, representing the percentage impact on country k's imports of commodity i of the national model of country k of a one percentage increase in country k's exports of NORDHAND-commodity j.

iii. The matrix W^k, defined above, is constructed. The following relation applies:

$$(15) \quad W^k = \widehat{M^k}^{-1} \cdot T'_{Mk} \cdot U^k$$

The impact matrix, to be used in the trade model, for country k, results from inserting (15) into (13):

$$(16) \quad V^k = \widehat{M^k}^{-1} \cdot T'_{Mk} \cdot U^k \cdot \widehat{\bar{A}^k} \cdot \widehat{A^k}^{-1}$$

3.4. Transforming estimates used in, and outputs from, the national models and retransforming outputs from the trade model

The procedure of transforming estimates used in, and outputs from, the national model of country k to satisfy the requirements of the trade model requires two share transformation matrices, T_{SAk} and T_{SMk}. The typical element of T_{SAk}, t_{ij}^{SAk}, represents the share in total exports of commodity j of the national model of country k accounted for by exports of those micro-commodities that simultaneously belong [3] to commodity j of the national model of country k and NORDHAND-commodity i. The typical element of T_{SMk}, t_{ij}^{SMk} represents the share in total imports of commodity j of the national model of country k accounted for by imports of those micro-commodities that simultaneously belong to commodity j of the national model of country k and NORDHAND-commodity i. The share transformation matrices are formally defined by (17) and (18):

---

1) The matrix Z^k is of order $(n^k \cdot 36)$.

2) The matrix U^k is of order $(n^k \cdot 36)$.

3) The share transformation matrices are constructed on the basis of actual figures for 1980, expressed in the national currency of the country in question.

$$(17)\quad T_{SAk} = T'_{Ak} \cdot \widehat{INV\ \tilde{A}^k_N} \quad \text{1) 2)}$$

$$(18)\quad T_{SMk} = T'_{Mk} \cdot \widehat{INV\ \tilde{M}^k_N} \quad \text{3) 4)}$$

From the definitions of the matrices T_{SAk} and T_{SMk} it follows that they are both of order $(36 \cdot n^k)$.

As mentioned in section 3.1, the currency used in the trade model5) is different from the currencies used in the national models. Taking account of this fact, the following relation for transforming estimates, used in the national model of country k, of country k's intra-Nordic exports, applies6):

$$(19)\quad X^k_o = c^k \cdot T_{SAk} \cdot \tilde{\bar{A}}^k_{No} \quad \text{7)}$$

where

c^k = units of US\$ per unit of the national currency of country k; figures for the year under consideration.

$\tilde{\bar{A}}^k_{No}$ = estimates, used in the national model of country k, of country k's intra-Nordic exports of those components of the commodities of the national model of country k that are classifiable in terms of SITC-commodities; national currency of country k; vector of order $(n^k \cdot 1)$.

Analogously, the following relation for transforming figures for country k's imports, calculated in the national model of country k, applies:

$$(20)\quad B^k_o = c^k \cdot T_{SMk} \cdot \tilde{M}^k_{No} \quad \text{8)}$$

where

---

1) The matrix T_{Ak} and the vector $\tilde{A}^k_N$ are defined in section 3.3.

2) If the matrix $\tilde{A}^k_N$ had satisfied the conditions for invertibility of matrices, $\widehat{INV\ \tilde{A}^k_N} = \widehat{\tilde{A}^k_N}^{-1}$. However, as will be returned to below, the vector $\tilde{A}^k_N$ contains some elements that are equal to 0 and, consequently the matrix $\widehat{\tilde{A}^k_N}^{-1}$ is not defined.

3) The matrix T_{Mk} and the vector $\tilde{M}^k_N$ are defined in section 3.3.

4) If the matrix $\tilde{M}^k_N$ had satisfied the conditions for invertibility of matrices, $\widehat{INV\ \tilde{M}^k_N} = \widehat{\tilde{M}^k_N}^{-1}$. However, as will be returned to below, the vector $\tilde{M}^k_N$ contains some elements that are equal to 0 and consequently, the matrix $\widehat{\tilde{M}^k_N}^{-1}$ is not defined.

5) The currency in the trade model is US\$.

6) (19), and also (21), applies under the assumption that the internal composition (in terms of micro-commodities) of country k's exports (classifiable in terms of SITC-commodities) of each commodity of the national model of country k is unaffected by destinational factors.

7) The vector X^k_o is defined in section 3.2.

8) The vector B^k_o is defined in section 3.2.

$\tilde{M}^k_{No}$ = figures, calculated in the national model of country k, for country k's imports of those components of the commodities of the national model of country k that are classifiable in terms of SITC-commodities; national currency of country k; vector of order $(n^k \cdot 1)$.

In section 3.3 it was noted that the commodities of the national models contain components that are not classifiable in terms of SITC-commodities. In fact, exports/imports of some commodities of the national models contain only components that are not classifiable in terms of SITC-commodities[1].

This means that the vectors $\tilde{A}^k_N$ and $\tilde{M}^k_N$ contain elements that are equal to 0. This further means that (cfr. (9) and (11)) the matrices T_{Ak} and T_{Mk} contain rows in which all elements are equal to 0 and, correspondingly that (cfr. (17) and (18)) the matrices T_{SAk} and T_{SMk} contain columns in which all elements are equal to 0. In the following, the matrices that are identical to T_{SAk} and T_{SMk}, respectively, except for the fact that the columns in which all elements are equal to 0 have been deleted, are denoted T^*_{SAk} and T^*_{SMk}[2].

We now present a procedure for transforming outputs from the trade model that is appliable for those k for which $n^{k*} < 36$[3].

The vector of outputs (from the trade model) for country k's intra-Nordic exports is, in the following, denoted $X^k_{(fin)}$. For transforming outputs (from the trade model) of country k's intra-Nordic exports, the following relation applies:

$$(21) \quad \bar{\tilde{A}}^{k*}_{N(fin)} = \frac{1}{c^k} \cdot (T^{*\Delta}_{SAk})^{-1} \cdot X^{k\Delta}_{(fin)} \quad ^{4)}$$

where $T^{*\Delta}_{SAk}$ is identical to T^*_{SAk} except for the fact that $36 - n^{k*}$ rows have been deleted[5] and where $X^{k\Delta}_{(fin)}$ is identical to $X^k_{(fin)}$ except for the fact that the corresponding $36 - n^{k*}$ elements have been deleted.

The vector of outputs (from the trade model) for country k's imports is, in the following, denoted $B^k_{(fin)}$. For transforming outputs (from the trade

---

[1] In other words exports/imports of these commodities consist exclusively of items (e.g. services) that are not classifiable in terms of SITC-commodities.

[2] The matrices T^*_{SAk} and T^*_{SMk} are both of order $(36 \cdot n^{k*})$, where n^{k*} is the number of columns in T_{SAk} and T_{SMk} containing elements different from 0.

[3] This condition is satisfied at least for the Norwegian national model, MODAG.

[4] If the vector $\bar{\tilde{A}}^{k*}_{N(fin)}$, defined by (21) and being of order $(n^{k*} \cdot 1)$, is extended to include the $n^k - n^{k*}$ zero elements that correspond to the $n^k - n^{k*}$ columns of T_{SAk} that was deleted in order to arrive at the matrix T^*_{SAk}, we arrive at the vector $\bar{\tilde{A}}^k_{N(fin)}$ which is the vector $X^k_{(fin)}$ transformed to satisfy the requirements of the national model of country k.

[5] It should be noted that this deletion have to be done in such a way that the resulting matrix, $T^{*\Delta}_{SAk}$, which is of order $(n^{k*} \cdot n^{k*})$, satisfy the conditions for invertibility of matrices.

model) of country k's imports, the following relation applies:

$$(22)\quad \tilde{M}^{k*}_{N(fin)} = \frac{1}{c^k} \cdot (T^{*\Delta}_{SMk})^{-1} \cdot B^{k\Delta}_{(fin)} \quad ^{1)}$$

where $T^{*\Delta}_{SMk}$ is identical to T^{*}_{SMk} except for the fact that 36 - n^{k*} <u>rows</u> have been deleted[2] and where $B^{k\Delta}_{(fin)}$ is equal to $B^{k}_{(fin)}$ except for the fact that the corresponding 36 - n^{k*} <u>elements</u> have been deleted.

3.5. Summary of the technical description

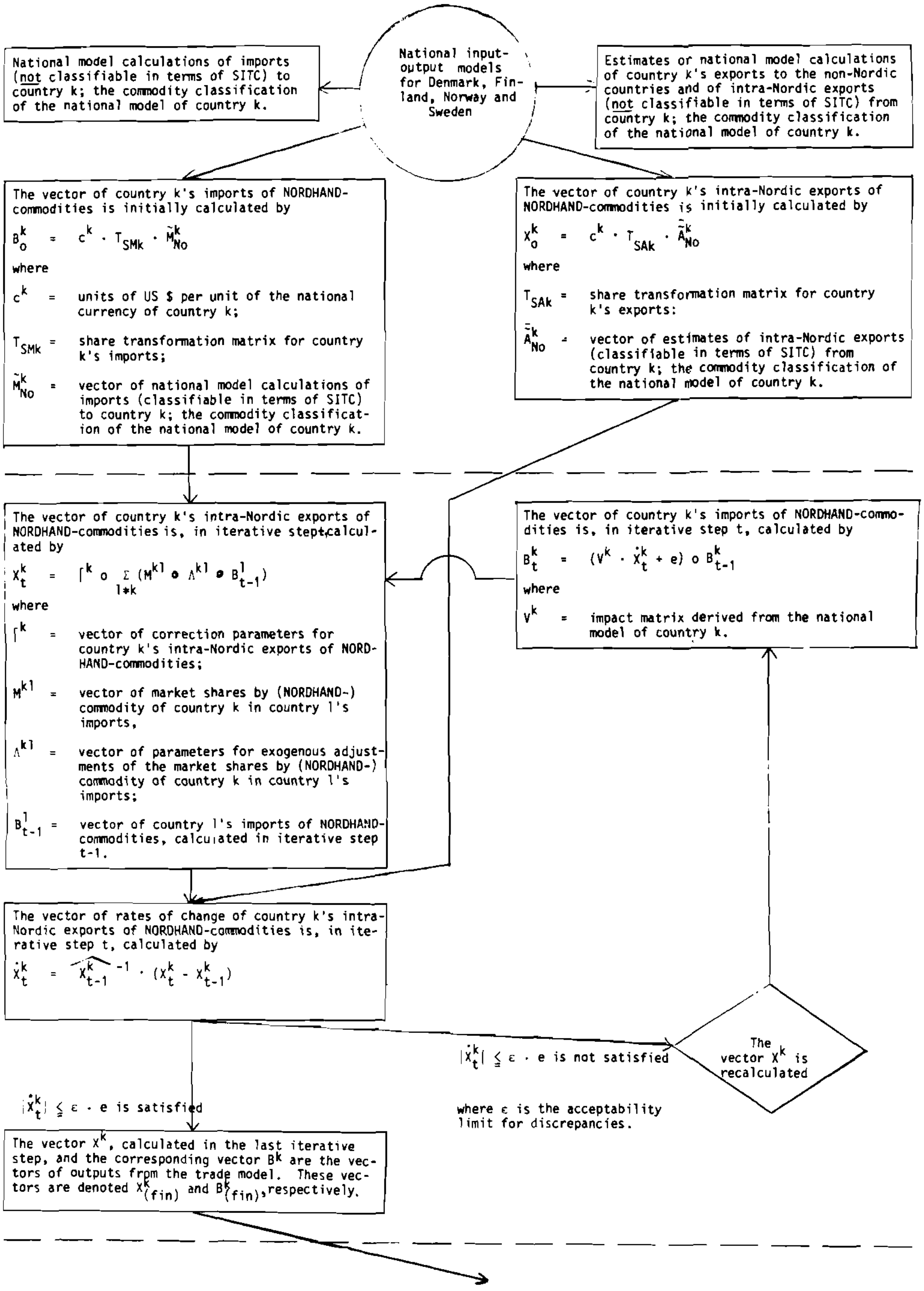
The technical description of the model system is, in the following, briefly summarized in the form of a flow-chart by means of which the interrelations between the various parts of the model system should become particularly apparent. This flow-chart, which is presented below, is a more precise version of the figure presented in section 3.1[3].

---

[1] If the vector $\tilde{M}^{k*}_{N(fin)}$, defined by (22) and being of order (n^{k*} · 1), is extended to include the n^{k} - n^{k*} zero elements that correspond to the n^{k} - n^{k*} columns of T_{SMk} that was deleted in order to arrive at the matrix T^{*}_{SMk}, we arrive at the vector $\tilde{M}^{k}_{N(fin)}$ which is the vector $B^{k}_{(fin)}$ transformed to satisfy the requirements of the national model of country k.

[2] It should be noted that this deletion have to be done in such a way that the resulting matrix, $T^{*\Delta}_{SMk}$, which is of order (n^{k*} · n^{k*}), satisfy the conditions for invertibility of matrices.

[3] For more precise definitions of the symbols defined in the flow-chart, cfr. sections 3.2 - 3.4.



National input-output models for Denmark, Finland, Norway and Sweden

National model calculations of imports (not classifiable in terms of SITC) to country k; the commodity classification of the national model of country k.

Estimates or national model calculations of country k's exports to the non-Nordic countries and of intra-Nordic exports (not classifiable in terms of SITC) from country k; the commodity classification of the national model of country k.

The vector of country k's imports of NORDHAND-commodities is initially calculated by

$$B_o^k = c^k \cdot T_{SMk} \cdot \tilde{M}_{No}^k$$

where

c^k = units of US $ per unit of the national currency of country k;

T_{SMk} = share transformation matrix for country k's imports;

$\tilde{M}_{No}^k$ = vector of national model calculations of imports (classifiable in terms of SITC) to country k; the commodity classification of the national model of country k.

The vector of country k's intra-Nordic exports of NORDHAND-commodities is initially calculated by

$$X_o^k = c^k \cdot T_{SAk} \cdot \tilde{A}_{No}^k$$

where

T_{SAk} = share transformation matrix for country k's exports:

$\tilde{A}_{No}^k$ = vector of estimates of intra-Nordic exports (classifiable in terms of SITC) from country k; the commodity classification of the national model of country k.

The vector of country k's intra-Nordic exports of NORDHAND-commodities is, in iterative step t, calculated by

$$X_t^k = \Gamma^k \circ \sum_{l \neq k} (M^{kl} \circ \Lambda^{kl} \circ B_{t-1}^l)$$

where

Γ^k = vector of correction parameters for country k's intra-Nordic exports of NORDHAND-commodities;

M^{kl} = vector of market shares by (NORDHAND-) commodity of country k in country l's imports,

Λ^{kl} = vector of parameters for exogenous adjustments of the market shares by (NORDHAND-) commodity of country k in country l's imports;

B_{t-1}^l = vector of country l's imports of NORDHAND-commodities, calculated in iterative step t-1.

The vector of country k's imports of NORDHAND-commodities is, in iterative step t, calculated by

$$B_t^k = (V^k \cdot \dot{X}_t^k + e) \circ B_{t-1}^k$$

where

V^k = impact matrix derived from the national model of country k.

The vector of rates of change of country k's intra-Nordic exports of NORDHAND-commodities is, in iterative step t, calculated by

$$\dot{X}_t^k = \widehat{X_{t-1}^k}^{-1} \cdot (X_t^k - X_{t-1}^k)$$

$|\dot{X}_t^k| \leqq \varepsilon \cdot e$ is not satisfied

where ε is the acceptability limit for discrepancies.

The vector X^k is recalculated

$|\dot{X}_t^k| \leqq \varepsilon \cdot e$ is satisfied

The vector X^k, calculated in the last iterative step, and the corresponding vector B^k are the vectors of outputs from the trade model. These vectors are denoted $X_{(fin)}^k$ and $B_{(fin)}^k$, respectively.

(continued opposite)

The vectors $\tilde{\bar{A}}^{k*}_{N(fin)}$ and $\tilde{M}^{k*}_{N(fin)}$ are calculated by

$$\tilde{\bar{A}}^{k*}_{N(fin)} = \frac{1}{c^k} \cdot (T^{*\Delta}_{SAk})^{-1} \cdot X^{k\Delta}_{(fin)} \quad \text{and}$$

$$\tilde{M}^{k*}_{N(fin)} = \frac{1}{c^k} \cdot (T^{*\Delta}_{SMk})^{-1} \cdot B^{k\Delta}_{(fin)},$$

respectively. $T^{*\Delta}_{SAk}$, $X^{k\Delta}_{(fin)}$, $T^{*\Delta}_{SMk}$ and $B^{k\Delta}_{(fin)}$ deviate from T_{SAk}, $X^{k}_{(fin)}$, T_{SMk} and $B^{k}_{(fin)}$, respectively, in the ways described in section 3.4. When the vectors $\tilde{\bar{A}}^{k*}_{N(fin)}$ and $\tilde{M}^{k*}_{N(fin)}$ are calculated, the vectors $\tilde{\bar{A}}^{k}_{N(fin)}$ and $\tilde{M}^{k}_{N(fin)}$ are easily obtained in the way described in section 3.4.

The vectors $\tilde{\bar{A}}^{k}_{No}$ and $\tilde{M}^{k}_{No}$ are substituted by the vectors $\tilde{\bar{A}}^{k}_{N(fin)}$ and $\tilde{M}^{k}_{N(fin)}$, respectively.

4. AREAS OF APPLICATION FOR AND FURTHER DEVELOPMENT OF THE NORDHAND MODEL SYSTEM

In section 3, a technical description of the NORDHAND model system was provided. In this section some types of problems for which the model system is supposed to be applied and some of the lines along which the model system is supposed to be further developed are briefly described.

Some of the supposed areas of application for the NORDHAND model system are the following ones:

a) Making a prognosis for the future development of imports and of intra-Nordic exports[1] under the assumption of constant intra-Nordic market shares, and under reasonable assumptions about the economic policies pursued in the Nordic countries and about the development of the world economy.

b) Making prognoses for the future development of imports and of intra-Nordic exports.[2]
   - under alternative assumptions about the development of the intra-Nordic market shares.
   - under the assumption of an expansive economic policy pursued unilaterally in one of the Nordic countries.
   - under the assumption of coordinated expansive economic policies in the Nordic countries.

c) Analyzing the effects on imports and on intra-Nordic exports of

---

1) Through the relations in the national models it is then possible to make a prognosis, consistent with the prognosis for the future development of imports and of intra-Nordic exports, for the future development of other variables.

2) Through the relations in the national models it is then possible to make prognoses, consistent with the prognoses for the future development of imports and of intra-Nordic exports, for the future development of other variables.

various policy measures used in one or more of the Nordic countries.

The technical description provided by section 3 is a technical description of a first version of the NORDHAND model system. Some of the lines along which this first version is supposed to be further developed are the following ones:

a) Making the model system more comprehensive in the sense of including non-Nordic countries.

b) Making the national models more similar with respect to model structure.

c) Making the trade model more elaborate by incorporating price relations.

THE EXTERNAL TRADE DATA IN THE NORDHAND PROJECT: A SHORT DESCRIPTION OF THE STRUCTURE AND DEVELOPMENT OF TRADE BETWEEN THE NORDIC COUNTRIES, 1970–1981

Bent Thage and Arvid Stentoft Jakobsen
Danmarks Statistik, Copenhagen, Denmark

1 The trade data

For each of the four countries Denmark, Finland, Norway and Sweden there has for the period 1970-81 been established the following data on an annual basis:

(a) Exports and imports of commodities subdivided according to 12 countries/country groups and 36 commodity groups. The subdivisions have been chosen specifically to allow study of the main characteristics of the Nordic foreign trade, but at the same time the disaggregation has been kept at a manageable level. The countries/country groups are shown in table 2 and the commodity groups in table 3. The commodity groups are aggregated from two or three digit SITC, and are also defines so as to be aggregates of the 119 commodity groups defined in the IIASA/INFORUM project. The data have in all cases been established directly from the national foreign trade statistics. So for each of the four countries there exist two 36 x 12 matrices (one for exports and one for imports) for each of the twelve years 1970-81 and an updating to cover 1982 as well is at present taking place.

(b) Unit values for exports and imports for each of the 36 commodity groups for 1970-81. The unit values exist for each of the four countries, but are not further disaggregated by exporting or importing country. With a few exceptions the unit values are calculated from the OECD foreign trade data.

(c) Average annual axchange rate from national currencies to US dollars published in OECD: Statistics of Foreign Trade, Series A.

By means of (c) it is possible to transform the data mentioned in (a) into a common unit, US dollars, in current prices and by means of (b) further to make the transformation into a constant price concept which can be taken as a measure of volume.

The following analysis is based exclusively on trade data converted into US dollars. It should, however, be kept in mind that this transformation usually will give a growth in trade (in current prices) different from the one measured in the national currency, as the exchange rate varies over time. The measures at constant prices will not be so influenced, but for the aggregates they will of course depend on the choice of base year.

It is pointed out that these data and the subsequent analysis cover only commodities whereas services have been left out both for practical and theoretical reasons. In the total balance of payments context services do however play a considerable role in the Nordic countries. Of the total imports of goods and services in 1981 services counted for 30 per cent in Norway and about 15 per cent in the three other countries. For exports the percentages were about 20 for Finland and Sweden, 25 for Denmark, and 33 for Norway. The level of these percentages has been rather stable over the last decade.

2 The "country papers"

In order to obtain a first impression of the structure and development of the Nordic trade it was in the beginning of 1983 decided, that the participants in the Nordhand project from each country should work out an analysis for the period 1970-81 based on their own data organized in a number of standard tables (and converted into US dollars). These papers are now available for Denmark, Norway and Sweden and shortly also for Finland. The papers each cover 20-25 pages and are not available in English. As these papers are themselves summaries of the developments in the period 1970-81 it is easily understood that within the limits of this paper it is only possible to give a rather fragmentary descriptive analysis. This analysis is based exclusively on the standard tables in the "country papers".

3. The structure in 1981

In table 1 is shown imports and exports of commodities for each of the four countries. These figures are also related to gross domestic product (GDP). This reveals a striking similarity between the countries as fas as dependence on foreign trade is concerned. Exports and imports make up about 25-30 per cent of GDP in all four countries. When it comes to the dependence in intranordic trade the picture is a bit more varied, but generally speaking the level is about 20 per cent of total trade.

Table 2 shows for each country the percentage distribution of exports and imports on the 12 countries/country groups used in Nordhand. To be noticed is the big part of Norwegian exports going to UK (natural gas and crude oil) and that Eastern Europe is the most important trading partner for Finland. Apart from this the patterns for distribution on geographical areas are quite identical, and if you did not know it would be hard to tell from the figures that Denmark is the only Nordic member of the EEC. In fact for all four countries the EEC is a much more important trading partner than the Nordic countries.

In table 3 is shown a distribution of total Nordic exports on the 36 commodities. For each commodity is also shown how much is exported to countries outside the Nordic area. The overall per cent is 79,5, but there is a considerable variation between commodities. To be noticed is the big share which rather primary products have in total Nordic exports. It concerns gas and crude oil (Norway), ores (Sweden), food (Denmark), wood products and paper (Finland, Norway and Sweden), iron and other metals (Sweden, Norway). It is also characteristic that these commodities only to a limited extend are traded between the Nordic countries, where more manufactured products are dominating. Whereas about 90 per cent of the above mentioned products are exported to countries outside the Nordic area, this is only the case for about 70 per cent of the more fabricated products (see bottom of table 3).

4. The developments 1970-81

The average annual growth rates 1970-81 at constant prices are shown in table 4. With two exceptions (imports to Norway and Sweden) trade with countries outside the Nordic area has had a faster growth in volume than intranordic trade. The trade between Denmark and Sweden has in particular had a slow growth. On the other hand no negative growth rates are found. All four countries have experienced a faster growth in exports than in imports over the period. This can be seen as the real adjustment to the deterioration in the terms of trade caused by increase in energy prices,

Table 1 Main characteristics of Nordic foreign trade 1981 (Mill. US dollars)

	Denmark	Finland	Norway	Sweden
GDP	58.134	49.127	57.138	112.494
Imports	17.431	14.199	15.625	28.867
Exports	15.975	13.976	18.165	28.562
Percentage share of GDP:				
Imports	30,0	28,9	27,3	25,7
Exports	27,5	28,4	31,8	25,4
Percentage share of foreign trade with other Nordic countries:				
Imports	20,1	16,0	26,9	19,0
Exports	19,8	21,4	14,9	23,9

Table 2 Distribution of Nordic foreign trade by country 1981 (Current prices)

		Denmark		Finland		Norway		Sweden	
		Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
1	Denmark	.	.	3,3	2,2	4,1	6,1	7,8	6,2
2	Finland	2,1	3,7	.	.	1,8	4,4	6,5	6,6
3	Norway	6,2	4,3	4,7	2,5	.	.	9,6	6,1
4	Sweden	11,5	12,0	13,4	11,3	9,0	16,4	.	.
1-4	Nordic countries	19,8	20,1	21,4	16,0	14,9	26,9	23,9	18,9
5	UK	13,6	11,9	10,7	8,1	40,0	13,6	10,0	12,0
6	Germany FR	16,7	18,6	9,1	12,1	17,9	14,7	11,3	16,2
7	Other EEC countries	15,0	16,8	12,1	10,1	8,8	11,9	17,4	14,3
8	USA, Japan, Canada	8,9	12,7	5,0	11,8	5,1	17,7	8,3	12,5
9	Other OECD countries	6,1	4,4	4,5	4,4	3,4	4,9	7,9	5,8
10	Eastern Europe	1,8	3,7	26,5	26,5	1,4	2,6	3,7	4,4
11	OPEC-countries	5,7	3,3	4,4	5,8	2,0	1,7	7,0	9,3
12	Other countries	12,3	8,7	6,5	5,2	6,5	6,1	10,6	6,4
Total		100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

Table 3 Exports 1981. From the Nordic area, total and to the rest of the world (Current prices. Mill. US dollars)

Commodity[1]	Total exports from the four Nordic countries 1	Of which to other than Nordic countries 2	Export share to rest of the world (=2/1) 3
1. Agricultural products	1.798,7	1.518,9	84,4
2. Fishery products	1.345,1	1.165,3	86,6
3. Forestry products	286,7	98,7	34,4
4. Coal	63,9	21,9	34,2
5. Gas	3.012,2	3.000,6	99,6
6. Crude oil	5.412,8	5.241,9	96,8
7. Petroleum products	2.874,4	1.325,6	46,1
8. Electric power	314,6	60,7	19,3
9. Iron ore	426,6	392,9	92,1
10. Other ores and minerals	496,2	365,5	73,7
11. Food products	5.630,2	4.971,8	88,3
12. Beverage and tobacco	272,7	224,8	82,4
13. Textiles	1.550,0	857,2	55,3
14. Clothing, leather, footwear .	1.432,7	754,2	52,6
15. Sawn and planed wood	2.022,7	1.762,9	87,2
16. Furniture (also of metals) ..	1.152,5	782,5	67,9
17. Other wood products	1.096,8	842,5	76,8
18. Wood pulp	2.436,5	2.323,9	95,4
19. Paper and paper products	6.694,5	5.945,4	88,8
20. Printing and publishing	283,0	127,8	45,2
21. Rubber products	297,0	174,2	58,7
22. Primary chemicals and plastics	2.454,7	1.763,4	71,8
23. Other chemicals and plastic products	3.028,5	2.090,4	69,0
24. Non-metallic mineral building materials..................	570,4	393,0	68,9
25. Glass and ceramic products ..	158,4	93,4	59,0
26. Iron and steel	3.197,2	2.439,1	76,3
27. Non-ferrous metals	2.550,1	2.123,5	83,3
28. Metal products	2.298,5	1.554,4	67,6
29. Non-electric machinery	9.551,1	7.561,3	79,2
30. Electric machinery	3.991,4	2.968,8	74,4
31. Motor vehicles	3.982,4	3.163,5	79,4
32. Ships, oilrigs, etc.	2.944,7	2.513,6	85,4
33. Other transport equipment ...	414,1	273,9	66,1
34. Precision instruments	1.158,3	924,8	79,8
35. Other manufacturing products.	654,2	434,9	66,5
36. Other products	237,0	217,3	91,7
Total	76.086,6	60.471,1	79,5
Sum of commodities No. 5, 6, 9, 10, 11, 15, 17-19, 26, 27	32.975,8	29.410,0	89,2
Sum of other commodities	43.110,8	31.061,1	72,0

---

[1] An exact description of each commodity in terms of SITC is given by Paal Sand and Gunnar Sollie in "Technical description of the Nordhand model system" also presented at this conference.

although in the case of Norway this explanation is not valid.

In table 4 the growth rate of each trade flow is given twice, namely partly seen from the exporters point of view and partly seen from the importers point of view. For example it is seen that Danish exports to Finland had a growth rate of 4,8 per cent whereas Finnish imports from Denmark had a growth rate of only 3,9 per cent. Other comparisons of growth rates show similar or even bigger differences. It is well known that foreign trade statistics in current prices show more or less different figures depending on whether they are reported by the exporter or the importer.

Table 4 Average annual growth rate 1970-81, constant prices*

	Reporting country:							
	Denmark		Finland		Norway		Sweden	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Denmark	.	.	3,4	3,9	1,7	4,3	0,8	0,4
Finland	4,8	6,1	.	.	5,2	11,4	3,9	6,7
Norway	4,8	3,3	8,4	6,5	.	.	2,1	3,1
Sweden	0,7	0,3	4,7	3,1	1,7	2,7	.	.
Total Nordic countries	2,3	1,8	5,2	3,6	2,0	4,1	2,1	3,5
All countries..	5,4	2,1	5,7	3,8	6,0	3,5	3,3	1,4

* Denmark, Finland, Norway = 1975-prices. Sweden = 1980-prices.

Such differences can, however, usually be explained by the problems of cif-fob, timing of registration, faulty classification, etc., and do not appear to be important on the more aggregated level, even though a number of such problems have been detected at the 36 commodity group level. The main cause for the differences in table 4 is however the deflation procedure used. In deflating imports it is assumed that the price development is independent of the origin, and in deflating exports the same index is used for all buyers. The table shows that this hypothesis does not hold and that a choice has to be made. The expectation will be, that the unit prices of the exporter are the ones to be relied on, and this is in agreement with the usual treatment in foreign trade models.

Table 5 shows for both imports (A) and exports (B) the development in the relative shares in the intranordic trade over the years 1970, 1975 and 1981. The reporting country is in the heading of the table. The general tendency to relative decline in the intranordic trade is seen from the table. It is interesting to notice that the decline is primarily seen in the export shares. This is explained by a relatively slow growth in Nordic trade compared to the world trade. For example did Finland increase its share in Sweden's imports from 5,57 per cent in 1975 to 6,65 per cent in 1981, whereas at the same time Sweden's share in Finnish exports declined sharply from 18,05 per cent to 13,36 per cent. (Please note that there is no contradiction between these two developments).

Part A of the table showing the development in market shares has been further disaggregated by commodity. Only the table showing the developments in Danish market shares in the other Nordic countries has been reproduced

Table 5

A: Nordic countries' import share in each others markets 1970, 1975 and 1981, current prices

Importing country	Denmark			Finland			Norway			Sweden		
	1970	1975	1981	1970	1975	1981	1970	1975	1981	1970	1975	1981
Exporting country:												
Denmark		.		2,92	2,99	2,18	6,22	5,80	6,13	7,75	7,06	6,21
Finland	3,01	2,62	3,71		.		2,38	2,89	4,36	5,14	5,57	6,65
Norway	3,95	4,84	4,30	2,38	2,60	2,50		.		5,81	6,62	6,14
Sweden	15,93	14,22	12,05	16,11	15,93	11,30	20,11	19,24	16,43		.	
	22,89	21,68	20,06	21,41	21,52	15,98	28,71	27,93	26,92	18,70	19,25	19,00

B: Share of export going to other Nordic countries, 1970, 1975 and 1981, current prices

Exporting country	Denmark			Finland			Norway			Sweden		
	1970	1975	1981	1970	1975	1981	1970	1975	1981	1970	1975	1981
Importing country:												
Denmark		.		4,09	3,59	3,32	7,19	7,24	4,11	9,79	8,63	7,78
Finland	2,33	2,24	2,07		.		2,45	2,74	1,81	6,28	7,16	6,48
Norway	7,09	6,57	6,22	3,69	4,71	4,71		.		10,83	11,15	9,59
Sweden	16,88	14,96	11,50	15,11	18,05	13,36	16,18	15,85	8,99		.	
	26,30	23,77	19,79	22,89	26,35	21,39	25,83	25,83	14,92	26,90	26,94	23,85

Table 6 The Danish share in the total imports of the other Nordic countries 197o, 1975 and 1981 (based on figures in current prices)

	Finland			Norway			Sweden		
	197o	1975	1981	197o	1975	1981	197o	1975	1981
1	2.39	3.04	3.53	2.27	3.62	4.98	4.60	6.29	7.17
2	8.19	.90	3.68	43.17	37.79	30.47	37.54	37.15	37.80
3	.07	.02	.02	1.46	5.81	5.12	2.75	7.43	3.76
4	.00	.00	.00	2.37	2.12	1.82	1.95	3.05	2.06
5	.00	.00	.00	9.55	4.30	.01	21.43	8.38	4.15
6	.03	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.72	.71	6.94	7.38	3.76	7.37	10.01	10.62
8	16.92	.00	.00	.00	.00	9.37	64.56	5.08	9.30
9	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	.42	13.95	.72	.72	.69	.78	1.83	2.11	1.69
11	5.94	6.46	9.25	17.21	23.87	22.84	26.05	20.10	14.96
12	5.14	3.42	1.53	19.05	3.16	3.54	17.36	18.88	8.18
13	3.68	3.51	2.94	15.64	15.12	15.93	10.25	10.15	9.47
14	8.09	6.50	3.39	20.15	13.00	11.67	9.72	6.91	6.42
15	2.78	1.38	3.72	5.81	7.24	3.56	8.67	13.10	9.20
16	8.17	3.65	4.64	22.32	17.39	28.37	18.54	15.88	18.67
17	16.06	4.63	2.10	11.71	8.06	8.45	12.93	10.40	8.42
18	2.00	.00	.00	.33	.64	1.35	7.75	14.81	7.90
19	5.07	3.14	1.73	7.42	5.44	4.64	10.93	9.16	8.67
20	4.39	5.03	4.92	18.30	14.56	13.24	22.30	15.38	12.68
21	2.12	1.73	2.71	4.12	3.72	4.27	5.08	3.54	2.81
22	3.05	3.04	2.68	2.47	3.08	4.92	3.83	4.07	3.85
23	5.08	4.56	4.57	13.99	14.21	12.49	9.98	12.06	11.65
24	6.30	4.84	3.69	13.02	14.06	12.30	10.80	14.10	11.69
25	5.71	2.75	2.32	4.97	7.84	6.95	11.98	14.38	12.80
26	.43	.98	1.33	3.61	2.53	3.18	2.76	4.62	5.83
27	.90	1.92	1.24	2.02	2.72	3.77	1.66	1.61	2.43
28	3.60	4.08	4.54	8.79	6.86	7.86	7.62	8.45	7.26
29	3.96	4.80	2.92	5.91	5.63	5.56	6.34	6.39	5.42
30	4.50	4.21	4.05	7.17	6.53	6.29	8.61	6.32	5.92
31	.50	.49	.51	.62	.64	1.65	1.26	1.13	1.68
32	8.95	3.39	.60	3.11	1.74	.94	4.65	3.55	6.62
33	.92	1.24	.78	1.71	5.90	3.26	5.67	11.50	6.24
34	3.34	3.20	3.81	3.43	3.98	3.39	3.05	3.52	2.99
35	9.29	14.03	9.82	13.90	12.23	7.55	7.45	7.89	5.71
36	.00	.00	.66	26.53	19.37	10.98	9.76	9.11	9.62
total	2.92	2.99	2.18	6.22	5.80	6.13	7.75	7.06	6.21

Table 7 (As table 5, but exclusive of energy products, i.e. commodities No. 4-8)

A: Nordic countries' import share in each others markets 1970, 1975 and 1981, current prices

Importing country	Denmark			Finland			Norway			Sweden		
	1970	1975	1981	1970	1975	1981	1970	1975	1981	1970	1975	1981
Exporting country:												
Denmark	.	.	.	3,28	3,63	3,10	6,47	6,12	6,86	7,63	7,27	6,70
Finland	3,34	3,22	4,56	.	.	.	2,58	3,21	5,00	5,59	6,67	7,58
Norway	4,30	5,18	4,00	2,68	3,15	3,23	.	.	.	6,02	6,41	5,76
Sweden	17,18	16,14	11,81	17,84	19,13	15,65	21,46	20,93	17,60	.	.	.
	24,82	24,54	20,37	23,80	25,91	21,98	30,51	30,26	29,46	19,24	20,35	20,04

B: Share of export going to other Nordic countries, 1970, 1975 and 1981, current prices

Exporting country	Denmark			Finland			Norway			Sweden		
	1970	1975	1981	1970	1975	1981	1970	1975	1981	1970	1975	1981
Importing country:												
Denmark	.	.	.	4,12	3,60	3,10	6,83	7,16	6,16	9,57	8,06	6,36
Finland	2,38	2,30	2,11	.	.	.	2,50	3,13	3,30	6,29	7,17	6,65
Norway	7,10	6,46	6,17	3,72	4,73	4,66	.	.	.	10,74	11,05	9,44
Sweden	15,36	13,31	9,90	14,74	17,83	12,01	15,42	15,22	14,55	.	.	.
	24,84	22,07	18,18	22,58	26,16	19,77	24,75	25,51	24,01	26,60	26,28	22,45

here as table 6. It shows that behind the relatively smooth developments shown by the overall shares are found considerable shifts for individual commodities. So at the detailed level the picture of the intranordic trade is a much more dynamic one.

From table 3 and 6 is seen that trade in energy products (commodities No. 4-8) both overall and between the Nordic countries is considerable and has increased strongly from 1970 to 1981. As the trade in refined petroleum products (which in 1981 amounted to about 20 per cent of the total trade between Denmark and Sweden) is mostly a question of where the multinational oil companies have placed their refineries and the Norwegian gas and oil from the North Sea cannot be seen as a part of the general Nordic trade pattern, table 5 have been recalculated after leaving out the energy products. The results are shown in table 7. Even though the general picture from table 5 is upheld, there are important differences in part A of the table for Denmark and in part B for Norway. When energy is excluded the Norwegian trade pattern with the Nordic countries has been quite stable over the period. The decline of import share in the Swedish market for the other Nordic countries is even more outspoken in this table.

EFFECTS OF A DEVALUATION: THEORETICAL FOUNDATIONS OF AN ANALYSIS WITHIN THE FRAMEWORK OF THE NORDHAND MODEL SYSTEM

Sturla Henriksen
Central Bureau of Statistics, Oslo, Norway

INTRODUCTION

The purpose of this paper is to give a theoretical foundation for the analysis of the effects of a devaluation within the frame of the present version of the NORDHAND-model system.

In the first part of this paper an equilibrium model for world trade of manufactured products is developed. The model is based on works by Samuelsen (1973), Deppler and Ripley (1978) and Frenger, Jansen and Reymert (1979).

In the second part of the paper, the NORDHAND-model is discussed and related to the theoretical model. The last part outlines a formal analysis of the effects of a devaluation.

1. AN EQUILIBRIUM MODEL FOR WORLD TRADE OF MANUFACTURED PRODUCTS

The structural model consists of a set of pricesetting functions, a set of demand equations and a set of equilibrium conditions.

Like in Armington (1969) the products are distinguished not only by their kind, e.g. machinery and textiles, but also by their place of production. Thus Swedish and Norwegian textiles are in the model distinguished as two different products. The products are distinguished from one another in the sense that they are imperfect substitutes in demand.

Thus, one good is not only different from any other good, but also assumed to be differentiated (from the buyers point of view) by the producers country of residence. Using these assumptions, the goods are considered to be homogeneous in each country's exports, and heterogeneous in each country's imports.

There are L countries in the model, each of which produces goods and sells them on the world market in competition with each other.

The model is treating each country as a "macro-producer".

The supply of exports from country k is derived assuming profitmaximizing behaviour and imperfect competition. The assumption of imperfect competition follows from the assumption that the products are imperfect substitutes in demand. This principally gives each exporting country monopolistic position, making it difficult, or even meaningless, to use supply equations for export. The supply of a given product will instead be represented by the following pricesetting-function

$$PXk = PXk(\underset{+}{\frac{1}{Ek}}, \underset{+}{\bar{P}Xk}, \underset{+}{QXk}; CXk) \qquad (1.1a)$$

(The +- signs under the arguments denote positive first-order derivates.) Here PXk is the unit price of the good exported from country k measured in a numeraire currency. Ek denotes the rate of exchange (price pr. unit) of the numeraire currency measured in units of country k's currency). $\bar{P}Xk$ is a weighted average of the competing countries export unit prices for the given good measured in the numeraire currency:

$$\bar{P}Xk = \sum_{l \neq k} \beta_l PXl \qquad (1.1.b)$$

where β_l are the weights.

Furthermore, in (1.1.a) QXk denotes variable unit costs measured in the numeraire currency. CXk denotes the capital stock. The elasticity of the export unit price w.r.t. the variables of the function (1.1.a), will depend on the country's competitive position on the export market. If the product has close substitutes in demand, the exporting country will behave like a price taker, and the elasticity of PXk w.r.t. $\bar{P}Xk$ will be positive and close to one, while the elasticity of PXk w.r.t. 1/Ek and QXk will be positive and close to zero. If, on the other hand, the product has no close substitutes, in demand, the exporting country will behave like a price setter, and the elasticity of PXk w.r.t. $\bar{P}Xk$ will be positive and close to zero, while the elasticity of PXk w.r.t. 1/Ek and QXk will be positive and greater than zero.

<u>The demand for imports</u> is determined in two steps. This approach presupposes independence between a given exporting country's share in a given country's imports, and the level of the imports. Furthermore, it is assumed that the same good produced in different countries are imperfect substitutes in demand, and that the shares of each exporting country in other countries imports is determined by relative import prices.

<u>In the first step</u> country k's share of country l's imports of a given good (SMlk) is determined as a function of the price of imports to country l from country k (PMlk), and the price of imports to country l from all other countries competing with country k in country l's import market:

$$SMlk = SMlk(\widehat{P\underset{\div}{M}}l1, \ldots, \widehat{P\underset{\div}{M}}lL) \qquad (l \neq k) \qquad (1.2')$$

Here "^" denotes prices measured in country l's currency.

The function (1.2') is assumed to have been derived from a product function or a utility function on the basis of cost minimization or utility maximization. Furthermore (1.2') is assumed to be homogenous of degree 0 in all prices. Consequently, dividing by the exchange rate, the arguments in (1.2') can be measured in the numeraire currency:

$$\begin{aligned} SMlk &= SMlk(\widehat{PM}l1/El, \ldots, \widehat{PM}lL/El) \\ &= SMlk(P\underset{\div}{M}l1, \ldots, P\underset{\div}{M}lL) \qquad (l \neq k) \qquad (1.2) \end{aligned}$$

The size of the first-order derivates of SMlk can be given the following interpretation: If a good imported to country l from country k and country j are close substitutes, it will be of relatively little importance for the demanders in country l which of the goods they are buying. Hence, a small change in relative import prices results in relatively considerable changes in the shares of imports.

The exporting countries' shares in each country's imports must sum to unity:

$$\sum_{k \neq l} SMlk = 1 \qquad (1.3)$$

<u>In the second step</u> the level of country l's demand for imports of a given good (Ml) is determined as a function of total domestic demand (Dl), and the unit price of domestic production (PHl) in relation to an index of

import prices (PMl) for the good:

$$Ml = Ml(\underset{+}{Dl},\underset{+}{PHl/PMl}) \qquad (1.4)$$

The index of import prices for each good is defined as a function of all prices of imports of the good from different countries:

$$PMl = PMl(\underset{+}{PMl1},\ldots,\underset{+}{PMlL}) \qquad (1.5)$$

Total imports of the good to country l from country k (Mlk) is given by

$$MlK = SMlk \cdot Ml \qquad (l \neq k) \qquad (1.6)$$

Each country's total exports of a good must, per definition, equal the sum of all other countries' imports of the good from that country:

$$Xk = \sum_{l \neq k} Mlk \qquad (1.7)$$

The model is completed by assuming a relation between the unit price of imports to country l from country k (PMlk) and the unit price of exports from country k(PXk):

$$PMlk = PMlk(\underset{+}{PXk}) \qquad (l \neq k) \qquad (1.8)$$

Summarizing the model, the system (1.1) to (1.8) gives L(3L+2) independent equations in L(3L+2) endogenous variables for each good:

Endogenous variables:		Number of variables:
PXk	- Price per unit of exports from country k	L
$\bar{P}Xk$	- Weigthed average of unit prices of eksports from countries competing with country k on the export market	L
SMlk	- Country k's share of country l's import	L(L-1)
PMlk	- Price per unit of imports to country l from country k	L(L-1)
Ml	- Volume of total imports to country l	L
PMl	- Index of unit prices for imports to country l	L
Mlk	- Volume of imports to country l from country k	L(L-1)
Xk	- Volume of exports from country k	L

Exogenous variables:		
Ek	- Price per unit of the numeraire currency measured in country k's currency	L
QXk	- Variable unit costs in country k	L
CXk	- Volume of capital stock (or production capacity) in country k	L
Dl	- Volume of domestic demand in country l	L
PHl	- Unit price of domestic production delivered to the domestic market in country l	L

2. THE NORDHAND MODEL SYSTEM

The NORDHAND model can be related to the above described theoretical model by using L=5 countries: Denmark (D), Finland (F), Norway (N), Sweden (S) and the rest of the world (W).

In the present version of NORDHAND, only the volume-variables Xk and Mlk(l=D,F,N,S) are endogenously determined, while the rest of the variables are treated exogenously. This implies that the present model is a pure quantity model.

The NORDHAND model reduces the system (1.1)-(1.8) to a system consisting of (1.6) and (1.7). This system, solved w.r.t. Xk(k=D,F,N,S), is represented by the equation (1) in the paper "Technical description of the NORDHAND model system" (included in this proceedings volume) by P. Sand and G. Sollie.

In the model system (1.1)-(1.8) adjustments of the exchange rates causes changes in relative prices and thereby changes in traded volume of goods.

In order to do an analysis of the impacts of a devaluation, it will be necessary to expand the present NORDHAND model. It seems logical, as a first step, to do this by endogenizing each exporting country's share of each Nordic country's imports.

One way of doing this is to start by specifying the relations between export unit prices and import unit prices given in function (1.8). As a simplified specification can be used:

$$PMlk = \Theta^{lk} \cdot PXk \qquad (l \neq k) \qquad (2.1.a)$$

where - l=D,F,N,S
- k=D,F,N,S,W

Combining (2.1.a) and (1.2) gives

$$SMlk = SMlk(\Theta^{l1}PX1,\ldots,\Theta^{lL}PXL) \qquad (l \neq k) \qquad (2.1.b)$$

The constant elasticity of substitution (CES) demand system set out by Armington (1969) provides a basis for developing a manageable set of export demand relationships. The approach involves the assumption that (i) the elasticities of substitution between competing products in a given market are independent of market shares, and that (ii) the elasticity of substitution between two competing products in a given market is the same as that for any other pair of competing products in the same market. While equal in cross-sections of a given market, the elasticities of substitution will in general be different across different markets. By introducing the additional assumption that the elasticities of substitution are constant over time, estimates of (2.1.b) can be done by pooling cross-sections and time-series data. In NORDHAND's database PXk and SMkl (k=D,F,N,S; l=D,F,N,S,W) are available for the period 1970-81.

As a proxy-variable for PXW can be used the indices of import unit prices for the Nordic countries, which are available in the database.

While estimating the functions for each Nordic country's share of the other Nordic countries imports, the share of the rest of the world is residually determined by using the condition that market shares must sum to one:

$$SMlW = 1 - \sum_{k \neq l} SMlk \qquad (2.1.c)$$

where - l,k=D,F,N,S

For most goods, the share of the rest of the world is relatively large. Thus, errors in the estimations of the Nordic countries shares will result in relatively smaller errors in the shares of the rest of the world.

3. OUTLINE OF A FORMAL ANALYSIS OF THE EFFECTS OF A DEVALUATION

By including the estimated import share functions, the NORDHAND model system will consist of the following equations:

$$Xk^N = \sum_{l} SMlk \cdot Ml \qquad (3.1)$$

where l,k = D,F,N,S

$$SMlk = SMlk^{*}(PX1,\dots,PXL) \qquad (l \neq k) \qquad (3.2)$$

where l,k = D,F,N,S

$$SMlW = 1 - \sum_{k \neq l} SMlk \qquad (3.3)$$

where l,k = D,F,N,S

The system (3.1) to (3.3) gives 20 independent equations in 20 endogenous variables for each good:

Endogenous variables:		Number of variables:
Xk^N	- Volume of exports from country k to the other Nordic countries (k=D,F,N,S)	4
SMlk	- Country k's share of country l's imports ($l \neq k$) (k=D,F,N,S,W and l=D,F,N,S)	16

Exogenous variables:		
Ml	- Volume of total imports to country l (l=D,F,N,S)	4
PXk	- Price per unit of exports from country k (k=D,F,N,S,W)	5

An analysis of the effects of a devaluation within this model system, must start with calculations of the effects on the other Nordic countries currencies. When one Nordic country devaluates its currency, the other Nordic countries (except Denmark) will devaluate their currency somewhat in relation to the rest of the world. The reason is that the other Nordic countries currencies are included in the "baskets" which determine the values of each Nordic country's currency (except Denmark).

Adjustments in the rates of exchange will in general have two kinds of "firstorder"-effects on the countries' imports:

(i) The level of imports is changed if the adjustments result in changes in relative prices between domestically produced and imported goods.

(ii) The distribution of import shares on exporting countries is changed if the adjustments result in changes in relative prices between imports from competing countries.

In the system (3.1) to (3.3) the level of imports is determined exogenously. Thus, so far the level of imports is assumed to be generated by the national input/output models.

Changes in the exporting countries' shares of each Nordic country's imports is generated by the system (3.1) to (3.3). The starting point will be assumptions on how a devaluation affects the export unit prices measured in the numeraire currency. A general design of this assumed relationship can be the pricesetting-functions given in (1.1.a):

$$PXk = PXk\left(\underset{+}{\frac{1}{Ek}}, \underset{+}{\bar{P}Xk}, \underset{+}{QXk}; CXk\right) \qquad (3.4)$$

where k = D,F,N,S.

A devaluation of country k's currency means that $\frac{1}{Ek}$ is reduced. The elasticity of PXk w.r.t. $\frac{1}{Ek}$, εPX^k, will be a measure of the effect of a devaluation on the export unit price (the latter measured in the numeraire currency):

$$\varepsilon PX^k = \begin{cases} 0 \text{ no effect} \\ -1 \text{ full effect} \end{cases} \tag{3.5}$$

A report from Statens Industriverk (1983) shows that the average magnitude of ε for manufactured goods (excl. ores) was -0.5 after the Swedish devaluation in 1982.

The relations in (3.4) consists of 4 sets (=number of Nordic countries) of 36 behavioural equations (=number of NORDHAND goods). These can principally be treated in two ways. Either they can be estimated to include the rates of exchange directly in the market share relations (3.2 to (3.3), or they can be determined by different assumptions or scenarios. At the present stage of the NORDHAND project, the latter solution seems to be most realistic.

A flow-chart of the analysis is shown on the next page:

A Nordic country k devaluates, and this is put into the relations for dependence between the currencies of the Nordic countries (1). New rates of exchange are generated (2). These will, by assumptions of the exporters price behaviour (3), result in new export unit prices (4). Furthermore, the import unit prices are changed (5). If relations given in (1.8) are established and estimated, the new import unit prices will be functions of the new export unit prices (5'). The new export and import unit prices will enter exogenously into the national input/output models ((6), (7)), generating new figures of total imports (8). The new export unit prices also enter the equations determining the distribution of market shares (9), and new market shares are calculated (10). The new figures for market shares and total imports are then used as new input in the present NORDHAND model (here called "1. NORDHAND-version") ((11), (12)), and new figures for intra-Nordic exports and total imports are generated (13).

Literature:

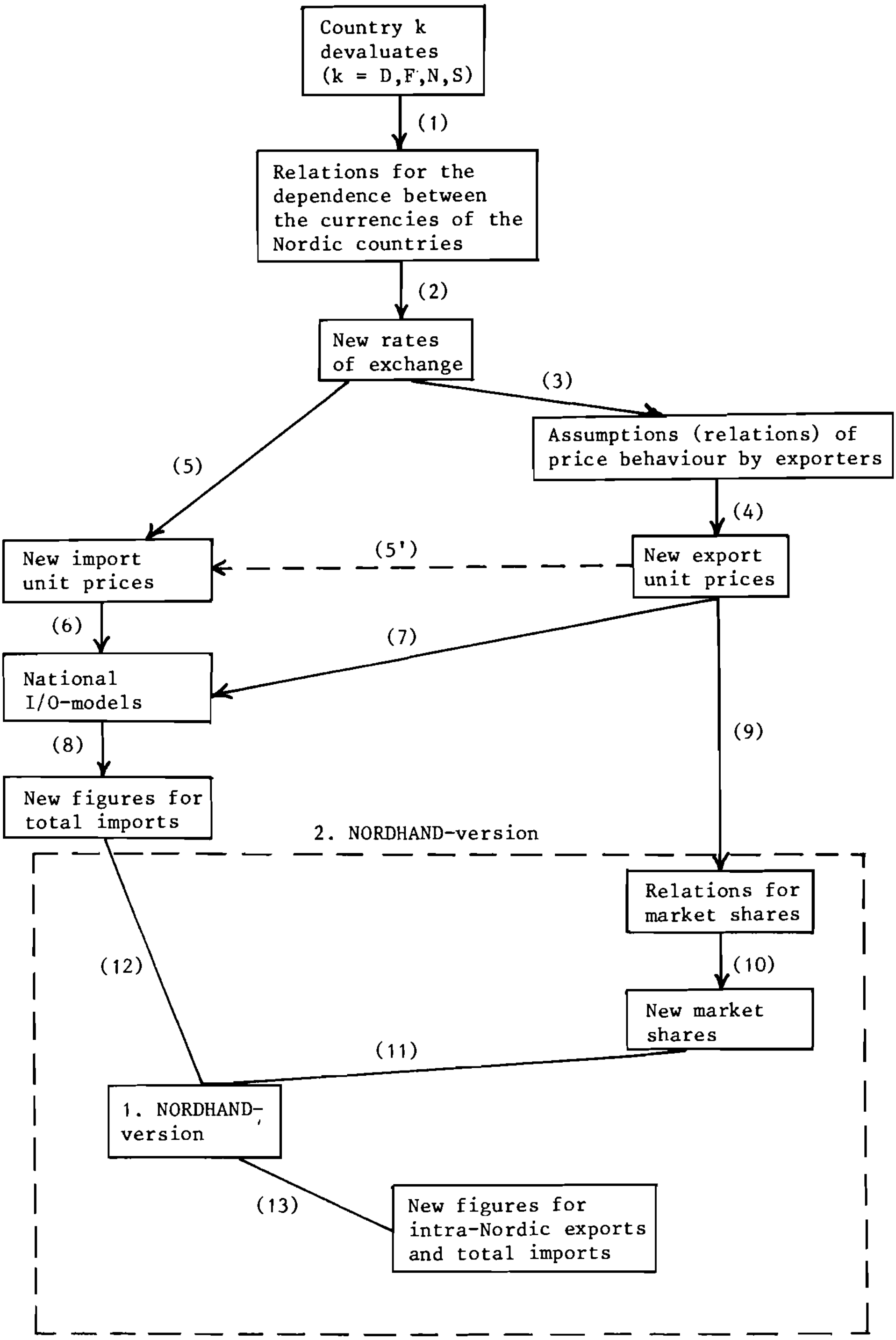
Armington, P. S. (1969): "A theory of demand for products distinguished by place of production", IMF Staff Papers 16.

Deppler, M.C. and D. M. Ripley (1978): "The World Trade Model: Merchandise trade", IMF Staff Papers 25.

Frenger, P., E. S. Jansen and M. Reymert (1979): "Modell for norsk eksport av bearbeidde industrivarer". Rapporter 79/29, Central Bureau of Statistics, Oslo.

Samuelsen, L. (1973): "A new model of world trade", OECD Economic Outlook: Occasional Studies (December 1973), Paris.

Statens Industriverk (1983): "Industriens strategier vid 1982 års devalvering. En första delrapport", SIND PM 1983: 3, Stockholm.


Country k devaluates (k = D,F,N,S)
(1)
Relations for the dependence between the currencies of the Nordic countries
(2)
New rates of exchange
(3)
Assumptions (relations) of price behaviour by exporters
(5)
(4)
New import unit prices
(5')
New export unit prices
(6)
(7)
National I/O-models
(9)
(8)
New figures for total imports
2. NORDHAND-version
Relations for market shares
(12)
(10)
New market shares
(11)
1. NORDHAND-version
(13)
New figures for intra-Nordic exports and total imports

EFFECTS OF A SWEDISH DEVALUATION ON TRADE AND PRODUCTION IN THE NORDIC COUNTRIES: CALCULATIONS USING THE NORDHAND MODEL SYSTEM

Hans Olsson
Statens Industriverk, Stockholm, Sweden

1. Introduction

If one of the Nordic countries devaluates its currency - as Sweden did 1977, 1981 and 1982 - this will in the first place affect the economy of the devaluating country itself. However, due to the close trade relations in the Nordic area considerable effects might be expected also in the other Nordic countries - presumably in opposite directions.

A devaluation in, say, Sweden will lead to increased import prices in relation to prices of domestic production, and to decreased Swedish export prices on foreign markets in relation to other countries production. In due course this will lead to decreased market shares for foreigners in the Swedish market and to increased market shares for Swedish exporters in foreign markets. This will mean increased production in Sweden, both for sales on the domestic and foreign markets. For certain products the case may be different - as will be clear in the following - but the general result will be something of this kind.

Now, since some 15 or 20 per cent of the other Nordic countries' exports go to Sweden, the reduced Swedish imports will have a negative impact on their exports and production. Also, since some 15 or 20 per cent of the other countries' imports come from Sweden, the increased competitiveness of Swedish exports will mean increased imports and a further negative impact on their production. Another, but probably less important, negative effect on the other Nordic countries will result from e.g. Norway loosing market shares to Sweden in e.g. the Danish market. Finally, it is possible that e.g. Norway looses market shares outside the Nordic area. However, due to the fact that Sweden's market shares for most products are small outside the Nordic area, the latter squeezing-out effect will be rather unimportant. Exceptions might exist in e.g. Finland loosing market shares to Sweden on the European markets for wood and paper products.

The effects mentioned so far may be described as the primary or first-round effects. These are clearly positive for Sweden - the devaluating country - and negative for the other countries. The label first-round does not imply that the effects are to be seen immediately or before all other effects. Rather, the label is a matter of logics. In practice it may take 2 or 3 years before these first-round adjustments are finished. Effects of a secondary character begin - in spite of this - to appear rather soon, parallell to the development of primary effects. These secondary effects are of several kinds.

Inevitably, the increased production in Sweden and decreased production in the other countries will increase and decrease, respectively, imports of input goods into production. This will tend to reverse the effects on production somewhat: there will be some more exports from the other Nordic countries to Sweden and some less exports from Sweden to the other Nordic countries.

Also, there will be an increase in income in Sweden and a decrease in income in the other Nordic countries, resulting from the changes in value added of production. In real terms, admittedly, these income changes will be offset partially by the changes in prices of imports. The changes in income may induce further changes in demand for imports and thus further changes in bilateral trade flows.

The extent of changes of the latter kind will depend on the measures taken by the economic policy makers. The authorities in Sweden may, for instance, decide to keep private real income unchanged in order to secure the positive effects on balance of trade.

In real life many things except a devaluation affects trade flows and production figures. In order to isolate and measure the effects of a devaluation it is useful, if not necessary, to use some kind of a model.

The present calculations of the effects on the Nordic countries trade and production have been made with the help of data and estimates belonging to the NORDHAND model system for the Nordic countries. The trade model included in this system has 36 different product groups (services are not included). Unfortunately, all the behavioural equations that would be needed for a correct calculation of effects on bilateral trade flows for all commodity groups are not yet available. With supplementary information on price behaviour and assumed elasticities from other models and investigations, it has nevertheless been possible to make some indicative calculations which seem reasonable on a macro level.

Before embarking on the actual results it is necessary to discuss the different assumptions made for two main product categories, homogenous products and heterogenous products.

2. Homogenous and heterogenous products

Homogenous products are products like agricultural products, fuel and raw materials of different kinds. For such products the price is given on the world market, leaving only slight and temporary possibilities for different sellers to charge different prices. Thus, all sellers and buyers could be assumed to trade at the same world market price. After a devaluation of the Swedish krona, the Swedish import price of such a product will increase by the increase in price of foreign currency. If the product, apart from being imported, also is produced in Sweden, the price of the domestic production will increase by the same amount, adjusting to the world market price level. There will be no increase in relative price for imported goods and no increase in import volumes - at least not in the first round.

Likewise, for Swedish exports of homogenous products, the price could be assumed to be unchanged on the world market. This would mean an increase, measured in Swedish currency, by the increase in price of foreign currency. Thus, there will be no lowered relative Swedish export price and no increased demand from abroad.

While giving no volume effects, it should be pointed out that the devaluation results in increased profit margins for homogenous products. In some cases this might lead to increased willingness to sell and thus to higher market shares from the supply side. Such effects are, however, not incorporated in the calculations that follow.

For heterogenous products, i.e. clothing, engineering products and other manufacture products, the case is different. Here, there exist no well-defined world market prices. Swedish producers can, after a devaluation, by keeping their price increases on the home market below the rise in import prices, gain market shares in relation to imports. This would of course limit the increase in profit margins per unit of output as compared with homogenous products.

An increase in relative import prices is the likely result. This increase will most probably, however, not be as big as the increase in price of foreign currency. First, there will probably be some increase in Swedish profit margins, limiting the rise in relative import prices. Second, the price of imported input goods will increase - like all imports - making costs higher. Third, the import prices themselves may increase less than the price of foreign currency, if foreign producers lower their profit margins in order to preserve their competitiveness on the Swedish market.

On the Swedish export markets for heterogenous products, Swedish firms will probably lower their price measured in foreign currency - which was not the case for homogenous products. Should they keep their price unchanged in Swedish currency the price abroad would fall by the same amount as the decrease in price of Swedish currency. The actual relative export price decrease will, however, probably be lower than that, implying some increase, measured in Swedish crowns. The reasons are about the same as indicated above for relative import prices: some increase in Swedish profit margins, increased costs for imported inputs and that foreign competitors may lower their profit margins to maintain their competitiveness.

The Annex indicates which products have been considered homogenous and heterogenous, respectively.

3. Calculation of first round effects

The calculations below are based on the assumption that Sweden devaluates its krona by 10 per cent. It is further assumed that all other exchange rates are unchanged in relation to each other. In practice, when Sweden devaluates, Norway and Finland (but not Denmark) will also devaluate somewhat in relation to the rest of the world. The reason is that the Swedish krona is included in the baskets of currencies which determine the values of these countries currencies. Such "secondary" devaluations are not taken into account here; they could, however, be handled in the same way in separate calculations.

Effects on Swedish imports

For heterogenous products, a devaluation of 10 per cent is assumed to result in a 5 per cent increase in Swedish relative import prices. The reasoning behind such an assumption was developed in Section 2 above. The actual figure is of course uncertain but the one chosen has some support in experience. The price elasticity for import volumes is put at 1.2, a figure that corresponds roughly to several previous estimates. This will mean that Swedish imports of heterogenous products will decrease by 6 per cent, 5 times 1.2.

As indicated in table 1, relative import prices are assumed to have the same development, irrespective of which country it comes from. Thus there will be no changes in the foreign suppliers' prices in relation to each other. Consequently, all countries will maintain their shares in Swedish imports. All exporters to Sweden will in other words find their exports to Sweden fall by 6 per cent.

For homogenous products, as discussed in Section 2 there will be no increase in relative import prices and hence no effects on import volumes.

Table 1 First round effects on Swedish imports of heterogenous products

Percentage changes

Imports from:	Relative import price (1)	Relative import price (2)	Share in imports	Import volume	Weight
Norway	+5.0	0.0	0.0	-6.0	
Denmark	+5.0	0.0	0.0	-6.0	
Finland	+5.0	0.0	0.0	-6.0	
Others	+5.0	0.0	0.0	-6.0	
Total imports	+5.0	(0)	(0)	-6.0	100

(1) price of imports from each country in relation to domestic price
(2) price of imports from each country in relation to average import price.

Effects on other Nordic countries' imports

In tables 2, 3, and 4 the effects on the other Nordic countries' imports of heterogenous products are displayed. By a reasoning similar to that for relative import prices (again see Section 2) Swedish export prices are assumed to decrease by 5 per cent in relation to foreign producers. This means that the average import price for a given country will decrease by 5 multiplied by the Swedish share in its imports - for instance in the case of Norway (table 2) by 1.0 per cent. The price elasticity of import volumes is still assumed to be 1.2. This will for Norway produce a total increase in imports of Heterogenous products of 1.2 per cent - the bottom row of table 2.

To continue the example of Norwegian imports (the cases for Denmark and Finland are principally the same with somewhat different figures) there will also be changes in market shares, resulting from the decrease in Swedish export prices. Now the column relative price (2) becomes essential. It will be seen that the price of Norwegian imports from Sweden has decreased by 4 per cent in relation to average import price. The decreased Swedish export price is found also in the denominator of the relative price; this is why the decrease is 4 and not 5 per cent as in relative price (1). This might seem odd at first glance, but has an important technical advantage when modelling the development of market shares. It is possible to use the same price elasticity for market shares for all exporter to the market, and still maintain the condition that market shares sum to unity, if the relative price is calculated in that way. The result is, effectively, that the price response is weighted according to the exporters' shares in the market. The theoretical ground for this, in turn, is that it is easier to reach a given per cent increase in exports if the exporters market share is low than if it is already high.

The price elasticity of market shares have been assumed to be 1.8. This corresponds to some econometric evidence that market shares' elasticity are somewhat larger than total imports' elasticity. This is also reasonable on theoretical grounds. Should they be of the same magnitude, there would be no decrease in the non-Swedish countries' exports to the market (as opposed to the case in tables 2, 3 and 4) but only an increase in Swedish exports.

As is seen in the tables the effects on Swedish market shares in the other Nordic countries imports will be increases of about 7 to 8 per cent. Other exporters, including the other Nordic countries, will find their shares drop by 1 to 2 per cent.

Table 2 First round effects on Norwegian imports of heterogenous products

Percentage changes

Imports from:	Relative import price (1)	Relative import price (2)	Share in imports	Import volume	Weight
Sweden	-5.0	-4.0	+7.2	+8.5	20
Denmark	0.0	+1.0	-1.8	-0.6	7
Finland	0.0	+1.0	-1.8	-0.6	5
Others	0.0	+1.0	-1.8	-0.6	68
Total imports	-1.0	(0)	(0)	+1.2	100

(1) price of imports from each country in relation to domestic price
(2) price of imports from each country in relation to average import price.

Table 3 First round effects on Danish imports of heterogenous products

Percentage changes

Imports from:	Relative import price (1)	Relative import price (2)	Share in imports	Import volume	Weight
Sweden	-5.0	4.2	+7.6	+8.7	15
Norway	0.0	+0.8	-1.4	-0.4	4
Finland	0.0	+0.8	-1.4	-0.4	4
Others	0.0	+0.8	-1.4	-0.4	77
Total imports	-0.8	(0)	(0)	+1.0	100

(1) price of imports from each country in relation to domestic price
(2) price of imports from each country in relation to average import price.

Table 4 First round effects on Finnish imports of heterogenous products

Percentage changes

Imports from:	Relative import price (1)	Relative import price (2)	Share in imports	Import volume	Weight
Sweden	-5.0	-4.1	+7.4	+8.6	18
Norway	0.0	+0.9	-1.6	-0.5	2
Denmark	0.0	+0.9	-1.6	-0.5	3
Others	0.0	+0.9	-1.6	-0.5	77
Total imports	-0.9	(0)	(0)	+1.1	100

(1) price of imports from each country in relation to domestic price
(2) price of imports from each country in relation to average import price.

The bilateral trade volumes' changes are roughly equal to the sum of changes in total imports to the market and changes in market shares.

For homogenous products (as mentioned in Section 2) no relative price changes are assumed to take place. Hence, trade volumes are assumed to be unchanged, too.

Effects on non-Nordic countries' imports

The effects on the imports of heterogenous products into countries outside the Nordic area could be analyzed in the same way as those of the Nordic countries. It is clear from table 5 that the effect of a 5 per cent decrease in Swedish export prices on the average import are very small in this area.

Table 5 First round effects on other countries' imports of heterogenous products

Percentage changes

Imports from:	Relative import price (1)	Relative import price (2)	Share in imports	Import volume	Weight
Sweden	-5.0	-4.8	+8.6	+8.8	4
Norway	0.0	+0.2	-0.4	-0.2	1
Denmark	0.0	+0.2	-0.4	-0.2	1
Finland	0.0	+0.2	-0.4	-0.2	1
Others	0.0	+0.2	-0.4	-0.2	93
Total imports	-0.2	(0)	(0)	+0.2	100

(1) price of imports from each country in relation to domestic price

(2) price of imports from each country in relation to average import price.

The reason is of course that Sweden's share of the imports is much smaller than in the Nordic countries. Consequently the effect on the non-Nordic countries' total imports is very small, assuming the same import price elasticity as before, 1.2.

The decrease in relative prices of imports from Sweden will produce an increase in Swedish market shares which is somewhat bigger than in the Nordic countries, using the same elasticity as before, 1.8. The interpretation of this is, as indicated earlier, that is is easier to increase market shares if their levels are low.

For the other Nordic countries there will be only small increases in relative prices and small decreases in market shares, reflecting the fact that Sweden's market shares are small. Even a fairly big increase in them will not squeeze other countries' shares very much.

This applies to heterogenous products in total. For certain products, mainly in the wood and paper industries, Sweden's shares are larger and the squeezing-out effect thus also larger. Finnish exports of paper and paper products to non-Nordic countries is, for instance, estimated to fall by about 1 per cent rather than the 0.2 per cent in table 5.

For homogenous products, as before, no volume effects are assumed.

Effects on the Nordic countries exports

The first-round effects of the Swedish devaluation on the four Nordic countries exports are now easily calculated. For instance, the percentage change in Swedish exports to Norway is given by the change in Norway's imports from Sweden in table 2. Collecting figures from tables 1 to 5 and weighting with the different markets' shares in each country's exports gives the total exports of heterogenous products. These export changes are recorded in table 6.

Table 6 First round effects on the Nordic countries' exports of heterogenous products

Percentage changes, volume

Sweden	+8.7
Norway	-1.3
Denmark	-1.1
Finland	-1.3

Effects on total commodity trade

Imports and exports of homogenous products are by assumption not affected in volume by the Swedish devaluation. Adding figures for heterogenous products (calculated from table 6) and the unchanged figures for homogenous poducts, gives percentage changes for total commodity trade that are less than for heterogenous products alone. It might be specially noted in table 7 that Norwegian total exports are relatively little affected, depending on the large share of oil (a homogenous product) in its exports. The effect on Finnish total exports, containing a high proportion products classified as heterogenous, is more pronounced.

Table 7 First round effects on the Nordic countries' total commodity imports and exports

Percentage changes, volume

	Imports	Exports
Sweden	-3.7	+7.1
Norway	+0.8	-0.3
Denmark	+0.6	-0.6
Finland	+0.6	-1.0

As a final conclusion, regarding the first-round effects, it should be noted that the positive effects on Swedish real trade are several times larger than the corresponding negative effects on the other Nordic countries.

4. Further effects: imports of input goods.

The effects calculated so far are almost certainly not the final effects of a Swedish devaluation. In Sweden industrial production is increased, partly through increased exports and partly through increased sales on the home market, substituting imports. In the other Nordic countries production is instead reduced, because of increased import penetration and decreased exports. These production changes will generate changes in imports of goods used as inputs into production.

The calculations of such secondary effects are based on the assumption of unchanged final demand for industrial products within each country. This means that the changes in imports from the first round are fully matched by changes in production in the opposite direction. These changes in production together with the changes in exports give the effects on total production. It is estimated that the import content in production is 30 per cent (this figure seems to be about the same in the Nordic countries). The production changes will then induce secondary import changes as given by table 8.

Table 8 Second round effects on the Nordic countries' total imports, resulting from changed import requirements in production

Percentage changes, volume

Sweden	+3.1
Norway	-0.3
Denmark	-0.3
Finland	-0.4

Table 9 Second round effects on the Nordic countries' total exports

Percentage changes, volume

Sweden	-0.1
Norway	+0.3
Denmark	+0.4
Finland	+0.5

These import changes will in turn change bilateral trade flows within the Nordic area. Assuming now unchanged market shares from the first round, secondary export changes are given by table 9. Swedish exports have now decreased (although very little), depending on the decrease in imports into the other Nordic countries. The other Nordic countries exports have increased somewhat, depending on the secondary increase in Swedish imports, which dominates over the decreases in imports into the other Nordic markets.

Starting with tables 8 and 9 a third round of effects on imported input can be calculated, a fourth, fifth and so on. The changes after the third round are very small. In table 10 the final effects on the Nordic countries' imports and exports are given, still assuming unchanged final demand in each country.

In table 11 are shown these final changes in real foreign balance expressed as per cent of GDP. The positive effect on the Swedish GDP is quite considerable, about 2 per cent. The negative effects on the other Nordic countries GDP are more limited, the effect on Finland's GDP being somewhat larger than the effects on GDP of Norway and Denmark.

Table 10 Full effects on the Nordic countries' total imports and exports, including effects of changed import requirements in production

Percentage changes, volume

	Imports	Exports
Sweden	-1.4	+7.1
Norway	+0.7	-0.2
Denmark	+0.5	-0.3
Finland	+0.5	-0.6

Table 11 Full effects on the Nordic countries' GDP

Percentage changes, volume

Sweden	+2.1
Norway	-0.2
Denmark	-0.2
Finland	-0.3

5. Income effects on imports

The changes in GDP shown in table 11 also lead to changes in real national income. It should be noted that the changes in real income are less than the changes in GDP. This is because terms of trade have been changed, which affects the spending power of the income. Sweden, for instance, has through its lowering of terms of trade transferred some of its income abroad. Less than half of the real GDP increase is left as an increase in real national income. For the other Nordic countries the small decreases in GDP correspond to even less decreases in real national income.

The income changes have been assumed to generate no changes in imports. This may or may not be the result in practice. Policy makers in Sweden may wish to prevent imports from rising and could achieve this for instance by forcing savings to increase in the economy as a whole.

Even with no such reactions from the policy makers, it seems unlikely that the increase in imports in Sweden out of increased income will exceed 1 per cent. The other Nordic countries' total exports will then increase by at most 0.2 per cent. The increments to GDP from such increases will be very unimportant.

6. Disaggregated calculations

With the NORDHAND model system it is possible to produce calculations of the effects or a Swedish devaluation on a 36 commodity group level. The procedure is wholly parallell to what has been shown above for two commodity groups. As yet, however, the design of the trade model is not quite ready to produce accurate results on the disaggregated level. Most important, import and market share elasticities with respect to price are not avaliable for the

36 groups. Also, some technical problems in connecting the core trade model with the national input-output models remain, which disturbes the results.

It might be instructive, however, at this stage to present first round result for one commodity group where the results could be expected to differ from those for total trade. The group chosen is paper and paper products. The price elasticity for total imports is assumed to be 1.2 (the same as for heterogenous products on average) and the price elasticity for market shares to be 2.2 (somewhat above that of heterogenous products on average, indicating a somewhat more easy substitution between different foreign suppliers). In table 12 the results are summarized, the results for heterogenous products in total also given for comparison.

Table 12 First round effects on the Nordic countries imports and exports of paper and paper products, and of heterogenous products in total

Percentage changes, volume

	Imports		Exports	
	Paper, paper products	Heterogenous products, total	Paper, paper products	Heterogenous products, total
Sweden	-6.0	-6.0	+10.0	+8.7
Norway	+2.9	+1.2	-1.1	-1.3
Denmark	+2.8	+1.0	-2.7	-1.1
Finland	+1.8	+1.1	-1.1	-1.3

The result for Finnish exports may be specially commented. As mentioned earlier, Finland tends to loose rather much exports in non-Nordic markets because of Sweden's rather high market shares there. On the other hand, a very small portion of Finnish paper exports goes to Sweden. Hence the recuced Swedish imports play a very small role for Finnish paper exports. For heterogenous products in general the case is different. Here a large portion of Finnish exports goes to Sweden. This explains why Finnish exports of paper actually fall less than exports of heterogenous products in total.

7. Conclusions

It is clear from the analysis that a Swedish devaluation to a certain degree affects production and income in the other Nordic countries. In part, this is a result of increased penetration of Swedish exports on their home markets. Also, declining Swedish imports and increased Swedish competition on export markets affect the other Nordic countries' exports. This effect is partly offset, however, by increased second round exports to Sweden, following the expansion of Swedish production.

The negative effects on GDP of the other Nordic countries when Sweden devaluates by 10 per cent are very small, while the increase in Sweden's GDP is quite substantial, about 2 per cent.

It should finally be born in mind that the impacts on real national income are far less than on real GDP, the reason being the changes in terms of trade. This applies both to the positive impact in Sweden and the negative impacts on the other Nordic countries.

Annex

Homogenous products are:

Agricultural products
Fishery products
Forestry products
Coal
Gas
Crude oil
Petroleum products
Electric power
Iron ore
Other ores and minerals
Food
Beverages and tobacco
Wood pulp
Non-ferrous metals

Heterogenous products are:

Textile products
Clothing, leather and footwear
Sawn and planed wood
Furniture
Other wood products
Paper and paper products
Printings
Rubber products
Primary chemicals and plastics
Other chemicals and plastic products
Non-metallic mineral building materials
Glass and ceramic products
Iron and steel
Metal products
Non-electrical machinery
Electrical machinery
Motor vehicles
Other transport equipment
Precision instruments and watches
Other manufactured products

DISPROPORTIONAL GROWTH AND STRUCTURAL CHANGE IN THE EUROPEAN COMMUNITIES

Michael Landesmann
University of Cambridge, Cambridge, UK

1. INTRODUCTION

This paper will formulate a model of interdependent structural change in the economies of the member states of the European Communities. The formulation and implementation of such a model has become possible because a unified structural data base for the different member countries of the European Communities has become available over the past few years.

The idea of the model presented in this paper is the following:

Since the different member countries of the European Communities represent a group which has achieved a similar stage of industrial development, and since these countries are linked together in the same free trade zone thus approaching a state of similarity in their access to the different world markets including that of the European Communities itself, we are in a good position to compare the different countries' industries competitive performances in world and domestic markets.

The pattern of interdependent disproportional growth and structural change of the member countries of the European Communities follows then the following pattern:

The different industries competitive performances relative to that of other competitor countries' industries' performances determines the evolution of their respective market shares in world and domestic markets. The evolution of these market shares together with the overall growth of demand for the different products in the different markets and the geographical orientation of the different countries' industries towards selling in a particular mix of markets, determines the growth of sales and output of the different national industries over time. Since the evolution of market shares depends upon the competitive strength of the different national industries relative to that of competitor countries the disproportional growth pattern of the different countries' national industries are shown to be interdependent. An important aspect of this exercise is the detailed examination, by means of cross-section and time series analysis of what determines the evolution of the competitive strengths/weaknesses of the different national industries of the member countries of the European Communities, which lies at the root of the particular disproportional growth pattern experienced by these economies.

However, there are other - more traditional - elements of this exercise. One is the analysis of the determinants of the overall evolution of demand patterns for the different commodities in the different markets and this part of the exercise involves the estimation of demand systems as traditionally done in many econometric models.

The second is the consideration of a crucial feedback of the overall growth and productivity performances of the different national economies and the evolution of their levels and structures of demand.[1]

2. FEATURES OF THE MODEL

The model analysing interdependent disproportional growth and structural change in the European Communities will have two levels:

On one level we are to estimate the disproportional growth patterns of demand for the different commodities $i=1,\dots,n$ in the different markets towards which the European industries are orientating their sales. These markets comprise:

- their own domestic market
- the markets of the rest of the European Communities
- the markets of the rest of the world.

For these three markets demand systems are being estimated of the AIDS-type[2] estimating the shares (w_i) of the different commodities in total expenditure ($\bar{x}$) on market M in the following way:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log(\bar{x}/p) \qquad (2.1)$$

where P is the price index defined by

$$\log P = \alpha_0 + \sum \alpha_k \log p_k + \tfrac{1}{2}\sum_{k\ell}\sum \gamma_{k\ell} \log p_k \log p_\ell \qquad (2.2)$$

Having estimated the expenditure pattern in each market, given the pattern of total expenditure and relative prices, we will - as a next step - estimate how the expenditures by commodity are being allocated amongst the different suppliers of these commodities. This is the level at which the market shares of the different national producers in the different markets (domestic, EC, RoW) are being determined.

The approach we take to estimating market share equations is an eclectic one, making use however of the information we have of the 'relative characteristics' of the different suppliers to the particular market M. The functional relationship in general is of the form:

$$\frac{e_{jM}^{C}}{x_j^{M}} = f^{M}\left(\frac{s_{kj}^{C}}{\sum_{C'} w_{C'M} \cdot s_{kj}^{C'}} \; ; \; \bar{x}_j^{M}\right) \qquad (2.3)$$

In this formula we indicate that the market share which exporter C can obtain on market M (where x_j^M stands for total expenditure on commodity j in market M as determined by equation system 2.1.) depends upon his "supply characteristics" (s_{kj}^C) relative to those of the mix of competitors (C') he encounters on market M (the weights of these competitors on market M are given by $w_{C'M}$).

---

[1] This link has recently been demonstrated in an elegant theoretical model in L. Pasinetti (1981).

[2] See Deaton, A.S. and J. Muellbauer (1980a).

The superfix M on f^M indicates that parameters of the functional relationships between market shares and relative characteristics of the different suppliers are market-specific, i.e., the evaluation mechanism of the different supply characteristics and of their combinations can be different between different markets (e.g. the consumers of one market are relatively more interested in prompt delivery than in price).

The estimation of a system of market share equations, given the decision on the total allocation of consumers in market M towards purchases of commodity i, i.e. given x_i^M, follows similar principles as budget share equations, except that the system is derived - in our case - not only from a sensitivity of consumers towards relative prices but also towards other types of characteristics.[3]

If we choose again a logarithmic formulation of the functional relationship between market shares of the different suppliers C' of commodity i to market M, w_{CM}^i, and relative supply characteristics of supplier C vis-à-vis competitors C', S_{Ci}^k, we get a formulation of the following form:

$$w_{CM}^{i} = \alpha_i + \sum_k \sum_{C'} \gamma_{CC'}^{k} \log S_C^k + \beta_C \log (X_i^M / P_i^M) \qquad (2.4)$$

where k represents the k^{th} type of supply characteristic included

and P_i^M is the price index for commodity i supplied in the aggregate on market M (i.e. it is a weighted average of the supply prices of the different competitors supplying market M)

The parameters $\gamma_{CC'}^k$ measure the change in C's market share following a proportional change in C's k^{th} supply characteristic relative to its competitors with total expenditure on commodity i in market M held constant. The restrictions to be imposed on this system of market share equations derived from theory (adding-up properties, homogeneity, symmetry) will not be discussed here (they can be looked up in A. Deaton & J. Muellbauer's(1980b) excellent textbook).

We have seen so far that the total expenditure pattern - amongst different commodities - in each market is determined by budget share equations of the type (2.1) and that the allocation of expenditure by commodity amongst the different competitors on market M is determined by market share equations of the type (2.4).

Given total expenditure for each market M, denominated in a common currency so that we can compare the purchasing power of the different markets, and given relative supply characteristics (including relative supply prices) of the different competing producers we obtain from their two-stage estimation

---

[3] For reasons of space we are not able to show the derivations - from indirect utility functions containing as arguments a variety of supply characteristics of the commodities supplied by different producers - here and they will be available in a more extended version of this paper.

procedure[4] total sales by each of the competing producers in the different markets.

$$\text{i.e. } y_{iM}^{C} = w_{CM}^{i} \cdot x_{M}^{i} \tag{2.5}$$

and total sales in all markets determines total sales of industry i

$$y_{i}^{C} = \sum_{M} w_{CM}^{i} \cdot x_{M}^{i} \tag{2.6}$$

The relative sales pattern of the different national industries depend therefore upon

- the relative supply characteristics of these industries relative to the competitor industries in the different markets and the particular way how the different markets evaluate these differences in supply characteristics (i.e. price, quality etc.), and, secondly,
- particular expenditure patterns on these different markets.

The result of this budget - and market share equation system is also a particular 'market-orientation' of the different national industries, i.e. the fact that different industries will sell different proportions of their produce to different markets (domestic and different export markets).

In the following we will restrict ourselves to discussing those aspects of the econometric exercise which relate to estimating the effects of relative supply characteristics on the competitive performances of the different producers in the different markets.

These characteristics comprise factors which determine the

- price - and the
- non-price competitiveness

of the different producers.

Since we are interested in the factors 'behind' the immediate relative price ratios on world and domestic markets we use variables indicating

- cost-competitiveness decomposed into relative productivity levels and factor prices, and over-/under valuation of the exchange rate, and
- pricing policies of the different producers as shown in profit margins on sales made by producers in general.[5]

The determinants of non-price competitiveness considered in our study are:

- relative efforts made by the different producers to modernise their capacities and introduce new production techniques
- indicators for product quality and for the type of products the different producers offer on the different markets.

---

[4] The two stages should not in fact be estimated independently since relative prices of the different commodities on market M, p_i^M, are themselves dependent upon the mix of producers supplying this market with these commodities, which is estimated in stage two, while the shares of expenditure allocated to purchasing different types of commodities, which are determined in stage one, are the independent variables in the market share equations estimated in stage two, so that the two stages should strictly be estimated interdependently.

[5] Because we use profit margins in general we do not allow for discriminating pricing policies by producers in different markets such as dumping would constitute.

3. SOME ECONOMETRIC RESULTS

Market share equations of the type (2.4) have been estimated both on time series data from the Statistical Office of the European Communities as well as on a particular set of cross-section data:

The time series are available on the basis of 25 NACE-CLIO industries (15 of which are manufacturing, agriculture and energy products for which also trade data are published).[6] For these industries data on output, employment, value added, investment, exports (total/to EC), imports (total/to EC) and final consumption data were obtained. From these data the demand systems of type (2.1) were estimated with - for this level of aggregation - strong emphasis on separability between large product groups and also a system of market share equations was set up which, however, also used information from another more detailed set of statistics. This other data set was derived from the Industrial Census which has been published for the member countries of the European Communities for the years 1976, 1977, 1978 and from a very detailed set of trade statistics[7] which have been available to the author for the years since 1975. The Census Statistics yielded much more information on the comparable supply characteristics of the different national industries of the European Communities. They were also available on a more detailed level (125 NACE-CLIO industries) and lent themselves well to a cross-section study of the effects of relative supply-characteristics on competitiveness for variables for which no information was contained in the time series data. Because of shortage of space and because the econometric exercise has not been completed yet we will here report only some of the results of this cross-section study for a particular group of sub-industries.[8]

In the following we report the results from the estimation of a simplified version of the system (2.4) of the form

$$w_{CM}{}^{i} = \alpha_C + \beta_C \log\left(\frac{\bar{x}}{P*}\right) + \sum_k \gamma_{CC'}{}^{k} \log \frac{s_{Ci}{}^{k}}{\sum_{C'} w_{C'} s_{C'i}{}^{k}} \tag{3.1}$$

where $P* = \sum_s w_{sM} \cdot p_{sM}$

with w_{sM} as the weights of the different sellers (comprising C and C' on market M).

---

[6] These data are published in an Appendix to Eurostat: National Accounts, Detailed Tables and were available on magnetic tape to the author.

[7] See Eurostat: Structure and Activity of European Industry for the Census statistics and see Eurostat: Analytical Tables for the trade statistics.

[8] The industries included in this particular cross-section exercise are 6 metal products industries, 8 mechanical engineering industries, 4 instrument engineering, 1 electrical engineering, 1 office equipment and 5 transport industries.

Since we are still working on various indicators for non-price competitiveness (which comprise product quality indicators and indicators for the degree of modernisation of production facilities such as the age composition of the capital stock used and the skill composition of the labour force) the estimates of the models of type (3.1), presented below, are still very preliminary and exclude most of the non-price variables.

In the time series estimates, market shares are simply a function of relative labour unit costs (LUR), an indicator for the over-/under-valuation of the national currency (XR)*, of relative investment efforts (investment per employee) undertaken over the past three years (IER) and of the volume of demand (YT) for the particular product in market M (market M in the case presented below is the demand for E.C. products in the European Communities).

In the cross-section estimates we have included two additional terms: Relative profit margins per unit sold (PRR) as an indicator for the relative pricing policies adopted by the different national producers (the variables have been standardised for differences in the degree of capital intensity between the different industries) and the relative volume of total sales (SAR) (as an indicator of relative scales of production vis-à-vis the mix of foreign competitors in market M (in this case the market for E.C. produce in the whole of the industrialised world).

---

*As an indicator for the "over-/under-valuation" of national currencies we have used the ratio of the current exchange rate to the purchasing power parity rate.

TABLE 3.1 Cross-section Estimates
dependent variable: shares of EC producers in the industrialised world's demand for EC produce; estimated across 25 industry groups* for the years 1976, 1977, 1978

	Fed. Rep. Germ.			France		
regressors:	76	77	78	76	77	78
YT	-.05	-.03	-.04	-.04	-.03	-.03
	(1.4)	(.9)	(1.2)	(.9)	(.7)	(.7)
LUR	-.16	-.23	-.18	-.34	-.34	-.31
	(1.4)	(1.3)	(.3)	(2.1)	(2.3)	(1.9)
PRR	-.11	-.03	-.04	-.46	-.01	-.15
	(.8)	(.2)	(1.0)	(1.7)	(.03)	(1.0)
SAR	.57	.58	.62	.89	.88	.85
	(8.2)	(5.9)	(9.7)	(8.8)	(13.4)	(13.3)
Interc.	3.7	3.5	3.5	3.9	3.5	3.6
	(7.0)	(5.4)	(6.2)	(5.1)	(4.9)	(5.1)
$\bar{R}^2$	.834	.754	.822	.821	.907	.900

	Italy			U.K.		
YT	-.01	-.03	-.03	-.07	-.05	-.04
	(.3)	(.5)	(.34)	(1.4)	(1.1)	(1.2)
LUR	.03	.25	.49	-.39	-.36	-.12
	(.1)	(1.0)	(1.3)	(2.1)	(2.0)	(.7)
PRR	.03	-.39	-.32	-.07	-.13	.11
	(.1)	(1.6)	(1.0)	(.4)	(.7)	(1.3)
SAR	.9	.89	.42	.52	.58	.62
	(7.4)	(5.8)	(5.0)	(3.0)	(4.8)	(6.5)
Interc.	3.3	3.8	3.9	3.6	3.5	3.8
	(4.3)	(3.8)	(2.9)	(5.1)	(4.9)	(6.8)
$\bar{R}^2$	.772	.662	.560	.334	.490	.663

*See footnote (8) above; t-ratios in brackets; R^2 corrected for degrees of freedom.

TABLE 3.2 Time series estimates

	YT	LUR	XR	Interc.	$\bar{R}^2$	DW
			F.R.G.			
4. Metals	-.036	-.209	.039	.945	.929	1.9
	(.97)	(10.8)	(.13)	(2.3)		
5. Minerals	-.056	-.072	-.418	.886	.218	1.6
	(1.6)	(1.4)	(1.7)	(2.1)		
6. Chemicals	-.031	-.190	-.350	.717	.838	2.05
	(1.0)	(4.1)	(1.9)	(1.8)		
7. Metal Pds.	-.042	-	-.603	.80	.929	3.3
	(4.1)		(6.6)	(7.1)		
8. Mach.	-.041	-.076	-.115	.918	.523	2.6
	(3.4)	(1.7)	(.62)	(5.6)		
9. Office Mach.	-	-	-.718	-	.734	1.9
			(2.2)			
10. Electr. Gds.	-.045	-.085	-.452	.890	.631	2.9
	(3.3)	(2.0)	(3.4)	(5.0)		
11. Transp. Eqn.	-	-.0704	-	.205	.718	2.1
		(2.1)		(1.0)		
12. Food, Dr., T.	-.034	-.074	-.408	.606	.861	2.7
	(3.9)	(4.6)	(6.4)	(5.6)		
13. Text., Cl., L.	-.058	-.025	-.209	.85	.958	2.5
	(12.8)	(1.9)	(4.3)	(15.4)		
14. Paper & Print.	-.0198	-.071	-.332	.512	.833	2.2
	(3.4)	(4.3)	(4.2)	(6.74)		
15. Rubber & Plant.	-.03	-.044	-.027	.686		2.4
	(1.3)	(.87)	(.23)	(2.5)		
16. Other Manuf.	.031	-.033	-.394	-	.663	1.6
	(2.1)	(1.2)	(2.5)			
			France			
4. Metals	.016	-.0987	-	.229	.939	2.2
	(.9)	(9.3)		(1.7)		
5. Minerals	.097	-.041	-.406	-.827	.856	1.7
	(6.7)	(.81)	(2.2)	(5.5)		
6. Chemicals	.33	-.077	.242	-.038	.88	1.7
	(2.8)	(3.5)	(1.5)	(.23)		
7. Metal Pds.	.045	.071	-.316	-.459	.904	1.8
	(4.15)	(2.3)	(12.5)	(5.2)		
8. Mach.	.027	-.053	-.453	-.954	.141	1.6
	(1.5)	(.7)	(1.9)	(.74)		
9. Office Mach.	-.0664	.021	-	.850	.941	1.95
	(8.9)	(1.2)		(10.2)		
10. Electr. Gds.	.051	-.049	-.367	-.342	.733	1.6
	(5.12)	(1.1)	(2.7)	(3.2)		
11. Transp. Eqn.	.092	-.067	-.65	-.685	.885	1.5
	(7.96)	(.85)	(3.1)	(3.5)		
12. Food, Dr., T.	.067	-	-.41	-.712	.91	1.9
	(7.1)		(3.8)	(7.3)		
13. Text., Cl., L.	.074	-.044	-.449	-.573	.77	1.5
	(3.3)	(.64)	(2.5)	(4.3)		
14. Paper & Print.	.053	-.039	-.53	-.381	.644	1.6
	(4.4)	(.58)	(2.6)	(2.0)		
15. Rubber & Plant.	.061	-	-	-.441	.897	2.2
	(3.96)			(4.62)		
16. Other Manuf.	.048	-	-.344	-.438	.766	1.7
	(5.0)		(2.1)	(4.2)		

Italy

	YT	LUR	XR	Interc.	$\bar{R}^2$	DW
4. Metals	-.042	-.068	-.778	.466	.982	3.1
	(4.1)	(9.5)	(5.3)	(4.0)		
5. Minerals	-.088	-.066	-.421	.912	.974	1.3
	(1.5)	(3.3)	(2.0)	(1.6)		
6. Chemicals	-.07	-.034	-.152	.774	.930	2.5
	(4.5)	(7.0)	(1.5)	(4.8)		
7. Metal Pds.	-.079	-.044	-.135	.779	.993	2.7
	(3.3)	(5.0)	(2.2)	(3.4)		
8. Mach.	-.115	-.517	-	1.08	.995	2.4
	(10.1)	(9.9)		(10.2)		
9. Office Mach.	-.123	-.046	-.069	1.06	.839	2.2
	(3.8)	(3.6)	(.598)	(3.9)		
10. Electr. Gds.	-.068	-.041	-.083	.662	.992	2.0
	(3.7)	(6.1)	(1.2)	(3.8)		
11. Transp. Eqn.	-.057	-.023	-	.576	.962	2.2
	(3.1)	(2.6)		(3.2)		
12. Food, Dr., T.	-.078	-.052	-.398	.85	.940	2.1
	(2.4)	(5.8)	(5.8)	(2.6)		
13. Text., Cl., L.	-.048	-.094	-.581	.492	.970	1.3
	(.31)	(1.6)	(1.1)	(.31)		
14. Paper & Print.	-.058	-.550	-.409	.593	.970	2.6
	(1.5)	(3.5)	(3.7)	(1.6)		
15. Rubber & Plant.	-.068	-.048	-.179	.678	.982	2.0
	(2.8)	(7.2)	(2.0)	(3.2)		
16. Other Manuf.	-.125	-.089	-.491	1.28	.976	1.6
	(2.0)	(4.4)	(2.3)	(2.1)		
U.K.						
4. Metals	-.048	-.02	-	.544	.880	2.1
	(3.0)	(3.3)		(3.0)		
5. Minerals	-.056	-.045	-.222	.568	.955	1.8
	(1.8)	(5.5)	(3.6)	(1.9)		
6. Chemicals	-.054	-.036	-.276	.609	.857	1.0
	(.94)	(2.8)	(.78)	(.96)		
7. Metal Pds.	-.014	-.028	-.230	.177	.903	2.2
	(.28)	(1.9)	(3.9)	(.38)		
8. Mach.	-.015	-.048	-.563	.213	.822	2.4
	(.26)	(2.4)	(4.4)	(.44)		
9. Office Mach.	-.35	-.138	-.397	2.99	.895	1.6
	(5.8)	(7.0)	(6.4)	(6.1)		
10. Electr. Gds.	-.04	-.042	-.363	.437	.795	2.7
	(.626)	(2.5)	(3.1)	(.74)		
11. Transp. Eqn.	-.039	-.028	-.364	.541	.169	1.6
	(.34)	(.59)	(1.9)	(.526)		
12. Food, Dr., T.	+.013	+.011	-.353	.148	.758	1.5
	(.466)	(3.9)	(3.0)	(.44)		
13. Text., Cl., L.	-.044	-.028	-.218	.52	.631	2.0
	(1.0)	(1.95)	(3.4)	(1.3)		
14. Paper & Print.	-.159	-.075	-.332	1.6	.963	2.5
	(8.2)	(11.6)	(9.0)	(9.1)		
15. Rubber & Plant.	-.05	-.038	-	.475	.985	1.5
	(1.4)	(3.6)		(1.4)		
16. Other Manuf.	-.076	-.045	-.24	.774	.961	2.1
	(5.1)	(11.1)	(6.6)	(5.6)		

4. SOME FURTHER EXTENSIONS OF THE MODEL OF DISPROPORTIONAL GROWTH AND ITS RELEVANCE FOR STRUCTURAL CHANGE ANALYSIS

Since the subject of this conference is 'Changes in Inter-industry Transactions', I would like to make some comments on the relevance of the above described pattern of interdependent disproportional growth for the analysis of changes in national and international inter-industry relationships.

The picture which emerges from the previous discussion is that there are basically two forces at work leading to disproportional growth of different national industries:

- the pattern of structural change in national and international demand for different commodities
- the relative competitive strengths and weaknesses of the different national industries relative to their international competitors in the different markets.

The analysis of strengths and weaknesses of the different national industries vis-à-vis international competitors on home, Rest of the EEC, and the RoW markets yields also interesting results for the study of patterns of change of national and international inter-industry relationships:

Firstly, it gives us some insight into the disaggregated dynamics of import-penetration.

Competitive performances do not only show up in affecting imports versus sales by domestic producers to final consumers, but it also affects absorptions of inputs from domestic or foreign sources. Only a certain proportion of total imports goes directly to final demand, the other imports are used as inputs for domestic industries.[9] Hence as a result of changes in the competitiveness of the different producers in the European Communities, the networks of international inter-industry relationships in the EC change over time.

Table 4.2 presents some figures on the proportions of inputs of different kinds (agricultural, energy, etc. inputs) which have been imported in the four bigger EC member countries. These proportions are derived from the Input-Output Tables for 1965 (where available), 1970 and 1975 issued by the Statistical Office of the European Communities.

A similar picture can be presented if the export-orientation of the different national industries is examined from the point of view of the disproportional growth patterns experienced by these industries and their effects on national inter-industry relationships.

Take the case where technology does not change: if different national industries experience - due to a particular growth pattern of demand and/or due to changing market shares - different rates of output growth, then the demand for inputs of these industries will also grow at different rates.

---

[9] Table 4.1 gives a breakdown of imports for final consumption purposes and intermediate absorptions for the 4 bigger EC member countries for the year 1975.

Table 4.1 (all in Mio ECU)

	Total Imports 1975	Imports for Final Consumption 1975	Imports for Intermediate Absorption 1975
Fed. Rep. of Germ.	73144.5	23603.4	49541.1
France	51191.1	15263.5	35927.6
United Kingdom	52201.3	17293.1	34908.2
Italy	35611.4	7368.3	28243.1

Table 4.2

Import Shares in the Absorption of Intermediate Inputs

	UK70	UK75	FR65	FR70	FR75	GE65	GE70	GE75	IT65	IT70	IT75
1. Agriculture	10.0	6.9	3.2	9.1	8.5	6.8	9.5	8.8	12.5	14.5	15.5
2. Energy	29.1	48.5	38.5	37.2	59.6	22.5	29.6	41.1	61.8	67.2	71.4
3. Metals	25.3	22.9	17.6	31.4	31.1	23.5	15.1	11.1	22.8	48.4	30.8
4. Minerals	11.4	9.0	6.0	4.3	4.0	7.8	11.3	11.2	10.9	12.8	9.1
5. Chemicals	27.3	23.8	22.9	30.2	29.7	15.8	21.2	18.4	16.7	21.7	18.7
6. Metal Prod	21.3	16.8	13.0	25.8	13.3	7.7	15.8	12.2	12.1	36.4	8.6
7. Machinery	9.7	14.1	11.2	18.6	25.5	10.1	11.1	10.8	10.0	12.1	9.7
8. Office Mach	11.3	20.4	15.1	11.7	8.0	13.1	21.3	18.0	20.6	18.5	16.1
9. Electrical Gds	15.1	21.8	11.8	18.6	21.8	11.2	14.6	15.1	26.4	29.0	22.8
10. Motor Vehicles	13.2	9.3	8.3	16.3	16.6	8.7	9.9	10.3	12.3	18.9	16.1
11. Transp Equipm	27.7	24.8	7.8	21.7	18.9	9.3	29.4	26.2	23.2	51.2	25.1
12. Food,Drink,Tob	31.8	25.7	10.0	16.6	10.2	20.0	18.4	18.7	14.2	24.7	19.4
13. Text,Cloth,Leath	24.9	24.1	17.9	20.5	23.4	28.2	21.1	27.1	19.8	23.9	18.0
14. Paper, Print	37.6	30.1	13.1	24.1	17.6	21.9	20.1	17.2	19.2	16.6	13.2
15. Rubber,Plastics	29.4	19.8	24.4	26.0	28.0	19.3	18.0	17.6	26.6	36.6	29.6
16. Other Manuf	42.4	32.7	12.9	19.9	16.6	22.7	13.5	15.4	32.3	46.3	28.1
17. Construction	15.7	7.2	7.2	11.0	13.9	5.3	8.7	10.0	5.1	31.3	5.9
18. Market Serv.	23.2	13.0	9.4	17.4	8.4	5.9	7.1	7.4	8.4	25.8	8.4
19. Non-Market Ser.	8.3	6.7	8.0	5.1	4.5	20.7	13.5	7.0	5.3	12.3	6.7

Faster growing industries will therefore also have to reorientate their intermediate sales away from the slow growing domestic industries and towards either the fast growing domestic industries or towards export markets.[10] We will thus expect to observe a process of decoupling of the more competitive group of industries from its domestic base (i.e. from the existing network of national inter-industry relationships) and the stronger integration of its intermediate sales in particular export markets.

Finally, concerning extensions and further work with this model I would like to mention one particular point: one of the useful features of the type of market shares model described in sections 2 and 3 is that it lends itself well to the use of a relatively heterogeneous data-base where different sets of supply characteristics can be compared with different groups of competitors. (E.g. for the other EC member countries more detailed information of their supply characteristics and their determinants are known than for other competitors). In this case market share equations will be formulated for the particular market segments (as distinct from market shares) where e.g. U.K. producers are mainly competing with other EC producers. And the market share equations which analyse the determinants of competitive success or failure in the different market segments of this type can use different sets of comparable supply characteristics for the competitors in this market segment. The determinants of the market segments themselves will then simply constitute another stage in a recursive system.

---

[10] In fact, if we take the group of faster growing industries as a whole - and if this group is not one decomposable part of a decomposable system - this group will by necessity have to re-orientate its intermediate sales towards export markets.

References:

Deaton, A.S. and J. Muellbauer (1980a). An Almost Ideal Demand System. Amer. Econ. Rev., June 1970, Vol. 70, No. 3, pp. 312-326.

———— (1980b). Economics and consumer behavior. C.U.P.

Pasinetti, L. (1981). Structural Change and Economic Growth. C.U.P.

Statistical Office of the European Communities: Five Yearly Input-Output Tables.

____ : Structure and Activity of Industry.

____ : Analytical Tables of Foreign Trade.

III. Interindustry Interactions and Energy Analysis

VARIATIONS IN INPUT–OUTPUT COEFFICIENTS: THE APPLICATION OF ESTIMATION AND FORECASTING TECHNIQUES FOR THE CASE OF POLAND

Łucja Tomaszewicz
Department of Statistics and Econometrics, University of Łodz, Łodz, Poland

1. CRITERIA FOR THE IMPORTANCE OF INPUT-OUTPUT COEFFICIENTS. EMPIRICAL RESULTS

Consider the model

$$y_t = (I-A)X_t \tag{1}$$

where: $y_t = [y_{it}]$ is a vector of final output ,
$X_t = [X_{it}]$ is a vector of gross output,
$A_t = [a_{ijt}]$ is a matrix of input-output coefficients .

A practical application of such a model in solving numerous problems connected with the formation of proper economic macro-proportions and economic equilibrium, i.e. among others with

- the determination of demand for the output of branches,
- the distribution of output among intermediate and final users,
- the utilization of production capacities of branches, etc.

is connected with the analysis of the behaviour of input-output coefficients in the investigated period. It is not always possible, and sometimes even unnecessary, to consider all the elements of matrix A_t. For practical reasons it is enough to concentrate on the important coefficients only /by consulting experts on expected changes or by constructing appropriate models of changes etc./.

We have assumed three basic criteria of coefficients importance[4]:

1/ Large values of coefficients a_{ijt} or related values. Even small inaccuracy in determining the values of these coefficients can influence, to a great extent, the correctness of solution of model (1).
2/ "Strong" connections between coefficient a_{ijt} and the whole economic system. The change of such coefficient can cause significant changes in the processes of production and distribution in the whole economy.
3/ Significant changeability of coefficient sequence $\{a_{ijt}\}$ in time.

Of course, each of these criteria, when considered separately, may order the importance of coefficients in a different way. On the one hand, there are large fairly stable coefficients most frequently linking the raw material sector with manufacturing ones, e.g. agriculture with food industry, which are not always strongly connected with other economic sectors. On the other hand, it is easy to point out relatively small although not stable in time coefficients or these strongly connected with other branches, e.g. transportation with other branches. With relation to this it seems that only joint consideration of the above criteria can properly evaluate their importance.[1]

On the basis of the above three criteria the methods for the determination of coefficients importance can be divided into [4]:

- direct ones based on the values of particular coefficients or their sequences and - according to the purpose of the study - their related values,
- indirect ones - in which the basis for evaluation of importance is the measure of the influence of an identical /in per cent/ change of particular coefficient on
  - the level of final output of the branch, under the assumption the gross output is unchanged /in this case exactly one element of vector y is changed in fact/,
  - the value of gross output of branches at unchanged final output.

The simplest measure in the group of direct measures is the absolute value of the coefficient, i.e.

$$d_{ij}^{(1)} = a_{ij} = \frac{X_{ij}}{X_j} , \qquad (2)$$

where X_{ij} is an input-output flow of the i-th branch to the j-th branch and X_j - the value of gross output of the j-th branch.

The higher the coefficient value, the greater importance is given to it.

According to the purpose of the study in the group of direct methods for evaluating coefficients importance related values such as

---

[1] It should be stressed that we mean the testing of importance in the context of model (1) on the basis of a given input-output balance or their sequence. If model (1) was a part of a model constructed not only to obtain consistent production plans it probably would not be necessary to use all of these criteria. Moreover, it cannot be excluded that quite different measures of importance might prove useful, e.g. in optimization model the degree of sensitivity of the optimal solution to the change of particular coefficient.

$$d_{ij}^{(2)} = \frac{x_{ij}}{\sum_i x_{ij}} = a_{ij}\frac{x_j}{\sum_i x_{ij}}, \tag{3}$$

$$d_{ij}^{(3)} = h_{ij} = \frac{x_{ij}}{x_i} = a_{ij}\frac{x_j}{x_i}, \tag{4}$$

$$d_{ij}^{(4)} = a_{ij}\frac{x_j}{\sum_j x_{ij}} \tag{5}$$

can be also considered with some generalization of these measures

$$d_{ij}^{(5)} = \sqrt{a_{ij}h_{ij}} = \frac{x_{ij}}{\sqrt{x_i x_j}}, \tag{6}$$

$$d_{ij}^{(6)} = \frac{x_{ij}}{\sqrt{\sum_i x_{ij}\sum_j x_{ij}}}. \tag{7}$$

These measures allow to obtain the information about coefficient importance only from the point of view of a given supplier and user. Before we pass to the indirect measures, which allow to carry out the evaluation of coefficient's influence on the behaviour of balanced economic system as a whole, we shall devote some attention to the measures based on the changeability of the coefficients in time.

The most frequently used measures are: relative differences in two moments of time between two balances. Having a sufficiently long series a_{ijt} the investigation of the coefficients changeability can be done by estimating trend function

$$a_{ij} = fa_{ij}(t).$$

The measure of importance of coefficients could be the derivative of this function in point t = T /T - forecasting period/

$$d_{ij}^{(7)} = \frac{dfa_{ij}(t)}{dt}. \tag{8}$$

Taking into account the results of the application of the other measures of importance it seems possible to consider as a

---

[2] It is easy to notice that measures $d^{(1)}$ and $d^{(2)}$ give similar hierarchy of coefficients importance if the share of net output in gross output is not too much differentiated in particular branches.

criterion not only the level of derivative in moment $t = T$ but also lower bound of confidence interval assuming that the coefficient is important if at high probability, it changes significantly in time and upper bound of this interval, assuming that the coefficient is important if it is possible /e.g. 5% probability/ that it changes significantly.

Let us now consider indirect methods for the evaluation of coefficient importance. We mentioned above two extreme cases which can result from a change of some coefficient a_{ij}. In the first case /unchanged gross output level/ the measure of the change of exactly one element in final output vector $y_i = - p/(100\, a_{ij}X_j)$/p - per cent of coefficient change/ is equally one sided as the above presented direct measures. In the second case the most frequently used measure is a so-called coefficient of tolerable limits

$$d_{ij}^{(8)} = \frac{1}{a_{ij}\left(0.01 b_{ji} + \max\limits_{k}\left\{b_{ki}\; X_j/X_k\right\}\right)}, \tag{9}$$

where b_{ji}, b_{ki} are the elements of matrix $(I-A)^{-1}$. The values assumed by these measures are interpreted as a per cent change of the value of coefficient a_{ij}, which causes a change in the output level of the i-th branch by 1%. The lower the value of $d_{ij}^{(8)}$, the more important is a given element of matrix A for the economic system as a whole.

In order to compare simultaneously the importance of input-output coefficient we proposed [4] the procedure for ranking of the obtained results. Particular elements a_{ij} are ordered within each criterion in a decreasing importance order by giving them the ranks

$$R_1^{(k)} = 1,\ R_2^{(k)} = 2, \ldots, R_m^{(k)} = m,$$

where $k = 1,2,\ldots,K$ - successive criteria, $m = n x n$ - the number of elements of matrix A.

The sum of ranks obtained by a given element with respect to all criteria, i.e.

$$R_i = \sum_{k=1}^{K} R_i^k \qquad i = 1,\ldots,m. \tag{10}$$

or a mean rank

$$\bar{R}_i = 1/K \sum_{k=1}^{K} R_i \tag{11}$$

is then the measure of importance of a given element.

The decision which level of R_i /or $\bar{R}_i$/ characterizes the important coefficient, is arbitrary and depends practically on the "scatter" of importance measures obtained with respect to various criteria. It may be therefore different for particular input-output balances.

1.1. Some Comments on Empirical Results

The importance of input-output coefficients has been analysed for the years 1971 and [4] for the years 1975 and 1980, on the basis of balances presented at current producer's prices in 15 aggregated industries[3] being: 1/ fuel and power industry, 2/ metallurgy, 3/ metal and electro-engineering industry, 4/ chemical industry, 5/ building materials, glass and pottery industry, 6/ wood and paper industry, 7/ light industry, 8/ food industry, 9/ other industrial branches, 10/ construction, 11/ agriculture, 12/ forestry, 13/ transport and communication, 14/ trade, 15/ other material goods and services. These numbers are also used in presented tables, which are a graphic representation of the obtained results.

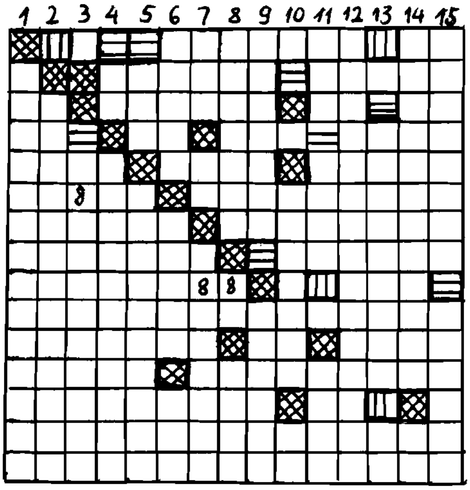


FIGURE 1 Important coefficients 1971

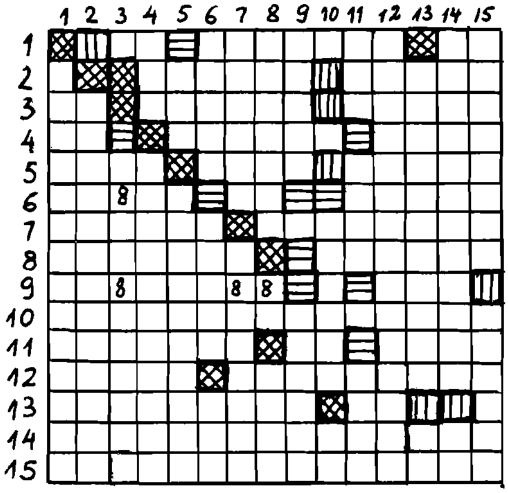


FIGURE 2 Important coefficients 1975

---

[3] An increased disaggregation level of branches up to 31 /used in the INFORUM system/ did not cause any significant changes in the distribution of coefficients importance. Only some technological links hiding in particular aggregates are marked more distinctly.

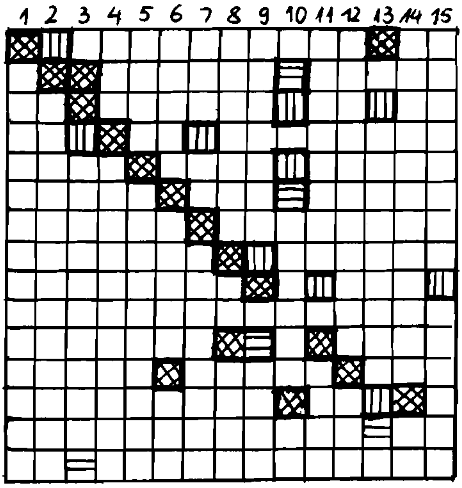


FIGURE 3 Important coefficients 1980

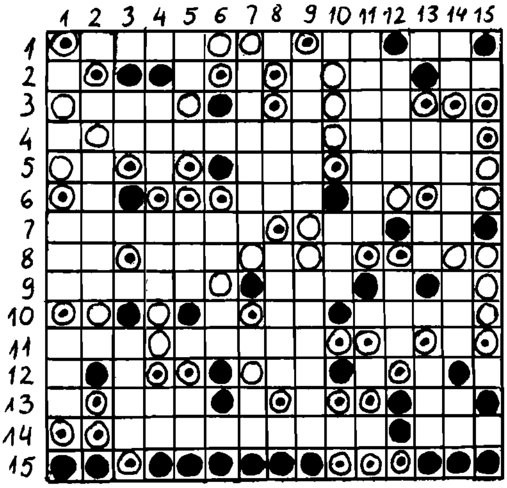


FIGURE 4 Trends of coefficients

The lined area denotes that the coefficient was assumed to be the most important in relation to ▤ 3 or 4 measures, ▥ 5 or 6 measures, ▩ 7 measures, and 8 denotes a coefficient with low tolerance coefficient /at other criteria being unsatisfied/. A thicker frame points out to a coefficient which is assumed to be most important from the point of view of rank sum. ● denotes that the determination coefficient R^2 of the trend function for the coefficient is in the interval (1,0.9>, ⊙ - in the interval (0.9,0.8>, ○ - in the range (0.8,0.7>.

The series of measures $d^{(1)}$-$d^{(6)}$ and $d^{(8)}$ ordered from the point of view of decreasing importance as well as that obtained from summing up of ranks have been analysed. Each of these series consists of 30 elements since it was observed that the scatter of values of different importance criteria for further elements in the ordered series increased significantly. In the ranking procedure the changeability of the coefficients in time has not been taken into account. The second part of this paper is devoted especially to the analysis of trend functions of coefficients.

Analysing Figures 1, 2, 3 it can be concluded that the most important coefficients are placed first of all on the main diagonal /it may be a result of sometimes significant aggregation of branches/ and coefficients which characterize the connections between sectors and branches of raw material and manufacturing type, e.g. metallurgy for metal and electro-engineering industry /a_{23}/, chemical industry for light industry /a_{47}/, forestry for wood and paper industry /a_{126}/ etc. The importance of these coefficients is almost identical for the three years considered.

For additional checking of this hypothesis 5 subsequent most important coefficients for each measure and each balance were chosen. It appeared that in most cases these were the same coefficients.

2. THE ANALYSIS OF INPUT-OUTPUT COEFFICIENT CHANGEABILITY BASED ON TREND FUNCTION

For all 225 balance coefficients /15 x 15 branches/ the trend functions have been estimated. The below presented estimation has been prepared on the basis of balances /in producers' prices/ constructed for the seventies. These are the balances for the years 1971-75, 1977, 1979-80. There are also balances for the period 1966-70. They are not, however, comparable with the following ones because of a significant change in branch classification in the seventies. The following trend functions were taken into account

I/1 $a_{ijt} = \alpha_0 + \alpha_1 t,$

II/2 $a_{ijt} = \alpha_0 + \alpha_1 t + \alpha_2 t^2,$

III/3 $\ln a_{ijt} = \alpha_0 + \alpha_1 t,$

IV/4-6 $\ln a_{ijt} = \alpha_0 + \alpha_1/(t+\vartheta),$

V/7-9 $\ln a_{ijt} = \alpha_0 + \alpha_1 \ln(t+\vartheta),$

VI/10-12 $\ln a_{ijt} = \alpha_0 + \alpha_1/(t+\vartheta) + \alpha_2 \ln(t+\vartheta),$

$$\vartheta = 0,\ 5,\ 10.$$

A graphic representation of the obtained results is shown in Fig. 4. There, and also in the next Table 1 the estimation results for the trend function are grouped according to determination coefficient R^2, taking into account that beginning with its value equal 0,7 with all parameters estimates important, it can be assumed that the input-output coefficient is characterized by given tendencies of changes in time. It follows from Table 1 that the best fitted function to the real changes of coefficients in time are the inverse-logarithmic functions 10-12 , i.e. the functions with minimum or maximum values. This result is not unexpected. The analysis of changes in the input-output structure allowed to observe an increase of many coefficients up to the maximum values attained in the years 1975, 1977 or 1979, and then their significant decrease was noted. Material costs increase in these years /especially in 1975, 1977/ was observed even for the coefficients which revealed on the average a declining trend.

TABLE 1 Trend functions of coefficients according to the maximum R^2 coefficient

R^2 (1,0.97		R^2 (0.9,0.8>		R^2 (0.8,0.77	
Number of coefficient i/j	R^2 value /number of function/	Number of coefficient i/j	R^2 value /number of function/	Number of coefficient i/j	R^2value /number of function/
1/12	0.91 /10/	1/1	0.83 /12/	1/6	0.76/3/
1/15	0.96 /10/	1/9	0.80 /11/	1/7	0.70/5/
2/3	0.92 /11/	2/2	0.88 /10/	2/10	0.72/11/
2/4	0.91 /12/	2/6	0.89 /2/	3/1	0.78/1/
2/13	0.94 /10/	2/8	0.86 /1/	3/5	0.79/1/
3/6	0.99 /10/	2/11	0.82 /11/	3/10	0.77/5/
5/6	0.98 /1/	3/8	0.81 /10/	4/2	0.73/10/
6/3	0.95 /2/	3/13	0.88 /11/	4/10	0.79/10/
6/10	0.90 /11/	3/14	0.89 /10/	4/12	0.79/10/
7/12	0.92 /11	3/15	0.82 /9/	5/1	0.79/2/
7/15	0.93 /11/	4/15	0.82 /1/	5/15	0.78/5/
9/7	0.95 /10/	5/3	0.80 /9/	6/12	0.77/10/
9/11	0.92 /6/	5/5	0.84 /11/	6/15	0.75/11/
9/13	0.93 /2/	5/10	0.84 /2/	7/9	0.71/2/
10/3	0.96 /10/	6/1	0.84 /5/	8/7	0.75/10/
10/5	0.95 /1/	6/4	0.88 /8/	8/9	0.73/11/
10/10	0.99 /10/	6/5	0.87 /6/	8/14	0.72/11/
12/2	0.91 /1/	6/6	0.89 /7/	8/15	0.76/9/
12/6	0.97 /10/	6/13	0.83 /11/	9/6	0.70/6/
12/10	0.95 /6/	7/8	0.81 /10/	10/2	0.71/7/
12/14	0.92 /10/	8/3	0.85 /12/	10/4	0.78/7/
13/6	0.97 /11/	8/11	0.85 /12/	10/15	0.74/4/
13/12	0.93 /10/	8/12	0.82 /11/	11/4	0.79/11/
13/15	0.92 /1/	9/4	0.89 /10/	12/7	0.76/4/
14/12	0.92 /10/	10/1	0.87 /2/		
15/1	0.95 /11/	10/7	0.87/5/		
15/2	0.93 /11/	11/10	0.85 /7/		
15/4	0.96 /10/	11/11	0.84 /10/		
15/5	0.92 /11/	11/13	0.89 /1/		
15/6	0.95 /10/	11/15	0.82 /11/		
15/7	0.91 /10/	12/4	0.88 /2/		
15/8	0.94 /10/	12/5	0.84 /6/		
15/9	0.93 /10/	12/12	0.89 /10/		
15/13	0.96 /11/	13/2	0.86 /12/		
15/14	0.95 /10/	13/8	0.88 /9/		
15/15	0.93 /11/	13/10	0.87 /7/		
		13/11	0.81 /6/		
		14/1	0.85 /1/		
		14/2	0.86 /1/		
		15/3	0.89 /11/		
		15/10	0.80 /11/		
		15/11	0.86 /11/		
		15/12	0.84 /1/		

In Table 1 the values of R^2 were stressed for the coefficients which had been assumed important. There are 15 such coefficients. Thus, over half of 30 coefficients being important reveal a tendency to change in time. To determine the scale and tendency of these changes the above-mentioned measure of changes being supplementary to the importance measures of the coefficient, should be applied additionally.

3. RESULTS OF EXPERIMENTS ON THE APPLICATION OF SOME TECHNIQUES FOR FORECASTING OF INPUT-OUTPUT COEFFICIENTS

The input-output coefficients can have only some determined values /non-negative, ranging from zero to unity, their sum in a column does not exceed unity/. Due to this, and also due to scarcity of statistical information in the input-output tables the most frequently used techniques of forecasting and adjustment of coefficients are the techniques based on some base matrix and the values which should be attained by the sum of row and column of the forecasted matrix.

The classical, though still most frequently used are the biproportional RAS-type methods and techniques of mathematical programming. In the case when many input-output tables are available, a mixed method of mathematical programming and regression analysis [6] based on lsm in the estimation /and forecasting/ of input-output coefficients with imposed constraints on them can be employed. The mixed method requires sufficiently long series of final and total outputs. On the other hand, very seldom econometric forecasting techniques based on trend functions /or regression functions/ are applied as the only forecasting methods, Such forecasts usually require some adjustment to be made because of the conditions which must be satisfied by the coefficients. Generally, biproportional or mathematical programming methods are used in adjustment. Finally, to complete the review of methods applied in coefficient forecasting, heuristic methods based on experts' opinions and evaluations should be mentioned. With relation to the previous methods employing statistical data from the previous period, they are called ex ante methods [5] , and their theoretical basis is often performed in terms of Bayesian approach [3].

In literature many general observations concerning the methods of forecasting the input-output coefficients and especially the assumed base matrix, can be found. From the studies [1] , [2] carried out for the economies with relatively stable input-output structures /also in the sense of stable tendencies of changes - linear and exponential trend functions/ it follows that the base matrix composed of values of coefficient trends /chosen/ or of the coefficients forecasted using other methods employed in projections yields worse results than the application of the matrix from a given year, especially from a period close to the forecasted one.

From the analysis of input-output coefficient stability for the Polish economy in the seventies it follows that an increase of material costs especially in the years 1975, 1977 and then their decrease occurs. In this case it may appear that, first of all, taking the base matrix more distant from the forecasted period and characterized by lower material costs can give better results than it is the case with the base matrices closer to the forecasted period but characterized by material costs increase. Secondly, taking the values of chosen coefficients of short-term forecasts based on trend functions and introducing them to the base matrix by applying e.g. a modified RAS method, may also increase the accuracy of the forecasts.

To verify these hypotheses an ordinary RAS method was used to obtain the coefficients for 1980 assuming as a basis the matrices for the years 1971, 1975 and 1979. The obtained results are compared with the real matrix for 1980. The modified RAS algorithm was also used by introducing to base matrices for important coefficients the values of trend function for the year 1980.[4]

We should keep in mind that the RAS method assumes that in the forecasted period the matrix A is biproportional to the base matrix A^o, i.e.

$$A = RA^oS,$$

where R and S are diagonal multiplier matrices. Thus, the forecast of each element of the matrix $A = [a_{ij}]$ is a product of the input values and some multipliers r_i and s_j:

$$a_{ij} = r_i a_{ij}^o s_j.$$

These multipliers are determined from the identity

$$\sum_{j=1}^{n} r_i a_{ij} s_j = a_{i.} \quad ,$$

$$\sum_{i=1}^{n} r_i a_{ij}^o s_j = a_{.j} \; .$$

The values of $a_{i.}$ and $a_{.j}$ being the sums in rows and columns of

---

[4] The 1980 coefficients were obtained by the extrapolation of the trend functions estimated on the basis of 7-element series of observations /including 1979/. For extrapolation, similarly as in the previous case, these functions were chosen which were characterized by the highest determination coefficient and significance of all parameters estimates. They were usually the same functions as those presented in Table 1.

the forecasted matrix, respectively, are assumed to be known.

The RAS algorithm was modified in the following way. The matrices of trends and zeroes $T = [t_{ij}]$ were constructed according to the rule that $t_{ij} = 0$ for the coefficients which did not reveal changes in time and $t_{ij} \neq 0$ and equal to the values of forecasts for the coefficients changing in time. Then the base matrix was modified

$$a_{ij}^{o'} = \begin{cases} 0 & \text{for } t_{ij} \neq 0 \\ a_{ij}^{o} & \text{for } t_{ij} = 0 \; . \end{cases}$$

Of course, the sums in rows and columns of the base matrix changed respectively.

$$a'_{i.} = a_{i.} - \sum_{j=1}^{n} t_{ij},$$

$$a'_{.j} = a_{.k} - \sum_{i=1}^{n} t_{ij}.$$

Hence, the forecast of matrix A' is obtained

$$A' = R'A^{o}S',$$

where $R'$and S' denote multipliers determined for matrices A' and $A^{o'}$. In the final stage the forecast of the proper matrix is determined

$$A = A' + T.$$

Table 2 presents a comparison of the results of application of the ordinary and modified RAS methods. The measure of accuracy of the forecasts are the differences between the obtained values of 1980 coefficients and the real values presented in the form of euclidean norms /the roots of squares sums/ of rows in the matrices of differences. The obtained results confirm the assumed hypothesis. The base matrix of 1971 gave better results of adjustment than the 1975 matrix. Similarly, slightly better results were obtained in the case of modifying these matrices by the values of selected coefficients determined using the extrapolation of trend function for the year 1980.

The problems presented in the paper are only a fragment of research carried out at the Institute of Econometrics and Statistics, University of Łódź, on the application of input-output techniques to the studies on the effect of changes in the structure of inter-industry interactions on the economic macroproportions and balance of the economy.

TABLE 2 Comparison of norms of the difference-matrix rows

	Base matrix 1971		Base matrix 1975		Base matrix 1979	
	Ordinary RAS	RAS with trends	Ordinary RAS	RAS with trends	Ordinary RAS	RAS with trends
1	0.126	0.085	0.147	0.073	0.030	0.065
2	0.033	0.048	0.040	0.053	0.010	0.041
3	0.062	0.100	0.073	0.100	0.010	0.055
4	0.025	0.032	0.035	0.062	0.013	0.027
5	0.028	0.018	0.024	0.016	0.004	0.008
6	0.060	0.038	0.075	0.067	0.006	0.014
7	0.017	0.020	0.016	0.019	0.008	0.007
8	0.036	0.123	0.102	0.128	0.020	0.123
9	0.051	0.059	0.039	0.059	0.018	0.011
10	0.043	0.031	0.020	0.033	0.004	0.014
11	0.113	0.060	0.064	0.027	0.028	0.026
12	0.142	0.051	0.121	0.049	0.003	0.048
13	0.095	0.127	0.075	0.110	0.008	0.030
14	0.106	0.105	0.184	0.182	0.053	0.055
15	0.069	0.049	0.053	0.042	0.003	0.012
Matrix norm	0.299	0.279	0.332	0.313	0.076	0.180

Three of those problems have been presented in the first part of the paper. According to the problem, research is carried out in the system of 15 x 15 branches or 31 x 31 groups of industries. Many studies on input-output coefficients in the latter system are also applied in the INFORUM-type model for Poland.[5]

REFERENCES

[1]Barker, T.S. /1975/. Some Experiments in Projecting Intermediate Demand. In: Estimating and Projecting Input-Output Coefficients. Input-Output Publishing Company, London.

[2]Chapman, D. /1978/. Forecasting Technological Coefficients. VII Conference of Economists, Sydney, August-September 1978.

[3]Lawson, T. /1979/. Some Notes on Forecasting Technological Coefficients. Growth Project Paper 478, Cambridge.

[4]Lipiński C., Tomaszewicz, Ł. /1982/. Important Coefficients in the Input-Output Models for Poland. 9th Conference on Problems of Building and Estimation of Large Econometric Models Łódź, December 1982.

[5]Tilamus, C.B. /1966/. Input-Output Experiments: The Netherlands 1948-61. Rotterdam University Press, Rotterdam.

[6]Tomaszewicz, Ł. /1983/. Integrated Models of National Economy /in Polish/, Państwowe Wydawnictwo Ekonomiczne, Warsaw

---

[5] The adaptation of SLIMFORP/INFORUM system to computers in Poland is led by Dr.A.Tomaszewicz, the author of many computer programs for the above reasearch.

EXPERIENCES OF STUDYING CHANGES IN INPUT–OUTPUT COEFFICIENTS IN FINLAND

Osmo Forssell
Department of Economics, University of Oulu, 90101 Oulu, Finland

1. MEASUREMENT OF CHANGES

Different methods are used in studying changes of input coefficients. This is often due to available information. Ideal situation exists when a time serie of annual input-output tables compiled consistently and using the same concepts and methods are available. This kind of full information situation exists only in few countries. In Finland input-output tables are available for years 1956, 1959, 1963, 1965, 1970, 1978 and 1980. These tables have been compiled using different concepts, classifications and methods. So different measurements of changes have been used in studying stability of input coefficients and impacts of their changes on development of outputs.

Measurement of changes in input-coefficients have been made in Finland using methods outlined as follows.

$$\ln(a_{ij}(0)/a_{ij}(t)) = -\ln(a_{ij}(t)/a_{ij}(0)) \qquad (1)^{1}$$

This measure is symmetric and independent on the choice of the year for comparison. (Theil, 1966, p. 256-282). It is used for analysing changes of individual coefficients. These measures must be weighted by their shares in the intermediate demand or in the use of intermediate input when forecasting ability of output and price model is analysed.

$$\Sigma_j x_{ij}(t)\,|\ln(a_{ij}(0)/a_{ij}(t))|/\Sigma_j x_{ij}(t) \qquad (2)$$

$$\Sigma_i a_{ij}(t)\,|\ln(a_{ij}(0)/a_{ij}(t))|/\Sigma_i a_{ij}(t) \qquad (3)$$

Absolute values measure average changes of coefficients. Non-absolute values measure errors of estimates of intermediate demand and use of intermediate inputs. The measures of the equations (1) - (3) may also be applied in studying variations of input coefficients between establisments inside an industry. Disperision measures of statistics are often used, too.

---

[1] $a_{ij}(t)$ is an input coefficient in the year (t)

$x_{ij}(t)$ is use of output of industry i as an input in industry j in the year (t)

When input-output tables are not available for several years only impacts of changes of input coefficients may be analysed. The impacts on intermediate demand and use of intermediate inputs can then be examined. Measurement presumes that data on output,

$$\ln\{\Sigma_j a_{ij}(0)x_{ij}(t)/(x_i(t)+m_i(t)-y_i(t))\} \qquad (4)$$ [2]

$$\ln\{\Sigma_i a_{ij}(0)x_i(t)/(x_j(t)-z_j(t))\} \qquad (5)$$

imports, final demand and value added by industries are known for some year (t) in addition to input coefficients of the year (0).

One input-output table alone may be used for studying possible changes of input coefficients. Changes are then simulated and sensitivity of input coefficients is examined. The measure d_{rs} indicates how many

$$d_{rs} = 1/a_{rs}(\max_i(b_{ir}/x_i)x_s + 0{,}01b_{sr}) \qquad (6)$$ [3]

percents an input coefficient a_{rs} may change such that the output of any industry does not change more than one percent. The finad demand is supposed to be constant. The smaller the value d_{rs} is the more sensitive the coefficient a_{rs} is. (Mäenpää, 1981).

Comprehensive description of structural changes is got in an analysis of change in the use of some special input. The change is then decomposed into four components as follows: growth, structure of demand, general input-output technology, and special input technology. (Mäenpää & Karinen & Viitanen, 1981)

a) Growth: $E(0)B(0)(\bar{g} - 1)y(0)$ (7a)[4]

b) Structure of demand: $E(0)B(0)[y(t) - \bar{g}y(0)]$ (7b)

c) General input-output technology: $E(0)[B(t) - B(0)]y(t)$ (7c)

d) Special input technology: $[E(t) - E(0)]B(t)y(t)$ (7d)

---

[2] $x_i(t)$ and $x_j(t)$ are an output of industry i and j in the year (t), $m_i(t)$ is imports of commodities characteristics to industry i in the year (t), $y_i(t)$ is final demand for industry i in the year (t), and $z_i(t)$ is value added in industry j in the year (t).

[3] b_{ir} and b_{sr} are coefficients of Leontief's inverse matrix $B = (I - A)^{-1}$

[4] E(0) and E(t) are matrices of direct special input coefficients B(0) and B(t) are Leontief's inverse matrices
y(0) and y(t) are vectors of final demand, $\bar{g}$ is an average growth rate of final demand: $\Sigma_i y_i(t)/\Sigma_i y_i(0)$

The separation of the causes for changes in input coefficients is not clear and unambiguous since they operate simultaneously. When high correlation between causes exists, the effects of different causes are hard to indentify from empiral data. The size of input coefficient may be determined by the following function (Forssell, 1972).

$$a_{ij}(t) = f_{ij}(K_j, L_j, M_j, N_j, u_{ij}) \qquad (8)^5$$

Substituting this equation for the input coefficients in an open static input-output model gives the following model

$$x_i(t) = \Sigma_j f_{ij}(K_j, L_j, M_j, N_j, u_{ij}) x_j(t) + y_i(t) \qquad (i=1, \ldots, n) \qquad (9)$$

The parameters of these equations could be estimated by simultaneous estimation methods. Information on stability of input coefficients could be got simultaneously. However, the short length of the available time series and difficulties in identification often act to constrain this kind of estimation. A simple least square estimation method must be applied directly to the equations of input coefficients (8).

2. OBSERVATIONS

Changes of input coefficients were observed according to the equation (1) between 1956, 1959, 1963 and 1965. The four greatest input coefficients, the coefficient for other intermediate inputs and the coefficient of value added were then analysed in 21 manufacturing industries. Coefficients referred to value inputs (Forssell, 1970).

TABLE 1 Distribution of changes in input coefficients according to size of changes

Size of	1956-coefficients			1959-coefficients		1963-coefficients
change %	1959	1963	1965	1963	1965	1965
0-5	11,8	14,2	11,0	19,2	17,5	18,3
5-10	13,4	11,0	16,5	13,8	18,3	13,5
10-15	12,6	9,4	18,2	16,2	15,8	17,4
15-20	10,2	15,0	5,5	12,3	9,5	7,9
20-30	21,3	12,6	11,8	17,7	14,3	17,5
30<	30,7	37,8	37,0	20,8	24,6	25,4
Total	100,0	100,0	100,0	100,0	100,0	100,0

Measurements were also made according to the formulas (2) and (3). These observations are presented in table 2.

Observations made in this study indicate that changes of input coefficients are remarkable. Relative changes of small coefficients are greater than changes of great coefficients.

---

[5] K_j is technical development in industry j, L_j is relative price of input in industry j, M_j is product mix in industry j, N_j is change of output in industry j, and u_{ij} is a residual term.

TABLE 2 Weighted changes of the four greatest input coefficients, intermediate demand

observation period and its length	absolute changes	net changes
1963-65 (2 years)	0,114	0,075
1956-59 (3 years)	0,145	0,103
1959-63 (4 years)	0,122	0,970
1959-65 (6 years)	0,133	0,116
1956-63 (7 years)	0,144	0,096
1956-65 (9 years)	0,150	0,105

The change in the greatest input coefficients were observed to increase with the length of the observation period. The regression equation between the square of median of the weighted absolute changes of input coefficients on rows and time was:

$$(\text{median})^2 = 0{,}0074t^{0{,}8} \qquad (10)$$

Consequently the median of changes of input coefficients was 8,6 % in the first year and later increased less than proportionally. After 10 years it was 21,7 %. The size and rapidity of changes could not be considered to be different from those observed in other countries.

Changes of individual input coefficients eliminate each others even rowwise. This decreases errors in forecasts of intermediate demand due to changes of input coefficients by one fourth.

Change of input coefficient is obvious at once when observation is made. Then the change somehow settles down to its level, which increases only little when time goes on. Different practise in compilation of input-output tables, inaccuracy of basic statistics, and different cyclical stage in observation years are reason beside real factors cousing these changes in coefficients. In Finland input-output tables for 1965, 1970, 1978 and 1980 are input-output tables of the second generation. Analyses of changes of input coefficients between these years must be made in a study adjusted to concepts, statistical solutions and classifications followed in compilation of these tables.

In a preliminary study the calculations were made by 1970 coefficients for the years 1971 and by 1965 coefficients for 1966-1975. The calculations were made according to the formulas (4) and (5). Data of national accounts on household consumption, government consumption, gross domestic fixed capital formation, change in stocks and statistical discrepancy had then to be transformed into classifications of input-output tables. Observed impacts of changes of input coefficients on intermediate demand were in some industries rather great. These preliminary results pointed out that it was too early to make conclusions on changes of input coefficients. Imperfections in the underlying statistics, unstability of convertes with fixed distributions and problems related to deflation to constant prices had obviously so great impacts on observations (Forssell, 1982).

The variation in the input coefficients of establishments may be due to the following factors:

- differences in the unit price of inputs
- differences in the commodity-mix produced
- differences in production methods.

The unit price of inputs, when measured in terms of buyer's price, can be influenced by transport costs, the volume of purchases, the quality of inputs, etc. Differences in the quality of inputs may be associated with differences in the types of commodities produced since commodities of different types and qualities require different inputs.

Establishments within a group may be specialized in the production of various commodity-mixes within the range of commodities applicable to the group. Differences in commodity-mix and in production methods are thus dependent on each other, at least partly. Differences in production methods may also be explained by factors such as the scope of productive activity, combination of different production methods, age of establishments, etc.

Analytical isolation of the factors accounting for the dispersion of input coefficients is rendered difficult because such factors are often intercorrelated. The dispersion due to differences in unit prices and commodity-mix can nevertheless, to some extent, be isolated by re-calculating the coefficients using uniform or average unit prices and rearranging commodity-mixes. The residual dispersion may then chiefly be attributed to differences in production methods.

These problems were analysed for breweries, playwood mills, sulphite pulp mills, sulphate pulp mills, glass factories, and nail and steel wire factories in 1959 using establishment data (Forssell, 1969). It was concluded that about two thrids of the explained dispersion of input coefficients among establishments may be attributed to heterogeneity in commodity mix, and one thrid to replacement of the particular principal inputs by other inputs. Prices were found to exert practically no influence upon variation of input coefficients among eslablishments.

When using the 38-sector I/O-model of the FMS with the data of the year 1970, the d-measure gave the results presented in table 3.

TABLE 3 Sensitivity of input coefficients

Size of change %	Number of input coefficients	Cumulative %-distribution
0 % < d ≤ 5 %	22	1.6
5 % < d ≤ 10 %	22	3.2
10 % < d ≤ 20 %	45	6.5
20 % < d ≤ 50 %	38	9.3
50 % < d ≤ 100 %	136	19.3
100 % < d	1100	100.0

Only 3.2 % of the input coefficients could change 10 % at most without causing more than 1 % prediction error to the gross product of any sector. On the other hand nearly 81 % of the coefficients must change more than 100 % to cause prediction error of more than 1 % (Mäenpää, 1981).

Mäenpää calculated further by using Monte Carlo experiment how much the prediction errors of the model are reduced when the most important 22 input coefficients are constant correctly. All the other coefficients were then changed +/- 10 % at radom, -10 %, and +10 %. The results were as presented in table 4.

TABLE 4 The prediction errors when input coefficients were changed

Change of coefficients	the largest error of industries all the coefficients changed	 22 coefficients constant	the average error all the coefficient changed	 22 coefficients constant
+/- 10 %	8,8 %	3,2 %	2,3 %	1,1 %
- 10 %	-18,8 %	-10,3 %	-7,2 %	-4,5 %
+ 10 %	22,9 %	11,2 %	8,4 %	4,9 %

Errors due to changes of input-output coefficients are then reduced remarkably if the most important coefficients are estimated correctly.

Changes of energy use of the Finnish economy between 1970 and 1978 were analysed in the whole framework of structural changes. The equations (7) were used in decomposing changes into four components. The energy inputs were measured in joules and in marks. The directly measured energy commodity inputs were converted to types of primary energy. The results are presented in table 5 (Mäenpää & Karinen & Viitanen, 1981).

TABLE 5 The shares of different causes in changes of energy use between 1970 and 1978

Causes	Total final demand	Household consumption	Exports
Growth	+63,5	+79,7	+110,4
Structure of demand	+31,8	+48,3	-44,8
Input-output technology	+9,5	+0,8	+10,4
Energy technology	-4,8	-28,8	+24,0

When changes of input coefficients are considered as a part of other structural changes in the economy their role is rather small. This might be mainly caused by different directions of changes. Use of open static input-output model for structural analyses is then unsensitive for changes in input coefficients.

Changes which appear in input coefficients may be due to the following causes:

1. Technological change
   - changes in quality of inputs which is often due to technological development in other industries
   - learning, when production methods and organizations are used more efficiently than before
   - renewing of production equipment
2. Changes in relative prices of inputs, which causes substitution among inputs
3. Changes in product-mix of industries
4. Changes in scale of production.

These causes of changes in input coefficients were analysed for 21 manufacturing industries[6] related to forestry sector 1954-1965 (Forssell, 1972).

The correlation between input coefficients and the share of the principal product in the total output was fairly low and their sings varied. The correlation between the input coefficients and the proportional changes of outputs was very weak.

The estimated equations indicated that product-mix, proportional prices of inputs and mechanization of production process (measured by degree of electrification and mechanization and time) seem to have the strongest effects on the input coefficients. These factors had varied effects on different inputs and among the same coefficients between industries. General factors influencing on input coefficients could then not be found out.

Technical development of the production process was the factor most widely affecting the input-output coefficients. It had first of all effects on primary and electric energy inputs, but it also influenced the coefficients of raw material inputs. Proportional prices had stronger effects on material input than on inputs related to use of machines. Consequently they had effects on the ratio between intermediate inputs and primary inputs. Product-mix had fairly even effects on different inputs, but its effects were smaller than those of proportional prices of inputs and of mechanization of the production process.

3. CONCLUSIONS

The size of the changes in input coefficients and the accuracy of the forecasts made with constant coefficients input-output models indicates that the model is not good for the long term evaluation purposes. Views of using the model for structural analyses and for simulations are much better. The input-output model even with constant input coefficients is useful in studing patterns of economic structural change and industrial adjustments. The model may be made better for these kind of analyses by evaluating changes in the most important and strategic input coefficients. Their number is then remarkably decreased. Evaluation of changes of coefficients concerns first of all technological development which is closely related to expected changes of relative prices. Both causes have substitution effects among inputs. Time-paths of substitution processes due to tehnological development trends are then central research objects in the furure.

REFERENCES

Forssell, O. (1969). Statistical Unit, Classification and Aggregation in Finnish Input-Output Study, Industrial Planning and Programming Series No. 2, Interindustrial Comparisons of Interindustry Data, United Nations, New York, 1969.

---

[6] The industries whose coefficients were analysed form a recursive chain of outputs and principal raw material inputs in the following main groups: I Mechanical and chemical processing of wood (7 industries), II Manufacture of wood products (6 industries), III Paper and cardboard industries (2 industries), and IV Paper and cardboard using industries (6 industries)

Forssell, O. (1970). Changes of Input-Output Coefficients in Finland 1954-1965, Central Statistical Office of Finland, Helsinki , 1970.

Forssell, O. (1972). Explaining Changes in Input-Output Coefficients for Finland, Brody A., Carter A.P. (ed), Input-Output Techniques, 1972, North-Holland Publishing Company.

Forssell, O. (1982). Changes in Input Coefficients and Possibilities to Forecast Them, Smyshlyaev A. (ed), Procedings of Task Force Meeting on Input-Output Modeling (1981), Collaborative Paper June 1982, IIASA.

Mäenpää, I. (1981). The Sensitivity of the FMS Input-Output Model to Changes in Input-Coefficients, Proceding of the 3rd Finnish-Soviet Symposium in Economics, No. 12 the Finnish-Soviet Committee on Scientific-Technological Cooperation, Helsinki 1981.

Mäenpää, I., Karinen, T., Viitanen, M. (1981). Hyödykkeiden energiasisältö, Panos-tuotostutkimus Suomen kansantalouden energiakäytöstä vuosina 1970 ja 1978, Sarja B: 21, Kauppa ja Teollisuusministeriö, Energiaosasto, Helsinki 1981.

Theil, H. (1966). Applied Economic Forecasting, North-Holland Publishing Company, 1966.

ANALYSIS OF CHANGING ENERGY COEFFICIENTS IN AUSTRIA, 1964–1980

Christian Lager
International Institute for Applied Systems Analysis, Laxenburg, Austria

1. INTRODUCTION

This paper sets out to explain changes in energy input coefficients in Austria over the period 1964-1980. Most studies dealing with changing input structures explain changing coefficients in terms of changes in relative prices using the neoclassical cost-minimizing model. Many types of production functions have been applied, including translog (Halvorsen 1977; Christensen-Jorgensen-Lau 1971), Diewert (Diewert 1971; Bonnici 1983; Taylor 1979), and Cobb-Douglas. However, neoclassical theory--like all other theories--only holds under certain conditions. One of these conditions is that the outputs of individual industries should be homogeneous; but, because of a lack of homogeneous data, neoclassical theory is often applied to aggregated industry figures.

Therefore, one aim of this study was to develop a technique to estimate more homogeneous input coefficients from aggregate industry data using econometric tools.

Besides prices, a lot of other factors affect input coefficients. One of the factors is the varying output mix of industries. Bayer (1982) subdivided the energy/output ratio for the Austrian manufacturing sector as a whole into a technology effect and a production-structure effect. He found that the technology effect declined between 1956 and 1973 at an average annual rate of 2.6% and between 1973 and 1980 at a rate of 1.3%, while the production-structure effect rose from -0.6% per annum prior to 1973 to 1.3% after the first oil shock. While the decline of the aggregate energy coefficient in the fifties and sixties was effected by capital-intensive changes from coal to oil and gas technologies, the major part of the decrease in the energy/output ratio after the first oil shock was due to changes in output structures from energy-intensive basic sectors to the final production industries of the manufacturing sector.

Analyzing the effects of changing output structures on the energy demand of Austrian industries for 1964-1973, Foell et al. (1979) pointed out that energy demand projections for industries could be improved by considering explicitly product-mix changes within industry branches.

Therefore the present study mainly concentrates on product-mix effects and attempts to analyze on an industry level the phenomenon reported by Bayer for the whole manufacturing sector.

Product-Mix Versus Aggregation Effects. Most establishments produce more than one homogeneous commodity but are always classified according to their characteristic product. Therefore, the total output of individual industries consists of an often wide variety of different commodities.

Therefore a clear distinction must be made between product-mix effects and aggregation effects: while aggregation effects refer to varying aggregation levels of industries, product-mix effects--which are emphasized in this study--refer to different commodity structures[1].

2. THE DATA

The monthly Austrian census of manufactures provides data concerning energy inputs and production of goods on a highly disaggregated level for commodities but by relatively aggregated industries. While in most other countries the census of manufactures covers the whole manufacturing sector, in Austria only industrialized establishments are covered. Energy inputs are valued in purchasers' prices, while commodity outputs are valued in producers' prices. Monetary figures and quantity data in physical units (tons, MWh) are both available.

For this study the following recalculations were carried out. Total outputs at 1971 prices were obtained, using volume indices of production on the industry level.

To avoid double accounting, consumption of electricity produced for own use, coal inputs (for coke production) in the ferrous metal industry, and producers' gas inputs in the glass industries were excluded. To obtain figures for the consumption of purchased energy, waste wood and other scrap were also excluded. Some energy inputs which are not covered by the Austrian census of manufactures over the whole period (1964-1980) were also excluded. These energy inputs are not very important (e.g. district heating, gasoline) and they are not closely related to the basic technologies of the industries concerned, so that the exclusion of these fuels will not significantly affect the results.

To convert all energy inputs into common units, Terajoule (TJ) figures were calculated by multiplying physical units with the appropriate calorific values.

Out of all the industries recorded by the census of manufactures, the five most energy-intensive industries were selected for this study. Though the basic ferrous metal industry is very energy-intensive, it was excluded because its output is too homogenous for any significant effects of product mix on energy input to be detected. Time series from 1964 to 1980 of energy inputs by commodities and total outputs were calculated for the following industries:

ISIC[2]	Industry
3411	Pulp and paper
36 excl. 362	Nonmetallic mineral products (except glass)
3720	Nonferrous metals (except casting)
31	Food, beverages, and tobacco
35 excl. 3530	Chemical and rubber products

---

[1] Because homogenous commodities are often produced using different technologies (for example, electrolytic aluminum and foundry aluminum), a distinction between product-mix and process-mix might be emphasized in any extension of the analysis.

[2] Because of national peculiarities, the ISIC two-, three-, and four-digit classifications used do not completely describe the content and activities of the respective sectors.

In 1980 these energy-intensive industries used more than 45% of the energy covered by the monthly census of manufactures.

TABLE 1 Energy input per unit of total output (1971 prices)(TJ/million AS).

Industry	1965	1970	1975	1980
Nonmetallic mineral products	4.10	3.30	3.01	2.58
Paper	2.65	2.49	2.28	1.98
Food, beverages	0.46	0.41	0.42	0.36
Nonferrous metals	1.36	1.16	1.08	0.87
Chemicals	1.86	1.19	0.85	0.62

Table 1 shows the energy input per unit total output over the period studied. A relatively steady decline of energy coefficients is observed for all the industries.

To analyze how changing production structures have affected energy input coefficients, the outputs of the most energy-intensive commodities for the five industries were calculated by multiplying commodity outputs in physical units by constant 1971 prices. This was done on the most disaggregated commodity level available. The resulting product-mix coefficients are shown in Table 2.

TABLE 2 Product mix of five industries (commodity output/total output of each industry: percentages, based on 1971 prices).

Industry	1965	1970	1975	1980
Food, beverages, tobacco				
Sugar	6	6	8	6
Beer	13	11	10	8
Distilled products	3	3	4	4
Pulp, paper				
Wood pulp (sulfate)	27	23	21	18
Wood pulp (sulfite)	5	6	6	5
Wood shavings	6	5	4	3
Nonmetallic mineral products				
Cement	28	28	27	23
Lime	3	2	2	2
Bricks (baked clay)	12	8	7	6
Nonferrous metals				
Copper (electrolytic)	10	9	10	12
Aluminum (electrolytic)	28	26	21	18
Aluminum (foundries)	1	1	1	2
Zinc (electrolytic)	2	2	3	2
Chemicals				
Rubber products	16	15	12	11
Basic chemicals	14	13	13	12
Fertilizers	9	7	5	4

3. THE MODEL

It is assumed that the total energy requirement v_i of an industry i can be distributed between the industry's commodity outputs so that the amount v_{ij} specifies the energy use for producing an amount q_{ij} of commodity j:

$$v_i(t) = \sum_j v_{ij}(t) \qquad (1)$$

The total output of the industry is given as

$$q_i(t) = \sum_j q_{ij}(t) \qquad (2)$$

Thus, a commodity-related input coefficient can be defined as

$$a_{ij}(t) = \frac{v_{ij}(t)}{q_{ij}(t)} \qquad (3)$$

With given product-mix coefficients

$$c_{ij}(t) = \frac{q_{ij}(t)}{\sum_j q_{ij}(t)} \qquad (4)$$

the industry's energy-input coefficient (b_i) can be defined as a linear combination of product-mix coefficients and commodity specific energy-input coefficients[1,2]:

$$\text{Model 1:} \quad b_i(t) = \sum_j a_{ij}(t) \cdot c_{ij}(t) \qquad (5)$$

With given input coefficients $b_i(t)$ and product-mix coefficients $c_{ij}(t)$ for industry i, the commodity-related input coefficients a_{ij} were estimated by least squares[3]:

---

[1] This assumption is referred to as the "commodity-technology" approach (UN 1973); see also Gigantes Matuszewski (1968).

[2] In contrast to our time-series approach, Divay-Meunier (1982) used this method to estimate 10 coefficients from a cross-section micro-data set.

[3] For this and the following regressions, GLM (General Linear Model) and NLIN (Non Linear) procedures from the "Statistical Analyzing System" package were used.

$$b_i(t) = (\sum_j c_{ij}(t) \cdot \alpha_{ij}) + \varepsilon_i(t)$$

where α_{ij} is an estimate for a_{ij} and $\varepsilon_i(t)$ is an error term.

Table A1 of the Appendix shows the estimates, the standard errors (in parentheses) and the R^2 values for Model 1, which is that defined in eqn.(5).

Because energy coefficients are not stable over time, the estimation of Model 1 might be interpreted as average energy coefficients between 1964 and 1980.

A comparison with engineering data makes it possible to roughly evaluate the various estimates. Those for cement and lime, paper, copper, and sugar are within the bounds given by engineering data; the estimates for aluminum are low but reasonable, while those for beer are very far from those predicted from engineering data.

To refine the commodity-related coefficients and separate them from other effects (e.g. technical progress, substitution between energy and other inputs), a time variable representing unspecified technical progress was introduced. Technical progress was assumed to grow (or decline) at a constant instantaneous rate r.

To simplify the estimation procedure it is assumed that technical progress contributes uniformly to all commodity technologies within a given industry, so that

$$a_{ij}(t) = a_{ij}(0) \cdot \exp(r_i \cdot t) \qquad (t = 1,2,\ldots,17) \tag{6}$$

and

$$\text{Model 2:} \quad b_i(t) = \sum_j c_{ij}(t) \cdot a_{ij}(0) \cdot \exp(r_i \cdot t) \tag{7}$$

Coefficients $a_{ij}(0)$ and r_i were estimated with nonlinear least squares using an iterative Gauss-Newton approach.

Nonlinear models with many parameters are very difficult to specify and fit. Therefore, commodities produced within industries are clustered into two groups: energy-intensive commodities and the rest of the output.

Thus, Model 2 can now be defined as:

$$b_i(t) = \exp(\gamma_i \cdot t) \; (c_{i1}(t) \cdot \alpha_{i1} + (1-c_{i1}(t)) \cdot \alpha_{i2}) + \varepsilon_i(t)$$

where

$c_{i1}(t)$ = the product mix of energy-intensive commodities,
α_{i1} = an estimate of the energy coefficient for energy-intensive commodities,
α_{i2} = an estimate of the energy coefficient for the rest of the output,
γ_i = an estimate for r_i, and
$\varepsilon_i(t)$ = an error term.

Estimates, standard errors, and the R^2 values of Model 2 (as defined by eqn.(7)) are shown in Table A2 of the Appendix.

All estimates for the commodity-related input coefficients, except that for electrolytic nonferrous metals, seem reasonable. The estimates for the growth rate of technical progress might also be considered to lie in an acceptable range. The extreme rate of chemicals may be due to statistical biases: though differentiation is very difficult and has only minor analytical advantages, in Austria an attempt is made to separate energy inputs for energy end-use purposes from energy inputs as raw materials.

Because of a lack of comparable data, the latter category (energy as a raw material) was neglected in this study. But in the chemical industries some fuels (e.g. natural gas) are important raw materials. The rapidly declining energy-input coefficients might be due to the increasing statistical distinction between energy as a raw material and energy as a fuel.

To quantify changes of industry energy-input coefficients due to changing output structures an attempt was made to separate product-mix effects from other effects.

$$\beta_i^*(t) = (c_{i1}(1)\alpha_{i1} + (1-c_{i1}(1)\alpha_{i2}))\ \exp(r\cdot t) \tag{8}$$

gives an estimate of the industry's input coefficients using current technology but with the product mix of the base year, 1964. With the help of β^*, the changes of estimated input coefficients between the base year and the current year can be subdivided into technology and product-mix effects:

$$\Delta\beta_i = \underbrace{[\beta(1) - \beta^*(t)]}_{\substack{\text{technology}\\ \text{effect}}} + \underbrace{[\beta^*(t) - \beta(t)]}_{\substack{\text{product-mix}\\ \text{effect}}} \tag{9}$$

To express technology and product-mix effects as percentages of total changes in coefficients, eqn. (9) was divided by $\Delta\beta_i$; the results are shown in Table 3.

TABLE 3 Percentage of changes in input coefficients due to product-mix effects (total change between current and base year = 100).

Industry	66	68	70	72	74	76	78	80
Nonmetallic mineral products	-133.6	-14.0	10.1	0.8	6.6	9.5	13.6	16.8
Chemicals	8.5	5.4	9.5	10.8	8.7	8.9	8.6	6.7
Paper	13.4	9.6	12.1	20.9	16.8	14.5	12.9	10.7
Food, beverages	80.7	86.3	85.4	78.1	79.8	78.2	80.7	78.1
Nonferrous metals	11.9	10.2	47.0	63.6	58.1	48.7	46.6	42.8

For the nonmetallic mineral products, chemicals, and paper industries the contribution of product-mix effects (10–15%) to the total change in energy coefficients is rather small. On the other hand, for the nonferrous metal and the food and beverages industries the product-mix effect appears to be responsible for a remarkable contribution of between 40 and 80%. Figures 1 and 2 show the actual and predicted paths of the input coefficients for the two latter industries; the "separated-out" trends given by $\beta_i^*(t)$ are also shown.

To compare the effects of changing output structures with those caused by changing energy prices, price elasticities were calculated. Price indices (1964=100) were calculated by dividing total energy costs of the industries concerned at current prices by total energy costs at constant 1971 prices[1].

To simplify the estimation procedure it was assumed that all commodity-related energy coefficients of a given industry have the same elasticities (r_i):

$$a_{ij}(t) = a_{ij}(0) \cdot p_i(t)^{r_i}$$

and therefore

$$\text{Model 3: } b_i(t) = p_i(t)^{r_i} \cdot \sum_j c_{ij}(t)\, a_{ij}(0)$$

As for Model 2, energy-intensive commodities were distinguished from the rest of the output, so that

$$b_i(t) = p_i(t)^{\gamma_i} \left(c_{i1}(t) \cdot \alpha_{i1} + (1-c_{i1}(t))\alpha_{i2}\right) + \varepsilon_i(t)$$

where γ_i is an estimate of the price elasticity r_i.

Table A3 in the Appendix shows the estimates, standard errors, and R^2 values for Model 3.

In addition, traditional price elasticities were estimated for all industries to compare the product-mix approach with more traditional methods:

$$b_i(t) = k_i \cdot p_i(t)^{\bar{\gamma}_i} + \varepsilon_i(t)$$

The results of the comparison are shown in Table 4.

The introduction of product-mix effects into the estimation procedure produces a decline in price elasticities of between 8 and 48%, and an increase in R^2 values, so that the hypothesis that changes in output structure seriously affect input coefficients might be confirmed. For the nonmetallic mineral products, chemicals, and paper industries, the introduction of product-mix coefficients causes a relatively small increase in R^2 and a small decrease in elasticities. This might indicate that price changes affect energy consumption more than do changes in product-mix. Figures 3 and 4 compare the

---

[1] For an extended analysis the use of real prices instead of nominal prices should be considered.

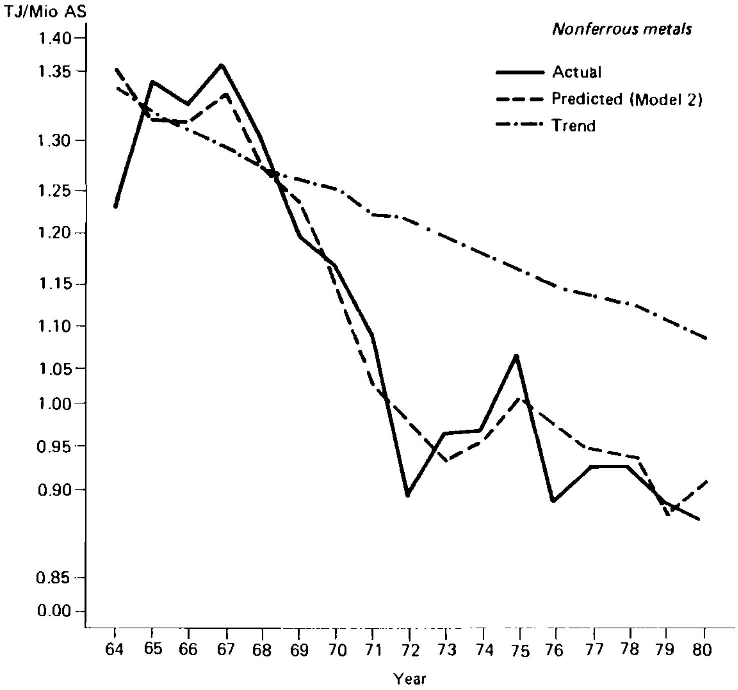


FIGURE 1

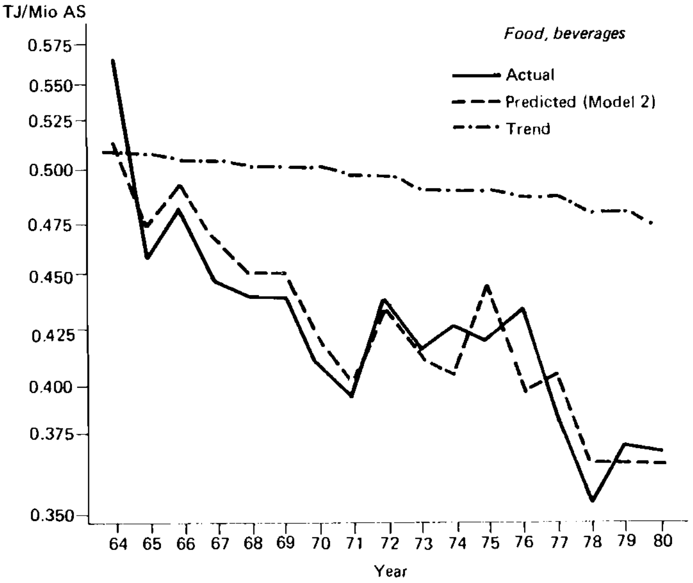


FIGURE 2

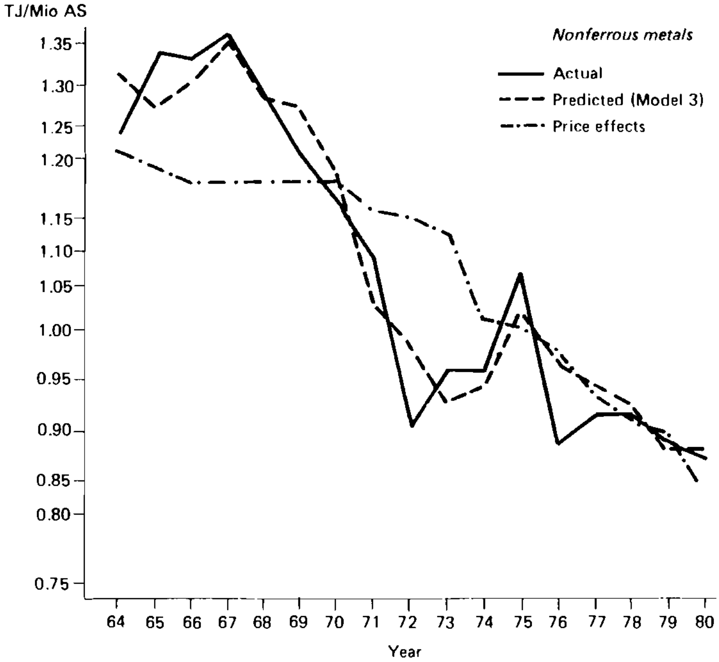


FIGURE 3

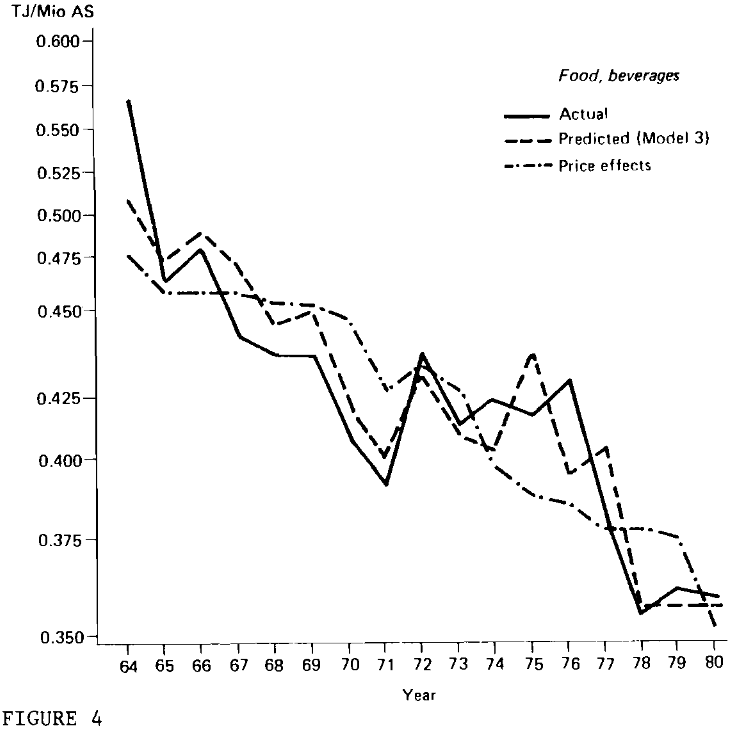


FIGURE 4

TABLE 4 Comparison of price elasticities calculated with and without product-mix effects: estimates, standard errors (in parentheses), and R^2 values.

Industry	With product-mix γ_i			Without product mix $\bar{\gamma}_i$		
Nonmetallic mineral products	-0.21	(0.09)	0.997	-0.35	(0.04)	0.867
Chemicals	-0.85	(0.28)	0.980	-0.95	(0.11)	0.835
Paper	-0.14	(0.03)	0.999	-0.22	(0.03)	0.830
Food, beverages, tobacco	-0.03	(0.06)	0.998	-0.21	(0.04)	0.630
Nonferrous metals	-0.31	(0.12)	0.997	-0.79	(0.17)	0.606

actual and predicted paths of energy coefficients. Values from the alternative model with "pure" price elasticities (without product-mix effects being introduced) might emphasize the explanatory power of production effects.

On the other hand, the improved R^2 values and a notable decline in elasticities could indicate that product-mix changes have a high explanatory power for the food and beverages and nonferrous metal industries.

4. COMPARISON OF ESTIMATES WITH ENGINEERING DATA

To evaluate the estimated commodity-related (base year) coefficients, available engineering data (Boustead-Hancock 1979, Alber 1983) expressed in MJ/kg (=TJ/1000 tonnes) were revalued using prices (million AS/1000 tonnes) to obtain a comparable TJ/million AS basis. This comparison demonstrated that most of the estimated coefficients lie within technologically reasonable bounds, as shown in Table 5.

TABLE 5 Comparison of estimated coefficients with engineering data (both in TJ/million AS).

Commodity	Estimated coefficients			Engineering data
	Model 1	Model 2	Model 3	
Pulp	5.9	3.4	4.1	3.0-4.3
Paper	1.6	2.5	1.9	0.5-2.7
Cement	10.0	9.1	11.9	8.4-12.5
Lime				9.6-11.7
Aluminum (electrolytic)	4.0	3.0	3.2	5.1-6.3
Other metals (electrolytic)	1.7			1.0-1.6
Sugar	2.4	2.2	2.3	2.3
Beer	2.5			9.8

All estimated coefficients except those for beer in Model 1 and for sugar and beer in Models 2 and 3 seem reasonable.

APPENDIX

Table A1 Model 1: $b_i = \sum_i c_{ij} \cdot a_{ij}$.

Industry (i)	Commodity (j)	Estimates, X_{ij} (TJ/million AS)[a]		R^2
Nonmetallic	Cement and lime	10.0	(1.4)	0.999
	Bricks (baked clay)	16.1	(1.7)	
Pulp and paper	Pulp (sulfite)	5.9	(0.6)	0.998
	Paper	1.6	(0.4)	
Nonferrous metals	Aluminum (electrolytic)	4.0	(0.3)	0.997
	Aluminum (foundries)	3.6	(10.6)	
	Copper (electrolytic)	1.7	(2.1)	
Chemicals	Fertilizers, rubber products, basic chemicals	5.3	(0.6)	0.970
Food, beverages, tobacco	Sugar	2.4	(0.7)	0.998
	Beer	2.5	(0.5)	
	Distilled products	1.1	(3.5)	

[a] Standard errors in parentheses.

Table A2 Model 2: $b_i(t) = \sum_j c_{ij}(t) \cdot a_{ij}(0) \cdot \exp(r_i \cdot t)$.

Industry	Commodity	Estimate[a]				R^2
		a_{ij} (0) (TJ/Million AS)		r_i		
Paper	Pulp	3.38	(0.29)	-0.015	(0.002)	0.999
	Paper	2.46	(0.16)			
Food, beverages, tobacco	Sugar, beer	2.16	(0.48)	-0.004	(0.006)	0.998
	Other output	0.09	(0.12)			
Nonferrous metals	Nonferrous metals (electrolytic)	2.96	(0.32)	-0.013	(0.005)	0.998
	Other output	0.27	(0.24)			
Nonmetallic mineral products	Cement, lime	9.09	(2.18)	-0.025	(0.003)	0.999
	Other output	2.09	(1.08)			
Chemicals	Basic chemicals, fertilizers, rubber products	3.35	(0.52)	-0.067	(0.006)	0.996
	Other output	1.26	(0.39)			

[a] Standard errors in parentheses.

Table A3 Model 3: $b_i(t) = \sum_j c_{ij}(t) \cdot a_{ij}(0) \cdot p_i(t)^{r_i}$.

Industry	Commodity	Estimate[a]				R^2
		$a_{ij}(0)$		r_i		
Nonmetallic mineral products	Cement and lime	11.9	(4.0)	-0.21	(0.09)	0.997
	Rest of output incl. bricks	0.13	(1.8)			
Pulp, paper	Pulp	4.1	(0.36)	-0.14	(0.03)	0.999
	Paper	1.8	(0.16)			
Nonferrous metals	Nonferrous metals (electrolytic)	3.15	(0.25)	-0.31	(0.12)	0.997
	Other output	0.05	(0.16)			
Chemicals	Fertilizers, rubber products, basic chemicals	3.08	(1.01)	-0.85	(0.28)	0.980
	Rest of output	0.60	(0.65)			
Food, beverages, tobacco	Sugar, beer	2.29	(0.41)	-0.03	(0.06)	0.998
	Rest of output	0.06	(0.09)			

[a] Standard errors in parentheses.

REFERENCES

Alber (1983) Analyse der Energieströme bei der Produktion von Nahrungs- u. Genussmittel. Dissertation an der Wirtschaftsuniversität Wien.

Bayer (1982) Energieverbrauch und Einsparungsmöglichkeiten in der Industrie. Monatsberichte des Österreichischen Instituts für Wirtschaftsforschung, 1.

Bonnici (1983) The Relevance of Input Substitution in the Inter-Industry Model. European Economic Review, 22.

Boustead-Hancock (1979) Handbook of Industrial Energy Analysis. Ellis Horwood Ltd.

Christensen-Jorgenson-Lau (1971) Conjugate Duality and the Transcendental Logarithmic Production Function. Econometrics, 39.

Diewert (1971) An Application of the Shephard Duality Theorem: A Generalized Leontief Production Function. Journal of Political Economy.

Divay-Meunier (1982) Two Methods of Elaborating IO-Tables. In J. Skolka (Editor), Compilation of IO-Tables. Lecture Notes in Economics and Mathematical Systems, 203.

Foell, W.K. et al. (1979) Assessment of Alternative Energy/Environment Futures for Austria: 1977-2015. RR-79-7. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Gigantes Matuszewski (1968) Rectangular IO-Systems, Taxonomy and Analysis. Paper presented at the 4th International Conference on Input-Output Techniques, Geneva, Switzerland.

Halvorsen (1977) Energy Substitution in US Manufacturing. Review of Economics and Statistics, Vol. LIX.

Taylor (1979) Estimations of Price Effects on IO-Coefficients. Paper presented at the 7th International Conference on IO-Techniques.

UN (1973) A System of National Accounts. United Nations, New York.

ENERGY INTENSITY FACTORS IN THE HUNGARIAN ECONOMY SINCE 1960

Pál Erdösi
Institute of Industrial Economics, Fö u. 68, 1027 Budapest, Hungary

1. INTRODUCTION

The role of the energetics has increased in the whole world by the recent decade's oil shocks. The latest ones - together with other problems of the world economics interrelating each other - have still called a world-wide recession in the industry. On the other hand, it is often said in western countries: a 4-5 $/b decrease of oil price is expected to result in 0,5 % increase of GDP in the OECD region and USA.

In the socialist countries also similar economical consequences have arisen, although they have been delayed there as the result of the self-sufficiency in energy supply of the CMEA.(However, the delay has unpleasant effects too.)

By the 1980s the difficulties of the balance of payments have generally increased all over the world, mainly because of the very high oil prices. To compensate these difficulties there are possibilities as follows

- to reduce the productions, first that of high energy intensity
- to restructure the national production to achieve lower energy intensity
- to obtain energy conservation by decreasing the losses of consumption and
- to substitute the imported oil by domestic sources, which is, however, an extraordinary expensive program because of the high investment costs.

The question of the energy intensity of national production has consequently got into the center of the general interest in the analizing and internationally comparing the development of the economy for the present time and for the future too. As a consequence of the efforts mentioned above is the general aim of reducing the energy intensity. All these circumstances are resulting in a great restructuring of the whole national economy. The possibility to carry on these very important changes in the economy is given because of the multiplied ratio between the energy intensities of the branches (producer units) of the economy.

2. AIM OF THE STUDY

It follows from the above said, that the right effect of the different energy intensities of the industry branches (products) can and has to be evaluated only on the level of the national economy, i.e. measured by changing of the efficiency, of produced or realised incomes, of national sources necessary for development e.g. investments, imports etc. (The energy intensity itself - low or high - alone doesn't give the possibility to decide how to develop the economy in the future.)

This study deals still only with the different energy intensity factors of branches necessary for the evaluation of the effects of the differences between them. It doesn't deal with the evaluating methods themselves at all though many of them have been worked out till now in Hungary.

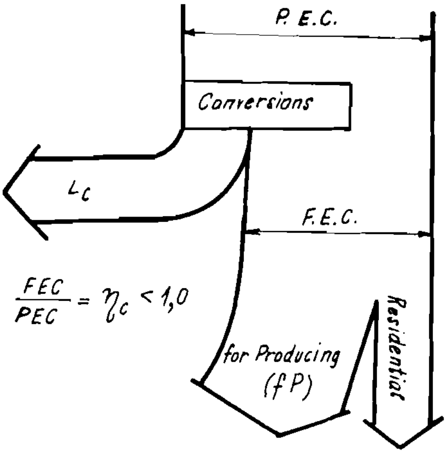
3. SOME PRINCIPAL METHODICAL REMARKS

There are only the characteristics necessary for the correct meaning and using of the energy intensity factors detailed here.

3.1. Energy Aspects

A very simplified energy flow diagram can be seen in the Fig.1. The three main phases on it are that of the primary and of the final energy consumption (PEC and FEC), between them the third one is the energy conversions, involving the conversions'losses (L_c). Within FEC two components as minimum has to be distinguished i.e. electric energy and the other energy carriers (steam, fuels etc.). FEC is divided into two parts: the energy consumption of producers (fP) and the residential one.

The different energy intensity factors may be correctly interpreted only for the producers, calculated on the base of fP (and that converted back onto the phase of PEC through η_c), without the residential consumption.



PEC	Primary Energy Consumption
FEC	Final Energy Consumption
L_c	Conversions' losses

FIGURE 1 Energy flow

3.2. Fundamental Relationships

The connection between the P production and E energy consuption of producers (fP or fP/η_c) can be written as

$$E = P \cdot e_a = \sum_i P_i \cdot e_i = P \cdot \sum_i s_i \cdot e_i \qquad s_i = P_i/P$$

where:

P the product value (GDP, national income etc.) in Ft or $\$$
E the energy consumptions in the phases of fP and PEC in J or kWh
e the energy intensity factors in the dimensions of E/P,
with "a" index as average
with "i" index for the branches
i the division of the producers onto different units
- on the national level: Industry-Building Industry-Transportation-Agriculture-Services
- on the industrial level: the branches and special units themselves.

According to the formula the E energy consumption depends at the same time on the quantity and the structure of the P production. The e_a energy intensity factor is defined by the structure as the weighted average of the branches ($e_a = \sum_i s_i \cdot e_i$). On the base of that relationship it can be predetermined the main role of the industry in forming the magnitude of e_a average energy intensity factor. Namely, the other producer areas have either relatively lower $s_i = P_i/P$ proportion or their e_i factor is small related to the industrial average. Therefore, if we want to deal with the dependence of the economy-development in the function of the energy intensity of the production, we can be constrained to analize only the structure of the industry. Moreover, the industry can be divided into two significant parts which have their own energy intensity factors with a multiple ratio to each other. (I.e. the production of raw materials and the end products respectively.)

4. ENERGY INTENSITY FACTORS; TRENDS OF THEIR CHANGES

Different energy intensity factors can and have to be used for different purposes. All these have, however, one common property. They give the possibility to concept numerically how to ensure the consistency between energetics and economy, including planning and development. This consistency is especially important because of the high demand of the energy industry in the national resources (e.g. investments), and that demand is very much changing in the function of the magnitude of the energy intensity factors.

The following short abstracts are taken from several studies worked out in the previous years.

4.1. Factors Related to Production Values

These types of coefficients can characterize the branches or the whole economy. Their general dimensions:

- in the numerator of the fractions E may be energy or electric energy in J or kWh (calculated in the phase of FEC or PEC), in the denominator the P value in Ft or $ of e.g. brutto production, GDP, incomes, profit
- the numerator and the denominator, both in value, the energy calculated on the base of energy prices, the dimensions Ft/Ft or $/$.

Global factors changes (related to national income). The approximate formation of the national average energy and electric energy intensity factors between 1960-1975 are illustrated in Fig.2 and 3, the marks and namings comply with those of Fig.1.

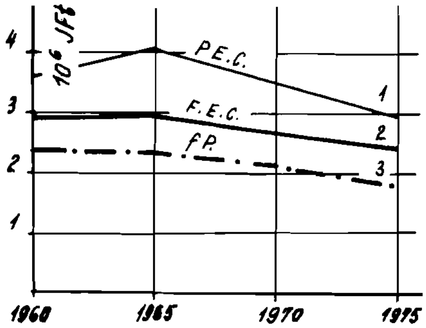


FIGURE 2 Global energy intensity factors

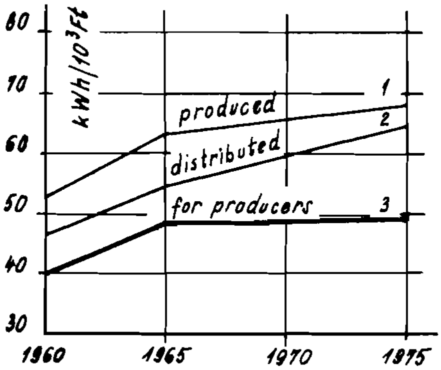
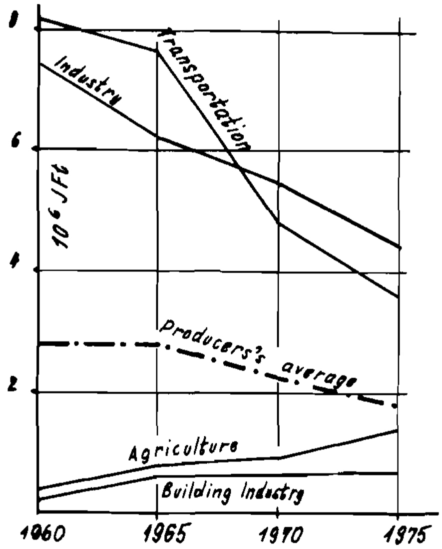


FIGURE 3 Global electric energy intensity factors

The differences between the curves 1 and 2 resp. 2 and 3 on the Fig.2 resp. 3 are the residential consumptions of energy resp. electric energy, which are out of our investigations. The curves 3 of both diagrams are the final consumptions for producing (fP). The trends of curves are approximately similar to international ones. Fig.3 shows well the relatively greater increase of the electric energy, while the tendency of the total energy intensity factors - which include inside themselves the electric energy too - is improving (i.e. decreasing), as it can be seen in Fig.2. It is therefore important since the proportion of the industrial production - the energy intensity of which is relatively the highest - increased essentially during the analized period.

The average curves 3 of Fig.2 and 3 are drawn also on the Fig.4 and 5 together with the energy intensity factors of the producing sectors. There are - the diagrams show too - multiple ratios between the magnitude of these factors and their trends are also different while the global coefficients are weighted averages of the components' factors.



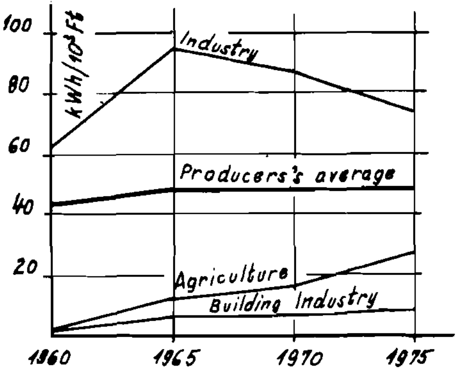
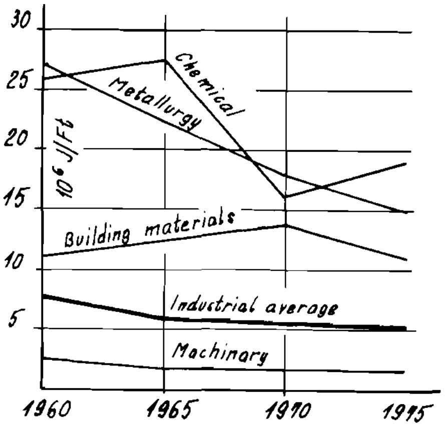


FIGURE 4 Intensity of sectors

FIGURE 5 Electric intensity of sectors

However, these sectors are not homogeneous from the aspect of energy intensity as it is proved by the curves of Fig.6 and 7, where the energy intensity of industry branches are illustrated between 1960-1975.

Naturally, the investigation can be deepened into greater details, more and more homogeneous grouping.



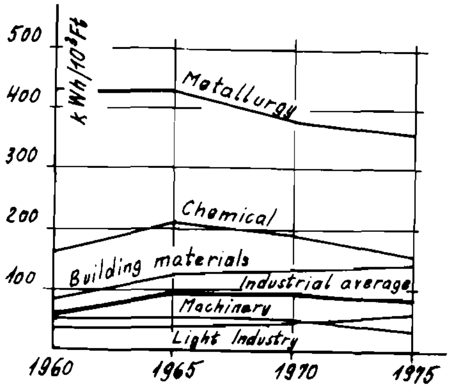


FIGURE 6 Intensity of branches

FIGURE 7 Electric intensity of branches

The reasons of the changing. On the base of the formula, $e_a = \sum_i s_i \cdot e_i$ it is obvious and it was proved by the diagrams too, that the changes of the global factors are also produced

- by the changing (generally improving) of the e_i factors of branches and
- by the changing of production structure.

Fig.8 shows which influences of the global factors can be reached by improving the e_i branch factors. It may be said that this effect is not negligible. Without the improvement of the specific energy consumptions (e_i) the total energy demand would be about one third higher than the actual in the 1980s. It means that with specific consumptions of the year 1960 the energy consumption would have shaped according to the curves 1' and 2' in the phase of FEC or PEC. The savings arise from two sources:

- One is the improvement of specific consumptions in FEC phase. It can be reached mainly by substituting the coal by oil and gas,
- the other is reducing the losses in the energy conversion processes, mainly in power generation and boylers (resulting also by using more oil and gas).

The two types of savings are drawn separately too, on the bottom of the diagram the first marked with s_f and the second with s_c.

Regarding the industry and the total production Fig.9 illustrates the effects of all factors influencing the change of the e_a global energy intensity factors during the period 1960-1977. The total Δe change (improvement) of the e_a energy intensity factors comes from different sources, according to the Δe indexes, as follows

F	improvement of specific energy consumption (change of energy structure) e_i
A	the change of the structure of the investigated main industry branches
B	the change of the internal structure of the investigated main industry branches
S	both structure effects A+B together (summarized vectorially)

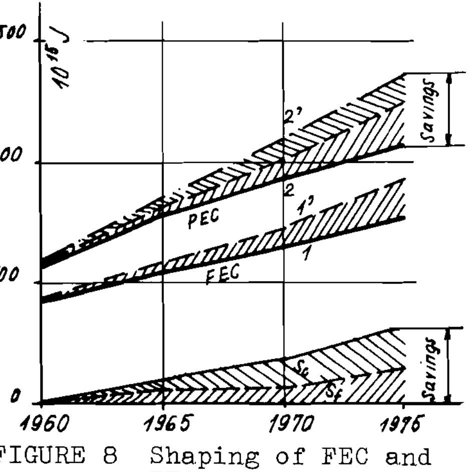


FIGURE 8 Shaping of FEC and PEC

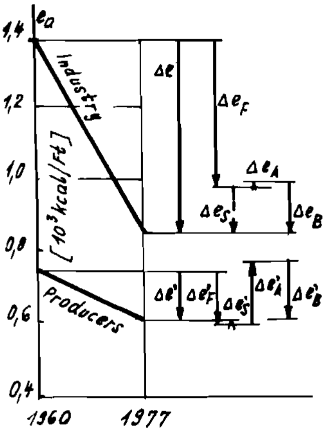


FIGURE 9 Changes of energy intensity

On the base of the diagram it may be expressed for the past investigated period as most importants:

- the main improvement of the global energy intensity factors originates from the improvement of e_i-s
- within the industry the structure changes have compensated each other from the aspect of energy intensity ($\Delta e_A \cong 0$)
- concerning the whole economy, the rate of the industrial production increased, this situation increased the global energy intensity factor (the arrow of the $\Delta e_A'$ goes upwards)
- the internal structure change of the investigated industry branches (Δe_B) has essential effect onto the e_a change.

Other types of energy intensity factors (related to value). Instead of national income other values (e.g. GDP, total production etc.) can be used as the basis of relation for energy intensity factors. The factors of different basis can be converted by the rates between the different values.

Energy intensity of smaller producing units. The investigated industry branches are not homogeneous. That means that the smaller units inside them are of different energy intensities, sometimes with very great differences. Table 1 shows the minimum and maximum values together with the average energy intensity factors for all the main industry branches, in the phase of PEC of energy flow, related to GDP, calculated on the price level of 1976.

Table 1 Energy intensities of industry branches in 10^6J/Ft GDP

	Min.	Average	Max.
Mining[a]	3,5	3,6	3,8
Metallurgy	10,6	11,3	29,5
Machinery	0,6	0,8	1,0
Building materials	1,4	6,1	14,3
Chemicals[a]	0,7	5,1	9,0
Light industry	0,4	1,4	9,0
Food industry	0,7	0,7	0,7
Non specified	0,9	2,8	5,0
Total Industry[a]	0,4	2,8	29,5

[a] Without energy branches

Table 2 contains the intensity factors in the same concept as Table 1, but related to the total production values (tpv) and min. and max. values of statistical data based on a much more detailed division of branches.

Table 2 Energy intensities of industry branches in 10^6J/Ft tpv

	Min.	Average	Max.
Mining[a]	0,1	1,5	2,3
Metallurgy	0,5	1,7	6,2
Machinery	0,3	0,3	0,3
Building materials	0,1	2,5	6,7
Chemicals[a]	0,3	1,6	19,4
Light industry	0,1	0,4	1,7
Food industry	0,3	0,3	0,3
Non specified	0,03	0,3	2,1
Total Industry[a]	0,03	0,8	19,4

[a] Without energy branches

Similar differences charecterize the branches in the aspect of the intensity in electric energy too.

Energy content of the production. These types of energy intensity factors give an orientation in Ft/Ft about the rates of the energy costs in the total production values or related to the external output of the production. Analizing the data of these types taken from a special investigation we can summarize very interesting issues. In 1980 the average values of the specific energy content were approximately 0,06 Ft/Ft tpv and 0,20 Ft/Ft output. While existing these averages, there is a very wide interval between the lower and the upper factor values. The productions of low energy intensity have a direct factor about 0,02-0,03 Ft/Ft tpv and of the higher intensity (generally the production of raw materials) between 0,20-0,70 Ft/Ft tpv. The total factor values of both gropus are naturally nearer to each other, accumulating the energy consumption from the former producing process phases by the material flow. Thus the two groups have the total factors between 0,15-0,20 respectively 0,30-0,90 Ft/Ft output.

It has to be emphasized that these values will deteriorate (inrease) in the future because of further rise of energy prices in the CMEA countries towards the world market prices. Therefore the efficiency will be affected in a high degree by the structure of the future production. An interesting example for that is shown in Fig.10. The earlier about constant energy content of the agricultural production has risen in a great extent after the oil crises and the process will continue in the future too. The actual value between the two lines 1 and 2 will depend on how many Ft has to be spent in the production for one $.

4.2. Energy Intensity and National Investments

A certain investment in a branch involves an energy demand growth, expressed by a factor of J or kWh per Ft investment. On the other hand, to consume a certain energy surplus by a branch it is necessary to invest some establishments, according to its Ft investment/J or kWh factors. These factors are very different for the branches in function of their energy intensity.

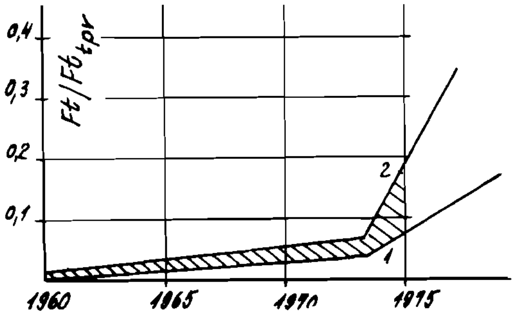


FIGURE 10 Energy content of agricultural production

To provide the energy surplus for the new-established producers, there are necessary energetical investments too, expressed also by factors of Ft per J or kWh. Dividing these factors by those of the branches, we have a very important new factor for measuring the energy intensity of the branches. These new factors of Ft energy/Ft branch have the meaning how much additional energetical investment is inevitably necessary when establishing 1 Ft for the branches. In Table 3 can be found the approximate values of these special a_i energy intensity factors by which the balance of the I total national investments[1] can be controlled for the future planning. This equilibrium is a very important condition to attain the consistence of the whole economy-development. By the formula, the condition is expressed - summarizing the i=1...n branches - as follows

$$I = \sum_i (I_i + a_i \cdot I_i) = \sum_i I_i \cdot (1+a_i) = I \cdot \sum_i r_i \cdot (1+a_i)$$

from which comes: $\sum_i r_i \cdot (1+a_i) = 1{,}0$. ($r_i = I_i/I$ is the rate of the investment of the i-th branch related to the whole one.)

4.3. Specific Energy Consumptions

There are some special selected products (materials) of high energy intensity which are handled separately in the general national planning too. It is very characteristic that they give the greater part of the total energy consumption of the industry. At the same time, their proportion in the total production value is very low. These can be seen approximately in Table 4 relating to the year 1980.

This speciality is very favorable from the viewpoint of long term planning, because the estimations of the perspective energy demands can be carried out with a greater certainty, i.e. the expectable demands can be planned in a more narrow interval. Namely:

---

[1] The residential has to be analized separately

Table 3 The additional a_i factors in Ft/Ft

	Min.	Average	Max.
Mining[a]	0,27	0,3	0,4
Metallurgy	0,2	1,2	6,8
Machinery	0,23	0,24	0,25
Building materials	0,2	0,6	1,0
Chemicals[a]	0,1	0,7	1,8
Light industry	0,3	0,34	0,6
Food industry	0,3	0,3	0,3
Non specified	0,25	0,32	0,5
Total Industry[a]	0,1	0,5	6,8

[a] Without energy branches

Table 4 Proportions of selected products

	measured in	
	Ft	Joule
Selected Products	1/4	2/3
The Others	3/4	1/3

- The energy demands for producing the selected products can be planned on the base of specific consumption, which have been worked out technically and are very reliable.
- The Others are of very low energy intensity, therefore relatively great uncertainties of the planned Ft values have only a little influence on the total energy demand.

The specific energy and electric energy consumptions have been regularly determined in PEC and FEC phase of the energy flow. Table 5 contains both types of the specific consumptions for the main selected products (materials) calculated from the statistical data of the year 1980. (The values of the specific consumptions include energy+electric energy, the latter converted into Joule.)

4.4. Cumulated Factors

The end products coming out from each branches are connected with the other previous process phases by the material flows. As a result of such connections it often occurs, that the end products of low energy intensity become of high intensity through the material consumptions. E.g. the about 7,5 GJ/t specific energy consumption of meat production increases about to 47,7 GJ/t, if we count the energy consumptions of all the previous processes, materials (animal keeping, plantculvation, fertilizing, engine fuels etc.).

Table 5 Specific energy consumptions in GJ/t

	in FEC	in PEC
Iron	20,4	21,4
Iron and steel casting	13,4	16,7
SM steel	4,5	4,9
Smithed and stamped steel	15,5	19,2
Aluminiumoxid	15,7	21,6
Aluminium	65,8	198,6
Cement	4,5	5,7
Lime	6,9	7,1
Glasses	18-26	19-28
Ammonia	40,5	48,0
Caustic lye	15,2	41,3
Ethylen	133,9	135,9
Acethylen	206,9	247,7
Artificial fertilizers	39,2	47,5
Paper	12,9	22,2
Ready made leather	22,4	33,0
Sugar	17,2	25,8

It is obvious that on national level the correct evaluation of products from the aspect of energy intensity may be carried out on the base of cumulated factors. The most precise way for determining these cumulative factors is to use input-output models. However for the practice it may be sufficient to calculate only the direct connections instead of using complicated models, which have to be worked out in the most cases in the future.

4.5. Elasticity Factors

The fundamental relationships between E energy consumption and P production - explained in the Chapter 3.2. - are valid in the case of growth of E and P parameters i.e. for ΔE and ΔP. It means that the connection between ΔE and ΔP is created by the energy intensity of the ΔP production growth structure. Therefore the growth rates and also the value of $r = (\Delta E/E):(\Delta P/P)$ elasticity factors depend on the production structures of P and ΔP, i.e. on the energy intensity of the economy development. It has to be emphasized that great differences may be in the r factors in the function of how we calculate the energy consumption (national or without residential, in phase of PEC or FEC). It is correct only to calculate with the energy for production, while the other case often occurs internationally too. Table 6 shows approximately both elasticity factors between 1960-1982 in 5-years periods (national in PEC, the other in FEC). Because of the specialities of the years after 1980 it has no sense to calculate the factors to those years. Still the effects of these extraordinary events can be evaluated by comparing the r factors of 1975-1982 to those of 1975-1980.

Table 6 Elasticity factors

		$\frac{1965}{1960}$	$\frac{1970}{1965}$	$\frac{1975}{1970}$	$\frac{1980}{1975}$	$\frac{1982}{1975}$	$\frac{1982}{1980}$
National	r_N	1,38	0,47	0,46	0,65	0,50	0
For Production	r_P	0,79	0,16	0,54	0,59	0,36	-0,5

5. REFERENCES

The whole study including tables and illustrations are based on former investigations carried out personally and/or by personal guidance of the author in working groups, published in periodicals and in official studies in the previous years.

6. CONCLUSION

It has been numerically proved in this study that the energy intensities of the producing units vary in an extraordinary wide interval, their rates to each other are multiple. That situation has great influences on the efficiency of the national production and affects the possibility of the future economy development too. Separate, here not explained investigations, based on these energy intensity factors, as introduced in great lines also in the presented study too, clearly prove, that the influences and effects are very significant. Therefore the role of the energy intensity of the production in the future economy planning becomes more and more important, forced in an increasing extent by the future situation of the world energy supply.

INPUT–OUTPUT ANALYSES OF THE CHANGES IN ENERGY CONSUMPTION IN DANISH INDUSTRIES, 1966–1979

Ellen Pløger
Energy System Group, Risø National Laboratory, 4000 Roskilda, Denmark

1. INTRODUCTION

Energy is from a theoretical point of view an input just like many others but after the "first" energy crisis in 1973, energy has been in the focus for both economical and political reasons.

The dramatic shift in the status of energy was followed by a large number of studies of energy consumption in both the past and the future. A common charateristic for most of these (and later) studies was that they based the descriptions and simulations on the development in the relation between GDP and total energy consumption. This approach can of course give some interesting information but the danger of hiding important underlying trends should be stressed.

Therefore in order to provide more disaggregated informations about the structure of energy consumption and hereby to improve energy forecasts and energy conservation schemes it is necessary to make more detailed models than the above mentioned and specially to improve the knowledge of industrial energy consumption.

Looking at the statistics it appears that there are several problems concerning such models. In contrast to the energy consumption by households there is often a lack of data on the energy consumption in industries. This problem combined with the problem of providing data on the interaction of industries makes it difficult to trace the energy flows through the economy.

The paper presents a method of using input-output calculations to provide a split of the overall trend in the industrial energy consumption into a demand and a technology component. The results from the input-output calculations on Danish data for the period 1966-79 are discussed.

In part 2 a description of the data sources is given. In part 3 the changes in energy consumption in Danish industries are split into a part caused by changes in technology and a part caused by changes in final demand.

In part 4 it is analysed whether the shifts between Danish production and imports have influenced the energy consumption in Denmark. Finally part 5 shows how the results of the analysis are influenced by the methods used for constructing input-output tables.

2. BASIC DATA OF THE ANALYSES

2.1. Data sources

An input-output analysis of energy consumption causes the following 2 requirements for data. Firstly input-output (IO) tables for the first and the last year of the period to be analysed are needed and these IO-tables must be available in constant prices. Secondly it is necessary to have energy data that are directly compatible with the IO-tables.

The Danish system of national accounts is based on the balancing of a commodity-flow system containing 3-4000 commodities and 117 industries. The annual IO-tables which for the time being exist for the period 1966-79 are constructed directly from this system. For a small open economy like the Danish one it is very important how imports are treated in the IO-tables. In the Danish tables it is assumed that the ratio of domestic output to imports is identical in all domestic uses, but the assumption is applied on a very detailed level (1600 commodities). (This way of treating imports is a big step forward compared to the method used in a set of preliminary tables where the constant ratio assumption was applied on a level of 130 characteristic commodities, (cf. part 5)).

The commodity-flow system contains approximately 20 energy products and these are special in two ways compared with the other commodities:

Firstly the balances for energy products are established in both monetary and physical units as the compilations of data matrices for energy in physical terms is necessary because the average price of energy products differs substantially between different uses. This fact makes it inadvisable to carry out energy analyses based exclusively on data in monetary terms. Secondly the energy products are treated in a separate system of balancing. The supply of each of the products is distributed on the 117 industries and the different categories of final demand using a great deal of very heterogeneous information. One of the main sources is the survey of energy consumption in industrial establishments with 20 or more employees. These surveys are made every 2. or 3. year and they give information of the energy consumption in physical terms of approximately 15 energy products. In the years where no surveys are carried out, the data are based accounting information of the expenditure on fuel and power combined with the information from the latest energy survey.

The energy consumption by smaller industrial establishments is calculated by extrapolating for each branch the relation between energy consumption and the size of the establishment known from those establishments covered by the survey.

2.2. Trends in the industrial energy consumption

In order to get an expression for the total energy consumption in each of the 117 industries the consumption in physical terms has been transfered to calorific values.

As a simple tranference to calorific values would cause problems of double counting the concept of energy consumption applied in the calculations is "net" energy consumption "in the sense that electricity, district heating and gaswork gas - but not refined petroleum products - have been replaced by the inputs of energy products into the transformation". (cf.(1) p. 22). Thus, the energy consumption in the branches: "Electric light and power", "Gas manufacture and distribution" and "Steam and hot water supply" will appear to be very low because it covers only the energy used for motor vehicles and the energy consumption in "Petroleum refineries" is 0 as the energy consumption of refined petroleum products is calculated ab refineries (or as imports c.i.f.).

Besides avoiding the problems of double counting this concept of energy consumption will also secure that any substitution from electricity to other energy products will not appear as an increase in the energy consumption in the specific industry.

Looking at the data for Denmark table 1 shows the energy consumption in industries for the years 1966-80.

TABLE 1 Energy consumption in Danish industries 1966-79.

Year	EC (TJ)	EC/GDP (TJ/mill.kr.)
1966	338782	2.02
1967	350861	2.02
1968	365133	2.03
1969	396373	2.07
1970	418491	2.13
1971	411103	2.05
1972	439257	2.07
1973	449327	2.04
1974	415400	1.90
1975	402318	1.86
1976	450921	1.96
1977	462190	1.96
1978	483584	2.02
1979	479373	1.93
1980	452171	1.83

EC : Energy consumption
GDP : Gross domestic product at 1975-prices

It is seen that the energy consumption (EC) has increased 33.5% over the period or approximately 2% per year but that the growth primarily took place before the energy crisis in 1973. It is worth noticing that the energy consumption decreased by 10.5% from 1973-75 but that the 1976 level was equal to the 1973 level. The second energy crisis can be seen by the decrease from 1978 to 1980.

The energy coefficient which is shown in column 2 states the energy consumption per unit of GDP at constant 1975-prices. This coefficient shows a rather fluctuating picture with an increase from 1966 to 1970, a downward trend until 1975, a new increase until 1978 and at the end a drop from 1978 to 1980. It is obvious that a coefficient with this kind of fluctuation is not a suitable tool for projections of the future energy consumption unless one is able to give a precise description of what factors have caused the fluctuations.

3. A MODEL FOR CHANGES IN DOMESTIC ENERGY CONSUMPTION

3.1. Production and energy consumption

The existence of annual IO-tables and supporting data matrices for energy consumption makes it possible to study the development of the energy consumption in different industries along with a study of the development in the interaction of industries and their supply to final demand.

Considering the energy consumption in a single industrial establishment it is obvious that this consumption may change for 3 reasons:

A. Changes in the output level

Any shift in the demand for the produced good or service will change the energy consumption.

If the production technology remains the same the change in output will cause a proportional changes in energy consumption because traditional IO-models assume that the maginal input structure is equal to the average input structure.

B. Changes in technology

Changes in the production technology will change the energy consumption even if the output level is unchanged. The existence of IO-tables for more than a single year makes it possible to incorporate this effect in the analysis but it will however only be possible to trace the changes in technology that influence the interaction of industries and thereby the IO-coefficients.

Changes in technology, when interpreted as changes in the composition of inputs on delivering industries, will involve both foreign and domestically produced goods and services. The analyses will deal with the "total" technology (exogeneous model) as well as the part of technology that involves only goods and services produced in Denmark (endogeneous model).

C. Changes in the output mix of the establishment

Any shifts between products of different energy intensity will affect the energy consumption per average unit of output.

With the available statistical sources it is unfortunately not possible to separate the effect of changing technology and changing output mix and the common effect will be treated under the heading of technological changes.

The transference of the 3 above mentioned factors from the micro- to macrolevel permits the use of an IO-analysis.

The study will deal with the period 1966-79 but in order to get a more detailed view of the development the period has been subdivided into 4 parts: 1966-70, 1970-73, 1973-75, 1975-79. This subdivision has been chosen because of the data sources as the energy matrices are considered to be of a higher quality in years for which energy surveys have been carried out (1966,70,73,75,78).

3.2. The influence of demand and technology on energy consumption

The basis of the analysis is a static IO-model with endogeneous imports (i.e. the import matrix is separated out)

$$1)\quad x=(I-A)^{-1}\cdot D\cdot d$$

where x is a column vector for the output of industries

$(I-A)^{-1}$ is the inverse Leontief matrix

D is a matrix for the composition of final demand where a column contains the proportions delivered from industries into each category of final demand.

d is a column vector for the absolute level of final demand by category.

By means of the energy matrices it is possible to calculate the energy consumption per unit of output in each of the 117 industries. If a vector for this energy consumption is introduced in (1), one gets an expression for the total energy consumption in industries in a single year.

2) $e * x = e * ((I-A)^{-1} \bullet D \bullet d)$

where e is a vector for the energy consumption per unit of output.

The symbol $*$ denotes element multiplication whereas $\bullet$ denotes common matrix multiplication.

As equation (2) can be established for any year, the change in the energy consumption between the years t and t-1 can be written as:

3) $e_t * x_t - e_{t-1} * x_{t-1} = e_t * ((I-A)_t^{-1} \bullet D_t \bullet d_t) - e_{t-1} * ((I-A)_{t-1}^{-1} \bullet D_{t-1} \bullet d_{t-1})$

Equation (3) makes it possible to split the change in energy consumption into one part caused by changes in technology (4) and another part caused by changes in final demand (5).

4) Technology: $e_t * ((I-A)_t^{-1} \bullet D_{t-1} \bullet d_{t-1}) - e_{t-1} * ((I-A)_{t-1}^{-1} \bullet D_{t-1} \bullet d_{t-1})$

5) Demand: $e_t * ((I-A)_t^{-1} \bullet (D_t \bullet d_t - D_{t-1} \bullet d_{t-1}))$

From (4) it is seen that changes in technology are interpreted as changes in either the energy consumption per unit of output or in the IO-coefficients, even though these changes could be caused by changes in the output mix.

The possibility to distingquish between changes in IO-coefficients and energy coefficients is due to the applied concept of energy consumption. Changes in the energy consumption per unit of output will of course change the IO-coefficients but as these changes are multiplied by the energy coefficients, which are negligible in the energy producing industries the factor for changes in IO-coefficients will be exclusive of changes in the energy coefficients.

From (5) it is seen that the demand factor covers both changes in the level and in the composition of final demand.

In table 2 the results of the IO-calculations are shown for the whole period as well as for the 4 subperiods. In the calculations the IO-tables in 1975 prices are used. The model treats the imports as endogeneous so the results are comparable with the changes that can be calculated from table 1.

TABLE 2 Changes in industrial energy consumption 1966-79 (TJ)

Period	Demand	Technology	Total
1966-70	63455	16247	79703
1970-73	47863	-17020	30843
1973-75	-19969	-27045	-47014
1975-79	76525	531	77056
1966-79	161038	-20450	140588

Table 2 shows that the demand component caused an increase in the energy consumption in all subperiods except 1973-75 where there was a decrease in the energy consumption. The changes over the whole period were heavily influenced by the demand component while technology has only had a slight decreasing effect, but it can be seen from the table that if the demand had remained unchanged at the 1966-level the energy consumption would have decreased by 20450 TJ over the period.

3.3. A further decomposition

It has earlier been mentioned that the demand component covers changes in the volume as well as changes in the composition of final demand and that the technology component covers changes in the IO-coefficient as well as changes in the energy consumption per unit of output. A split of the total change in energy consumption in these 4 parts can be done using equation (4) and (5).

The technology component can be split into:

Changes in IO-coefficient: $e_t \ast ((I-A)_t^{-1} - (I-A)_{t-1}^{-1}) \bullet D_{t-1} \bullet d_{t-1}$

Changes in energy-coefficient $(e_t - e_{t-1}) \ast ((I-A)_{t-1}^{-1} \bullet D_{t-1} \bullet d_{t-1})$

For the demand component it is possible to make a similar simple split between the changes in D and the changes in d. However, the changes in d will cover both changes in the level of final demand and the shifts between the different categories. In order to isolate the changes in the level of final demand a special vector $d^{\ast}$ is constructed as:

$$d^{\ast} = d_t \left(\sum_i d_{t-1}^i \Big/ \sum_i d_t^i \right)$$

where d^i is the different categories of final demand. This means that in $d^{\ast}$ the composition of the different categories of final demand is the same as in year t but the level of the total final demand is as in year t-1. By using $d^{\ast}$ the demand component (5) can be written as:

6) $e_t \ast (I-A)_t^{-1} \bullet (D_t \bullet (d_t + d^{\ast} - d^{\ast}) - D_{t-1} \bullet d_{t-1})$

6) can be split into 2 components:

Changes in the composition of final demand: $e_t \ast ((I-A)_t^{-1} (D_t \bullet d^{\ast} - D_{t-1} \bullet d_{t-1}))$

Changes in the level of final demand : $e_t \ast ((I-A)_t^{-1} \bullet (D_t \bullet d_t - D_t \bullet d^{\ast}))$

As it is seen the component for changes in the composition of final demand includes changes in the relative importance of different categories of final demand as well as the changes in the branch composition of each of the final demand categories, while the component for changes in the volume of final demand covers only the changes in total final demand.

When the further split of the technology component is introduced it is necessary to weight one of the changes with matrices from different periods. For example the d and D matrices are from year t-1 in the component for the changes in IO-coefficients while the e vector is from year t. However, this problem can not be overcomed due to the underlying equation (2) but it is possible to shift the mixed weighting between the two subcomponents of technology.

Table 3 shows the results of the analysis of the changes in the industrial energy consumption in the whole period 1966-79 and in the 4 subperiods. For the period 1966-79 table 4 gives detailed results on 27 branches that are an aggregation of the basic 117 industries.

TABLE 3 Changes in industrial energy consumption 1966-79 (TJ)

	DEMAND			TECHNOLOGY			Industrial structure	Total change
	Total	Composition	Level	Total	IO-coef.	Energy-coef.		
1966-70	63455	-10384	73839	16247	-3306	19553	60150	79703
1970-73	47863	-5032	52895	-17020	-381	-16640	47482	30843
1973-75	-19969	-6909	-13060	-27045	-397	-26648	-20366	-47014
1975-79	76525	7213	69312	531	-4080	4611	72445	77056
1966-79	161038	-10710	171747	-20450	-7349	-13101	153689	140588

From the last row of table 3 it is found that the changes in demand were much more important for the changes in energy consumption in industries from 1966 to 1979 than the changes in technology. The figures show that if the final demand has remained unchanged from 1966 to 1979 the energy consumption would have decreased by 20540 TJ over the period when compared to the actual increase by 140588 TJ stresses the importance of changes in final demand. The split of both the demand and the technology component gives further information on the causes of the changes. It can be noticed that the increase in energy consumption was solely caused by the changes in the level of final demand while the 3 other factors slowed down this increase.

As the above analysis is based on a comparison of the energy-economy relations in the years 1966 and 1979 the results do not give any information about fluctuations in the intervening years and about whether the relative importance of the different factors was the same throughout the period. In order to get an answer to this question it may be useful to look at the results for the 4 subperiods. It should be noticed that a summation of the figures for each component over the 4 subperiods is not equal to the changes over the whole period. This is due to fact that in the calculations for the period 1966-70 for example, the demand component was calculated by using the 1970-technology while the same calculations for the period 1966-79 have used the 1979-technology. A summation over the subperiods will therefore imply a mixed technology of the years 1970,73,75 and 79 weighted by the changes in final demand in each subperiod. The problem is comparable with the use of chainindices.

Table 3 shows that the structure from the whole period cannot quite be transfered to the subperiods. Generally the changes in IO-coefficients are of little importance and the changes in the volume of final demand are still very important but the influence from the two other factors makes the picture shift between the periods.

The energy consumption per unit of output has increased from 1966 to 1970 which is not surprising as the energy costs at that time were of minor importance. It is on the other hand a bit surprising that the decrease in this factor was initiated as early as in the period 1970-73 and one would have expected the effects from the factor to continue after 1975. An explanation can be given by the detailed results which permit a study of each of the 117 industries. This shows that the increase in the energy consumption per unit of output during the period 1975-79 can be attributed to changes in the branch "Producers of government services". This seems reasonable as the winter of 1979 was exceptionally cold and as most of the energy consumption in this branch is used for heating. If the influence of

TABLE 4 Changes in industrial energy consumption by kind of activity 1966-79 (TJ).

		DEMAND			TECHNOLOGY			
		Total	Compo-sition	Level	Total	IO-coef.	Energy coef.	Total change
1	AGRICULTURE, HORTICULTURE, ETC.	8894	-7648	16542	-6055	-3017	-3038	2839
2	FORESTRY AND LOGGING	31	-4	35	5	-22	27	37
3	FISHING	1403	-1191	2594	-500	-276	-224	903
4	MINING AND QUARRYING	688	-365	1053	959	35	924	1647
5	MANUF OF FOOD, BEVERAGES, TOBACCO	13110	-4115	17225	671	4083	-3412	13781
6	TEXTILE, CLOTHING, LEATHER INDUSTRY	1540	-376	1916	-3986	-788	-3198	-2446
7	MANUF. OF WOOD PRODUCTS, INCL.FURNIT.	3300	-483	3783	169	512	-343	3468
8	MANUF. OF PAPER, PRINTING, PUBLISHING	5019	563	4456	-1969	-1268	-701	3049
9	CHEMICAL AND PETROLEUM INDUSTRIES	11958	2618	9340	-1519	1079	-2598	10439
10	NON-METALLIC MINERAL PRODUCTS	10596	-4192	14788	-4056	-764	-3292	6539
11	BASIC METAL INDUSTRIES	6348	1673	4675	-6165	-3561	-2604	183
12	MANUF. OF FABRICATED METAL PRODUCTS	8954	479	8475	-8344	-783	-7561	610
13	OTHER MANUFACTURING INDUSTRIES	607	91	515	-154	-45	-109	453
14	ELECTRICITY, GAS AND WATER	435	-196	630	114	-16	130	548
15	CONSTRUCTION	3011	-2216	5227	-1679	-1509	-170	1332
16	WHOLESALE AND RETAIL TRADE	12770	-2695	15466	-3596	314	-3910	9174
17	RESTAURANTS AND HOTELS	2018	-1121	3140	804	282	522	2823
18	TRANSPORT AND STORAGE	26942	2299	24643	2788	-2739	5528	29730
19	COMMUNICATION	2384	595	1790	77	213	-135	2462
20	FINANCING AND INSURANCE	2566	205	2361	1327	-213	1541	3893
21	DWELLINGS	878	201	677	285	-3	289	1163
22	BUSINESS SERVICES	2638	-219	2857	2461	818	1642	5099
23	MARKET SERVICES OF EDUCATION, HEALTH	684	-370	1054	131	-72	203	815
24	RECREATIONAL AND CULTURAL SERVICES	582	-29	611	-426	-21	-405	156
25	HOUSEHOLD SERVICES, INCL.AUTO REPAIR	1687	-2131	3818	-1453	312	-1766	234
26	OTHER PRODUCERS, EXCL. GOVERNMENT	109	44	65	-59	0	-59	50
27	PRODUCERS OF GOVERNMENT SERVICES	31887	7876	24011	9721	100	9621	41607
28	TOTAL	161038	-10710	171747	-20450	-7349	-13101	140588

this branch is deducted, the trend from the two previous periods will continue as expected.

The component for the changes in the volume of final demand follows the expected pattern with an increase in all periods except 1973-75 where the energy crisis caused downward economic trends.

TABLE 5 Changes in energy consumption of manufacture of cement, lime and plaster 1966-79 (TJ)

	DEMAND			TECHNOLOGY			
Period	Total	Composition	Level	Total	IO-coef.	Energy coef.	Total change
1966-70	4204	499	3705	2209	-318	2527	6413
1970-73	2999	147	2852	224	-567	791	3223
1973-75	-6389	-5727	-662	2562	1079	1483	-3826
1975-79	3983	1167	2816	-4904	-617	-4287	-920
1966-79	5137	-1841	6978	-248	-546	298	4889

To give an impression of how the detailed results can give further information table 5 shows the figures for the branch "Manufacture of cement, lime and plaster". Again the importance of the volume of final demand is underlined but it can also be seen how the figure for the total change can hide the influence from other factors. From 1973-75 the energy consumption of the branch decreased by 3826 TJ but the table shows that the energy consumption per unit of output actually increased. This may be caused by a rigidity in the production process as both demand components decreased substantially or may be explained by a change towards cheaper energy products which have decreased the incitements to introduce energy conservating technologies. In particular it should be noticed that in this period the component for changes in volume was less important than the other demand component which reflects the dramatic drop in construction.

TABLE 6 Energy consumption by kind of activity

Branch	EC 1966 (TJ)	"EC" 1979 (TJ)	Composition 1966 (%)	Composition 1979 (%)	Energy-coef. 1979 TJ/mill.75kr
1.	43342	49218	12.8	10.0	1.83
2.	62	71	0.0	0.0	0.22
3.	6337	7463	1.9	1.5	4.84
4.	1293	2016	0.4	0.4	4.08
5.	34297	51490	10.1	10.5	1.00
6.	7794	8545	2.3	1.7	0.74
7.	7090	10902	2.1	2.2	1.71
8.	9388	13138	2.8	2.7	1.11
9.	15632	28669	4.6	5.8	1.48
10.	34736	44568	10.3	9.0	6.92
11.	12865	15652	3.8	3.2	5.68
12.	23045	31217	6.8	6.3	0.70
13.	985	1547	0.3	0.3	0.96
14.	1211	1629	0.4	0.3	0.23
15.	13258	14760	3.9	3.0	0.39
16.	33993	47077	10.0	9.6	0.96
17.	5940	8241	1.8	1.7	1.43
18.	39052	63254	11.5	12.8	2.53
19.	2533	5130	0.7	1.0	0.98
20.	2697	5049	0.8	1.0	0.65
21.	726	1600	0.2	0.3	0.08
22.	2876	6332	0.8	1.3	0.63
23.	2128	2740	0.6	0.6	0.76
24.	1549	2111	0.5	0.4	0.66
25.	10422	12421	3.1	2.5	1.09
26.	132	241	0.0	0.0	0.12
27.	25410	57397	7.5	11.7	0.99
Total	338793	492482	100.0	100.0	1.14

EC : Energy consumption
"EC": Energy consumption calculated under the assumption of unchanged energy coefficients.

Note: Explanation of the branchnumbers can be found in table 4.

3.4. Shifts between high- and low energy intensive branches

Up till now the analysis has concentrated on the right hand side of equation 3, but it is of course also possible to use the left hand side of the equation. This can be written as:

$$7)\quad e_t * x_t - e_{t-1} * x_{t-1} = (e_t - e_{t-1}) * x_{t-1} + e_t * (x_t - x_{t-1}) = A+B$$

where A expresses how the changes in the energy coefficients have affected the changes in the energy consumption and B expresses how changes in the industrial structure have affected the energy consumption.

As $x_{t-1} = (I-A)^{-1}_{t-1} \cdot D_{t-1} \cdot d_{t-1}$ part A is equal to the technology factor for changes in energy consumption per unit of output and B is equal to the sum of the 3 other factors shown in column 7 of table 3. It can be seen that substantial changes have taken place in the composition of Danish industry including shifts between high and low energy-intensive industries. Table 6 gives a more detailed picture of these shifts. The first column of the table shows the energy consumption in the 27 branches in 1966. If the changes in energy consumption caused by changes in output are added to the 1966 figures it can be analysed how the composition in the total energy consumption would have been in 1979 if energy consumption per unit of output had remained unchanged. From column 3 and 4 and the 1979 energy coefficients in column 5 it is seen that the relative importance of five of the six most energy intensive branches (agriculture etc., fishing, mining and quarrying, chemical and petroleum industries and non-metallic mineral products) has decreased over the period - only transport and storage have increased. These changes, together with the decrease in energy coefficients, must have caused the decrease in the overall energy coefficient that was seen in table 1. If the branch energy coefficients had remained unchanged the total energy coefficient would only have decreased from 2.02 to 1.98 while the actual decrease was from 2.02 to 1.93.

4. FOREIGN AND DOMESTIC PRODUCTION

In part 2 it was shown how the changes in the energy consumption in Danish industries have been influenced by changes in both technology and demand. These changes will however be influenced in two ways by the relation between domestic production and imports. Firstly a substitution between Danish production and imports will affect the Danish energy consumption. Secondly an introduction of energy saving technologies will due to different import quotas on different products not cause a proportional change in the domestic and the overall energy consumption.

This means that in order to get a more complete picture of the influence from changes in technology it is necessary to include foreign as well as domestic production.

The energy content in imports of non-energy commodities has been calculated by using the production functions for the Danish industries, (the socalled "self sufficiency method").

Thus the enlarged energy consumption (EEC) is calculated as:

$$EEC=EC+IEC$$

where EC is the energy consumption in Danish industries and IEC is the energy content in imports of non-energy commodities.

TABLE 7 Energy consumption and enlarged energy consumption in selected years (TJ)

	1966	1970	1973	1975	1979
EC	338785	418488	449330	402317	479373
index 1975=100	84	104	112	100	119
EEC	551983	678227	759547	671390	746837
index 1975=100	82	101	113	100	111
EC/EEC	0.61	0.62	0.59	0.60	0.64

It can be seen from table 7 that despite slight variations, the general trend seems to be the same for the development in EC and EEC for the period 1966-75 while EC increased more than EEC from 1975 to 1979.

In order to get a better understanding of the factors which caused the changes in EEC the above analysis has been applied using matrices that contain the demand for foreign as well as for domestic production. The results from this analysis will be in accordance with the changes in EEC shown in table 7.

TABLE 8 Changes in enlarged energy consumption 1966-79 (TJ)

	DEMAND			TECHNOLOGY			Total change
	Total	Composition	Level	Total	IO-coef.	Energy coef.	
1966-70	114381	-5287	119668	11862	13941	-2079	126243
1970-73	88926	-487	89413	-7605	2523	-10128	81321
1973-75	-40092	-18298	-21794	-48066	-32329	-15757	-88158
1975-79	121251	13266	107985	-45803	9490	-55293	75448
1966-79	258999	-8574	267573	-64146	-6159	-57987	194853

As indicated by table 8 the changes in EEC are just like the changes in EC mainly determined by changes in final demand. A comparison of the analyses of the changes in EC and in EEC is given in table 9. This indicates that the changes in final demand were relatively more important for the changes in EEC than for the changes in EC. These observations are mostly due to the fact that the demand and the technology factor were counteracting each other more in the changes in EEC.

TABLE 9 Comparison of the relative importance of different factors for the changes in EC and EEC.

		DEMAND			TECHNOLOGY			Total change
	Analysis	Total	Composition	Level	Total	IO-coef.	Energy coef.	
1966-70	EC	79.6	-16.3	116.3	20.4	-20.1	120.1	100.0
	EEC	90.6	-4.6	104.6	9.4	117.0	-17.0	100.0
1970-73	EC	155.2	-10.5	110.5	-55.2	2.2	97.8	100.0
	EEC	109.4	-0.5	100.5	-9.3	-33.3	133.2	100.0
1973-75	EC	42.5	34.6	65.4	57.5	1.4	98.6	100.0
	EEC	45.5	45.7	54.3	54.5	67.3	32.8	100.0
1975-79	EC	99.3	9.4	90.6	0.7	-757.1	857.1	100.0
	EEC	160.7	11.0	89.0	-60.7	-20.8	120.8	100.0
1966-79	EC	114.5	-6.6	106.6	-14.5	35.9	64.1	100.0
	EEC	132.9	-3.3	103.3	-32.9	9.6	90.4	100.0

EC : Analysis for changes in the energy consumption
EEC : Analysis for changes in the enlarged energy consumption.
Note : The total demand and technology factors are given as a percentage of the total change in energy consumption while the subcomponents are given as percentages of the demand respectively the technology factor.

While the relative importance of the two demand factors is more or less the same for both analyses, this is not true for the two technology factors. For the whole period 1966-79 the changes in energy consumption per unit of output were relatively more important for the changes in EEC but this pattern cannot be found for all the subperiods. For example the changes in IO-coefficient are not very important as far as changes in EC during the period 1973-75 are concerned. When however imports are included there has been dramatic changes in the interaction of industries, and these have particular caused a decrease in the demand by other industries for the products supplied by manufacturers of basic industrial chemicals, fertilizers and basic plastic materials.

The above mentioned relative decrease in EEC can however not solely be explained by a substitution from foreign to domestic production. The decrease in EEC can also be caused by an introduction of energy saving technologies because these will due to the different import quotas on different products not cause a proportional change in EC and EEC.

To sum up differences in the trends of EC and EEC are caused either by the structure of imports (differences in import quotas) or by a substitution between foreign and domestic production (changes in import quotas). From this knowledge and by using the results of the analysis of the changes in EC and EEC a more thorough trend analysis can be carried out.

Starting from the basic equation of the endogeneous (8) respectively the exogeneous model (9) it is seen that the differences in the calculations of EC and EEC are different $(I-A)^{-1}$ and D matrices.

$$8) \quad EC = e * ((I-A)^{-1} \cdot D \cdot d$$

$$9) \quad EEC = e * ((I-A_x)^{-1} \cdot D_x \cdot d$$

Because of this no futher explanation to whether the changes in imports have caused an increase or decrease in energy consumption are given by the components for changes in energy coefficients and for changes in the volume of final demand.

Thus taking into account only the changes in the IO-coefficients or in the composition of final demand the following changes in energy consumption can be calculated.

	EC	EEC
1966-70	-13690 TJ	8654 TJ
1970-73	-5413 TJ	2036 TJ
1973-75	-7306 TJ	-50627 TJ
1975-79	3133 TJ	22756 TJ

If these changes are combined with 1966 energy consumption two new time series for EC and EEC appear. These series, calculated from a method similar to chainindices, are shown in table 10 and reveal a picture quite different from the one shown in table 7. From the new data it can be concluded that the effect from changes in imports have tended to decrease the part of the overall Danish energy consumption that is taking place in Denmark.

This result underlines the importance of carrying out detailed energy analyses as these might reveal factors that are hidden in the aggregated figures.

TABLE 10 Adjusted energy consumption and adjusted enlarged energy consumption for selected years (TJ).

	1966	1970	1973	1975	1979
"EC"	338785	325095	319682	312376	315509
index 1975=100	108	104	102	100	101
"EEC"	551983	560637	562673	512046	534802
index 1975=100	108	109	110	100	104
"EC"/"EEC"	0.61	0.58	0.57	0.61	0.59

5. SENSITIVITY OF THE ANALYSIS

This results yielded by the analyses in part 3 and 4 will of cource be dependent on the data sources and especially on the quality of the IO-tables.

As the Danish IO-tables for the period 1966-75 exist in two versions, it is possible to test the sensitivity of the analysis in this respect.

The differences between the two set of tables that are of importance for the analysis can be summarised in the following 3 points:

1) Branch classification.
   The branch classification in the former tables followed 1958 ISIC and consisted of 130 industries.
   In the new tables the number of industries has decreased to 117 which are based on 1968 ISIC and which have been established by amalgamating or resequencing the 130 industries and adding two new ones.

2) Split of absorption matrix into foreign and domestic production.
   In both set of IO-tables it has been assumed that the ratio of domestic production to imports is identical in all domestic uses. However, in the preliminary tables the assumption was applied at the level of 130 industries while in the new tables the assumption is applied on the 1600 commodity level (four digit CCCN).

3) Establishment of the IO-tables.
   The former IO-tables were established by multiplication of the 130x130 make matrix by the 130x130 absoption matrix.
   The new IO-tables are established from the rectangular matrices by multiplication of the 117x1600 make matrix by the 1600x117 absoption matrix.

In the light of the differences stated in the 3 above mentioned points it is evident that the new IO-tables have been established by the use of much more detailed information and that unnecessary aggregation errors have hereby been avoided.

Table 11 shows a comparison of the analyses of the changes in the energy consumption in Danish industries from 1966 to 1975 based on both the former and the new IO-tables. The figures for each component are given as a percentage of the total change in the period. The subcomponents are also given as a percentage of the demand and the technology component respectively.

In the periods 1966-70 and 1970-73 the relative importance of the demand and technology component was almost the same in the two cases but in the period 1973-75 the technology component was the most important factor when the analysis was based on the new IO-tables, while the demand component was more important when the analysis was based on the former tables.

TABLE 11 Comparison of analyses carried out on the former and the new IO-tables.

		DEMAND			TECHNOLOGY			
	Version	Total	Composition	Level	Total	IO-coef.	Energy coef.	Total change.
1966-70	F	89.4	-21.1	110.5	10.6	-6.5	17.1	100.0
			(-23.6)	(123.6)		(-61.3)	(161.3)	
	N	89.3	-17.4	106.6	10.7	-4.4	15.1	100.0
			(-19.5)	(119.5)		(-41.1)	(141.1)	
1970-73	F	150.9	-35.9	186.8	-50.9	-12.9	-38.0	100.0
			(-23.8)	(123.8)		(25.3)	(74.7)	
	N	149.6	-28.1	177.6	-49.6	-0.4	-49.2	100.0
			(-18.8)	(118.8)		(0.8)	(99.2)	
1973-75	F	50.2	-101.6	151.7	49.8	-12.2	62.0	100.0
			(-202.2)	(302.2)		(-24.5)	(124.5)	
	N	42.4	-49.5	91.8	57.6	-1.5	59.1	100.0
			(-116.6)	(216.5)		(2.6)	(97.4)	
1966-75	F	147.8	-27.2	175.0	-47.8	-6.6	-41.2	100.0
			(18.4)	(118.4)		(13.8)	(86.2)	
	N	154.4	-14.2	168.5	-54.4	-3.6	-50.8	100.0
			(-9.2)	(109.2)		(6.6)	(93.4)	

F: Former IO-tables
N: New IO-tables
Note: The figures given in brackets are the subcomponents in percentage of respectively the demand and technology component.
It should be noticed that the figures for the new IO-tables are not directly comparable with the figures in table 3. This due to a different period composition of the 2 subcomponents for technolgy and a changed definition of composition of final demand as the concept used in this table covers only changes in the branches composition while changes in the relative importance of different categories of final demand is calculated under heading of changes in level. These chances have been made in order to make the results comparable with previous calculations on the former IO-tables.

If the relative importance of the four subcomponents are studied the most interesting phenomenon is that the influence from the changes in IO-coefficients has decreased in all periods, both in relation to the total changes in energy consumption and in relation to the change caused by changes in final demand.

This indicates that the IO-coefficients are more stable in the new IO-tables and that parts of the change in IO-coefficients which could be seen in the former tables was due to the method used in producing IO-tables. If the coefficients tend to be more stable in the new tables the relative importance of the changes caused by changes in the branch composition of final demand should also be diminished by using the new tables. This conclusion is in agreement with the figures given in table 11 and the overall conclusion must therefore be that an analysis based on the former tables will overestimate the influence from changes in the interdependence of industries.

6. CONCLUSION

The paper has shown how a method of combinating energy data and IO-tables can be used to explain the changes in energy consumption by changes in technology and in final demand.

The method has been applied to the domestic energy consumption as well as to the overall energy consumption that includes the energy content in imports of non-energy products. Differences in the trends of the 2 concepts of energy consumption can give information of the influence of changes in imports.

Finally the method has shown how the IO-analyses are dependent on the method used for constructing IO-tables.

References:

1) Danmarks Statistik. 1982.
Import-, beskæftigelses- og energimultiplikatorer 1979.
Nationalregnskabsnotat nr. 6.

2) Danmarks Statistik 1983.
Nationalregnskabsstatistik 1966-81.

3) Pløger, E. 1982.
Input-output analyse of udviklingen i erhvervenes energiforbrug 1966-75.
Nationaløkonomisk Tidsskrift, bind 120, nr. 3.

4) Reardon, W.A. 1974.
Input-output analysis of U.S. energy consumption.
Paper on the 6. international Input-Output Conference.

5) Thage, B. 1982.
Techniques in the compilation of Danish Input-Output tables: A new approach to the treatment of imports.
In Skolka, J. (ed.) Compilation of Input-Output tables.

THE STRUCTURE OF ENERGY PRODUCTION AND REQUIREMENTS IN THE EUROPEAN COMMUNITIES

Heinz Mürdter
Ifo-Institute for Economic Research, Münich, FRG

By initiating the development of input-output tables of energy flows for 1975 in seven member countries of the EC, the Statistical Office of the European Communities (EUROSTAT) established a data-base suited especially for inter-regional analysis of energy production and consumption. The new data-base records energy flows in values and in quantities, thereby allowing to calculate in an input-output analysis framework the direct and indirect energy requirements of production in value units and in physical units. This paper deals with the physical energy requirements of final demand and foreign trade, including the energy requirements for production of commodities by means of commodities, that is for intermediate production. The results presented can be of interest for energy demand models.[1)]

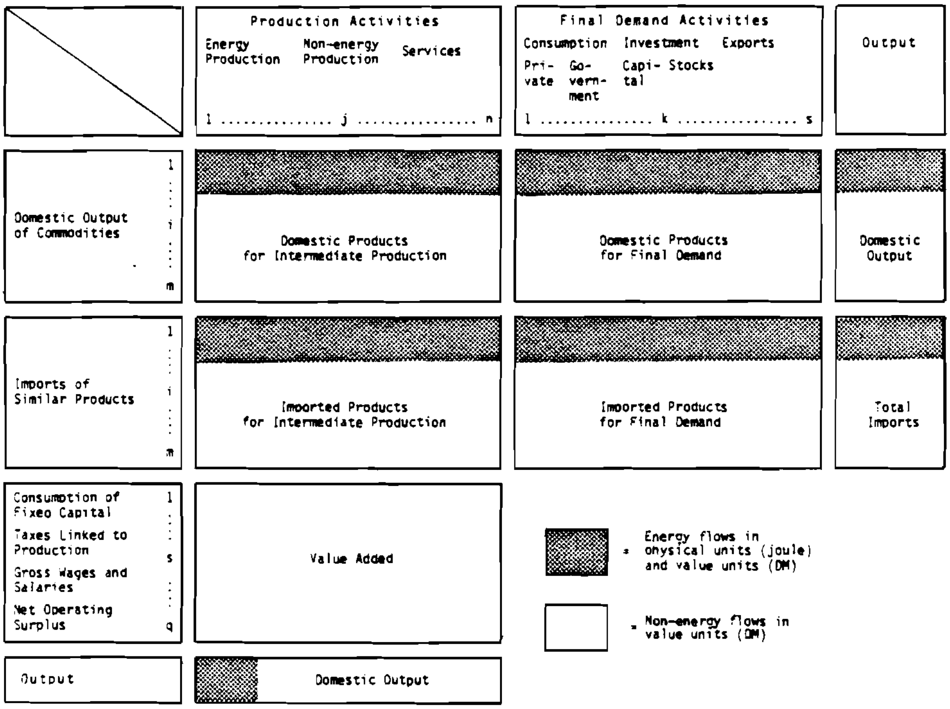
1. INPUT-OUTPUT TABLES OF ENERGY FLOWS IN THE EUROPEAN COMMUNITIES

The input-output tables of energy flows do not show energy flows only. They are complete input-output tables comprising all production and final demand activities in an optimal aggregation for analysing energy problems. All tables are based on the harmonized 'European System of Integrated Economic Accounts' (ESA), and distinguish 10 sectors for energy sources, 25 for nonenergy commodities and 10 sectors for services (including transportation services). Figure 1 will provide an idea of the information contents of the tables and the corresponding coefficient matrices.

---

1) The results presented in this paper are part of a research project which was supported by the German Science Foundation in the program 'Economics of Natural Resources'. A comprehensive report on the results of the research project 'Input-Output Analysis of Energy Flows 1975' will be published in Beutel/Mürdter (1983). This paper covers part of the material previously published in Beutel/Mürdter (1981), Beutel/Stahmer (1982) and Beutel (1983).

Figure 1: Input-Output Table of Energy Flows



The main topics of research to be tackled with these tables may be summarized in a few points:

- Interdependence of energy sectors

  The input-output tables of energy flows supply detailed information about the dependencies and interdependencies between the energy sectors, the other production sectors and final demand.

- Physical energy requirements of producing commodities

  With the help of input-output analysis the direct and indirect physical energy requirements of commodities can be determined. This includes energy contained in imported and invested products.

- Energy costs of commodities

  With the use of input-output analysis the total (direct and indirect) energy costs of goods and services can be determined. This allows to estimate the effects of sudden energy price increases on commodity prices.

- Simulation of alternative energy strategies and energy forecasting

  The input-output tables of energy flows can be utilized for energy simulation and energy forecasting. In particular, possible effects on the supply and demand of energy sources can be measured which result from a change of final demand, technology, and international trade.

All results in the research project have been derived under the assumption that the imports are produced with the national production functions. A special regional problem results from the fact that in some countries particular production activities are missing, for instance the production of coal in Italy, the Netherlands, and Denmark. All missing production activities were replaced by the french production functions.

2. INPUT-OUTPUT-ANALYSIS OF ENERGY REQUIREMENTS

The starting point for the following computations of energy requirements for commodities in EC-Countries is a well-known formula of input-output analysis:

$$Z = B(I-A)^{-1} Y$$

where $(I-A)^{-1}$ is the matrix of cumulative input coefficients (Leontief inverse), Y the matrix of final demand, while B represents one topic of economic interest, e.g. the consumption of energy, of labour and capital, or the joint product pollution per unit of output. The matrix Z represents the results for the energy requirements, the labour or capital requirements of the respective commodities, and the direct and indirect emmission of pollutants resulting from the production of commodities in a world of linear functions.

Double-counting is typical for input-output analysis. Therefore, the cumulative (inverse) input coefficients are economic multipliers which represent the cumulative sales or activity levels of the different sectors for a given unit vector of final demand. These sales have nothing to do with the value of a commodity. To determine the energy costs of a commodity it is necessary to eliminate double-counting of related primary and secondary energy sources.

If one wishes to determine the physical energy content of commodities the problem of double-counting arises again. It is obvious that the physical energy content of commodities can't exceed the sum of all primary energies (coal, crude oil, natural gas, nuclear fuels) which have been used up on all levels of production. Therefore, to avoid double-counting, all secondary energy sources (briquette, coke, electricity, produced gas, petroleum products) must be passed over in the calculation. Many empirial research articles[2] have been published, concerning the costs of commodities, however, the problem of doublecounting has been widely neglected.

With the following approach we are able to distinguish four standard measures of energy required to produce goods and services. The first two contain double-counting of primary and secondary energy sources, the second two are free of it:

- total energy requirements in joule, (E^{TJ}),
- total energy requirements in DM, (E^{DM}),
- primary energy requirements in joule, (E^{PJ}), and
- energy costs in DM, (E^{CO}).

3. PHYSICAL ENERGY REQUIREMENTS OF PRODUCTION

To facilitate understanding of the sets of coefficients involved in calculating the total energy requirements of production, we subdivide the matrix A of technical input coefficients into energy production activities and non - energy production activities. The total physical energy requirements of commodities can then be determined by the following formula:

---

[2] See for example Koch (1972), Reardon (1973), Bonhoeffer/Britschkat/Stiller (1974), Herendeen (1974), Wright (1975), Britschkat (1975), Bonhoeffer/Britschkat (1979), Hillebrand (1980), Stahmer (1981), Hillebrand (1981), Lager/Teufelsbauer (1981), Lager (1982), Harthoorn (1982), Flaschel (1982), Beutel/Mürdter (1981), and Beutel/Stahmer (1982). The problem of double-counting primary and secondary energy sources has been discussed in Britschkat (1977), Stahmer (1981), and Beutel/Stahmer (1982).

$$E^{TJ} = D(I-A)^{-1}\,\hat{Y} + \hat{T} \tag{2}$$

$$= \begin{bmatrix} D_1 & \vdots & D_2 \\ \cdots & \cdots & \cdots \\ 0 & \vdots & 0 \end{bmatrix} \cdot \begin{bmatrix} I - \begin{pmatrix} A_1 & \vdots & A_2 \\ \cdots & \cdots & \cdots \\ A_3 & \vdots & A_4 \end{pmatrix} \end{bmatrix}^{-1} \cdot \widehat{\begin{bmatrix} Y_E \\ \cdots \\ Y_{NE} \end{bmatrix}} + \widehat{\begin{bmatrix} Y_E \\ \cdots \\ 0 \end{bmatrix}}$$

where

E^{TJ} = total physical energy requirements of commodities (joule)

D = matrix of physical input coefficients for the use of energy per unit of output (joule/DM)

A = matrix of input coefficients for commodities (domestic and imported) per unit of output (DM/DM)

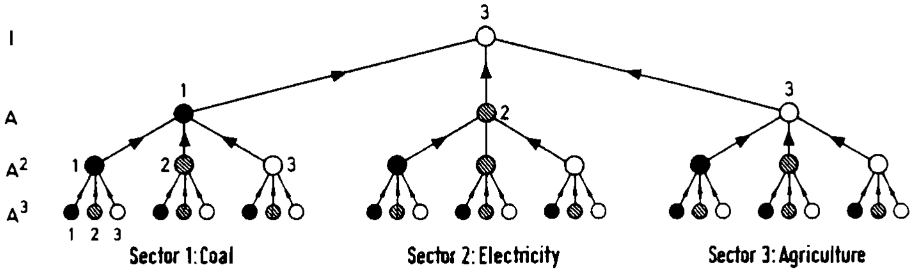
$\hat{Y}$ = diagonal matrix of final demand (DM)

$\hat{T}$ = diagonal matrix of final demand for energy sources (DM)

The flow chart in figure 2 for a simple economy with three commodities shows how the direct and indirect energy inputs sum up to the total energy requirements. For that purpose we can break up the inverse matrix into:

$$(I-A)^{-1} = I + A + A^2 + \ldots = \sum_{i=0}^{\infty} A^i \tag{3}$$

Figure 2: Physical Energy Requirements of Commodities



The expansion of the Leontief - inverse in (3) reveals also the reason why we have to add the matrix $\hat{T}$ in calculating the total physical energy requirements. Premultiplying by A leads to eliminating all commodities leaving intermediate production.

In our empirical application we adopt a slightly different approach, using a mixed input-output system in terms of physical and value units. The objective is to analyse an input-output table in which all energy flows will be given in physical units and all non-energy flows will be given in value units (as is the case in the input-output tables of energy flows).

$$E^{TJ} = H(I-A)^{-1}\hat{Y} + \hat{T} \tag{4}$$

$$= \begin{bmatrix} F_1 & \vdots & D_2 \\ \cdots & & \cdots \\ 0 & \vdots & 0 \end{bmatrix} \cdot \begin{bmatrix} I - \begin{pmatrix} F_1 & \vdots & D_2 \\ \cdots & & \cdots \\ G_3 & \vdots & A_4 \end{pmatrix} \end{bmatrix}^{-1} \cdot \widehat{\begin{bmatrix} J_E \\ \cdots \\ Y_{NE} \end{bmatrix}} + \widehat{\begin{bmatrix} J_E \\ \cdots \\ 0 \end{bmatrix}}$$

where

E^{TJ} = total physical energy requirements of commodities (joule)

F_1 = matrix of physical input coefficients for the use of energy per physical unit of output (joule/joule)

D_2 = matrix of physical input coefficients for the use of energy per value unit of output (joule/DM)

G_3 = matrix of input coefficients for non energy commodities per unit of physical output (DM/joule)

A_4 = matrix of input coefficients for non energy commodities per value unit of output (DM/DM)

J_E = vector of final demand for energy commodities (joule)

Y_{NE} = vector of final demand for non-energy commodities (DM)

The input coefficients of this input-output system have different dimensions. For the energy production we define one set of purley technical input coefficients (Joule/Joule) and a second set for the non-energy cost components (DM/Joule). The input coefficients for the non-energy production have two different dimensions for the energy (Joule/DM) and non-energy inputs (DM/DM). The approach in equation (2) leads to the same solution as the approach presented in equation (4) if an energy source is sold to all sectors at the same price. In reality, energy prices have a wide variety of prices and tariffs for different sectors. Therefore, we decided to use equation (4) to determine the physical energy content of commodities. This approach captures at least the effects of different prices for different users in the energy producing sectors.

Next, to avoid double-counting of primary and secondary energy sources, and to arrive at E^{PJ}, the primary energy requirements of production, the matrix H in equation (4) has to be replaced with a matrix H^P. This matrix only contains input coefficients for primary energy sources. All other rows in the matrix H^P contain zeroes. Remembering equation (1), the interpretation of the result is straightforward.

The input-output tables of energy flows include matrices for domestic and foreign intermediate inputs and for domestic and foreign goods and services for final demand (see fig. 1). Therefore, it is possible to make the following distinctions between domestic and imported commodities:

$K = K_d + K_m$	Matrix of Input Coefficients for Commodities
$H = H_d + H_m$	Matrix of Input Coefficients for Energy Sources
$Y = Y_d + Y_m$	Vector of Final Demand for Commodities
$T = T_d + T_m$	Vector of Final Demand for Energy Sources

where

d = domestic

m = imported.

Let us again assume that all imports will be produced with the national production function. Under this condition the general formula for the total physical energy requirements (4) can be split into the following parts for domestic and foreign energy sources:

$E^{TJ} =$	$H(I-K)^{-1} Y + T$	Total physical energy requirements	(5)
$=$	$H_d(I-K_d)^{-1} Y_d$	Domestic energy for domestic production	
$+$	T_d	Domestic energy for final demand	
$+$	$H(I-K)^{-1} K_m(I-K_d)^{-1} Y_d$	Foreign energy for foreign production of intermediate imports	
$+$	$H_m(I-K_d)^{-1} Y_d$	Foreign energy imported for domestic production	
$+$	$H(I-K)^{-1} Y_m$	Foreign energy for imported commodities of final demand	
$+$	T_m	Foreign energy directly imported for final demand	

The first two components represent all domestic energy sources. The second two components include the foreign energy sources which were necessary to produce the imported intermediate inputs. The last two components contain the foreign energy sources of the directly imported commodities of final demand.

4. EMPIRICAL RESULTS

With this theoretical background it is possible to analyze a multitude of questions concerning the energy requirements of producing certain commodities or, on a still higher level of aggregation, the energy requirements of certain categories of final demand.

Two topics of special interest in an international context are comparisons of the energy requirements of final demand and the energy requirements of imports and exports.

Table 1: Energy Requirements of Final Demand in the European Communities 1975

	Primary and secondary energy sources in terajoule				Direct and indirect primary energy requirements in terajoule			
	domestic production (1)	imports (2)	supply (3)	(1):(3) (4) %	domestic (5)	foreign (6)	total (7)	(5):(7) (8) %
Germany	11.448.971	7.073.130	18.522.101	61,81	4.693.404	10.516.044	15.209.448	30,86
France	7.192.687	5.890.156	13.082.843	54,98	1.155.536	7.779.590	8.935.125	12,93
Italy	5.532.605	5.287.867	10.820.472	51,13	563.965	6.603.008	7.168.823	7,87
Un. Kingdom	10.001.761	5.493.308	15.495.070	64,55	4.529.402	10.910.218	15.437.838	29,34
Belgium	1.852.017	2.286.887	4.138.904	44,75	223.110	3.544.892	3.781.457	5,90
Netherlands	5.664.204	2.872.835	8.537.039	66,35	3.030.560	5.378.935	8.414.715	36,02
Denmark	488.827	902.653	1.391.479	35,13	6.974	1.277.154	1.288.904	0,54

Source: Input-Output Tables of Energy Flows. Calculations by Ifo-Institute for Economic Research.

a. Energy requirements of final demand

The amount of energy used out of domestic production and out of imports can be obtained from the input-output tables of energy flows (columns (1) to (3) of table 1). The relative share of domestic energy sources could be considered as an indicator of the degree of domestic supply with energy sources. But this measure,biased not only by double-counting of primary and secondary energy sources, shows only the "top of an iceberg". A useful measure of dependence on domestic or foreign energy sources has to avoid double-counting and has to take into consideration the indirect energy reqirements of producing energy and commodities for final demand at home and abroad.

Using formula (4) and the decomposition in (5) leads to the results in columns (5) to (7) in table 1, showing the direct and indirect primary energy requirements of final demand in the seven countries in 1975.

The results in table 1, which were in part derived assuming the respective national production functions for imported energy sources, are teaching us two lessons. The extent of double-counting can be considerable (columns (3) and (7) and the reliance on foreign primary energy sources is increasing enormously (columns (4) and (8)) taking into account the indirect energy requirements.

Among the important industrialized countries of the EC, especially France and Italy have to cope with a high degree of foreign supply with primary energy sources. At least in the case of France this result may explain the forced enlargement of nuclear power capacity.

Going one step further in the analysis, it is possible to calculate the dependence on foreign energy sources for each energy source recorded in the input-output table of energy flows separately. Table 2 shows the dependence of the 45 economic sectors distinguished in the input-output tables of energy flows on crude oil imports.

As is the case with primary energy requirements for final demand, the dependence on crude oil imports is by far underestimated if only the direct level is taken into account. The over-all shares of imported crude oil and petroleum products of total supply of primary and secondary energy sources in the European communities are (naturally biased by double-counting) as follows:

Germany	3o,32 %
France	36,47 %
Italy	42,o6 %
United Kingdom	31,75 %
Belgium	39,4o %
Netherlands	31,6o %
Denmark	56,37 %

Table 2: Dependence of Economic Sectors on Crude-Oil Imports in the European Communities 1975

	Dependence on Crude-Oil Imports in per cent of direct and indirect primary energy requirements						
	BRD (1)	FRA (2)	ITA (3)	GBR (4)	BEL (5)	NED (6)	DEN (7)
01 Coal.............	1,18	2,25	2,25	1,34	2,31	0,60	2,78
02 Lignite..........	0,57	2,86	2,86	-	0,64	-	-
03 Coke.............	4,84	3,54	3,52	3,76	3,54	2,14	10,82
04 Crude oil........	46,80	99,84	99,84	182,08	99,68	96,62	99,49
05 Petroleum product	93,99	99,65	98,57	90,04	99,12	92,47	99,21
06 Natural gas......	1,50	0,83	0,81	0,97	1,94	0,05	-
07 Electricity......	10,95	82,24	81,67	26,36	39,40	5,57	63,14
08 Produced gas.....	45,74	18,48	17,93	32,62	-	-	56,46
09 Steam, hot water.	36,22	-	-	-	-	-	98,13
10 Nuclear fuels....	0,53	-	-	-	-	-	-
11 Water............	17,62	80,11	79,44	38,32	43,12	17,39	-
12 Agriculture......	63,52	86,32	85,66	64,52	69,90	27,80	87,20
13 Iron and steel...	15,93	30,65	30,44	32,69	15,15	15,10	70,62
14 Non-EGKS products	18,72	37,36	37,11	-	19,39	-	-
15 Non-ferrous metal	33,40	67,86	67,52	38,51	35,76	11,90	69,89
16 Aluminium........	15,82	75,81	75,24	35,63	-	-	-
17 Cement...........	47,23	76,24	75,41	19,26	24,20	11,29	35,44
18 Glass............	46,31	60,25	59,77	55,37	42,20	26,82	87,69
19 Ceramics.........	45,45	61,71	61,05	56,11	41,66	7,33	84,56
20 Other minerals...	44,68	72,14	71,48	52,23	35,80	18,49	57,84
21 Chemical products	42,26	75,81	75,28	57,02	51,29	41,13	85,27
22 Metal products...	24,54	44,82	44,53	40,23	27,43	17,59	74,43
23 Machinery........	34,98	55,00	54,62	44,17	33,67	19,14	76,72
24 Electrical prod..	39,43	62,62	62,29	48,37	39,33	23,24	76,97
25 Motor vehicles...	33,07	57,49	57,16	43,14	37,53	21,87	-
26 Other vehicles...	29,97	52,70	52,37	44,52	30,68	20,57	75,42
27 Food.............	58,61	77,62	77,09	59,09	65,24	25,89	85,48
28 Textiles.........	49,23	77,92	77,34	55,06	59,90	31,93	83,24
29 Leather..........	54,39	78,83	78,47	56,21	65,92	35,87	82,16
30 Wood.............	50,99	79,42	78,82	57,75	59,40	31,53	80,29
31 Paper............	44,24	75,05	74,72	48,75	53,15	19,78	54,37
32 Printing.........	46,54	75,48	74,86	52,26	56,25	21,01	64,10
33 Synthetics.......	43,12	77,22	76,76	51,56	53,21	34,65	81,21
34 Other products...	45,02	67,38	67,23	54,03	49,34	22,62	76,31
35 Buildings........	47,91	67,48	66,87	52,02	41,99	37,70	72,36
36 Repairs, recovery	41,22	60,02	59,64	-	59,04	21,47	79,35
37 Trade, restaurant	58,61	84,29	83,56	58,28	70,22	36,25	81,93
38 Railroad.........	38,69	85,60	84,79	59,15	58,21	17,13	91,22
39 Road transport...	72,49	93,39	92,56	83,11	93,90	79,29	95,72
40 Pipelines........	-	-	-	-	-	-	-
41 Inland navigation	90,35	99,07	98,05	-	93,74	88,09	-
42 Maritime transp..	92,61	97,78	97,33	89,36	96,50	89,03	86,50
43 Aviation.........	89,49	96,41	95,79	86,44	91,46	77,42	97,56
44 Private services.	54,04	83,92	83,17	47,80	61,99	27,06	78,69
45 Public services..	47,10	79,88	79,13	54,29	56,28	28,55	81,06
46 Total	45,14	75,94	75,29	53,72	57,62	38,99	82,97

Source: Input-Output Tables of Energy Flows.Calculations by Ifo-Institute for Economic Research.

b. Energy Requirements of Foreign Trade

The answer to the question if foreign trade alters total supply of energy sources for a given country can be given on two levels. On the direct level one has to balance exports and imports of primary and secondary energy sources to obtain the net position. To take into account the indirect energy requirements of the traded energy sources and of the commodities, the procedure to follow is the same as for final demand. Once again the assumption has to be made, that all imported commodities are produced with the national production functions.

Table 3: Energy Requirements of Foreign Trade

	Foreign Trade in Terajoule 1)			Direct and Indirect Primary Energy Requirements of Foreign Trade in Terajoule		
	Exports	Imports	Balance	Exports	Imports	Balance
Germany	1.149.471	7.073.130	-5.923.659	4.815.621	10.516.044	-5.700.423
France	677.313	5.890.156	-5.212.843	2.811.698	7.779.593	-4.967.895
Italy	826 664	5.287.867	-4.461.203	2.369.080	6.605.680	-4.236.600
Un.Kingdom	950.997	5.493.308	-4.542.311	5.106.106	10.913.886	-5.807.780
Belgium	694.148	2.286.887	-1.592.739	2.162.195	3.556.594	-1.394.299
Netherlands	3.394.413	2.872.835	+521.578	5.720.329	5.379.874	+340.455
Denmark	118.548	902.653	-784.105	371.753	1.277.255	-905.502

1) Primary and secondary energy sources.

Source: Input-Output Tables of Energy Flows. Calculations by Ifo-Institute for Economic Research.

The results in table 2 reveal all countries, with the exception of the Netherlands, to be net-importers of energy. Taking into account the indirect energy requirements does not change the net positions to a great extent. This result is mostly due to the national technology assumption. Inefficient or efficient use of energy reflects on both sides of the foreign trade account.

REFERENCES

Beutel, J. (1983). Input-Output Analysis of Energy flows for the European Communities, in The Use of Simulation Models in Energy Planning, Proceedings of the International Conference held at Risø National Laboratory, Roskilde (Denmark).

Beutel, J., Mürdter, H. (1981). Analyse der Deutschen Energiewirtschaft - Eine Auswertung der Energiebilanzen und der Input-Output-Tabellen für die Bundesrepublik Deutschland, in U.P. Reich, C. Stahmer (Hrsg.), Input-Output-Rechnung: Energiemodelle und Methoden der Preisbereinigung, Frankfurt a. M., New York 1981, pp. 5-70.

Beutel, J., Mürdter, H. (1983). Input-Output-Analyse der Energieströme 1975. Eine empirische Untersuchung für die Bundesrepublik Deutschland und Länder der Europäischen Gemeinschaften. Input-Output-Studien Bd. 14 des Ifo-Instituts für Wirtschaftsforschung, München, (forthcoming).

Beutel, J., Stahmer, C. (1982). Input-Output Analyse der Energieströme, in Allgemeines Statistisches Archiv, Vol. 3, pp. 209-239.

Bonhoeffer, F., Britschkat, G. Stiller, P. (1974). Zur Kosten- und Preiswirkung der Rohölverteuerung, in Wirtschaftskonjunktur 2/1974, pp. 31-38.

Bonhoeffer, F. Britschkat, G. (1979). Die Energiekosten-Studie des Ifo-Instituts, in J. Seetzen, R. Krengel, G. von Kortzfleisch (Hrsg.), Makroökonomische Input-Output-Analyse und dynamische Modelle zur Erfassung technischer Entwicklungen, Basel, Boston, Stuttgart, pp. 167-187.

Britschkat, G. (1977). Die Energiekostenbelastung der Wirtschaftssektoren der Bundesrepublik Deutschland in den Jahren 1961 bis 1964, 1968, 1971, 1973 und 1974, Ermittlung der Gesamtkosten, unveröffentlichtes Manuskript, München.

Flaschel, P. (1982). Input-Output Technology Assumption and the Energy Requirements of Commodities, in Resources and Energy, Vol. 4, pp. 359-389.

Harthoorn, R. (1982). Input-Output Analysis of Energy Requirements, Labor Force and Pollution in the Netherlands. The Netherlands Central Bureau of Statistics, Voorburg.

Herendeen, R. A. (1974). Use of Input-Output Analysis to Determine the Energy Cost for Goods and Services, in M. S. Macrakis (Ed.), Energy - Demand, Conservation and Institutional Problems, Cambridge, Mass., pp. 141-158.

Hillebrand, B. (1980). Nachfragestruktur und Energieaufwand, Ergebnisse einer Input-Output-Analyse für die Jahre 1962 bis 1975, in Mitteilungen des Rheinisch-Westfälischen Instituts für Wirtschaftsforschung, Jhg. 31.

Hillebrand, B. (1981). Energiesparen - langfristig die einzige Alternative. Zur Energiekostenbelastung der westdeutschen Wirtschaft in den Jahren 1970 bis 1978, in Mitteilungen des Rheinisch-Westfälischen Instituts für Wirtschaftsforschung, Jahrgang 32, pp. 159-179.

Koch, K. (1972). Energie als Kostenfaktor in der westdeutschen Wirtschaft. Ergebnisse der Input-Output-Rechnung des DIW für die Jahre 1954 bis 1966, in Vierteljahreshefte zur Wirtschaftsforschung des DIW, Heft 3/1972.

Lager, Ch., Teufelsbauer, W. (1981). Wofür wird wieviel Energie importiert - Eine Input-Output-Berechnung des totalen Importenergiegehalts der Endnachfrage, in Wirtschaftspolitische Blätter, Heft 2, 28. Jahrgang, Wien, pp. 5-16.

Lager, Ch. (1982). Ein Input-Output-Modell der Energiewirtschaft, in Mitteilungsblatt der Österreichischen Gesellschaft für Statistik und Informatik, 12. Jahrgang, Heft 45, pp. 13-25.

Reardon, W.A. (1973). Input-Output Analysis of U.S. Energy Consumption, in M.F. Searl (Ed.),Energy Modeling - Art, Science, Practice. Resources for the Future Inc., Washington, D.C.

Stahmer, C. (1981). Direkter und indirekter Energiegehalt der Güter der letzten Verwendung, in U.P. Reich, C. Stahmer (Ed.), Input-Output-Rechnung: Energiemodelle und Methoden der Preisbereinigung, Frankfurt, New York, pp. 71-114.

Wright, D.J. (1975). The natural resource requirements of commodities, in Applied Economics, Vol. 7, pp. 31-39.

INPUT–OUTPUT ANALYSIS OF ENERGY CONVERSION IN AUSTRIA, 1955–1980

Christian Lager[1], Karl Musil[2], and Jiri Skolka[2]
[1] *International Institute for Applied Systems Analysis, Laxenburg, Austria and Austrian Central Statistical Office, Vienna, Austria;*
[2] *Austrian Institute for Economic Research, Vienna, Austria*

AN INPUT-OUTPUT MODEL OF ENERGY CONVERSION

The present paper is a report on the first stage of a project carried out in the Austrian Institute of Economic Research, the aim of which is to build an energy-input-output model for Austria. The project consists of two partly complementary studies. The first one intends to fully utilize the energy balance sheets available for Austria since 1955. The framework of this model was developed by Lager (1982). The energy conversion model is to be linked first to a matrix of specific energy input of individual industries, and then to a dynamic input-output model (Mitter-Skolka, 1980; Skolka, 1981, Hahn-Schmoranz, 1983). The linkage of these first models has certain advantages: almost all necessary data are available, the development over time of the coefficients computed within the model can be analyzed, and the results can be used for forecasting. The link to the input-output model is technically simple. Furthermore, the existing useful-energy balance will be incorporated into the model. Forecasts of future changes in the coefficients will be based on the results of part one of the project. For cost and price analyses, however, this procedure is insufficient. Another energy-input-output model will therefore be put forth in part two, in which the existing input-output table is further disaggregated according to the requirements of an analysis of energy flows. This work will employ an energy model which was developed primarily in the IFO-Institute in Munich (Beutel-Mürdter, 1981), and which has been applied by the Statistical Office of the European Community uniformly for several countries (Chantraine, Pecci-Boriani, Persanaire, 1982). This model requires additional data. It is only applicable, however, to years for which an input-output table exists (1976 for Austria at the present time).

This article deals with the first section of part one of the project, i.e., the investigation of energy conversion in Austria. It will first discuss the energy conversion model for the year 1976, and then examine the development between 1955 and 1980 of certain important coefficients yielded by the model.

1.1 Data and Classifications

Each year the Austrian Statistical Central Office (ÖStZ) and the Austrian Institute of Economic Research (WIFO) publish energy balance sheets. Both balance sheets contain data on the supply (imports and domestic production) and demand by energy type in physical units. Both balance sheets divide the use of energy essentially into the following categories: transformation input in the conversion sector, final demand for energy, changes in stocks, transmission losses, and exports. In the WIFO-balance sheet the conversion sectors are delimited primarily along functional lines (i.e., a distinction is made not between producing and consuming units, but rather between production processes), in the ÖStZ-balance sheets primarily along institutional lines.

In this paper, "final consumption" is defined as the sum of energy consumption (heating, lighting, machines and vehicles) and non-energy consumption of end-users (input of energy sources as raw materials in the chemical industry, as building materials in road construction, and as lubricant for motors), plus the energy generating plants' own use of energy (e.g., consumption of electric power by electric power plants for pump stations, energy consumption for the extraction of crude oil).

Final consumption has to be distinguished from the transformation input of energy in conversion processes (e.g., in refineries and power plants) in which one form of energy is converted into a different form of energy (e.g., the input of crude oil in the refinery in the production of gasoline and diesel oil).

The concept "final consumption" is clearly different from the concept "final demand" as used in input-output analysis. Final demand denotes the demand for all goods and services (including energy) by private households (private consumption) and government (public demand), changes in inventories, investment, and exports.

A further distinction is made between "primary" and "secondary" energy. Primary energy is not converted (transformed); secondary energy is generated as a result of an energy conversion process. (Electricity from hydroelectric plants is secondary energy generated through the conversion of the primary energy "water power".)

The data of the energy balances are arranged in a system which is presented in Table 1. This table consists of two matrices, as do the input-output tables of the revised system of the national accounts (United Nations, 1968). The make-matrix shows to what extent each type of secondary energy is produced in each energy conversion process; the absorption matrix shows to what extent each type of primary and secondary energy is an input into these conversion processes. A matrix of final demand is linked to the absorption matrix. The classifications used can be seen in Tables 2 and 3.

The basic table was compiled in the following way: First, the balance was computed in physical units (kWh, ton, etc.). This balance was then converted into energy units (joule) by means of conversion factors (which changed somewhat between 1955 and 1980). This balance provided the basis for the computation of conversion losses, which are exhibited separately in the table. Because of lack of space, the details of the basic table are not presented, but its schematic arrangement is given in Table 1. The basic table provides the foundations for the following computations which are defined in mathematical terms in the appendix.

1.2 Coefficients of energy conversion

In the basic matrix, inputs into the energy conversion processes are related to their outputs. Three types of coefficients are used to describe these relationships: the technical coefficients of energy conversion, the market shares of the conversion processes, and the efficiency coefficients.

The technical coefficients of energy conversion are presented in Table 2; they were computed from the absorption matrix (matrices U/pt/ and U/st/ in Table 1; see matrices and equation (2) in the appendix). The columns of Table 2 correspond to energy conversion processes, the rows to primary and secondary energy types. The technical coefficients in the columns describe the structure of the input of various types of energy carriers in the energy conversion processes. Their sum is, by definition, equal to one.

The make matrix (see Table 1) was used to derive the "market shares" of the conversion processes in the domestic supply of energy. The matrix of market shares is not listed here. Because the energy balance is very disaggregated, almost every type of secondary energy is generated in only one conversion process, most shares are equal to 1. The only exception is electricity, which is generated in three conversion processes.

TABLE 1 A schematic representation of the energy conversion model.

		Domestic production		Input into conversion process	Losses	Final consumption					Inventory changes	Exports	Minus imports	Domestic supply
		Primary energy	Secondary energy			Manufact-uring	Transport-ation	Small users	Non-energy consumption	Own consumption				
Use of	Primary energy			U_{pt}	l_p	E_{pj}			k_p	c_p	d_p	x_p	$-m_p$	q_p
	Secondary energy			U_{st}	l_s	E_{sj}			k_s	c_s	d_s	x_s	$-m_s$	q_s
Output of conversion processes			v_{ts}		l_t									q_t
Primary energy		q'_p												
Domestic supply		q'_p	q'_s	q'_t										

TABLE 2 Technical coefficients of energy conversion in Austria, 1976.

		Hydro-electr. Plants	Thermal Power Pl. Utilities	Thermal Power Pl. Manuf. Ind.	District Heating Plants	Gas Gener.	Gas Works	Blast Furn.	Coke Ovens	Refineries
Primary Energy	Hard Coal		0,0032	0,0002	0,0201				0,9690	
	Lignite		0,3229	0,0178	0,2029	1,0000				
	Waste Products		0,0000	0,0329	0,1070					
	Wood									
	Peat									
	Crude Oil									0,9843
	Natural Gas		0,3412	0,4112	0,1432		0,8494		0,0047	
	Hydropower	1,0000								
	Residues									0,0157
Secondary Energy	Coke							1,0000		
	Motor Spirit						0,0191			
	Gas Oil		0,0013	0,0041						
	Heating Oil		0,3315	0,3362	0,5262					
	Petroleum									
	Liquified Gas				0,0006		0,1315			
	Other Petroleum Products									
	Refinery Gas			0,0963						
	Town Gas									
	Blast-furnace Gas			0,0895					0,0263	
	Coke-oven Gas			0,0118						
	Works Gas									
	District Heat									
	Electricity									
	Total	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000

TABLE 3 Direct input coefficients of secondary energy in Austria, 1976.

		Secondary Energy							
		Coke	Petroleum Products	Town Gas	Blast-furn. Gas	Coke-oven Gas	Works Gas	District Heat	Electricity
Primary Energy	Hard Coal	1.0450				1,0450		0,0275	0,0028
	Lignite						1,1734	0,2776	0,2831
	Waste Products							0,1464	0,0088
	Wood								
	Peat								
	Crude Oil		0,9930						
	Natural Gas	0,0050		0,8659		0,0050		0,1960	0,4037
	Hydropower								0,7294
	Residues		0,0159						
Secondary Energy	Coke				1,0000				
	Motor Spirit			0,0195					
	Gas Oil								0,0022
	Heating Oil							0,7201	0,3754
	Petroleum								
	Liquified Gas			0,1341				0,0008	
	Other Petroleum Products								
	Refinery Gas								0,0257
	Town Gas			0,0941					
	Blast-furnace Gas	0,0283			0,0962	0,0283			0,0238
	Coke-oven Gas					0,0045			0,0031
	Works Gas								
	District Heat								
	Electricity								0,0614
	Total	1,0783	1,0089	1,1136	1,0962	1,0828	1,1734	1,3684	1,9194

TABLE 4 Multiplicators of energy conversion in Austria, 1976.

	Primary Energy									Secondary Energy							
	Hard Coal	Lig-nite	Waste Prod.	Wood	Peat	Crude Oil	Natural Gas	Hydro-power	Residues	Coke	Petroleum Products	Town Gas	Blast-furnace Gas	Coke-oven Gas	Works Gas	Distr. Heat	Electr
Hard Coal	1.0000									1.0788			1,1935	1,0837		0,0275	0,0369
Lignite		1,0000													1,1734	0,2776	0,3016
Waste Products			1,0000													0,1464	0,0093
Wood				1,0000													
Peat					1,0000												
Crude Oil						1,0000					0,9930	0,1683				0,7159	0,4266
Natural Gas							1,0163			0,0053		0,9714	0,0058	0,0053		0,1992	0,4372
Hydropower								1,0000									0,7771
Residues									1,0000		0,0159	0,0027				0,0114	0,0068
Total Primary Energy	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0163	1,0000	1,0000	1.0841	1.0089	1.1424	1.1993	1.0890	1.1734	1.3780	1.9955

By comparing inputs and outputs of the various energy conversion processes, efficiency coefficients can be computed (equations (4) and (5) in the appendix).

The efficiency coefficient of hydroelectric power plants is assumed to be equal to 80 percent. No conversion losses were recorded in blast furnaces, briquettes and dry coal were not produced in 1976.

1.3 Interactions between energy sources

The computation of simple coefficients outlined above has been possible up to now on the basis of the energy balance, and would not justify the construction of an energy-conversion input-output model. The model, however, has the advantage that by certain mathematical operations (under certain assumptions) the conversion processes can be eliminated, and the interaction between inputs and outputs can be represented directly. These operations are explained in the appendix (equations (6) to (9)). The cumulative input coefficients, the so-called multiplicators, are derived first; the direct input coefficients which describe the interaction between energy sources are derived by re-inversion. The text, however, first discusses the direct input coefficients, and then the cumulative input coefficients.

The direct input coefficients indicate how many thermal units of one type of energy are needed to produce one thermal unit of the same or of another type of energy. The energy consumption of the energy supply systems is not taken into account, because it is not considered final consumption. The conversion and transmission losses are allocated proportionately. The complete table of direct input coefficients can be broken down vertically as well as horizontally into primary and secondary energy types, giving rise to 4 quadrants (see also equation (9) in the appendix). The first quadrant shows the interrelations between the inputs and outputs of primary energy (see equation (9c) in the appendix). The second quadrant shows the interrelations between the inputs of secondary energy and the outputs of primary energy. Because energy consumption by the energy utilities is allocated to final consumption, both quadrants remain empty, aside from the transmission losses of natural gas (input of natural gas in the production of natural gas) exhibited in the first quadrant.

The third and fourth quadrants of the matrix, containing the input coefficients of secondary energy for Austria in 1976, are found in Table 3. The third quadrant shows the direct input coefficients of the input of primary energy in the production of secondary energy (see also equation (9a) in the appendix). The fourth quadrant of the direct input coefficients matrix indicates the interaction between secondary energy sources (equation (9b) in the appendix).

All these values refer to the inputs of domestically produced and imported energy. The balances do not distinguish between the input of domestically produced and imported energy. Even in a conventional input-output table, it is difficult to make the distinction between domestically produced and imported flows of goods, but in most cases it can be done, because of the inhomogeneity of the production of the economic sectors. Energy sources, however, are very homogeneous, and it is often impossible to differentiate between domestically produced and imported energy (e.g., heating oil, electricity). For these reasons, no distinction is made between domestically produced and imported energy. But, if the matrix of direct input coefficients is used to compute cumulative input coefficients, this unavoidable weakness of statistical compilation of data turns into a conceptual problem. The cumulative coefficients in the inverse matrix show the interrelation of the energy sources under the assumption that imported energy is produced abroad with domestic technology. This assumption causes no problem with regard to primary energy - primary energy (in the conversion model) does not require energy inputs. This assumption, however, creates problems with regard to the production of secondary energy by means of secondary energy. If part of the secondary energy is imported, no domestic primary energy is required; it is "saved" by the import of secondary energy.

The type of coefficient (domestic or cumulative) to be used depends, aside from the question of availability, on the problem under investigation. If medium or long-term phenomena are being analyzed and forecasts are being made, the stability of the respective parameters is a precondition, so that the coefficients without regard to origin of the inputs are needed. The knowledge of import ratios is necessary, however, for the analysis of short-term effects on domestic production or the simulation of price changes due to cost-push effects. The principal aim of this study is a description of the technological interconnections in the conversion sector. Therefore, the cumulative input coefficients were used without regard to the origin of the energy sources.

The cumulative input coefficients are presented in Table 4. To avoid double counting, the table contains only data on the cumulative inputs of primary energy. The upper part of the table contains cumulative input coefficients for primary energy (computed according to equation (8c) in the appendix), and the lower part the cumulative input coefficients of primary energy for the production of secondary energy (these figures were computed in accordance with equation (8b) in the appendix).

For example, the figures in the column, "district heating", mean that for the delivery of 1 joule district heat to the end-user or for exports or to inventory, the following quantities of primary energy are required (in joule):

> 0.7159 crude oil; 0.2776 lignite; 0.1992 natural gas; 0.1464 waste products; 0.0275 hard coal; 0.0114 residues.

These figures are valid under the assumption that the imported secondary energy used in the production of district heat (it is evident from Table 3 that it can only be heating oil) is produced with domestic technology. It is also interesting to compare the sum of the direct input coefficients of primary energy (Table 3) with that of the cumulative input coefficients (Table 4). The differences indicate the losses contained in the input of secondary energy sources. The sum of the cumulative input coefficient for district heat is 1.3780, i.e., the delivery of 1 joule of district heat to final energy consumption required the input of about 1.38 joule of primary energy. The difference of the value of multiplicator to unity indicates the magnitude of cumulated conversion losses. The multiplicators for coke, town gas, blast-furnace gas, coke-oven gas and generator gas can be interpreted in the same fashion.

The conversion multiplicators of the generation of electricity are a special case. For 1 unit (1 joule) the input of the following primary energy sources were necessary in 1976:

> 0.771 hydropower; 0.4372 natural gas; 0.4266 crude oil; 0.3016 lignite; 0.0369 hard coal; 0.0093 waste products; 0.0068 residues; 1.9955 was the sum of primary energy inputs.

This means that for the production of 1 joule of electric energy, 2 joules were used, implying a cumulative efficiency of 50 percent.

The sum of these values can be so interpreted for only a specific year, because electricity is produced in Austria by means of two very different technologies. For electricity produced by hydroelectric power plants (58.07 percent of total production), it is assumed that water power is utilized at the rate of about 80 percent. The sum of the multiplicators for the various inputs of primary energy in thermal power plants is equal to 1.2184. In 1976, 41.94 percent of electricity was generated in thermal power plants. The data in Table 4 imply a multiplicator of 1.3382 for water power, and of 2.9058 for thermal power.

These multiplicators provide the basis for computing primary energy content in final consumption and the cumulative energy content in the components of final demand.

2. ENERGY CONVERSION IN AUSTRIA: 1955 TO 1980

2.1 The trends of the coefficients of energy conversion

The first part of the study explained the calculation of coefficients for energy conversion (direct input coefficients, market shares of conversion processes and efficiency coefficients) and of the coefficients of the interrelation of inputs and outputs by energy carriers (cumulative input coefficients), the size of these coefficients in the year 1976, and the interpretation of the results. The following section will present and analyze time series for selected coefficients.

Rapid economic growth in Austria and a strong rise in real income between 1955 and 1973 brought about a steep increase in energy consumption (total energy consumption increased from 414 PJ in 1955 to 915 PJ in 1973, i.e., by 121 percent). Increasing automation in production, technological changes in railroad transportation, increasing motorization, and the installation of more comfortable heating systems required more refined (i.e., derived or secondary) energy sources. The final consumption of primary energy (defined as the sum of energy and non-energy consumption by the manufacturing sector, transportation, small users, and energy supply utilities, plus transmission losses) declined from 155 PJ in 1955 to 130 PJ in 1973, i.e., by 16 percent, but the consumption of secondary energy tripled from 217 PJ in 1955 to 680 PJ in 1973, i.e., increased by 213 percent. The share of primary energy in total consumption dropped from 42 percent (1955) to 16 percent (1973). The domestic utility companies adapted rather rapidly to this development and constructed conversion plants to satisfy the rising demand for derived energy (final consumption of petroleum products increased from 68 PJ in 1955 to 447 PJ in 1973, i.e., by 557 percent; final consumption of electricity increased from 35 PJ in 1955 to 107 PJ in 1973, i.e., by 206 percent). The share of imported derived energy increased nonetheless. The production of derived energy in Austria made a substantial contribution to the Gross Domestic Product, contributing at the same time, however, to conversion losses in the energy balance. Conversion losses rose from 41 PJ in 1955 to 104 PJ in 1973 (by 154 percent), i.e., somewhat faster than final energy consumption (from 372 PJ in 1955 to 811 PJ in 1973, i.e., by 118 percent), causing total energy consumption to climb (from 414 PJ in 1955 to 915 PJ in 1973, i.e., by 121 percent).

In the two years following 1973, a sharp break in the long-term trend occurred. The strong increases in energy pricee in the seventies caused a slowdown in economic growth, accompanied by a shift of production from energy intensive to less intensive industries, and also a more economical use of energy, and an increased utilization of unconventional energy sources (e.g., waste products). Even though real Gross Domestic Product still grew, energy consumption in 1982 (815 PJ) was about as high as in 1973 (811 PJ). The mix of final energy consumption changed substantially: demand for secondary energy declined (from 680 PJ in 1973 to 628 PJ in 1982, i.e., by 8 percent), demand for primary energy increased (from 130 PJ in 1973 to 187 PJ in 1982,i.e., by 44 percent). This shift was a result of substitution processes in the heating sector and the differential development of demand. For example, in the heating sector, there is vigorous competition between the various energy sources, while in other cases, there are practically no substitution possibilities (e.g., coke for the production of iron, electricity for aluminum smelting, motor spirits, lubricants). The relatively small quantities of primary energy in final consumption are used almost exclusively for heating; for other purposes like mechanical work, lighting, and electrochemical plants, secondary energy is employed. In 1982, less energy was used for heating than in 1973, and more for other uses. The mix of final consumption shifted nonetheless from secondary to primary energy. The contribution of primary energy for heating increased, that of secondary energy decreased. The decline in the demand for secondary energy for the generation of heat was not offset by the rise in the demand for secondary energy in other areas.

The development, however, was not uniform for all secondary energy types. After 1973, consumers endeavoured to curtail total energy consumption, especially the use of expensive heating oil. The sale of heating oil did decrease strongly (from 330 PJ in 1973 to 259 PJ in 1982, i.e., by 22 percent); heating oil was substituted by (mainly imported) natural gas (the demand increased from 75 PJ in 1973 to 118 PJ in 1982, i.e., by 57 percent). Natural gas has several properties beneficial to the consumer (e.g., easy controllability, high efficiency of gas appliances, small emission of pollutants), and the conversion of heating systems to natural gas produced substantial savings. Heating oil was furthermore substituted for by other primary energy sources, such as wood (the demand increased from 26 PJ in 1973 to 34 PJ in 1982, i.e., by 31 percent) and combustible waste products (an increase from 2 PJ in 1973 to 11 PJ in 1982, i.e., by 450 percent).

In 1982, about as much energy flowed into final demand as in 1973; conversion losses were as high as in 1973. Thus, total energy consumption (sum of final consumption and conversion losses) stagnated (915 PJ in 1973 and 918 PJ in 1982) despite growth of the economy.

2.2 Small changes in the overall efficiency of energy conversion

The structure of energy conversion has undergone a pronounced change over time. Due to technical innovations, the efficiency of various conversion processes has improved markedly; the overall efficiency of energy conversion, however, has changed very little (see Table 5). In the following section, a distinction is made between the technical efficiency coefficient and the adjusted efficiency coefficient. The technical efficiency coefficient refers to the relation between energy output and cumulative (direct and indirect) energy input in conversion processes, and includes transmission losses. In 1955, the efficiency coefficient of total energy conversion was 81 percent, in 1973, 84 percent, and in 1982, 83 percent (i.e., an average of 1.20 units of energy input were required for one unit of secondary energy; energy conversion losses were 17 percent of energy input, and the thermal value of the derived energy was 83 percent of the energy input).

The small difference in the efficiency coefficients in the years 1955 and 1973 is mainly due to the rapid rise in the share of electricity generation and of the production of petroleum products in energy conversion. Conversion losses are very high in electricity generation, and very low in the production of petroleum products. The increasing share of electricity would have depressed the technical efficiency even further, had it not been possible to reduce the energy input in its generation process. (It is also possible that statistical inaccuracies have masked a more pronounced improvement in the average efficiency.) The differential growth rate of electricity generation and petroleum processing, and the different degree of improvement in the efficiency of electricity generation are responsible for the deterioration of the average efficiency between 1955 and 1964 and its improvement between 1964 and 1973.

The direct input coefficient remained unchanged between 1973 and 1982, as a result of the parallel expansion of the electricity and petroleum industries. Oil processing, more "economical" because of lower energy conversion losses, decreased, while the less economical electricity generation increased. This by itself would have significantly lowered the average efficiency. At the same time, however, the efficiency of electricity generation improved so strongly that the direct input coefficient remained unchanged.

Significant progress in energy utilization in the various conversion processes

Efficiencies in the generation of electricity and of district heat improved significantly. The measurement of direct input coefficients for district heat is not, however, without problems. District and building heating plants produce only heat; their energy input can therefore be attributed exclusively to one product. Cogeneration plants produce district heat and electricity. Also these plants can usually determine exactly how much of the energy input should be allocated to the production of district heat and how much to the generation of electricity. Difficulties arise, however, when district heat is supplied by a conventional thermal power plant. The actual energy input is compared with a hypothetical value calculated under the assumption that only electricity is generated and no heat is supplied. The difference between the two values is attributed to the output of district heat. Because of the large quantities of waste heat being utilized, it is possible to generate with one additional unit of energy more than one unit of district heat (the direct input coefficient is far below one, the efficiency coefficient of the plant far above 100 percent).

The direct input coefficient in the generation of electricity has declined strongly since 1955, as Table 7 indicates. In 1955, 2.09 units were required for the generation of one thermal unit of electricity, in 1980 only 1.72 units. This development is even more striking, if one considers that the share of hydropower in electricity generation has declined (see Table 6), implying a deterioration of the overall efficiency in electricity generation (for hydroelectric power plants a constant technical efficiency of 80 percent is assumed). At the same time, however, the efficiency of thermal power plants increased strongly enough to offset this effect. The technical efficiency of thermal power plants rose from 24 percent to 39 percent. A large part of this improvement was due to the growing share of district heating plants with a much higher efficiency because of the co-generation of electricity and district heat. The technical efficiency of a conventional coal-fired plant is around 23 percent, that of the new thermal power plants with co-generation around 40 percent (in the new plant at Korneuburg 44 percent). Since 1976, the improvement in efficiency of the thermal power plants has come to a standstill; low capacity utilization of the plants has occasionally even lowered the efficiency. The capacity of thermal power plants has grown only slowly in recent years. In 1978, several large plants were put into operation in Vienna and Lower Austria, and in 1980 a smaller plant opened in Lower Austria. A modern lignite power plant is scheduled for completion in Voitsberg in 1983. A significant improvement in the efficiency of the thermal plants can be expected in the next few years, largely attributable to the increasing utilization of waste heat. The technical efficiency of the Austrian thermal power plants ranks favourably in an international comparison. The technical efficiency of conventional thermal power plants in the European Community is just below 36 percent. In 1980, a technical efficiency of 37 percent was recorded for the Federal Republic of Germany, of 37 percent for France, Italy, and Denmark. The highest efficiency was shown by the plants (fired mainly by heating oil and natural gas) in the Netherlands (39 percent), the lowest efficiency by plants (mainly fired by coal) in Great Britain (33 percent) and the plants in Luxembourg (26 percent).

2.3 Increasing input of primary energy in conversion processes lowers cumulative input coefficient

The cumulative input coeficient indicates the amount of thermal units of primary energy required to supply the end-user (or foreign trade or inventory) with one unit of secondary energy. In this calculation, the input of secondary energy is replaced by the input of primary energy required for its production. The difference between the sum of the cumulative input coefficients and the sum of the direct input coefficients shows the sum of the conversion losses which is embodied in the cumulative energy source. The difference between the cumulative input coefficients and 1 indicates the magnitude of cumulative conversion losses which occur when a certain type of secondary energy is supplied to the end-user. The cumulative input coefficients may be equal to the direct input coefficients (if there is no input of secondary energy in the conversion plant), but they should not be smaller. Where this is the case (production of coke, at times in the generation of district heat and town gas), there are statistical errors (see Table 8).

The most important secondary energy source with significant changes in the input coefficients is electricity. The direct input coefficient fell from 2.095 (1955)

TABLE 5 Energy conversion.

	I	ENERGY CONVERSION INPUT PJ	ENERGY CONVERSION OUTPUT PJ	EFFICIENCY COEFFICIENT %	DIRECT INPUT COEFFICIENT
J55	I	296.5	241.0	81.3	1.2303
J56	I	306.8	247.9	80.8	1.2377
J57	I	319.2	263.8	82.7	1.2099
J58	I	294.5	245.6	83.4	1.1992
J59	I	302.3	246.5	81.6	1.2260
J60	I	322.6	263.5	81.7	1.2247
J61	I	338.4	270.9	80.0	1.2494
J62	I	366.3	293.0	80.0	1.2501
J63	I	393.2	311.5	79.2	1.2622
J64	I	428.4	338.1	78.9	1.2672
J65	I	438.2	359.4	82.0	1.2195
J66	I	455.2	372.1	81.7	1.2233
J67	I	464.6	382.3	82.3	1.2152
J68	I	502.4	414.2	82.4	1.2130
J69	I	537.8	434.5	80.8	1.2377
J70	I	590.3	495.8	84.0	1.1907
J71	I	655.3	547.3	83.5	1.1973
J72	I	685.6	575.4	83.9	1.1915
J73	I	741.0	620.8	83.8	1.1936
J74	I	720.7	608.4	84.4	1.1846
J75	I	692.5	582.0	84.2	1.1881
J76	I	753.1	617.4	82.8	1.2197
J77	I	716.5	595.8	83.1	1.2027
J78	I	766.7	643.9	84.0	1.1907
J79	I	819.5	690.6	84.3	1.1866
J80	I	806.4	680.1	84.3	1.1858
J81	I	742.8	621.5	83.7	1.1953
J82	I	690.8	575.1	83.3	1.2012

In the text and Table 5, the sum of columns of direct input coefficients is denoted by direct input coefficient, and its reciprocal value by efficiency coefficient.

TABLE 6 Production mix in electricity generation (%).

	I	THERMAL POWER PLANTS UTILI- TIES	THERMAL POWER PLANTS MANUFACT. INDUSTRY	THERMAL POWER PLANTS TOTAL SHARES	HYDRO-ELECTRIC PLANTS
J55	I	17.2	9.3	26.5	73.5
J56	I	16.8	9.2	26.1	73.9
J57	I	16.2	9.0	25.2	74.8
J58	I	13.2	8.5	21.7	78.3
J59	I	17.4	8.4	25.8	74.2
J60	I	16.9	8.7	25.6	74.4
J61	I	20.8	9.1	29.9	70.1
J62	I	23.3	8.6	31.9	68.1
J63	I	26.2	9.0	35.2	64.8
J64	I	26.4	8.9	35.3	64.7
J65	I	19.7	8.0	27.7	72.3
J66	I	20.4	7.4	27.2	72.8
J67	I	20.2	7.4	27.6	72.4
J68	I	21.9	7.4	29.3	70.7
J69	I	27.7	8.8	36.5	63.5
J70	I	21.1	8.2	29.3	70.7
J71	I	32.0	9.7	41.7	58.3
J72	I	31.0	10.3	41.3	58.7
J73	I	28.6	10.2	38.8	61.2
J74	I	23.6	9.5	33.1	66.9
J75	I	24.0	8.5	32.6	67.4
J76	I	32.5	9.4	41.9	58.1
J77	I	25.2	8.8	34.0	66.0
J78	I	25.8	8.8	34.6	65.4
J79	I	22.2	8.8	31.0	69.0
J80	I	22.5	8.2	30.7	69.3

TABLE 7 Direct input coefficients of electricity generation.

I I I	TOTAL	COAL	PETROLEUM PRODUCTS	GAS	ELECTRICITY	HYDRO-POWER	OTHER ENERGY SOURCES
J55 I	2.0948	.6266	.1680	.2966	.0800	.9235	.0000
J56 I	2.0934	.5710	.1445	.3652	.0841	.9285	.0000
J57 I	2.0483	.5695	.0938	.3612	.0846	.9393	.0000
J58 I	1.8887	.4037	.1134	.3079	.0801	.9836	.0000
J59 I	1.9840	.4989	.1684	.3123	.0803	.9321	.0000
J60 I	1.9451	.3999	.1536	.3800	.0767	.9349	.0000
J61 I	2.0454	.5439	.1830	.3600	.0774	.8811	.0000
J62 I	2.0523	.5351	.2653	.3208	.0756	.8554	.0000
J63 I	2.1249	.5750	.3354	.3160	.0772	.8143	.0071
J64 I	2.0943	.5360	.3811	.2883	.0698	.8130	.0062
J65 I	1.8956	.3759	.3088	.2279	.0683	.9083	.0064
J66 I	1.8835	.3982	.2481	.2497	.0674	.9140	.0061
J67 I	1.8684	.3792	.2752	.2316	.0661	.9096	.0066
J68 I	1.8882	.3759	.3143	.2348	.0679	.8883	.0071
J69 I	2.0151	.4415	.3613	.3396	.0680	.7971	.0077
J70 I	1.8484	.2653	.2117	.4101	.0662	.8882	.0068
J71 I	2.0379	.3697	.3634	.4989	.0664	.7326	.0069
J72 I	2.0269	.3126	.4241	.4776	.0675	.7368	.0083
J73 I	1.9752	.2621	.4090	.4590	.0668	.7683	.0099
J74 I	1.8375	.2639	.2319	.4309	.0615	.8402	.0090
J75 I	1.7958	.2171	.2726	.3884	.0627	.8472	.0078
J76 I	1.9193	.2859	.3775	.4563	.0614	.7294	.0088
J77 I	1.7684	.1658	.2765	.4264	.0605	.8290	.0102
J78 I	1.7745	.1643	.3078	.4057	.0615	.8213	.0139
J79 I	1.7576	.1382	.2815	.4009	.0580	.8626	.0165
J80 I	1.7164	.1811	.3226	.2663	.0582	.8665	.0216

TABLE 8 Cumulative input coefficients of secondary energy.

I I	COKE	PETROLEUM PRODUCTS	TOWN GAS	BLAST-FURNACE GAS	COKE-OVEN GAS	WORKS GAS	DISTRICT HEAT	ELECTRICITY
J55 I	.8189	1.0078	2.7539	.9132	.8291	1.0982	.	2.2908
J56 I	.8320	1.0659	2.5394	.9226	.8424	1.0972	.	2.2519
J57 I	.8566	1.0132	2.4164	.9709	.8667	1.1099	.	2.1860
J58 I	.8677	1.0177	2.0746	.9867	.8784	1.1293	.	1.9750
J59 I	.8849	1.0067	1.8165	.9902	.8923	1.1060	.	2.0725
J60 I	.9144	1.0007	1.7608	1.0355	.9190	1.1633	.	2.0281
J61 I	.9299	.9903	1.7161	1.0601	.9332	1.2103	.	2.1360
J62 I	.9026	1.0045	1.7618	.9994	.9062	1.2283	.	2.1404
J63 I	.8974	1.0044	1.7964	.9885	.9006	1.2521	.	2.2232
J64 I	.9134	1.0141	1.7476	1.0011	.9193	1.2731	.	2.1900
J65 I	.9342	.9954	1.6569	1.0214	.9342	1.2273	.	1.9644
J66 I	.9422	.9957	1.6470	1.0265	.9458	1.2717	.	1.9521
J67 I	.9455	.9937	1.5497	1.0323	.9492	1.2952	.	1.9331
J68 I	.9701	.9941	1.4802	1.0482	.9740	1.2022	.	1.9553
J69 I	1.0231	.9928	1.3151	1.0812	1.0272	1.1468	.	2.0956
J70 I	1.0653	.9785	1.1693	1.1245	1.0737	1.1015	.7999	1.9170
J71 I	1.0563	.9807	1.1477	1.1665	1.0649	1.1354	.6743	2.1163
J72 I	1.0740	.9806	1.1344	1.1627	1.0819	1.0741	.7551	2.1074
J73 I	1.0721	.9853	1.1368	1.1612	1.1155	1.0737	1.4081	2.0585
J74 I	1.0789	.9825	1.1312	1.1818	1.0835	1.0740	1.5277	1.9035
J75 I	1.0928	.9824	1.1365	1.1843	1.0982	1.1682	1.4111	1.8547
J76 I	1.0841	1.0089	1.1424	1.1994	1.0890	1.1734	1.3780	1.9956
J77 I	1.0948	1.0073	1.1498	1.1792	1.1005	1.1641	1.2719	1.8320
J78 I	1.0883	1.0067	1.0967	1.1238	1.0938	1.1741	1.3169	1.8370
J79 I	1.0962	1.0076	1.1028	1.0958	1.1022	1.3300	1.2860	1.8184
J80 I	1.0901	1.0054	1.0970	1.0907	1.0958		1.3078	1.7722

to 1.716 (1980), the cumulative input coefficient declined from 2.291 to 1.772. Both coefficients indicate that in electricity generation output decreased markedly. The difference between the two coefficients shows that losses embodied in the secondary energy, which was used as input in electricity generation, declined from 0.196 (2.291 minus 2.095) to 0.056. This improvement was brought about by the shift in the production mix in the electricity industry and by the improvement of the efficiency in the production of secondary energy sources. This trend has accelerated, especially since 1973, when the share of hydropower increased.

TABLE 9 Cumulative primary energy content (PJ).

	I	MANUFACT-URING INDUSTRY	TRANSPORT-ATION	SMALL USERS	NON-ENERGY CONSUMPTION	OWN CONSUMPT-ION	TOTAL CONSUMPT-ION	INVENT-ORY	EXPORTS	IMPORTS	DOMESTIC PRODUCTION
J55	I	163.8	59.9	152.9	7.6	27.2	411.3	-23.6	83.4	166.4	351.9
J56	I	175.6	66.6	153.0	8.3	27.5	430.9	8.0	93.4	172.3	344.0
J57	I	177.5	64.9	160.5	10.4	28.1	441.4	-7.4	76.5	188.4	336.8
J58	I	172.3	67.6	152.4	10.4	28.4	431.1	-5.9	67.5	180.6	323.9
J59	I	180.2	70.5	144.6	14.1	27.4	436.8	4.5	70.7	187.6	315.4
J60	I	200.2	77.2	152.5	15.6	27.9	473.4	-8.1	68.0	221.9	327.6
J61	I	203.9	80.0	154.5	18.1	28.2	485.6	3.5	57.2	219.3	320.0
J62	I	201.8	88.3	177.0	21.6	30.4	519.1	-.2	52.4	245.5	326.1
J63	I	204.9	95.7	204.8	23.1	32.8	561.3	-6.6	54.3	280.5	341.7
J64	I	220.8	101.2	196.3	25.7	33.7	577.6	-9.2	38.7	279.8	345.8
J65	I	216.2	105.0	196.9	29.5	30.8	578.4	-17.3	42.8	279.3	359.2
J66	I	217.9	112.5	194.0	33.3	30.1	587.8	-25.0	44.1	294.9	362.0
J67	I	212.7	115.0	210.1	34.7	29.5	602.0	-6.1	44.4	305.4	347.1
J68	I	223.7	122.2	227.8	37.3	31.4	642.4	-11.1	47.0	363.2	337.3
J69	I	249.1	127.9	249.4	43.9	35.4	705.8	13.0	48.6	419.2	322.2
J70	I	255.5	138.5	280.3	51.2	38.1	763.6	-18.9	55.0	479.7	357.8
J71	I	270.3	145.0	285.1	52.9	43.4	796.8	1.8	46.0	513.9	327.1
J72	I	279.7	158.8	300.4	55.1	46.5	840.6	-4.5	46.7	563.0	328.9
J73	I	292.2	172.4	336.4	59.4	46.9	907.4	-17.3	47.8	617.9	354.5
J74	I	304.4	161.4	307.5	61.5	44.2	879.0	-24.9	53.6	603.3	354.2
J75	I	276.1	164.5	309.5	59.6	42.1	851.9	-.1	56.2	554.3	353.9
J76	I	298.6	169.5	336.8	67.0	49.4	921.2	-12.8	53.0	661.4	325.6
J77	I	282.5	174.5	331.2	69.2	45.9	903.2	-2.1	54.0	612.0	347.3
J78	I	289.5	184.0	355.1	68.0	50.1	946.6	-34.1	50.4	677.7	353.1
J79	I	306.6	194.8	374.7	73.1	48.7	995.0	-40.3	54.0	725.7	363.5
J80	I	297.5	193.1	371.1	73.2	56.2	991.1	-29.9	56.1	729.0	348.0

According to the energy balance, the energy input in 1980 in the generation of 1 GWh electricity in a hydroelectric power plant was (by definition) 4.5 TJ (technical efficiency of the plant 80 percent), and in a thermal power plant 9.3 TJ (technical efficiency 38.8 percent), resulting in an average of 6.0 TJ (technical efficiency 60.3 percent). The corresponding values derived from the cumulative input coefficients (they also contain conversion losses embodied in the secondary energy input) were 4.8 TJ (adapted efficiency 75 percent), 10.0 TJ (adapted efficiency 36 percent) and 6.4 TJ (adapted efficiency 56.3 percent).

The cumulative input coefficients also yield information on the primary energy content of the various components of demand. In contrast to the conventional energy balance, the primary energy content indicates directly how much energy is required by an industry, if the conversion losses embodied in the various secondary energy sources are also taken into account. Table 9 shows the primary energy content by using sectors.

APPENDIX: OUTLINE OF THE ENERGY CONVERSION MODEL

For the energy conversion model, the energy balance is arranged in a make and absorption framework (Table 1). The first quadrant of the make and absorption system is divided into two matrices: the make matrix shows the volume of energy output in the various energy conversion processes. This system has the following advantages:

- The statistical data can be incorporated directly into the model

- The interaction of institutional and functional activities and commodity flows (who uses how much energy) is transparent and can be modelled if certain assumptions regarding technology are made.

The following symbols are used:

V/ts = (make) matrix of domestic production of secondary energy,
m/p = vector of imports of primary energy,
m/s = vector of imports of secondary energy,
U/pt = (absorption) matrix of primary energy input into conversion processes,
U/st = (absorption) matrix of secondary energy input into conversion processes,
l/s = commodity-related losses of secondary energy,
l/p = process-related conversion losses 2),
E/pj = primary energy: own consumption and energy and non-energy final consumption by using industries,
E/sj = secondary energy: own consumption and energy and non-energy final consumption by using industries,
d/p = change in inventories of primary energy,
d/s = change in inventories of secondary energy,
c/p = private consumption of primary energy,
c/s = private consumption of secondary energy,
k/p = public consumption of primary energy,
k/s = public consumption of secondary energy,
x/p = exports of primary energy,
x/s = exports of secondary energy,
q/p = supply or use of domestic primary energy,
q/s = supply or use of domestic secondary energy,
g/t = total inputs (or total outputs including conversion losses of conversion processes3),
I = identity matrix,
i = unity vector.
ϕ = zero element in the matrices.

From Table 1 the following identity can be derived:

$$(1)\quad \left(\begin{array}{c|c|c} \phi & \phi & U_{pt} \\ \hline \phi & \phi & U_{st} \\ \hline \phi & V_{ts} & \phi \end{array}\right) . i + \left(\begin{array}{c} l_p \\ \hline l_s \\ \hline l_t \end{array}\right) + \left(\begin{array}{c} y_p \\ \hline y_s \\ \hline \phi \end{array}\right) - \left(\begin{array}{c} m_p \\ \hline m_s \\ \hline \phi \end{array}\right) = \left(\begin{array}{c} q_p \\ \hline q_s \\ \hline g_t \end{array}\right) \qquad \left(\begin{array}{c} y_p \\ \hline y_s \end{array}\right) = \left(\begin{array}{c} E_{pj} \\ \hline E_{sj} \end{array}\right) . i + \left(\begin{array}{c} k_p \\ \hline k_s \end{array}\right) + \left(\begin{array}{c} c_p \\ \hline c_s \end{array}\right) + \left(\begin{array}{c} d_p \\ \hline d_s \end{array}\right) + \left(\begin{array}{c} x_p \\ \hline x_s \end{array}\right)$$

where Equation (1) defines the production of energy

- according to the commodity account, i.e., the domestic supply of energy (qp or qs) is equal to the energy input into the conversion processes (Upt.i and Ust.i resp.) plus the commodity related losses (lp and ls resp.) plus the final consumption of energy (yp, ys) minus energy imports (mp and ms, resp.)
- according to the production account, i.e., output of the domestic energy conversion processes (Vts.i) plus conversion losses (lt) is equal to the (direct) energy inputs into the conversion processes (gt).

Under the assumption of a linear limitational production function, the matrix of technical coefficients for the conversion sector is derived as follows:

$$(2)\qquad \left(\begin{array}{c} B_{pt} \\ \hline B_{st} \end{array}\right) = \left(\begin{array}{c} U_{pt} \\ \hline U_{st} \end{array}\right) . \widehat{g_t}^{-1}$$

The matrices Bpt and Bst show the share of energy types in total inputs of process t.

By making appropriate assumptions about technology (United Nations, 1968, p.48ff), a matrix Dts can be derived, which transforms the outputs of the conversion processes into the domestic supply of secondary energy. This matrix Dts is defined as matrix of market shares:

$$(3)\qquad (g_t - l_t) = D_{ts}\, q_s$$

Assuming a constant (technological) relation between commodity-related losses and the supply on the one hand, and conversion losses and inputs into the conversion processes on the other, the losses can be endogenized through the loss coefficients Lpp, Lss, and Ltt.

$$(4)\qquad \left(\begin{array}{c|c|c} L_{pp} & \phi & \phi \\ \hline \phi & L_{ss} & \phi \\ \hline \phi & \phi & L_{tt} \end{array}\right) = \widehat{\left(\begin{array}{c} l_p \\ \hline l_s \\ \hline l_t \end{array}\right)} . \left[\widehat{\left(\begin{array}{c} q_p \\ \hline q_s \\ \hline g_t \end{array}\right) + \left(\begin{array}{c} m_p \\ \hline m_s \\ \hline \phi \end{array}\right)}\right]^{-1}$$

Using (2), (3), and (4) the identity (1) can be rewritten.

$$(5)\qquad \left(\begin{array}{c|c|c} \phi & \phi & B_{pt} \\ \hline \phi & \phi & B_{st} \\ \hline \phi & D_{ts} & \phi \end{array}\right) . \left(\begin{array}{c} q_p \\ \hline q_s \\ \hline g_t \end{array}\right) + \left(\begin{array}{c|c|c} L_{pp} & \phi & \phi \\ \hline \phi & L_{ss} & \phi \\ \hline \phi & \phi & L_{tt} \end{array}\right) . \left[\left(\begin{array}{c} q_p \\ \hline q_s \\ \hline g_t \end{array}\right) + \left(\begin{array}{c} m_p \\ \hline m_s \\ \hline \phi \end{array}\right)\right] + \left(\begin{array}{c} y_p \\ \hline y_s \\ \hline \phi \end{array}\right) - \left(\begin{array}{c} m_p \\ \hline m_s \\ \hline \phi \end{array}\right) = \left(\begin{array}{c} q_p \\ \hline q_s \\ \hline g_t \end{array}\right)$$

The diagonal matrix of efficiency coefficients is given as

$$\left(\begin{array}{c|c|c} W_{pp} & \phi & \phi \\ \hline \phi & W_{ss} & \phi \\ \hline \phi & \phi & W_{tt} \end{array}\right) = \left(\begin{array}{c|c|c} I - L_{pp} & \phi & \phi \\ \hline q & I - L_{ss} & \phi \\ \hline q & \phi & I - L_{tt} \end{array}\right)$$

Using these efficiency coefficients (5) yields

(6) $$\left(\begin{array}{c|c|c} W_{pp} & \phi & -B_{pt} \\ \hline \phi & W_{ss} & -B_{st} \\ \hline \phi & -D_{ts} & W_{tt} \end{array}\right)^{-1} \left[\left(\begin{array}{c} y_p \\ \hline y_s \\ \hline \phi \end{array}\right) - \left(\begin{array}{c} W_{pp} \cdot m_p \\ \hline W_{ss} \cdot m_s \\ \hline \phi \end{array}\right)\right] = \left(\begin{array}{c} q_p \\ \hline q_s \\ \hline g_t \end{array}\right)$$

Through partitioned inversion, the demand form of the Leontief model can be obtained:

(7) $$\left(\begin{array}{c|c|c} M_{pp} & M_{ps} & M_{pt} \\ \hline M_{sp} & M_{ss} & M_{st} \\ \hline M_{tp} & M_{ts} & M_{tt} \end{array}\right) \left[\left(\begin{array}{c} y_p \\ \hline y_s \\ \hline \phi \end{array}\right) - \left(\begin{array}{c} W_{pp} \cdot m_p \\ \hline W_{ss} \cdot m_s \\ \hline \phi \end{array}\right)\right] = \left(\begin{array}{c} q_p \\ \hline q_s \\ \hline g_t \end{array}\right)$$

The matrices M contain the cumulative input coefficients (or multiplicators) which indicate to what extent the input of one energy type (or process output) is needed to deliver one unit of one energy type (process output) to final consumption. Since this project uses only a commodity-commodity model, the following system of equations replaces (7):

$$M \quad [y - W \,.\, m] = q$$

or in partitioned form

$$\left(\begin{array}{c|c} M_{pp} & M_{ps} \\ \hline M_{sp} & M_{ss} \end{array}\right) \left[\left(\begin{array}{c} y_p \\ \hline y_s \end{array}\right) - \left(\begin{array}{c} W_{pp} \cdot m_p \\ \hline W_{ss} \cdot m_s \end{array}\right)\right] = \left(\begin{array}{c} q_p \\ \hline q_s \end{array}\right)$$

where

(8a) $$M_{ss} = (W_{ss} - B_{st} W_{tt}^{-1} D_{ts})^{-1}$$

(8b) $$M_{ps} = W_{pp}^{-1} B_{pt} W_{tt}^{-1} D_{ts} M_{ss}$$

(8c) $$M_{pp} = W_{pp}^{-1} = (I - L_{pp})^{-1}$$

(8d) $$M_{sp} = \phi$$

The supply form of the model is obtained through the re-inversion of matrix M and the separation of the identity matrix

(9) $$(I - A^T) \quad q = y - W \,.\, m$$

or in partitioned form

$$\left[\left(\begin{array}{c|c} I & \phi \\ \hline \phi & I \end{array}\right) - \left(\begin{array}{c|c} A^T_{pp} & A^T_{ps} \\ \hline A^T_{sp} & A^T_{ss} \end{array}\right)\right] \cdot \left(\begin{array}{c} q_p \\ \hline q_s \end{array}\right) = \left(\begin{array}{c} y_p \\ \hline y_s \end{array}\right) - \left(\begin{array}{c} W_p \cdot m_p \\ \hline W_s \cdot m_s \end{array}\right)$$

The matrices AT correspond to the matrix of input coefficients of the conventional input-output model:

(9a) $$A^T_{ps} = B_{pt} W_{tt}^{-1} D_{ts}$$

(9c) $$A^T_{pp} = L_{pp}$$

(9b) $$A^T_{ss} = L_{ss} + B_{st} W_{tt}^{-1} D_{ts}$$

(9d) $$A^T_{sp} = \phi$$

A conventional input-output commodity-commodity table for the energy conversion sector is obtained by multiplying the technical coefficients by the diagonalized supply vector.

References

B.Barnanke - D.W.Jorgenson (1975): The Integration of Energy Policy Models, Computers and Operations Research, No.3.

J.Beutel - H.Mürdter (1981): Input-Output-Analysis of Energy Flows - An Interpretation of the Energy Balances and Input-Output-Tables for the Federal Republic of Germany, IARIW 17th General Conference, Gouvieux.

J.Beutel - C.Stahmer (1982): Input-Output Analyse der Energieströme, Allgemeines Statistisches Archiv, Heft 3: 209-239.

O.Bjerkholt - S.Longva - O.Olsen - S.Strom (1983): Analysis of Supply and Demand of Electricity in the Norwegian Economy, Central Bureau of Statistics of Norway, Oslo.

G.Bruckmann - Ed.(1980): Input-Output Approaches in Global Modelling, Pergamon Press, Oxford.

A.Chantraine - M.Pecci-Boriani - A.Persanaire (1982): The Application of Input-Output Analysis for Structural Comparison in the E.C. Countries, in Stäglin: 27-58.

Chen Xikang (1981): Total Synthetic Analysis of Energy Input, Journal of Systems Science and Mathematical Sciences, No.1: 69-76.

B.Fritsch - R.Codoni - B.Saugy (1980): The Use of Input-Output Techniques in an Energy-Oriented Model, in Bruckmann (1980): 421-447.

F.Hahn - I.Schmoranz (1983): Schätzung des österreichischen Kapitalstocks nach Wirtschaftsbereichen, Monatsberichte No.1: 40-52.

D.W.Jorgenson - E.A.Hudson (1974): U.S.Energy Policy and Economic Growth 1975-2000, The Bell Journal of Economics and Management Science, No.2: 461-514.

K.Koch (1972): Energie als Kostenfaktor der westdeutschen Wirtschaft, DIW, Vierteljahreshefte zur Wirtschaftsforschung, No.3: 203-213.

C.Lager (1982): Ein Input-Output-Modell der Energiewirtschaft, Mitteilungsblatt der Österreichischen Gesellschaft für Statistik und Informatik, No.45, March: 13-25.

C.Lager - W.Teufelsbauer (1981): Wofür wird wieviel Energie importiert?, Wirtschaftspolitische Blätter, No.2: 5-16.

B.Lehbert (1980): Vorschlag für ein Prognose- und Simulationsmodell des Umwandlungsbereiches der Energiewirtschaft in der Bundesrepublik Deutschland, Weltwirtschaftliches Archiv, No.1: 131-161.

P.Mitter - J.Skolka (1981): Entwicklung der Arbeitsproduktivität in Österreich 1964 bis 1977, Monatsberichte No.1: 19-31.

M.Oettl - W.Teufelsbauer (1979): An Integrated Quantity Value Energy Input-Output-Model, 7th International Conference on Input-Output Techniques, Innsbruck.

Österreichisches Institut für Wirtschaftsforschung (1979): Bewertung energiepolitischer Maßnahmen zur rationellen Energieverwertung, Gutachten im Auftrag des Bundesministeriums für Handel, Gewerbe und Industrie, Vienna.

Österreichisches Institut für Wirtschaftsforschung (1979, 1980): Energiebilanz des WIFO: Revision 1979, Ergänzung 1980.

Österreichisches Statistisches Zentralamt (1981): Energieausstoß und -einsatz der österreichischen Volkswirtschaft im Jahre 1979, Statistische Nachrichten, No.7: 340-347.

Österreichisches Statistisches Zentralamt (1982): Nutzenergieanalyse 1978, Beiträge zur Österreichischen Statistik, Heft 663, Vienna.

J.Skolka: Außenhandelsverflechtung der österreichischen Wirtschaft (1981): Ein Input-Output-Vergleich zwischen 1964 und 1976, Monatsberichte 10: 594-604.

R.Stäglin - Ed. (1982): International Use of Input-Output Analysis, Vandenhoeck & Ruprecht, Göttingen.

R.Stone - K.Wigley (1968): The Demand for Fuel, 1948-1975.A Submodel for the British Fuel Economy, Chapman & Hall, Cambridge.

United Nations (1968): A System of National Accounts, New York.

THE LONG-RUN PROFITABILITY OF ETHANOL IN HIGH-OCTANE GASOLINE: AN APPLICATION OF INPUT–OUTPUT ANALYSIS

H. David Robison
Department of Economics, University of Maryland, College Park, Maryland, USA

When using an input-output model to address a problem, it is often necessary to build a sub-model to provide additional detail for sectors of interest. This study uses a sub-model, driven by the 78 sector INFORUM input-output model, to examine the long-run profitability of building a plant to produce ethanol from corn for use as an octane booster in super (high-octane unleaded) gasoline in the United States. The effects of ethanol production on agricultural production and pricing are also examined based on classical supply and demand modeling of agricultural price determination.

In this study, the long-run profitability of ethanol production was found to be highly dependent on future movements of the real price of crude oil and the real value of federal and state subsidies for ethanol use in gasoline. At current nominal subsidy levels, with a constant real price of crude oil, ethanol can be produced profitably through 1995, though the profit margin declines throughout the period as the real value of the subsidies decline. For the relatively low levels of ethanol production (less than 2 billion gallons) predicted by the model, the effect on agricultural prices is minimal. Ethanol production of 3 to 5 billion gallons has a moderate impact on corn price, while the impact could be more considerable for volumes of 10 to 15 billion gallons.

Ethanol, or ethyl alcohol, is obtained by the fermentation of corn, or any other plant material with substantial amounts of carbohydrates. Besides its most common use, which is in alcoholic beverages, ethanol can be mixed in a one-to-nine ratio with gasoline in a refinery or at a shipping terminal to boost the octane rating of regular unleaded gasoline three points, producing unleaded super. An effective octane rating of 105-115 makes ethanol a good octane booster that could be used either in the refinery or at shipping terminals (where it would simply be blended with the gasoline). The one major problem with the use of ethanol in super gasoline is that the ethanol can be drawn out of the gasoline if the mixture comes in contact with water.

Currently, super gasoline made with ethanol is exempted from the federal tax on gasoline sales. In addition several states have granted similar exemptions from state gasoline taxes. The state-specific subsidies make ethanol blending at the pipeline terminal more likely to occur than use in the refinery process. Blending at terminals in states with subsidies sufficiently high to make ethanol profitable spares the refiner from the problems of keeping super-ethanol unleaded gasoline separate from super-nonethanol gasoline and reduces the likelihood of water contamination of the ethanol fuel.

Outline of Study

Measuring the profitability of ethanol production or the rather narrow effects ethanol production would have on the economy is impossible in the framework of INFORUM's aggregate I-O model, called LIFT. Both of the corn milling processes that can be used to produce ethanol (wet and whole corn milling) fall into the three digit Standard Industrial Classification 204, which is only a portion of the LIFT sector 9, Food and tobacco. In 1977, LIFT sector 9 had a total output of 208.4 billion dollars, of which all of corn milling accounted for less than 1.5%. In addition, all of agriculture comprises only a single LIFT sector, while the impact of large volume of ethanol production would be limited to corn and a few other crops.

One might wonder what the value of the I-O model is when the sub-model contains all the detail important in addressing the questions of interest in this study. The answer is that, given a crude oil scenario, LIFT provides forecasts of prices, gasoline consumption, and macroeconomic variables, all consistent with that crude oil price scenario. The ability to produce price forecasts consistent with various crude oil scenarios is essential to the sub-model, because the costs of producing ethanol - other than the corn cost - are assumed to move with an appropriate price index. For example, the cost of steam coal (per gallon of ethanol) in 1995 is the current cost multiplied by the LIFT price index for coal in 1995. Without the ability to factor the full effects of a change in crude oil price into all other prices, ethanol could appear to be profitable when, in fact, it is not.

The Corn Alcohol Model (CAM), a sub-model of the LIFT model, was constructed to give the sectoral detail necessary for calculating the price at which ethanol would be profitable to produce. In addition to the ethanol production detail, additional detail was provided for the agriculture sector, so the effects of ethanol production on crop prices could be examined. In order to keep the model a manageable size, the agricultural detail was limited to three crops -- corn, soybeans, and wheat -- which might significantly affect the cost or feel the impacts of ethanol production. There are three links by which ethanol production will impact upon the pricing of the three crops. First, ethanol production is an additional demand for corn, which will raise the equilibrium price. Second, because the three crops are substitutes in production, relative acreage shares may shift. Finally, ethanol production produces by-products which can substitute for corn and soy in certain uses, lowering their equilibrium prices.

The by-products must be carefully considered, not just because of their use as a corn and soy substitute, but because of their major influence on the profitability on ethanol production. For example, in 1981 the net value of the by-products from one gallon of ethanol by the wet corn milling process was 85.6 cents, which accounted for 59.7 percent of the corn input cost based on the production process described below. In this study, the prices of the by-products depend only on the prices for corn and soy.

Figure 1, a flow diagram of the CAM model, shows the basic supply and demand structure of the model. On the left side of Figure 1 are the demands for the crops including: ethanol demand for corn, animal feed demand, export demand, food and miscellaneous demand, and inventory demand. Note that, while it is included on the demand side of the model, inventory demand can have either a positive or negative sign. On average, inventories will be a positive demand for the crops, but in years of undersupply or excess demand inventory levels will fall, thus offsetting some portion of the other demands. The right hand side of Figure 1 shows the two sources of supply: the agricultural supply and the corn and soy equivalents of the ethanol by-products. In the upper center of Figure 1 are the exogenous variables, and in the lower center are the prices of the crops and by-products which are used to equate the supply and demands for each crop.

The model begins its solution process for each year by reading the values of the exogenous variables, block H of Figure 1. Those exogenous variables which are taken from LIFT are listed above the dotted line, while those variables that are wholly exogenous are listed below the line.

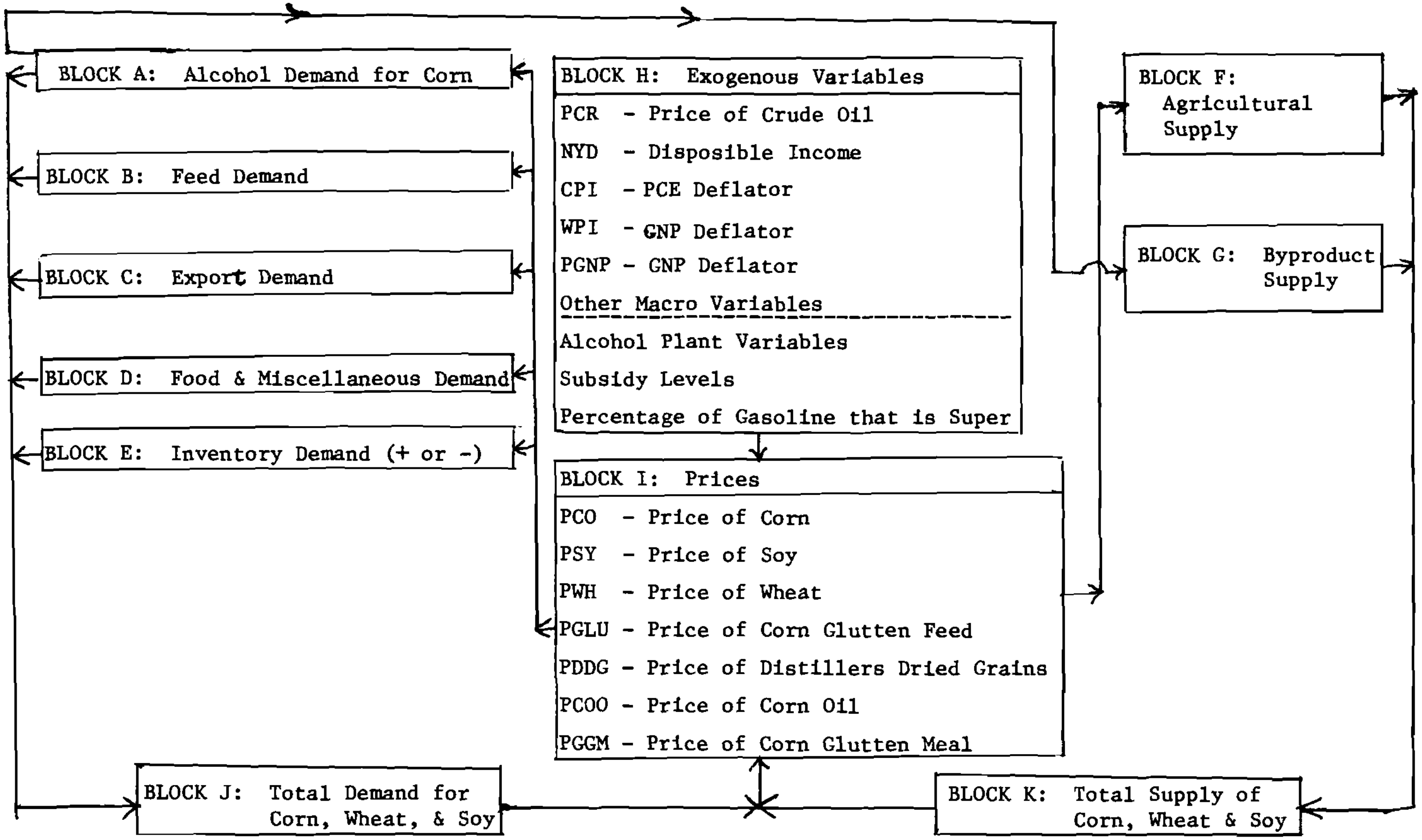

BLOCK A: Alcohol Demand for Corn
BLOCK B: Feed Demand
BLOCK C: Export Demand
BLOCK D: Food & Miscellaneous Demand
BLOCK E: Inventory Demand (+ or -)
BLOCK H: Exogenous Variables
PCR - Price of Crude Oil
NYD - Disposible Income
CPI - PCE Deflator
WPI - GNP Deflator
PGNP - GNP Deflator
Other Macro Variables
Alcohol Plant Variables
Subsidy Levels
Percentage of Gasoline that is Super
BLOCK F: Agricultural Supply
BLOCK G: Byproduct Supply
BLOCK I: Prices
PCO - Price of Corn
PSY - Price of Soy
PWH - Price of Wheat
PGLU - Price of Corn Glutten Feed
PDDG - Price of Distillers Dried Grains
PCOO - Price of Corn Oil
PGGM - Price of Corn Glutten Meal
BLOCK J: Total Demand for Corn, Wheat, & Soy
BLOCK K: Total Supply of Corn, Wheat & Soy

FIGURE 1

Exogenous variables taken from LIFT are macroeconomic variables, such as personal income, and prices.

The next step in solving the model is to take a first guess at the three crop prices for the first year of the projection. From the crop prices, the by-product prices are calculated and passed to the ethanol profitability calculation.

Given the crop prices, the by-product prices, and the engineering data[1] on ethanol production costs, the price of ethanol can be calculated. The basic assumption of the alcohol production portion of CAM is that refiners will switch to ethanol as an octane booster once they perceive the switch to be profitable. The breakeven point, the point at which the refiner can profitably use ethanol (at the terminal), is reached when the ratio of the price of ethanol to the gate price of gasoline at the refinery plus shipping costs to the terminal, federal and state tax subsidies, and value of the increase in octane falls (called RATIO) to 1.00. The state subsidy level is actually a weighted average of the various state specific subsidies, with the weights being the volume of ethanol currently being used as an octane booster in that state. The federal subsidy, applicable in all states, was raised to 50 cents per gallon in 1983 from its previous value of 40 cents per gallon. Note that because the prices for all other octane boosters are closely linked to the price of crude oil, the comparison of the price of ethanol to the price of gasoline and subsidies is implicitly considering all other octane boosters.

The quantity of ethanol demanded, and therefore the amount of corn used for ethanol, is determined by three things: the total consumption of gasoline, the percentage of total gasoline usage that requires octane boosting, and the fraction of super that uses ethanol as an octane booster. Total gasoline consumption and the percentage of total gasoline that requires octane boosting are both exogenous variables. Gasoline consumption is taken from the LIFT forecast because LIFT is better able to forecast both personal consumption expenditures for gasoline and intermediate use of gasoline than is the CAM model. The fraction of gasoline that requires octane boosting is exogenously specified to rise slowly between now and 1995. The fraction of super that uses ethanol as an octane booster is determined by a specified reaction function and the current profitability of ethanol. Set-up time and other change-over costs make it unlikey that all refiners would begin use of ethanol once the breakeven point is reached. The changeover rate depends on how far below 1.00 RATIO is, how long RATIO has been below 1.00, and on what percentage of refiners have already made the switch to ethanol use. In addition, it was felt that refiners would switch away from ethanol use more quickly than they began using it. To model this, a "profitability/use" reaction function was specified, having the previously described properties, to determine the fraction of super gasoline that would use ethanol as an octane booster each year. This reaction function also has the effect of smoothing the transition between non-ethanol and ethanol super production which, in turn, prevents major fluctuations in the agricultural markets.

Blocks B, C, D and E of Figure 1 depict the other four demands: feed, exports, food, and inventory change respectively. The feed demand equations estimate the demand for corn to be fed to animals directly as a function of feed prices and real disposable income, thereby avoiding dealing with fluctuations in the livestock market. (If better short-term forecasts of feed demand are desired a livestock model can replace the feed demand equations.) Export demand equations were specified rather than estimated, in order to obtain desired strong price elasticities and to allow the growth rates for export demand to be specified exogenously. To increase the short-term stability, inventory equations were included in the model. The inventory level of each of the three crops is a function of output, lagged output, and the real price of that crop. Because very little soy is directly consumed by humans, food and miscellaneous demand equations were estimated just for corn and wheat. Explanatory variables in the food and miscellaneous demand equations are real prices and real disposable income.

Development of the supply side of CAM^2, blocks F and G of Figure 1, involved estimating the supply of crops grown each year and equating the by-products of ethanol production to corn and soy. It should be noted that the supply of the crops grown each year does not depend on any contemporaneous prices because the crops are planted before the prices for the current period are known, and little can be done after the crops are in the ground to change the yield. Thus, the agricultural supply of each crop remains constant while the model is solving for a particular year, though it may change from year to year. Acreage planted in each of the three crops depend on lagged relative crop prices, farmer's costs, and time. Both acres harvested and yields for each crop depends on the number of acres planted in the respective crop and a time trend. Given acres harvested and the yield per acre, quantity grown is calculated by using the production identity: quantity grown equals acres harvested times yield per acre.

By-product supply -- the supply of corn gluten feed, corn gluten meal, corn oil, and distillers dried grains -- does vary with ethanol production during the solution process for each year. In order to avoid forecasting demand for each of the by-products, it was decided that each of the by-products, other than corn oil, should be equated to corn and soy on the basis of their protein and caloric content. More specifically, for each by-product a mix of corn and soy was calculated which would have the same calorie and protein content as one pound of the by-product. Once equated to their corn and soy values, the by-products then add to the total supply of corn and soy, and are assumed to be sold as feed for cattle or exported. Because by-product production varies with ethanol production, this component of agricultural supply can vary during the solution for a particular year. However, this variation in supply is quite small.

After a pass through the model, total supply and demand for the crops, blocks J and K of Figure 1 respectively, have been determined based on the initial guess at the price. If supply equals demand for each crop, the initially guessed prices are the equilibrium ones for that year. When one or more of the crops has unequal supply and demand, the model adjusts its guess of those crop prices and makes another pass through all the equations of the model. Prices are raised if demand is greater than supply, and lowered if demand is less than supply. This price adjustment continues until supply equals demand for each crop; then the model continues on to the following year, beginning again with the values of the exogenous variables and a first guess at prices.

Simulation of CAM

The beginning point for a forecast of CAM is determining the assumptions to be used by the LIFT model. Most important among these assumptions is the crude oil price assumption which, for the purposes of this paper, the real price of crude oil was assumed to remain constant. Given current oil market conditions, this is a fairly reasonable assumption. Other assumptions used in making the run of the LIFT model are that M2 grows at eight percent per year between 1982 and 1995, and that relative foreign to domestic prices remain constant between 1982 and 1995.

Given these assumptions, the LIFT model is run. The resulting forecast had an average growth rate of 2.6 percent per year in real GNP, and 1.9 percent for disposable income between 1982 and 1995. The unemployment rate fell from 9.7 percent in 1982 to 3.5 percent by 1995. Inflation, as measured by the GNP deflator fell to 5.5 percent in 1983 and remained in the 5 to 6 percent range throughout the remainder of the forecast.

The final step in the simulation process is the actual running of CAM, using the results of the LIFT forecast. The forecast produced by CAM under LIFT the assumptions with the CAM assumption that state subsidies falling from 46 to 38 cents per gallon is presented in Table 1. After recovering from 1982 lows, the prices of the three crops relative to the PCE deflator remain fairly stable over the forecast period. Total acreage planted in the three crops continues to grow, but the rate of growth slows from 3.1 percent in 1984 to 1.6 percent in 1995. As a result of the growth in total acres planted, the number of acres planted in each crop grows, although the relative shares continue to shift.

Consumption of gasoline per capita grows, but at less than 0.4 percent per year for the full range of the forecast. Total gasoline consumption then grows at 1.2 percent per year, 0.4 percent from the increase in per capita consumption and 0.8 percent from growth in population. The fraction of super gasoline that used ethanol as an octane booster rises from 23.6 percent in 1982 to 98 percent in 1995. As a result, the quantity of ethanol profitably produced rose from 415 million gallons to 3.809 billion gallons.

At first glance, the forecast appears to be a profitable one for ethanol producers, with relatively stable crop prices, growing per capita consumption of gasoline, and a steadily growing volume of ethanol. However, the position of ethanol producers grows more tenuous with each year as the profitability ratio (RATIO) -- the ratio of the price of alcohol to the price of gasoline plus subsidies -- rises from a low of .750 in 1982 to .994 in 1995. Noting again that RATIO must be less than or equal to 1.00 for profitable production of ethanol, the .994 RATIO in 1995 implies that ethanol plants must be running at the maximum level of efficiency of the plant's input parameters to be profitable. The major reason for the rising RATIO is a fall in the real value of the federal and state subsidies. The value in 1982 dollars of the subsidies given in 1995 is 42 cents, which if given in 1982 would yield a RATIO of 0.975. An additional reason for the rising RATIO is the increase in the price of corn caused by the use of corn for ethanol production.

In comparison to a run of CAM (not presented) with subsidies set at zero, the 1995 base case prices per bushel for corn, wheat, and soy, are 54 cents higher, 38 cents lower, and 12 cents higher respectively. The price of soy price is lower due to the increased supply of soy equivalent by-products. An additional 10 million acres is planted in corn, of which 8 million acres came from soy, 1 million from wheat, and 1 million from increased total acreage planted.

Summary

This study examines the long-run profit potential for producing fuel ethanol, using corn as a feedstock. The model built to address this question explicitly considers the ethanol plant costs, subsidies for ethanol use, and the impacts of ethanol production on agricultural prices. A macroeconomic forecast, and a set of prices consistent with that forecast, necessary to drive the detailed model are supplied by the INFORUM input-output model.

If the real price of crude oil remains constant (or falls), the long-run outlook for ethanol production is somewhat mixed. Substantial federal and state subsidies make ethanol profitable through 1995, barring any exogenous shocks to the market. With the fairly low profitability ratio, firms currently producing ethanol should certainly be earning substantial profits. However, in the forecast the declining real value of the subsidies raise the profitablility ratio to the breakeven point by 1995.

A continuation of this trend, evident in the Table 1, would leave ethanol unprofitable to produce after 1996. In addition, as the ratio rises towards 1.00 the size of market shock necessary to make ethanol unprofitable diminishes.

ENDNOTES

[1] The plant efficiency parameters were provided by the corporate sponsors of this research.

[2] I would like to acknowledge the help of Steven Silver, who developed the agricultural side of CAM as part of Ph.D. dissertation.

References

(1) Almon, Clopper, Jr., 'Building Models for Economic Forecasting,' Unpublished manuscript, 1982.

(2) Almon, Clopper, Jr., Buckler, Margaret B., Horwitz, Lawrence M., and Reimbold, Thomas C., *1985: Interindustry Forecasts of the American Economy*, Lexington, MA, Lexington Books, 1974.

(3) Hyle, Mathew, "An Interindustry Forecasting Model for Prices and Factor Incomes for the U.S.", unfinished Ph.D. dissertation.

(4) Robison, H. David, "Three Applications of Input-Output Analysis, unpublished Ph.D. dissertation.

(5) Silver, Stephen J., *A Feed and Livestock Model of the United States with an Application to the Possible Effects on U.S. Agriculture of Large-Scale Corn Alcohol Production*, Unpublished Ph.D. dissertation,1983.

```
TABLE 1             CAM  *** CASE 3 ***  BASE FLAT REAL PRICE OF CRUDE        PAGE    1


                    CAM  *** CASE 3 ***  BASE FLAT REAL PRICE OF CRUDE
                                          1977.0 1980.0 1981.0 1982.0 1983.0 1985.0 1987.0 1990.0 1992.0 1995.0

PCO      PRICE OF CORN  ($/BU)             2.150  2.524  3.299  2.449  2.883  3.762  4.378  5.084  5.695  6.735
PCOCPI     PRICE OF CORN / CPI ($/BU)      2.150  1.953  2.345  1.649  1.868  2.189  2.225  2.229  2.227  2.221

QCOS     TOTAL SUPPLY OF CORN  (BBU)       6.285  7.947  6.651  8.115  8.139  8.015  9.012  9.755 10.368 11.111
QCO        SUPPLY OF CORN GROWN  (BBU)     6.285  7.942  6.643  8.097  8.102  7.919  8.883  9.591 10.194 10.926
APCOB        % OF LAND PLANTED IN CORN     0.402  0.349  0.369  0.377  0.376  0.359  0.380  0.370  0.367  0.357
APCO         ACRES PLANTED IN CORN (HMAC   0.845  0.815  0.848  0.660  0.828  0.844  0.931  0.953  0.982  1.001
AHCO         ACRES HARVESTED CORN (HMAC)   0.715  0.724  0.730  0.737  0.709  0.723  0.799  0.817  0.842  0.858
YCO          YIELD OF CORN  (HBU/AC)       0.879  1.097  0.910  1.099  1.142  1.095  1.112  1.174  1.211  1.273
QCOEQ      SUPPLY OF CORN EQUIV (BBU)      0.000  0.005  0.008  0.018  0.037  0.095  0.129  0.164  0.174  0.185
QDDGCO      DDG EQIV IN CORN (BBU CO)      0.000  0.000  0.000  0.006  0.024  0.080  0.111  0.141  0.148  0.152
QCGMCO      CGM EQIV IN CORN (BBU CO)      0.000  0.000  0.000  0.001  0.001  0.001  0.001  0.001  0.002  0.002
QCGFCO      CGF EQIV IN CORN (BBU CO)      0.000  0.005  0.007  0.011  0.012  0.014  0.017  0.021  0.025  0.031

QCOD     TOTAL DEMAND FOR CORN    (BBU)    6.290  7.992  6.738  7.813  8.329  8.211  9.075  9.853 10.438 11.180
CCO        CONSUMPTION OF CORN    (BBU)    4.121  5.248  4.932  5.232  5.635  6.070  6.420  7.018  7.279  7.615
CCOF         CORN CONSUMP AS FOOD (BBU)    0.550  0.675  0.711  0.616  0.640  0.669  0.697  0.764  0.796  0.846
CFCO         CORN CONSUMP AS FEED (BBU)    3.571  4.519  4.139  4.441  4.669  4.620  4.675  4.922  5.058  5.241
QCOALC       CORN CONSUMP FOR ALC (BBU)    0.000  0.054  0.082  0.176  0.327  0.782  1.048  1.331  1.424  1.529
QCOINV     ADDITION TO INV OF CORN (BBU)   0.485  0.314 -0.584  0.248  0.196 -0.206  0.148 -0.023  0.054  0.020
EXCO       EXPORT OF CORN   (BBU)          1.684  2.430  2.390  2.333  2.497  2.347  2.507  2.859  3.106  3.545

CACO     CARRY OVER OF CORN FROM T (BBU)   0.884  1.618  1.034  1.282  1.478  0.971  1.172  1.280  1.360  1.422


PSYCO$   PSY / PCO                         3.167  2.481  2.361  2.834  2.715  2.489  2.591  2.614  2.731  2.781


PSY      PRICE OF SOY ($/BU)               6.809  6.250  7.780  6.957  7.821  9.353 11.346 13.288 15.553 18.727
PSYCPI     PRICE OF SOY / CPI ($/BU)       6.810  4.845  5.536  4.671  5.072  5.448  5.767  5.827  6.084  6.175

QSYS     TOTAL SUPPLY OF SOY (BBU)         1.289  2.282  1.863  2.061  2.032  2.304  2.394  2.750  2.951  3.294
QSY        SUPPLY OF SOY GROWN (BBU)       1.289  2.270  1.844  2.023  1.965  2.150  2.189  2.489  2.671  2.992
APSYB        % OF AP3 PLANTED IN SOY       0.239  0.307  0.306  0.273  0.278  0.293  0.279  0.292  0.296  0.306
APSY         ACRES PLANTED IN SOY (HMAC)   0.503  0.717  0.702  0.621  0.613  0.689  0.683  0.752  0.790  0.859
AHSY         ACRES HARVESTED SOY (HMAC)    0.494  0.705  0.688  0.613  0.607  0.680  0.677  0.745  0.783  0.851
YSY          YIELD OF SOY (HBU/AC)         0.261  0.322  0.268  0.330  0.324  0.316  0.324  0.334  0.341  0.352
QSYEQ      SUPPLY OF SOY EQIVS. (BBU)      0.000  0.012  0.019  0.038  0.067  0.154  0.205  0.260  0.280  0.302
QDDGSY       DDG EQIV OF SOY (BBU SOY)     0.000  0.000  0.000  0.009  0.035  0.116  0.162  0.205  0.215  0.221
QCGMSY       CGM EQIV OF SOY  (BBU SOY)    0.000  0.006  0.009  0.015  0.016  0.018  0.021  0.027  0.031  0.040
QCGFSY       CGF EQIV OF SOY  (BBU SOY)    0.000  0.006  0.010  0.015  0.016  0.019  0.022  0.028  0.033  0.041

QSYD      TOTAL SOY DEMANDED (BBU)         1.288  2.248  1.869  2.036  2.059  2.328  2.415  2.770  2.969  3.311
CSY         CONSUMP. OF SOY + EQIV (BBU)   0.866  1.235  1.116  1.213  1.229  1.372  1.425  1.581  1.676  1.780
QSYINV      ADDITION TO SOY IN INV (BBU)  -0.142  0.185 -0.041 -0.034 -0.019  0.022  0.003  0.013  0.015  0.012
EXSY        EXPORT OF SOY (BBU)            0.564  0.828  0.793  0.856  0.848  0.934  0.986  1.176  1.278  1.519

CASY      CARRY OVER OF SOY FROM T (BBU)   0.103  0.359  0.318  0.284  0.266  0.286  0.285  0.331  0.354  0.403
```

TABLE 1
continued

CAM *** CASE 3 *** BASE FLAT REAL PRICE OF CRUDE PAGE 2

		1977.0	1980.0	1981.0	1982.0	1983.0	1985.0	1987.0	1990.0	1992.0	1995.0
PWH	PRICE OF WHEAT ($/BU)	2.331	3.946	4.728	4.405	4.816	5.238	6.031	7.010	7.794	9.229
PWHCPI	PRICE OF WHEAT / CPI ($/BU)	2.330	3.057	3.358	2.957	3.125	3.052	3.066	3.074	3.049	3.044
QWHS	TOTAL SUPPLY OF WHEAT (BBU)	2.035	2.368	2.266	2.428	2.385	2.598	2.730	2.956	3.127	3.386
QWH	SUPPLY OF WHEAT (BBU)	2.035	2.368	2.266	2.428	2.385	2.598	2.730	2.956	3.127	3.386
APWHB	% AP3 PLANTED IN WHEAT	0.359	0.344	0.325	0.350	0.346	0.347	0.341	0.338	0.337	0.336
APWH	ACRES PLANTED WHEAT (HMAC)	0.755	0.803	0.745	0.798	0.761	0.815	0.834	0.870	0.900	0.943
AHWH	ACRES HARVESTED WHEAT(HMAC)	0.665	0.709	0.664	0.711	0.679	0.727	0.745	0.777	0.804	0.843
YWH	YIELD WHEAT (HBU/AC)	0.306	0.334	0.341	0.342	0.351	0.357	0.367	0.380	0.389	0.402
QWHD	TOTAL DEMAND FOR WHEAT (BBU)	2.042	2.343	2.314	2.407	2.406	2.622	2.743	2.972	3.140	3.397
CWHF	CONSUMPTION OF WHEAT (BBU)	0.666	0.664	0.664	0.673	0.685	0.701	0.709	0.732	0.742	0.756
CWHFE	CONSUM OF WHEAT AS FEED (BBU)	0.187	0.113	0.155	0.079	0.130	0.158	0.168	0.179	0.185	0.193
QWHINV	ADDITION TO WHEAT INVEN (BBU)	0.065	0.003	-0.024	0.017	-0.002	0.005	0.002	-0.000	0.002	0.001
EXWH	EXPORT OF WHEAT (BBU)	1.124	1.563	1.517	1.637	1.593	1.758	1.863	2.061	2.211	2.447
CAWH	CARRYOVER OF WHEAT FROM T (BBU)	1.177	0.928	0.905	0.922	0.920	0.925	0.929	0.933	0.936	0.940
AP3	TOTAL ACRES PLANTED (HMAC)	2.103	2.334	2.295	2.278	2.202	2.348	2.448	2.575	2.673	2.803
MACRO VARIABLES											
NPOP	POPULATION (HM)	2.202	2.277	2.297	2.319	2.340	2.384	2.428	2.491	2.530	2.583
NCPI	CONSUMER PRICE INDEX	1.000	1.292	1.405	1.491	1.540	1.715	1.966	2.279	2.555	3.031
NWPI	WHOLESALE PRICE INDEX	0.999	1.275	1.426	1.527	1.586	1.774	2.039	2.380	2.674	3.177
PGNP	GNP DEFLATOR	0.999	1.275	1.426	1.527	1.586	1.774	2.039	2.380	2.674	3.177
NYDPC	NOMINAL INCOME PER CAPITA	5.966	8.013	8.833	9.490	10.247	11.971	14.061	17.403	20.000	24.650
NYDPCD	PERSONAL INC. / CPI	5.966	6.202	6.287	6.365	6.654	6.980	7.152	7.636	7.828	8.133
NPPF	INDEX OF FARMERS COSTS	1.009	1.288	1.441	1.543	1.603	1.792	2.060	2.405	2.702	3.210
ALCOHOL SIDE VARIABLES											
CGAS	CONSUMP. OF GASOLINE (BBRL)	2.540	2.356	2.359	2.323	2.395	2.497	2.543	2.639	2.699	2.808
CGASPC	CONSUMP. OF GAS/NPOP (BRL)	11.532	10.351	10.267	10.019	10.233	10.474	10.476	10.593	10.668	10.872
PCR	PRICE OF CRUDE INDEX	1.000	2.346	2.910	2.666	2.631	3.041	3.469	4.102	4.620	5.395
PGAS	PRICE OF GAS ETH BLEND($/GAL)	0.479	0.918	1.134	0.997	1.046	1.207	1.365	1.596	1.782	2.070
PGASR	PROD PRI INDEX REFIN GAS	0.936	1.968	2.436	2.143	2.234	2.561	2.901	3.405	3.817	4.434
PGASS	GATE PRICE GASOLINE ($/GAL)	0.415	0.872	1.079	0.949	0.990	1.134	1.285	1.508	1.691	1.964
QALC	QUAN. ALC AS OCT BOAST. (BGAL)	0.000	0.125	0.189	0.415	0.797	1.953	2.625	3.334	3.561	3.809
QWALC	ALC FROM WET MILL (BGAL)	0.000	0.125	0.189	0.300	0.324	0.377	0.440	0.555	0.647	0.815
QCALC	ALC FROM WHOLE CORN(BGAL)	0.000	0.000	0.000	0.115	0.473	1.576	2.185	2.779	2.914	2.994
FRAC	FRAC. OF S.GAS MADE WITH ALC	0.000	0.097	0.147	0.236	0.360	0.601	0.768	0.912	0.952	0.979
RATIO	RATIO OF PALC TO PTOTAL	1.220	0.808	0.798	0.750	0.757	0.844	0.886	0.925	0.948	0.994
PTOTAL	PGASS+SUBSIDIES ($/GAL)	0.867	1.657	2.038	1.907	2.049	2.207	2.354	2.579	2.740	3.043
PGASS	GATE PRICE GASOLIN ($/GAL)	0.415	0.872	1.079	0.949	0.990	1.134	1.285	1.508	1.691	1.964
OCTPRE	OCTANE PREMIUM ($/GAL)	0.018	0.042	0.052	0.048	0.047	0.054	0.062	0.073	0.083	0.096
SHIPP	SHIPPING SAVINGS ($/GAL)	0.034	0.043	0.046	0.050	0.052	0.058	0.067	0.077	0.086	0.102
STATE	STATE SUBSIDY ($/GAL)	0.000	0.300	0.460	0.460	0.460	0.460	0.440	0.420	0.380	0.380
FED40	FEDERAL SUBSIDY ($/GAL)	0.400	0.400	0.400	0.400	0.500	0.500	0.500	0.500	0.500	0.500
PALC	PRICE OF ALC ($/GAL)	1.058	1.338	1.627	1.430	1.551	1.863	2.085	2.386	2.596	3.024
PWALCT	PRICE WET MILL ALC ($/GAL)	1.058	1.373	1.647	1.430	1.551	1.863	2.085	2.386	2.596	3.024
PWALC	PRICE WET MILL - ROI	0.912	1.187	1.439	1.207	1.320	1.604	1.787	2.039	2.206	2.560
PCALCT	PRICE WHOLE CORN ALC ($/GAL)	1.117	1.338	1.627	1.433	1.567	1.890	2.144	2.466	2.717	3.186
PCALC	PRICE WHOLE CORN - ROI	1.014	1.206	1.478	1.274	1.402	1.705	1.932	2.219	2.439	2.856

TABLE 1
continued

```
CAM  *** CASE 3 ***  BASE FLAT REAL PRICE OF CRUDE       PAGE    3


PISC     PRICE INDEX FOR STEAM COAL         0.986  1.105  1.165  1.276  1.316  1.464  1.712  2.029  2.321  2.835
PIEL     PRICE INDEX FOR ELECTRICITY        0.995  1.327  1.436  1.504  1.526  1.635  1.835  2.028  2.249  2.632
PILAB    PRICE INDEX FOR LABOR              1.000  1.304  1.441  1.521  1.632  1.828  2.140  2.482  2.811  3.398
PIOTH    PRICE INDEX FOR OTHER COSTS        0.999  1.275  1.426  1.527  1.586  1.774  2.039  2.380  2.674  3.177
PIFRT    PRICE INDEX FOR FREIGHT            0.997  1.241  1.347  1.445  1.516  1.693  1.934  2.246  2.501  2.960
PISAL    PRICE INDEX FOR SALES COSTS        0.999  1.275  1.426  1.527  1.586  1.774  2.039  2.380  2.674  3.177

PDDG       THE PRICE OF DDG'S (H$/TON)      1.212  1.434  1.702  1.461  1.654  2.018  2.426  2.836  3.287  3.942
PGLU       THE PRICE OF CGF (H$/TON)        0.913  1.030  1.379  1.209  1.362  1.646  1.987  2.325  2.708  3.255
PCGM       THE PRICE OF CGM (H$/TON)        2.100  2.369  3.171  2.780  3.132  3.785  4.571  5.348  6.230  7.487
PCOO       THE PRICE OF CORN OIL ($/LB)     0.307  0.263  0.238  0.239  0.269  0.330  0.396  0.463  0.535  0.642

  QUANTITY OF BYPRODUCTS

QDDG       QUANTITY DDC'S  (BLBS)           0.000  0.000  0.000  0.760  3.120 10.384 14.399 18.315 19.204 19.731
QCGM       QUANTITY CGM    (BLBS)           0.000  0.206  0.313  0.495  0.535  0.622  0.726  0.916  1.068  1.345
QCGF       QUANTITY CGF    (BLBS)           0.000  0.731  1.110  1.758  1.899  2.209  2.578  3.252  3.791  4.776
QCOO       QUAN. CORN OIL  (BLBS)           0.000  0.101  0.153  0.243  0.262  0.305  0.356  0.450  0.524  0.660

    BU   = BUSHEL
    BBU  = BILLION BUSHELS
    MAC  = MILLION ACRES
    HMAC = HUNDRED MILLION ACRES
    HBU  = HUNDRED BUSHELS PER ACRE
    LB   = POUND
    BLBS = BILLIONS OF POUNDS
    H$   = HUNDREDS OF DOLLARS
    BRL  = BARRELS
    MBRL = MILLION BARRELS
    BBRL = BILLION BARRELS
    MGAS = MILLION GALLONS
    BGAL = BILLION GALLONS
```

ZERO-GROWTH DYNAMICS OF INPUT–OUTPUT MODELS

Paolo Caravani
Istituto di Analisi dei Sistemi ed Informatica del C.N.R.,
Viale Manzoni 30, 00185 Rome, Italy

1. INTRODUCTION

Growth and distribution are inseparable aspects of multisector economies. Yet considerable efforts in separating the two were spent by economic theorists of the neoclassical tradition willing to pay, as usual, the gains in insight at the cost of abstraction. Their efforts were not addressed equally, greater attention being focused on growth, much less on distribution of sectoral ouput.

In economies experiencing fast growth, weak sectoral interaction and perfect competition balanced growth assumptions may prove a reasonable device to make predictions or suggest development policies. Even when more unbalanced conditions prevail the advantages of such a harmonious and ideal path have all-too-well been established in turnpike theory.

However, recent trends in all industrialized countries pushed turnpike time into the realm of science fiction, with yearly growth rates of aggregate output seldom exceeding 3 ∻ 4 percent in real terms, while sectoral quota under the swift upsurge of new technology and investment options suffer, or enjoy, shocks of up to 100 percent. A considerable toll for some, a modest pursuit for all.

If relative growth over average growth of the system as a whole became a central concern to sectorized societies, such awareness should surface theoretical thought by examining the consequences of new and more realistic assumptions. In what follows differences in production in different times and sectors will be looked at through normalizing lenses. The balanced growth abstraction will be replaced by the assumption that output vector is measured yearly so as to keep the sum of its components equal to one.

Sectoral output changes, relatively to one another, result from technological innovation which requires investment which depends on interest rates which relate to global economic growth. Assuming zero growth rate of aggregate output, as it is done here, no progress can be made at clarifying the nature of that link: sectoral dynamics will not be explained in terms of growth.

Sectoral dynamics will rather be described here as a function of technological choice. A set of rival technologies is assumed to exist in each sector, together with a pre-specified set of investment options and consumption possibilities. What will be known ex-post as the prevailing technology investment and consumption pattern is only known ex-ante as the cartesian product of those three sets. It is plausible to expect some of the uncertainty embodied in the technology, investment consumption sets will be transferred on output. By this transfer, the effects of technological improvement in sector A as they were expected assuming no interaction are offset partly by (uncertain) investment in sector B, partly by (uncertain) consumption in sector C. The question addressed here is the nature and the consequence of that transfer mechanism.

After reviewing the Leontief dynamic scheme in sec. 2, a bilinear convex model is introduced in sec. 3 with the aim of retaining the original significance of the intersectoral matrices while leaving room for predictive uncertainty in a more convenient mathematical form.

The resulting dynamic model is studied in sec. 4 and its properties are illustrated in sec. 5 with the aid of a numerical example. The main conclusion of the paper is that a certain invariance of long-run sectoral outputs can be established despite imperfect knowledge of the intersectoral matrices.

2. A REVIEW OF DYNAMIC LEONTIEF MODEL

In 1951 Prof. Wassily W. Leontief [5] introduced his now classical input-output model

$$x(t) = Ax(t) + y(t) \tag{1}$$

($x \sim$ output; $y \sim$ final demand; $A \sim$ technology) on the basis of the assumptions

A1 the economy comprises n productive sectors each producing one homogeneous good, with no joint production
A2 all plants operate at full capacity, so x denotes indifferently produced quantity or installed capacity
A3 production is characterized by constant returns to scale.

The model, in this form, is static.

When a model of final demand (y) is provided, dynamic aspects emerge. In a closed economy y comprises consumption and investment. The former is linked to the level of output via a propensity matrix C, the latter to the increase in capacity via a capital coefficient matrix B. Therefore

$$y(t) = Cx(t) + B[x(t+1) - x(t)] \tag{2}$$

which substituted into (1), yields the model in dynamic closed form (Leontief [6], 1953)

$$Bx(t+1) = [B + I - A - C]x(t) \tag{3}$$

Equation (3) may have different uses [9] depending on what subset of variables is known and what is not. When the use is that of predicting future outputs given x(0), the output vector at some base year, one should - in principle - solve (3) as a forward difference equation. This, however, strictly depends on two additional, awkward assumptions

A4 matrix B is invertible at all $t > 0$.
A5 A, B, C are known at all $t > 0$.

Assumption A4 fails when the economy includes a sector producing no capital goods, like agriculture [1], [3], [7], [8]. In that case, there are more capacity increases than capital goods so the latter do not explain the former uniquely. Matrix B is not full rank[1] and next year production lies somewhere within an uncertainty region. That region is the intersection of $\mathbb{R}^n_+$ with the set $\{x: x = \hat{x} + b,\ b \in \text{null}(B)\}$ where $\hat{x}$ is a solution of (3), a closed convex polyhedron. Denoting $\mathcal{M}[x(t)]$ this region, eq. (3) must be viewed as a point-to-set mapping associating $x(t)$ to

$$x(t+1) \in \mathcal{M}[x(t)] \tag{4}$$

Assumptions A5 fails because of natural uncertainty. What is known is that the triple $\{A,B,C\}$ prevailing at each future time is an element of the threefold cartesian product $\mathcal{A} \times \mathcal{B} \times \mathcal{C}$, a composite finite set collecting all possible options for technology, investment, and consumption. If the innovation rule $t \rightarrow \{A(t),\ B(t),\ C(t)\}$ is left unspecified, eq. (3) should, again, be viewed as point-to-set, with the l.h.s. taking on as many values as there are elements in $\mathcal{A} \times \mathcal{B} \times \mathcal{C}$. Some form ought to be assumed for these sets and we will explicitly replace A4, A5 by

A6 (convexity of alternatives) If $\{A_i, B_i, C_i\}$, $i = 1,2,\dots,m$ are possible options, then $u_i \geq 0$ and $\sum_{i=1}^{m} u_i = 1$ imply that $\sum_{i=1}^{m} u_i\{A_i, B_i, C_i\}$ is also a possible option.

Thus, for instance, if sector i's unit production requires from sector j 10 units of input under technology A_1 and 20 under A_2, and neither A_1 or A_2 is known to prevail in all plants but some use A_1, and the remaining A_2; then i's unit requirements from j shall fall anywhere between 10 and 20. Under convexity of alternatives eq. (3) is a point-to-set mapping of convex polyhedral type, just like (4).

We finally remark that if A_2 is dropped, output increase $x(t+1) - x(t)$ in the r.h.s. of (2) ought to be replaced by capacity increase $z(t+1) - z(t)$ with $\Delta z \geq \Delta x$, so that (3), written in terms of output, holds with $\geq$ replacing =. The mathematical consequence, again, is indeterminacy and $(\bar{3})$ becomes a point-to-set mapping of type (4). Our conclusions are

i) Leontief model poses severe restrictions to its use as a predictive tool
ii) when those restrictions are violated a point-to-set mapping of convex polyhedral type appears as the most natural mathematical substitute.

3. A BILINEAR CONVEX MODEL OF MULTISECTORAL PRODUCTION

Motivated by the preceding discussion, we consider an abstract characterization of a production process

$$y \in \mathcal{M}[x] \tag{5}$$

where x and y are sectoral production quota at time t and t + 1. As we are concerned with relative dynamics rather than growth, we shall assume normalized outputs so that, at all times, x and y are elements of the n-dimensional unit simplex

---

[1] b_{ij} is the quantity of investment goods produced by sector i per unit net capacity increase in sector j. If, for instance, the production process includes a sector k which produces no investment goods, typically agriculture, B will contain all zeros in row k and hence be singular.

$$S^{n-1} = \langle e_i \rangle_{i=1}^{n} \tag{6}$$

where e_i is the unit vector along the i-th axis of $\mathbb{R}^n$ and $\langle \cdot \rangle$ denotes convex combination. Several authors studied the case in which the graph of M

$$G(M) = \{(x,y): y \in M[x]\} \tag{7}$$

is a polyhedral convex cone, [2], [10], [11], [12]. In our case, given the restraints on x and y, $G(M)$ is the convex hull of a finite number N of points in $S^{n-1} \times S^{n-1}$, or

$$G(M) = \langle (x_i, y_i): y_i \in M(x_i) \rangle_{i=1}^{N} \tag{8}$$

A necessary and sufficient characterization of M can be given in terms of $n \times n$ Markov matrices[2].

Given a vertix (x,y) of $G(M)$, say the i-th, consider the set A^i of all Markov matrices satisfying y = Ax. To study the nature of this set, note that the elements a_{kj} of A must satisfy

$$\begin{cases} Ax = y \\ \mathbb{1}^T A = \mathbb{1}^T , \quad \mathbb{1}^T = \{11,\dots,1\} \\ a_{kj} \geq 0; \; k,j \in [1,n] \end{cases} \tag{9}$$

So, the solution set is the intersection of 2n hyperplanes in $\mathbb{R}_+^{n^2}$ containing at least the point $a_{kj} = y_k$ $(k,j \in [1,n])$ as direct substitution shows. Therefore, A^i is a nonvoid convex polyhedron expressible in terms of no more than a finite number m_i of such matrices

$$A^i = \langle A^\ell \rangle_{\ell=1}^{m_i}$$

Collecting all these matrices for each vertix, i, $i \in [1,N]$, let m be the cardinality of the resulting set A. Then

$$G(M) = \langle (x_i, y_i): y_i \in \langle A^\ell x_i \rangle_{\ell=1}^{m} \rangle_{i=1}^{N}$$

and $M(\cdot)$ is sufficiently characterized by

$$y \in \langle A^\ell x \rangle_{\ell=1}^{m} \tag{10}$$

This characterization is also necessary for otherwise there would be entries of A, say a_{ij}, either less than zero or greater than one and there would be vectors in S^{n-1} like e_j whose image under A would not be in S^{n-1} as assumed. Consequently, M-processes lead naturally to a production model of the form

---

[2] By $n \times n$ Markov matrix it is meant here a square matrix whose columns belongs to S^{n-1}.

$$x(t+1) = [\sum_{i=1}^{m} A^i u_i(t)]x(t) \tag{11}$$

with, at any t

$$\begin{cases} x(t) \in S^{n-1} & \text{i.e., no growth assumption;} \\ u(t) \in S^{m-1} & \text{i.e., convexity of alternatives;} \end{cases}$$

in the sense that any sequence $\{x(1),x(2),\dots\}$ such that all pairs $(x(t),x(t+1))$ are in the graph of M will be also generated by (11) by a proper choice of $\{u(1),u(2),\dots\}$[3]. Let us now return to the original Leontief model. Comparing (11) and (3) we get

$$[\sum_{i=1}^{m} A^i u_i(t)] = B^{-1}(t)[I + B(t) - A(t) - C(t)] \tag{12}$$

and we may interpret the A^i matrices in (11) in terms of technology investment and consumption matrices of a nonsingular zero-growth Leontief model.

4. ANALYTICAL DEVELOPMENTS

Any trajectory of (3) coincides with some of the trajectories of (11) when u(t) is arbitrarily chosen in S^{m-1}, so properties common to all trajectories of (11) are also shared by (3). This motivates our interest in (11).

When the measure of output is taken to be its value (one) at constant prices, each column of A^i, say the j-th, represents the unit-sum vector of marginal values of the output with respect to the j-th input. Average marginal value of output k with respect to all inputs is

$$\frac{1}{n} \sum_{j=1}^{n} a^i_{kj}$$

while its average value is simply $\frac{1}{n}$.

As inputs to sector k are outputs of other sectors, the difference

$$\Delta^i_k = \frac{1}{n} \sum_{j=1}^{n} a^i_{kj} - \frac{1}{n}$$

measures the potential gain (in terms of value) of sector k as it is allowed by all other sectors under technology i. Notice that Δ^i_k can be positive, zero or negative. We will assume that the technology eventually prevailing in each sector is such that the marginal value of the output with respect to every input exceeds its potential gain. In other words, the criterion for acceptance in the A-family is that no candidate matrix should include intersectoral transactions yielding lower marginal value than the allowed gain, for otherwise technological substitution would have no reason to take place.

Formally, this implies the restriction on the A^i matrices

---

[3] Formally, the structure of (11) is that of a bilinear control system with state variable x and control u. However, no control problem will be formulated at this stage, outside the mentioned choice of a control sequence for which (11) reproduces any given trajectory of (3).

$$r^i_k - n\,a^i_{km} < 1 \tag{13}$$

where

$$a^i_{km} = \min_{\ell,h,j} a^\ell_{hj} \qquad\qquad r^i_k = \sum_{j=1}^{n} a^i_{kj}$$

For subsequent developments, it is useful to introduce a family of closed convex polyhedra $\{S_\alpha\}$ defined by

$$S_\alpha \triangleq \langle \frac{1-\alpha}{n}\,\mathbb{1} + \alpha e_k \rangle^n_{k=1}, \quad \alpha \in [0,1]$$

with $\mathbb{1} \triangleq \{1\ 1\ 1\ \dots\ 1\}^T$.

Note that for $\alpha = 1$ $S_\alpha = S_1 = S^{n-1}$, the whole unit simplex; for $\alpha = 0$ $S_\alpha = S_o = \{\frac{1}{n}\}$, the set containing just the unit simplex centroid.

The family $\{S_\alpha\}$ is directed by inclusion in the sense

$$\alpha < \beta \Rightarrow S_\alpha \subset S_\beta$$

Therefore $S_\alpha \cap S_\beta = S_{\min(\alpha,\beta)}$ $S_\alpha \cup S_\beta = S_{\max(\alpha,\beta)}$ and $\tau = \{S_\alpha, \emptyset\}$ costitutes a topology of sub-simplices in S^{n-1}. As it will be convenient to work with metric spaces, we equip τ with the metric $\rho = |\alpha - \beta|$ and denote this space by $\mathcal{S}(\tau,\rho)$. It is then easy to prove that $\mathcal{S}$ is complete [4].

Next we turn to asymptotic properties of

$$x(t+1) = [\sum_{i=1}^{m} A^i u_i(t)]x(t) \qquad x \in S^{n-1} \qquad u \in S^{m-1} \tag{11}$$

and search for the smallest invariant in the $\{S_\alpha\}$ family under arbitrary control law $u(t) \in S^{m-1}$. More precisely, we wonder 1. whether there exists an S_α with $\alpha < 1$ such that $x(t) \in S_\alpha \Rightarrow x(t+1) \in S_\alpha$, 2. what is the minimum value $\hat{\alpha}$ of α for which this holds and 3. whether such an invariant is reachable from any initial state under arbitrary control.

Let the initial state be x. After one period, the set of states reachable by (11) is the image of x under a point-to-set mapping A_o: $S^{n-1} \rightarrow 2^{S^{n-1}}$

$$x \rightarrow A_o(x) \triangleq \langle A^i x \rangle^m_{i=1}$$

When x is let to vary in S_α, the reachable set is the image of S_α under the set-to-set mapping A_1: $\tau \rightarrow 2^{S^{n-1}}$

$$S_\alpha \rightarrow A_1(S_\alpha) \triangleq \bigcup_{u \in S_\alpha} \langle A^i x \rangle^m_{i=1}$$

This set is, in turn, contained in a minimal set S_β defined as

$$S_\beta \triangleq \{\bigcap_\gamma S_\gamma : S_\gamma \supset \bigcup_{x \in S_\alpha} \langle A^i x \rangle^m_{i=1}\}$$

and a second set-to-set mapping A_2: $2^{S^{n-1}} \rightarrow \tau$ is established

$$A_2\Big(\bigcup_{x\in S_\alpha}(A^i x)_{i=1}^m\Big) \triangleq S_\beta$$

The composition $A = A_2 \cdot A_1$ yields finally the mapping A: $\tau \to \tau$

$$S_\alpha \to A(S_\alpha) = S_\beta$$

which can be regarded as point-to-point in τ.
Stated in words, S_β is the smallest element in the $\{S_\alpha\}$ family containing the set of all states reachable from S_α in one period.

We can now prove the following

THEOREM 1. A is a contraction mapping on $S(\tau,\rho)$.

Proof. Fix α. Using the fact that convex polyhedra remain such under a linear transformation, we get

$$\{\sum_{i=1}^m A^i u_i x\colon\ x \in S_\alpha;\ u \in S^{m-1}\} = \bigcup_{u\in S^{m-1}}\Big(\frac{1-\alpha}{n}\sum_{i=1}^m r^i u_i + \alpha\sum_{i=1}^m a_k^i u_i\Big)_{k=1}^n$$

where $r^i = A^i \mathbb{I}$ and $a_k^i = a^i e_k$. Now we seek the smallest γ such that this union is contained in $\big(\frac{1-\gamma}{n}\mathbb{I} + \gamma e_j\big)_{j=1}^n$. This yields the condition

$$\sum_{i=1}^m \Big[\frac{r^i}{n}(1-\alpha) + \alpha a_k^i\Big]u_i - \frac{1-\gamma}{n}\mathbb{I} \geq 0 \qquad \forall\ k \in [1,n];\quad \forall\ u \in S^{m-1} \tag{14}$$

As the bracketed quantity is the convex hull of two nonnegative vectors, condition (14) is violated for γ smaller than a limiting value β satisfying

$$\beta = 1 - \min_{\substack{k\in[1,n]\\ u\in S^{m-1}}} \text{component}\ \{\sum_{i=1}^m [r^i(1-\alpha) + n\alpha a_k^i]u_i\}$$

For fixed k, the j-th component of this vector is an element of a convex bounded set, in fact of a closed interval of the real line. As the minimal element in a collection of closed intervals is the smallest number in the collection, we have

$$\beta = 1 - \min_{ijk}(r_j^i(1-\alpha) + na_{jk}^i\alpha) = 1 - \min_{ij}(r_j^i(1-\alpha) + n\min_k a_{jk}^i\alpha)$$

Rewrite this expression for $\alpha' \neq \alpha$ and let β' the corresponding β. Then

$$\rho(A(S_\alpha),A(S_{\alpha'})) = \rho(S_\beta,S_{\beta'}) = |\beta-\beta'| = \Big|\min_{ij}(r_j^i(1-\alpha') + n\min_k a_{jk}^i\alpha') -$$
$$- \min_{ij}(r_j^i(1-\alpha) + n\min_k a_{jk}^i\alpha)\Big| \leq (r_m^\ell - n\,a_{mn}^\ell)|\alpha-\alpha'|$$

where $a_{mn}^\ell = \min_{ijk} a_{jk}^i$ and the inequality holds by virtue of Lemma 1 (see Appendix). As the quantity in bracket is contained in (0,1) (see condition (13)) the theorem follows.

A contraction mapping on a complete metric space has a unique fixed point. Thus there exists just one $S_{\hat\alpha}$ in the $\{S_\alpha\}$ family such that

$$A(S_{\hat\alpha}) = S_{\hat\alpha}$$

Furthermore, the contractive property ensures monotonic convergence to $S_{\hat\alpha}$.

In terms of our problem, these results can be rephrased in the following

THEOREM 2. There exists just one set $S_{\hat\alpha}$ in the $\{S_\alpha\}$ family such that, for system (11)

i) No trajectory starting in $S_{\hat\alpha+\varepsilon}$ goes outside $S_{\hat\alpha+\varepsilon}$, $\varepsilon > 0$.
ii) All trajectories starting outside $S_{\hat\alpha}$ are eventually in $S_{\hat\alpha}$.
iii) All trajectories starting in $S_{\hat\alpha}$ stay in $S_{\hat\alpha}$.

Therefore $S_{\hat\alpha}$ contains all equilibrium points of (11). In particular, it contains the ergodic set, i.e. all equilibrium states under constant control. However, while all points outside $S_{\hat\alpha}$ are disequilibrium, only some points of $S_{\hat\alpha}$ are equilibrium[4].

Next we turn to the evaluation of $S_{\hat\alpha}$. The results are summarized in

THEOREM 3. The set $S_{\hat\alpha}$ in the $\{S_\alpha\}$ family is

$$S_{\hat\alpha} = \langle \frac{1-\hat\alpha}{n}\mathbb{I} + \hat\alpha e_k \rangle_{k=1}^{n}$$

with

i) $\hat\alpha = 0$ iff A^i are doubly Markov for all i
ii) $\hat\alpha = \dfrac{1}{1+n\hat h}$ otherwise

where $\hat h$ is computable finitely by the algorithm below.

Proof. From Thm 2 $S_{\hat\alpha}$ is characterized by the minimum value α for which

$$A(S_\alpha) \subset S_\alpha$$

This leads to the minimization problem: find min α such that

$$\sum_{i=1}^{m} u_i[\frac{1-\alpha}{n} r^i + \alpha a_k^i] = \sum_{j=1}^{n} \lambda_j[\frac{1-\alpha}{n}\mathbb{I} + \alpha e_j]; \quad k \in [1,n]; \; u \in S^{m-1}; \; \lambda \in S^{n-1}$$

or, find min α such that

$$\sum_{i=1}^{m} u_i[\frac{1-\alpha}{n} r^i + \alpha a_k^i] = \frac{1-\alpha}{n}\mathbb{I} + \alpha\lambda; \quad k \in [1,n]; \; u \in S^{m-1}; \; \lambda \geq 0$$

If all A^i are doubly Markov, all rows add up to one and $r^i = \mathbb{I}$ in which case $\sum_{i=1}^{m} u_i \alpha a_k^i = \alpha\lambda$; $u \in S^{m-1}$; $\lambda \geq 0$ is satisfied for all $\alpha \in [0,1]$ and $\hat\alpha = 0$. On the other hand, if at least one of the A^i is not doubly Markov, $\alpha = 0$ would imply

$$\sum_{i=1}^{m} u_i[\frac{r^i}{n} - \frac{\mathbb{I}}{n}] = 0, \quad u \in S^{m-1}$$

which is false for some u_i, since some components of r^i are less than one. This proves i). If $\alpha \neq 0$, we have

$$\lambda = \sum_{i=1}^{n} u_i[\frac{1-\alpha}{n\alpha}(r^i - \mathbb{I}) + a_k^i] \geq 0, \quad k \in [1,n]; \; u \in S^{m-1}$$

Thus, letting $h = \dfrac{1-\alpha}{n\alpha}$

---

[4] A finer topology than τ may improve the situation in this respect.

$$h(r^i - \mathbb{1}) + a_k^i \geq 0, \quad k \in [1,n] \tag{15}$$

As some components of $(r^i - \mathbb{1})$ are negative, the largest in absolute value is upper binding for h. The upper bound $\hat{h}$ is computable as follows.

Let $I \underline{\underline{\Delta}} \{(m,n)\}$ be the set of index-pairs where

$$\{r_\ell^i : i \in [1,m],\ \ell \in [i,n]\}$$

attains its minimum p. Clearly $(p-1) < 0$ is the minimal component of the bracket in (15). Let q be the minimal element in the array

$$\{a_{jk}^i : (i,j) \in I,\ k \in [1,n]\}$$

Then (15) implies $h \leq q/(1-p) = \hat{h}$, or

$$\alpha \geq \frac{1}{1+n\hat{h}} = \hat{\alpha}$$

This justifies the following

Algorithm (for the evaluation of $\hat{h}$)

1. Evaluate vector r^i by adding up rows of A^i
2. Find minvalue p in the array $\{r^i : i \in [1,m]\}$
3. Store index pairs where p is attained in set I
4. Find minvalue q in the array $\{a_{jk}^i : (i,j) \in I,\ k \in [1,n]\}$
5. Compute $\hat{h} = q/(1-p)$ and $\hat{\alpha} = 1/(1+n\hat{h})$.

5. INTERPRETATION OF THE RESULTS

The significance of the above results is that present uncertainty in the structural matrices of a multisector model can be related to the uncertainty affecting future output. More precisely, Thm 3 states that under a given set of technology investment and consumption options some output combinations are ruled out independently of the order in which those options may be adopted in time. No set of states outside $S_{\hat{\alpha}}$ is stably attained by the economy. Comparing $S_{\hat{\alpha}}$ with present sectoral composition of the output permits to judge which sectors are likely to enjoy a relatively stable situation, which ones are bound to suffer more or less drastic changes in their production quota.

As an illustrative example, assume a three sector economy with normalized output at period 1

$$x(1) = \{.147\ .655\ .198\}^T$$

From t = 2 onwards, assume total uncertainty over the following options

$$A^1 = \begin{bmatrix} .1 & .3 & .2 \\ .2 & .1 & .4 \\ .7 & .6 & .4 \end{bmatrix}; \qquad A^2 = \begin{bmatrix} .5 & .2 & .6 \\ .3 & .2 & .1 \\ .2 & .6 & .3 \end{bmatrix}; \qquad A^3 = \begin{bmatrix} .7 & .6 & .2 \\ .2 & .2 & .2 \\ .1 & .2 & .6 \end{bmatrix}$$

We are then led to study the asymptotic behaviour of (11) with m = 3 and arbitrary control. By Thm 3, x(t) will eventually enter $S_{\hat{\alpha}}$ with $\hat{\alpha} = 4/7 = .571$. The quota presently held by sector 2, $x_2(1) = .655$ is in a dis-equilibrium situation. Sector 2 will have to reduce its output by at least $.571 - .655 = -.084$, that is more than a 8.4% drop from present share of total output.

Howmuch more? That remains in the uncertainty margin: it depends on what the other sectors do within their respective growth margins which are .571 - .147 = +.424 for x_1 and .571 - .198 = +.373 for x_3. This, of course, depends on what technology investment and consumption pattern is actually going to prevail.

6. FINAL REMARKS: THE DEGREE OF REVERSIBILITY

Notice that the invariant set $S_{\hat{\alpha}}$ collapses to the simplex centroid as $n \to \infty$, if $\hat{h} \neq 0$. [Thm 3, (ii)]. On one hand this suggests that forecasting becomes more accurate as n grows; on the other hand, disaggregation looses much of its meaning when there is a large number of sectors exhibiting similar behaviour: a macroeconomic approach to equilibrium would probably suffice in this case.

For intermediate values of n, the size of $S_{\hat{\alpha}}$ decreases as $\hat{h}$ increases, that is, as p tends to one. In the limit case, we get $\hat{\alpha} = 0$ when all A^i are doubly Markov [Thm 3, (i)]. Interestingly, p = 1 is a reversibility condition. Reversing intersectoral flows, old outputs become new inputs and the matrix of the "reversed" process is the transpose of the old one.

In order for the reversed process to still represent a (hypothetical) production process, all matrices must be Markov and this is only possible if the original matrices were doubly Markov. The scalar p, in other words, can be taken to measure the degree of reversibility of the production process, or the extent to which a productive system would be able to produce its inputs from its own outputs. Of course, no society contains a fully reversible process, although a measure of reversibility could be defined as the proportion of plants, over the total number, whose inputs (outputs) are outputs (inputs) of some other *single* plant in the system. This is by no means a new concept in static production theory, where it is studied as imprimitivity of the technology matrix (11). Interestingly though, in the present dynamic context reversibility, as measured by p, tends to reduce long run output uncertainty regardless of the uncertainty affecting the structural matrices. Reversibility as a global property of multisectoral production seems to convey more information than is contained in the enumeration of all possible structural options.

APPENDIX

In the proof of Thm 1, use is made of the following

LEMMA. Let A_i, a_i: $i = 1,2,\ldots,n$ be scalars satisfying $A_i > a_i$, $A_p - a_p = K$ where $a_p = \min_i a_i$. Then, for all α and β in [0,1]

$$\left|\min_i[A_i(1-\alpha)+\alpha a_i] - \min_i[A_i(1-\beta)+\beta a_i]\right| \le K|\alpha-\beta|$$

Proof. For any i we have $a_p \le a_i$ and let $A_q \le A_i$. If p = q we have the situation in Fig. 1, and

$$\left|\min_i[A_i(1-\alpha)+\alpha a_i] - \min_i[A_i(1-\beta)+\beta a_i]\right| = (A_p - a_p)|\alpha-\beta| = K|\alpha-\beta|$$

If $p \neq q$ we have the situation in Fig. 2, and

$$\left|\min_i[A_i(1-\alpha)+\alpha a_i] - \min_i[A_i(1-\beta)+\beta a_i]\right| \le (A_p - a_p)|\alpha - \beta| = K|\alpha - \beta|$$

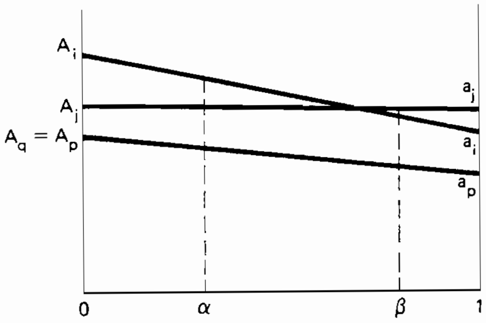


Fig. 1

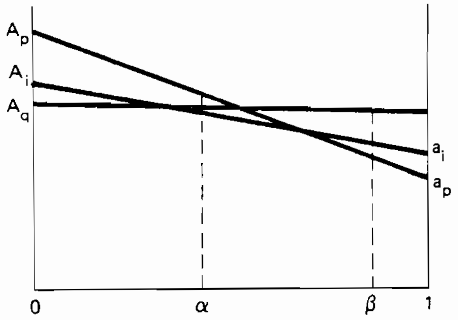


Fig. 2

REFERENCES

[1] Campbell, S.L. (1979). Non regular Singular Dynamic Leontief Systems. Econometrica, Vol. 47, pp. 1565-68.

[2] Evers, J.J.M. (1979). The Dynamic of Concave Input/Output Processes. Lect. Notes in Eco. and Math. Systems, Springer Verlag, Vol. 168, Ed. Kriens, pp. 73-114.

[3] Kendrick, D. (1972). On the Leontief Dynamic Inverse. Quarterly Journal of Economics, Vol. 86, pp. 693-696.

[4] Kolmogorov, A.N., Fomin, S.V. (1975). Introductory Real Analysis. Dover Publ.

[5] Leontief, W.W. (1951). The Structure of American Economy 1919-1939. 2nd ed. Oxford University Press, New York.

[6] Leontief, W.W. (1953). Studies in the Structure of American Economy. Oxford University Press, New York.

[7] Livesey, D.A. (1973). The Singularity Problem in the Dynamic Input-Output Model. International Journal of System Science, p. 437-440.

[8] Luenberger, D.G., Arbel, A. (1977). Singular Dynamic Leontief Systems. Econometrica, Vol. 45, pp. 991-995.

[9] Manne, A.S. (1974). Multisector Models for Development Planning. A survey in: Frontiers of Quantitative Economics, Vol. 11, M.D. Intrilligator and D.A. Kendrick edts. North Holland, pp. 449-489.

[10] Nikaido, H. (1972). Introduction to Sets and Mappings in Modern Economics. North Holland.

[11] Nikaido, H. (1968). Convex Structures and Economic Theory. Acad. Press.

[12] Rockafellar, R.T. (1974). Convex Algebra and Duality in Dynamic Models of Production. In Mathematical Models in Economics, Los editors, North Holland, pp. 351-378.

INPUT–OUTPUT MODELING OF FUEL, ENERGY, AND METAL CONSUMPTION IN CZECHOSLOVAKIA

Pavol Kárász
Computing Research Centre, Bratislava, Czechoslovakia

The level of fuel, energy and metal consumption in the process of production is, determined by inner structure of the production process. This is an area where knowledge of pertinent relationships and connections would create presumptions for increasing the efficiency in the consumption of these inputs of the production process.

The contribution is aimed at investigating some aspects of the influence of inner structure and qualitative level of production process the requirements of production for fuel, energy and metals in national economy. In our investigation the inner structure of the production process is given by corresponding indicators of input-output table with detailed classification.

We start with the assumption that the level of requirements of production for fuels, energy and metals is dependent on: the mode of production, basic production factors and the technical and economic production level.

The level of production requirements for fuels, energy and metals is given by a matrix of coefficients $Z= \| z_{ij} \|$, $i=1,\dots,n_z$, $j=1,\dots,n$. The individual rows of this matrix express the requirements of the production unit for: fuels, energy and metals in particular industries of national economy. It means that $n_z=3$ and n denotes the number of industries.

The mode of production is represented by the matrix $P= \| p_{ij} \|$, $i=1,\dots,m$, $j=1,\dots,n$ determined as follows:

$$P = \left\| \begin{array}{l:l} p_{ij} = a_{ij} & \text{for } i,j = 1,\dots,n \\ & \\ & \\ p_{ij} = h_{ij} & \text{for } i=n+1,\dots,m, j=1,\dots,n \end{array} \right\|$$

where a_{ij} represent technical coefficients, h_{ij} are direct coefficients of the value added, n denotes the number of industries and $m=n+r$ whereas r represents the number of components of value added depreciation, wages, other net production, profit and taxes; i.e.$r=5$/. Particular columns of the matrix P represent the volume and structure of production deliveries from corresponding industries, the structure and level of components of the value added needed for the production of one production unit in investigated industries. It means that the matrix P represents a cost structure of the production in the industries of national economy which makes, as a matter of fact, presumptions for investigating the inner structure of the mode of production in these industries. It should be, however, noted that the overall material requirements of production are given by a vector b where $b_j = \sum_{i=1}^{n} a_{ij}$ for $j=1,\dots,n$.

The basic production factors are given by the vector of the capital requirements of production $f=/f_1,\dots,f_n/$ and by the vector of labour requirements of production $p=/p_1,\dots,p_n/$.

The technical and economic production level is represented by vectors: $u=/u_1,\dots,u_n/$ - total technical and economic efficiency /it is given by net production per a worker/, $s=/s_1,\dots,s_n/$ - structure of capital funds/ is given by the proportion of productive machines in the total capital funds/, $v=/v_1,\dots,v_n/$- equipment by productive machines /is given by productive machines per a worker/.

We shall concentrate on investigating the following problem spheres:

- Is the mode of production in industries connected with the level of production requirements for the total material, fuels, energy and metals, then with the basic production factors and the technical and economic production level?
- What are the mutual relations between the production requierements for the total material, fuels, energy and metals, the basic production factors and the technical and economic production level?

We shall have to do with an investigation based on the indicators of above defined matrixes and vectors. For our needs they will be taken from the input-output table of the Czechoslovak economy for the year 1977.in the division of 89 production industries of national economy, i.e. n=89.

Connections between the mode of production and the requirements of production for fuels, energy and metals

Prior to the investigation of the industries of national economy from the aspect of the connections between the mode of production and the related requirements of production for fuels, energy and metals it is necessary to find a suitable expression of the mutual relations between the inner structure of the mode of production in these industries. The basic type of relations between the modes of production in particular industries is the similarity or dissimilarity in the inner structure of the production mechanism given by the cost structure of production. For example, if it hasbeen found out that a group of industries has, to a certain degree, a similar inner structure of the production, then it should be investigated if the industries of this group have also similar requirements for the investigated chosen inputs to the production with regard to the unit output; whether they have a similar technical and economic level, etc. Great significance is ascribed also to the investigation of the questions connected with the fact that in case that the industries have a similar mode of production, i.e. they are homogenous in a certain way, which of them makes better or worse use of the applied inputs; where can be found some reserves; where is it necessary "to improve", etc.

We shall say that the industries k,...,t have similar cost structure of production if and only if when the columns k,...,t of the matrix P are similar.

Similarity of the columns of the matrix P may be measured in different ways. With regard to the fact that for the needs of our investigation it is necessary to express the system of mutually related similarities of all columns of the matrix P, we shall use the hierarchical procedures of cluster analysis which make it possible to obtain such a system of relations. With regard to the experience obtained 1,2,3 we shall apply the Ward method. The application of this method is divided into two basic stages.

In the first stage the synthetic characteristics of the degree of similarity in cost structures of production between individual industries are calculated. These characteristics are called distances and in our case they are determined by the square of Euclidean metrics calculated between the individual columns of matrix P on the basis of the relation:

$$d^2_{kt} = \sum_{i=1}^{m} (p_{ik} - p_{it})^2 , \text{ for all k and t,} \qquad /1/$$

where d^2_{kt} denotes the distance between the industries k and t.

The more related is the cost structure of production in the industries k and t, the closer is the value of d^2_{kt} distance to zero and vice versa, the less related /i.e. more different/ is the cost structure of production in the industries k and t, the greater is the value of d^2_{kt}.

In the second stage the branches with the most related cost structure of production are groupped into clusters. In this process the industries 1,...,n, to which the appropriate distances belong, are considered to be a set of oneelement clusters $\{1\},\ldots,\{n\}$. First those two clusters are selected $\{i\}$ and $\{j\}$ the value of distance in which is minimum and they are fused into a new cluster i,j . Then a new set of clusters with n-1 elements is given

$$\{1\},\ldots,\{i,j\} , \ldots, \{n\} .$$

The repetition of this procedure enables to sequentially construct the sets of clusters with n-2, n-3, etc. elements till finally one large cluster is obtained containing all clusters of industries with a related cost structure of production. The distances between the individual clusters are given by:

$$d^2_{kh} = \frac{n_k + n_i}{n_k + n_h} \; d^2_{ki} + \frac{n_k + n_j}{n_k + n_h} \; d^2_{kj} + \frac{n_k}{n_k + n_h} \; d^2_{ij} \qquad /2/$$

where d_{kh} denotes the distance between clusters $\{k\}$ and $\{h\}$, where $\{h\}$ denotes cluster integration $\{i\}$ and $\{j\}$, i.e. $\{h\} = \{i,j\}$ while n_i , n_k , and n_h represent the number of elements in clusters $\{i\}^k$, $\{j\}$, $\{k\}$ and $\{h\}$.

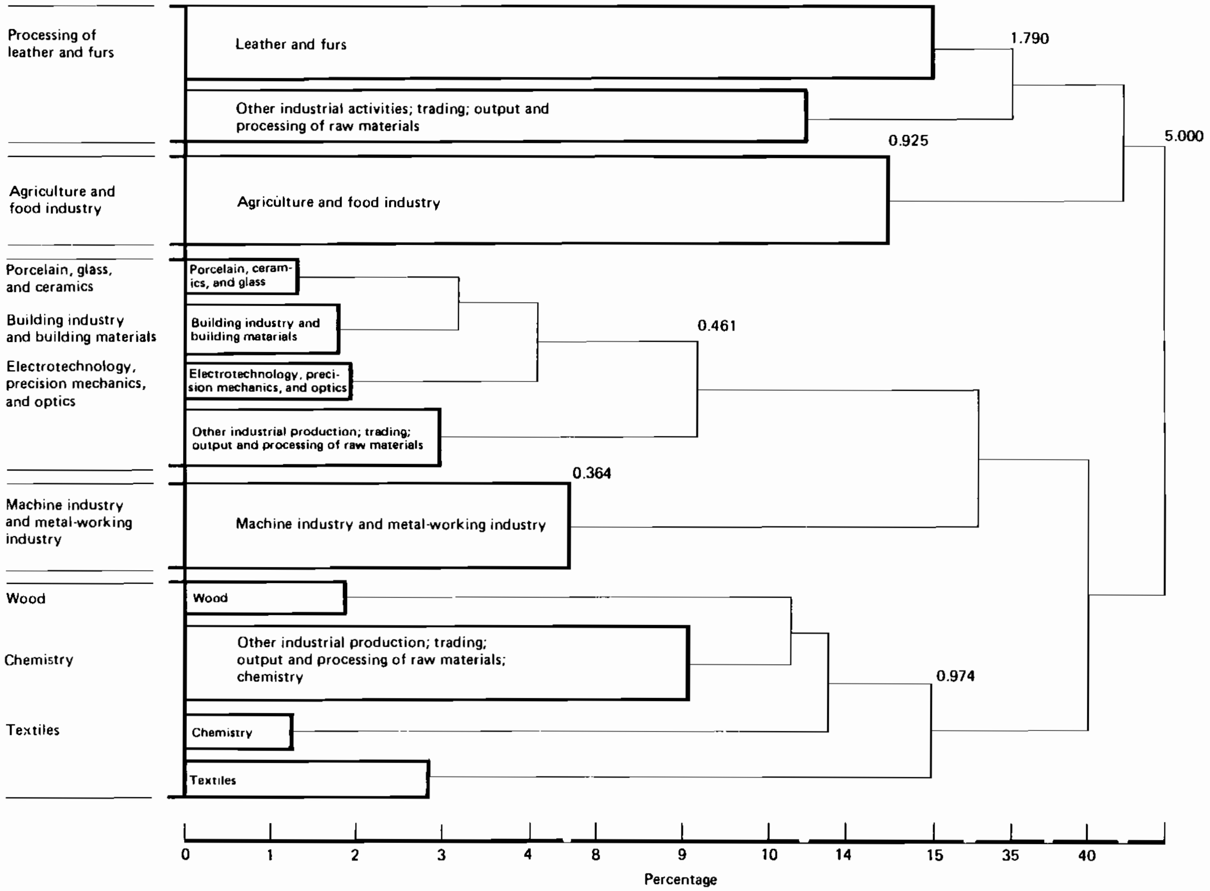


FIGURE 1 Hierarchy of similarity relations in cost structure of production.

Through applying the given method we have obtained a hierarchy of relations of similarity described by a dendrogram in Fig. 1 which, apart from absolute values of levels of distances in creating individual clusters, contains also their expression in percents.

According to the similarity of cost structure of production five basic clusters of industries are created in national economy. These basic clusters contain groups of the appropriate industries groupped into systems of smaller clusters with more strict relations of similarity among their cost structures of production. From these basic clusters only Agriculture and Food Industry and Machine Industry and Metal -working industry are homogenous from the subject-matter aspect. Other basic clusters contain industries the subject-matter homogenity of which is relatively heterogenous. These basic clusters include one or more homogenous clusters of industries from the subject-matter aspect which are followed by other related industries having the character of industrial activity, trading, output and processing of raw-materials.

The particular levels of material, requierements, capital, requirements and labour requirements of the production; requierement of the production for fuel, energy and metals; the total technical and economic efficiency, the structure of capital funds and equipment by production machines can be assigned to individual industries arranged according to the relations of similarity in the cost structure of production. These values represent a fundamental startingpoint for investigating any mode of production /i.e. the similarity of cost structures of production/ which means also a similar level of the investigated factors. This means, it is the guestion whether the mode of production in industries is connected with: the level of production requirements for the total material, fuels, energy, capital funds, manpower, the total technical-and economic efficiency, structure of capital funds and equipment by productive machines. To solve this problem we have used the following dissimilarity measure:

$z_k = \max_{ij} |w_i - w_j|$ for all i,j from each investigated /3/ cluster k while w_i and w_j denote the corresponding elements from individual vectors of investigated characteristics of production requirements and the technical and economic level. It means that each cluster consisting of industries with a related cost structure of production requires a particular - dissimilarity measure expressed by the relation /3/ for each of the investigated characteristics. In case that this value is at low level it indicates similarity and in case of high level we can speak of the difference between values of the appropriate characteristics. When we denote the value $\max_i w_i - \min_i w_i$ for every i from each of the investigated vectors as 100 %, then the appropriate z_k values be expressed in percentage with regard to these values.

The performed analysis pointed at a considerable heterogenity of the degree of difference between the investigated inputs of the process of production in industries with a related cost structure of production belonging to the investigated clusters. Some connections between the similarity of cost structure of production and the investigated inputs of production appeared to be in the case of material requirements of production, in the total technical and economic efficiency and production requirements for metals, fuels and energy. It means that in case when the industries have a similar mode of production, then they have also a similar requirements for material, metals, energy and fuels whereas they are also characterized by a similar total technical and economic efficiency, i.e. these characteristics are connected with the mode of production expressed by means of the cost structure of production. It follows then that the production requirements for fuels, energy and metals as well as for the total technical and economic efficiency influences the mode of production. The overall character of these relations can be expressed by the graph in Fig. 2.

It may be noted that the direct relation between the similarity in cost structure of production and appropriate levels of labour requirements of production and capital requirements of production,equipment by productive machines and the structure of capital funds was not identified.

The Effect of factors influencing the production requirements for fuels, energy and metals

This part is aimed at the determination of mutual relations between the production requirements for total material, fuel, energy, metals, basic factors and technical and economic level of production. First we shall concentrate on determining the hierarchy of mutual relations between the given factors and then we try to quantify them.

The starting-point for achieving our aim is represented by the matrix Z and vectors: b,f,p,u,s,v determined analogically as in the previous part. The mutual comparison of these vectors by means of the cluster analysis resulted in the hierarchy of relations given in Fig. 3. The dendrogram given in this figure expresses, by means of the hierarchy of similarity relations between the given vectors or, as a matter of fact, the hierarchy of mutual relations among the investigated characteristics as they are manifested in the structure of national economy. It means, for example, that in individual industries of national economy /among the investigated factors/ the production requirements for fuels is mostly connected with the production requirements for energy, then with the equipment with productive machines, total technical and economic efficiency, etc. The distances given in absolute and percentage expression represent a degree of dissimilarity of the corresponding factors. The high difference between labour and capital requirements and other investigated factors indicates that the relation between these requirements and other factors is very small. The mutual difference between other factors /represented by hatched part of dendrogram/ is relatively small which indicates the appropriate degrees of mutual subject-matter relations between corresponding factor.

Based on the assumption, that in the same way as this group of characteristics is mutually connected as well as influenced, we may presume that the corresponding parts of the subject-matter relations can be expressed by a functional relation:

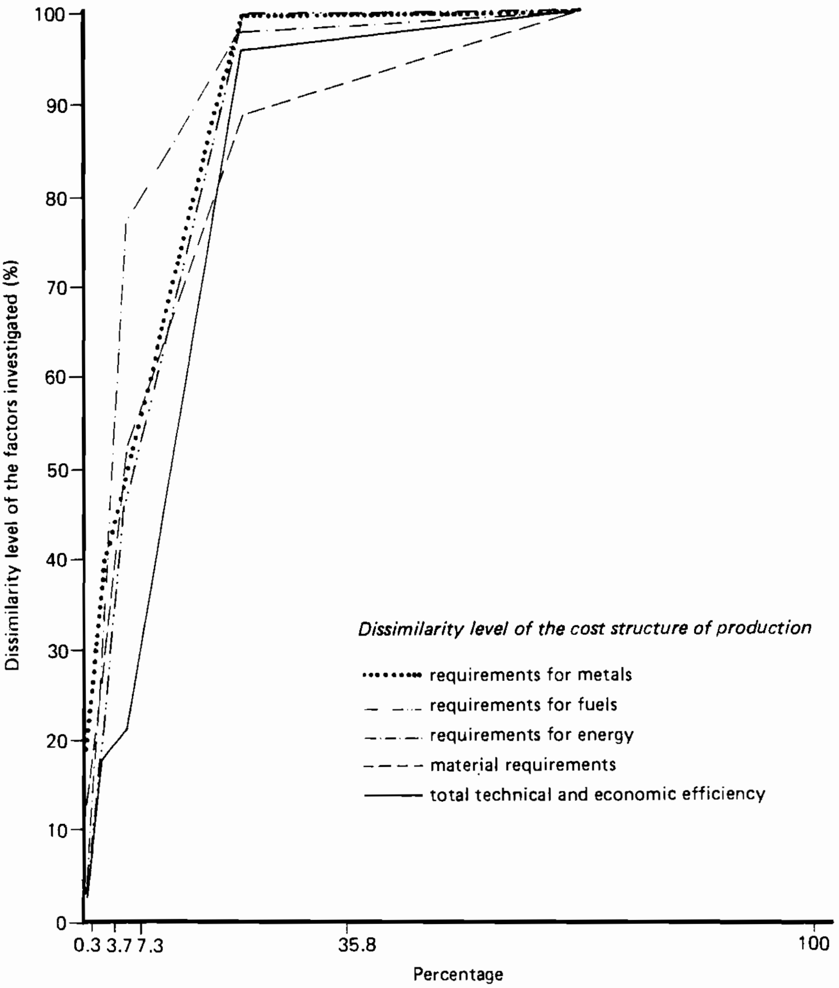


FIGURE 2 Relation between the mode of production and the level of the investigated factors.

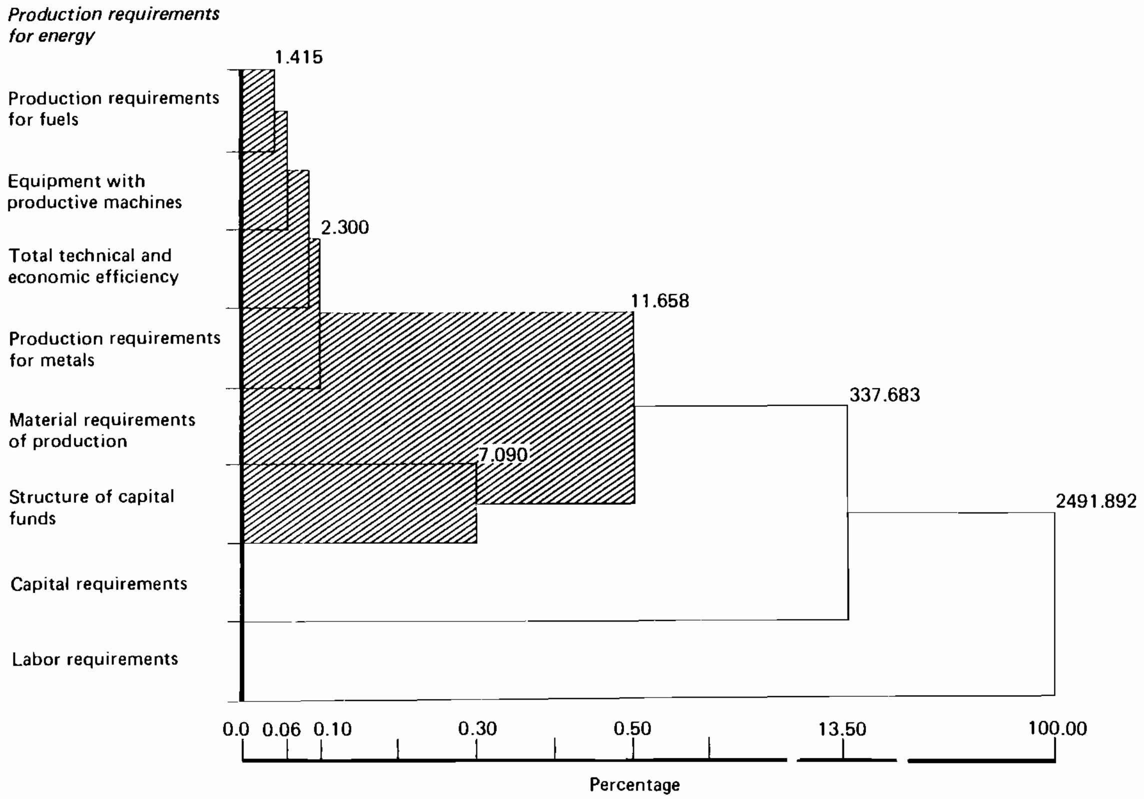


FIGURE 3 Hierarchy of similarity relations among the investigated production factors.

$$NE=a_1NP + a_2VVS + a_3TEU + a_4NK + a_5MN + a_6SVF + a_7FN + a_8PN \quad /4/$$

where the individual symbols denote: NE - production requirements for energy, NP - production requirements for fuels, VVS - equipment with productive machines, TEU - technical and economic efficiency, NK - production requirements for metals, MN - material requirements of production, SVF - structure of capital funds, FN - capital requirements, PN - labour requirements. The coefficients $a_1,\dots,a_8$ express the influences of corresponding factors for energy requirements of production. In the case of positive value a_i at the unit change of the appropriate factor and the unchangeability of other factors the value of energy requirements of production is a_i times increased and the value at negative coefficient a_i is a_i times decreased. The relation /4/ represents then by means of coefficients a_i an expression of the effect of the investigated factors on energy requirements of production. When interpreting these relation it is necessary to have respect the following two assumptions:

- level of energy requirements of production at the level of national economy is the consequence of energy requirements of production in individual industries of national economy
- a sphere of factors affecting the level of energy requirements of production is identical in all industries at the level of national economy as well.

The estimation of parametres of the relation /4/ was performed on the basis of these indicators which were used at the construction of the dendrogram in Fig. 3 applying the simple method of the least squares. The quantified equation has the following form:

$$NE = -0{,}2271\ NP + 0{,}3858\ VVS - 0{,}0557\ TEU - 0{,}0430\ NK - 0{,}0291\ MN + 0{,}0239 \cdot SVF + 0{,}0036\ FN + 0{,}0024\ PN, \quad /5/$$

where the appropriate determination index and the Durbin-Watson s coefficient of autocorrelation achieve the values of 0,791 and 2,02 which are highly significant with regard to the number of used industries.

The above mentioned facts indicate that the magnitude of the absolute value of coefficient a_i in /5/ concretely determine the magnitude of the influence of the corresponding factor on the energy requirements of production in national economy while the sign determines the direction of influence.

The level of energy requirements of production is most significantly increased by the equipment with productive machines and by the structure of capital funds whereas the capital and labour requirements of production show less influence in this field. Increase of the equipment by productive machines by a unit while preserving the unchanged level of other factors increases also the level of energy requirements of production 0,3858 times. The value of this coefficient is dependet first ofall on the technical level of productive machines. It means that a higher technical level of productive machines is connected with more economical operation and vice versa. The increase of the structure of capital funds by a unit at the unchanged level of other factors increases the energy requirements 0.0239 times. The value of this coefficient depends on the share of productive machines in the capital funds and on the total technical level of capital funds. It means that the increase of energy requirements of production corresponde, in fact, to the increase of the share of productive machines in the capital funds while the energy requirements can be reduced by increasing the technical level and economy in utilization and operation of the capital funds.

The level of energy requirements of production is decreased by the following factors: production requirements for fuel, total technical and economic level of production and the production requirements for metals and material. Among these factors rank as the most significant the production requirements for fuels where the increase of the value of this factor by a unit with no change of other factors indicates a reduction of energy requirements 0.2271 times. This fact follows mainly from the applied technological structure in national economy where a particular degree of substitution among energy and fuel requirements of production exists which means that the decrease of one of them is performed at the expense of the other one and vice versa. The increase of the total technical and economic level of production by a unit, while the level of other factors remains stable, decreases the energy requirements of production 0,0557 times. The value of the technical and economic level of production is closely connected mainly with the total level of assessment of material and raw-materials, overall technology, state and utilization of the capital funds and work organization. The increase of the level of production requirements for metals or material by a unit with the constant level of other factors lowers the level of energy requirements of production 0.043 or 0.0291 times. This fact indicates the production where one can find the producte with high requirements for metals and materials characterized by the property signalling that the higher are the requirements the lower are the demands for further working and processing and consequently for energy, too.

It follows from the above facts that at the given technological structure of production the investigated factors having an impact on the energy requirements of production can be divided into a group which, in its own way, increases the energy requirements of production and into a group which decreases it. In the first group a dominant role is played by a technical level of the capital funds as well as by a share and level of productive machines in capital funds, while here an important place belongs to the factor on manpower in relation to the capital funds. With-in the second group a significant role is played by the used technology, a particular level of substitution among energy and fuels, metals and materials as well as the factor of manpower in relation to the process of production. Consequently, this means that the coefficients in /5/ may be, to a certain degree, understood as some cumulants reflecting the level of the realized scientific and technical progress in the capital funds, manpower as well in the organization and management of the production related to the energy consumption in the process of production.

Literature

1. Kárász, P.: Application of cluster analysis at investigating the similarity industries in the cost structure of production.

   Informačné systémy, 10, 1981, n.3, pp. 243-256.

2. Kárász, P.: Connections in the cost structure of production detected by the application of cluster analysis, Statistika n.4,1982, pp. 158-170.

3. Kárász, P. et al.: Analysis of requirements of production and final demand for fuel, energy and metals in the structure of national economy. Výskumná práca č. 222, VVS Bratislava 1982.