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

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Anatoli Smyshlyaev, Editor

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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 re-search 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 pre-sented. 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 co-
operation 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 competi-
tion. 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 pos-
sible. Details of this practical application are found in the next paper by
Hans Olsson, who uses a two-sector commodity grouping for homogenous and heter-
ogenous 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 ex-
tension of this approach to the full sectoral level possible within the Nord-
Hand 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 with-
in 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 econo-
mies 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. Sev-
eral measures of the importance of I/O coefficients and alternative trend func-
tions 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 interpret 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. Indus-
tries 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 dis-
aggregated 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 addi-
tion 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 machine-
ry), 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 manu-
facturing 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 re-
tooling, 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 con-
tinued on the path towards higher industrialization. The impact on the econo-
my 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 underperfor-
mance by industries growing more slowly than the total, or as overperformance
by those growing faster than the total. The growth performances of the vari-
ous 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 indus-
tries 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 con-
tinuously 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 in-
clude SIC 28 – chemical and allied products; 35 – machinery (except electri-
cal); 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 non-ferrous 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.

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[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 back-
lash 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 - trans-
portation 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 drop-
ping 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 invest-
ment since 1972.

For SIC 29 - petroleum and coal products, the share in total manufactur-
ing 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 seven-
ties, 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 pro-
tected 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 - non-
electric 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,
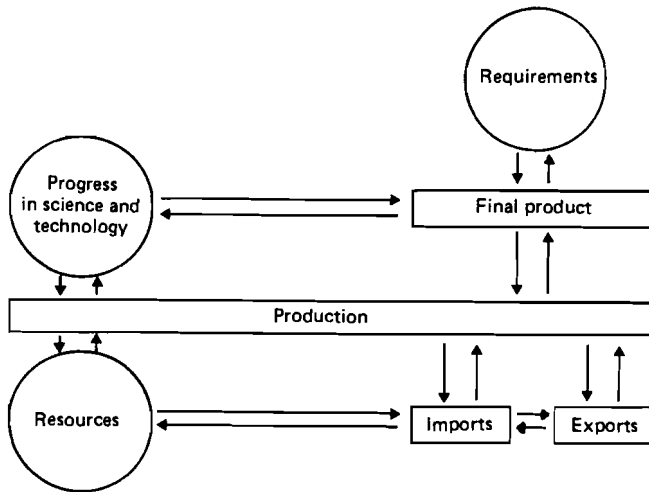
FIGURE 1   Causes of structural changes.

and results from science, and techniques, for instance, to facilitate house-
work. 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 con-
sumption of metals in the national economy. Finally, changes in the struc-
ture 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 struc-
tural 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, trans-
port, 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	Radiation technology
Computer science and technology	Cryotechnology
Control science and technology	Deep-sea technology
Manipulators, robots	Aeronautical and space engineering
NC Machines, computer integrated manufacturing systems	Biotechnology
	Gen. engineering
Optoelectronics	Plastics
Telecommunication systems	Silicates
Energy technologies	Composite materials
Metal forming techniques	Environmental protection techniques
Laser technology	
Vacuum engineering	

calculate the influence of new materials (such as plastics or composite mater-
ials) 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 ex-
port 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 sub-
divide 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 calcu-
late the output of wastes in the production and consumption processes and de-
termine 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

Intermediate products	Final product	Output of waste products

Secondary raw materials	Degree of utilization (recycling)
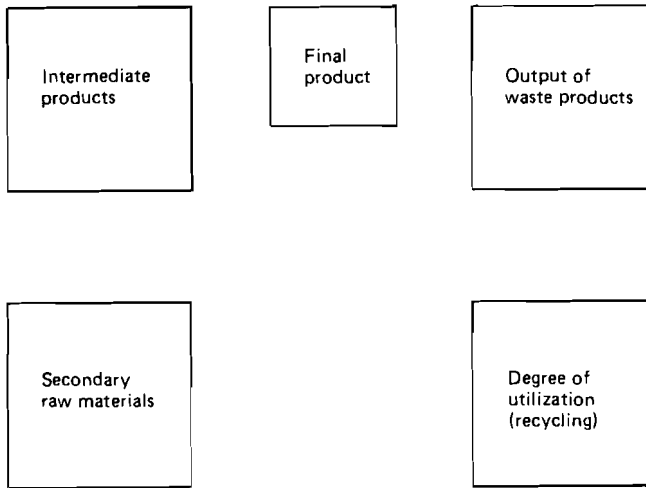
FIGURE 2   Incorporating recycling in macroeconomic input-output models.
          Source and detailed model: Sagert (1981).

specified waste products per unit of production or consumption, (b) the uti-
lizable 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 sub-
divided 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. There-
fore, 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.

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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 pres-
criptions, 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-0) analy-
tical framework have been found to provide a basis for such linkage, and
attempts have been made by model builders at incorporating I-0 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 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

$$X_i = \sum_{i=1}^{n} a_{ij}X_j + Y_i \tag{1}$$

or in matrix notation,

$$X = AX + Y \tag{1$'$}$$

whereby,

$$(I-A)\ X = Y \tag{2}$$

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,

$$Q_j = X_j - \Sigma^n_{i=1} X_{ij} \tag{3}$$

We can rewrite (3) as,

$$Q_j = X_j - \Sigma^n_{i=1} a_{ij}X_j = [1 - \Sigma^n_{i=1} a_{ij}] X_j \tag{4}$$

or in matrix notation,

$$Q = BX \tag{4$'$}$$

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

$$b_{jj} = 1 - \Sigma^n_{i=1} a_{ij} \qquad j = 1, \ldots, n$$

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,

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

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

$$Y_i = Y_{i_1} + Y_{i_2} + , \ldots, + Y_{im} \tag{6}$$

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

$$h_{ij} = Y_{ij}/Y_j \qquad j = 1, \ldots, m \tag{7}$$

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

Combining (6) and (7) we obtain

$$Y_i = \Sigma^n_{j=1} h_{ij}Y_j \qquad j = 1, \ldots, m \tag{8}$$

or in matrix notation

$$Y = HR \tag{8$'$}$$

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,

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

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

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[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 fiscal 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-0 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 man- power 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 compi- lation of I-0 tables for the Nigerian economy there were three different atte- mpts 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 hypo- thetical 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 gather- ing 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 regu- lar I-0 tables from industrial survey data and national accounts data, supple- mented 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 classi- fication 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

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[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 disaggregated 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 x n-1)	r	F (n x 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 <u>balance equations</u> as follows,

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

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, ..., 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 wr itten as follows:

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

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

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

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

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

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:

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

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 (1) factors of production. Alternatively looking at the chart row wise, it should be the case that,

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

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,

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

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 un-
reported 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.

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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 fallen 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) 1960	(HISTOR) 1970	(FORCST) 1980	(FORCST) 1990	(FORCST) 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

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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.

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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
1 Agr.,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
3 Food 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
8 Stone,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
10 Fabricated Metals	1.36	2.25	2.07	1.26	0.85
11 Machinery(non-elect)	2.17	2.88	2.60	2.04	1.50
12 Electrical Machinery	1.52	2.71	2.68	1.70	1.30
13 Transportation Equipment	1.66	2.41	2.62	2.62	2.30
14 Precision Instruments	0.41	0.57	0.60	0.48	0.35
15 Other Manufacturing	5.33	5.85	5.60	6.48	6.87
Services	37.87	46.00	53.79	58.42	60.65
16 Construction	6.43	8.09	10.05	11.34	12.69
17 Utilities(Private)	0.51	0.53	0.56	0.64	0.67
18 Trade	13.04	16.18	17.29	16.57	14.79
19 Finance & Insurance	1.77	2.51	2.87	3.08	3.24
20 Real Estate	0.19	0.56	0.94	0.71	0.58
21 Transp. & Communication	4.65	5.54	5.89	6.92	7.64
22 Other Services	11.28	12.59	16.19	19.16	21.04
Government	6.45	7.19	8.43	9.22	9.83
23 Government	5.69	5.79	6.57	7.23	7.71
24 Non-Profit Institutions	0.76	1.40	1.86	1.99	2.13

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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

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

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:

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

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

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

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 ith 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

$$\ln(L/Q) = b_0 + b_1 CON2 + b_2 time1 + b_3 time2 + b_4 PCQ + b_5 PCH$$

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

$$\ln(1.-R) = b_0 + b_1 time + b_2 PCQ.$$

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:

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

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

Years / Industries	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

Years / Measures of Development	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.

$$\bar{P}^{/VA/} = \hat{A}^{/VA/} /I-\bar{A}/^{-1} \hspace{3cm} /2/$$

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, $X_i^{/E/}$ 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 $\{\alpha X_{12}/X_2 + /1-\alpha/ X_{16}/X_6\}; \alpha$ is X_2/X_6 and the signs 2 and 6 refer to machinery and construction.

$$P^{/M/} = \hat{A}^{/M/} /I-A/^{-1} \hspace{3cm} /3/$$

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/

Year Industries	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

Years Measures of Development	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.

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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.
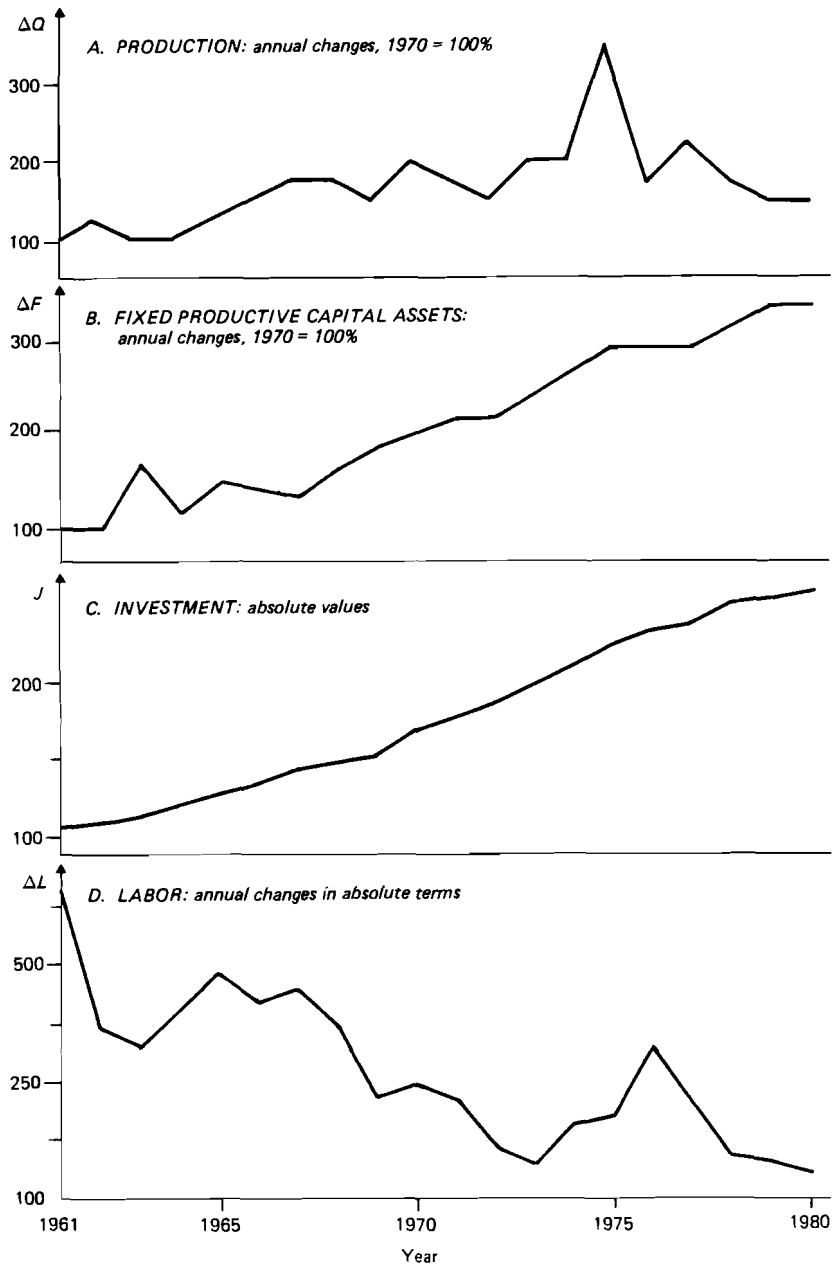
FIGURE 1 Growth of Soviet manufacturing industry, 1961–1980. Sources of data
are as follows: *A*, for all years from ref. [3], pp.126,127. *B*, for 1972 cal-
culated on the basis of the USSR capital assets input-output table in ref.
[6], pp.62–81; for all other years calculated using the capital assets 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 out-
puts 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).
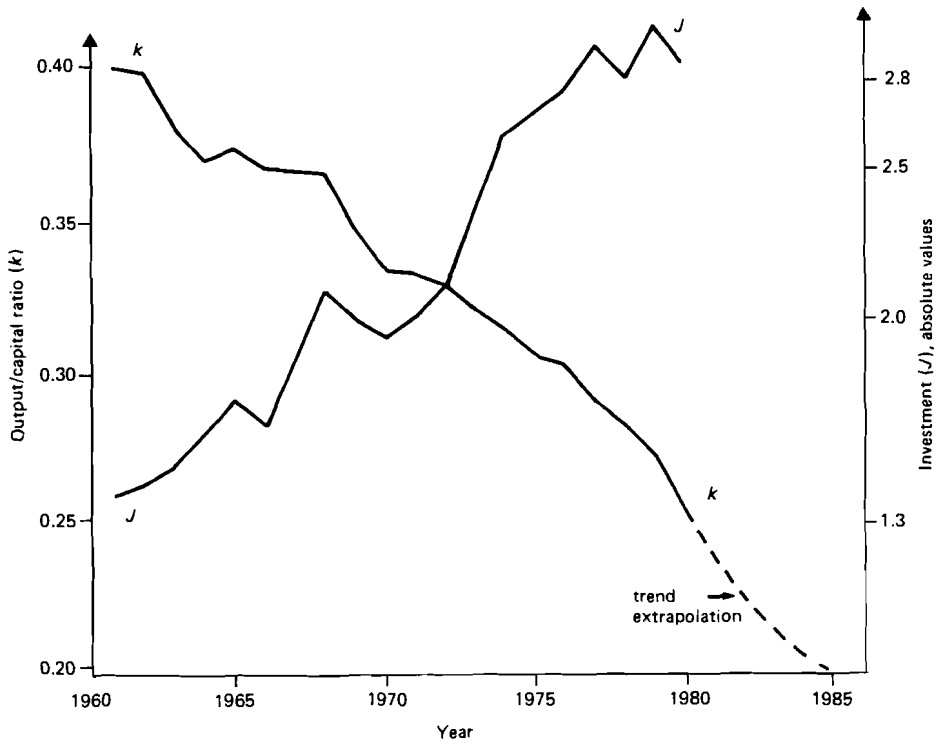
FIGURE 2 Investment indicators for the ferrous metals industry, 1961-1985.
Sources of data are as follows: ref.[3], pp. 126,127,135-137,141,338; ref.
[6], pp. 62-81,196,197,526.
Smoothed k (1960-1980):

$$k = 0.42 \quad - 0.0073\ t$$
$$(140.89) \quad (30.59)$$
$$R^2 = 0.98,\ DW = 1.08.$$
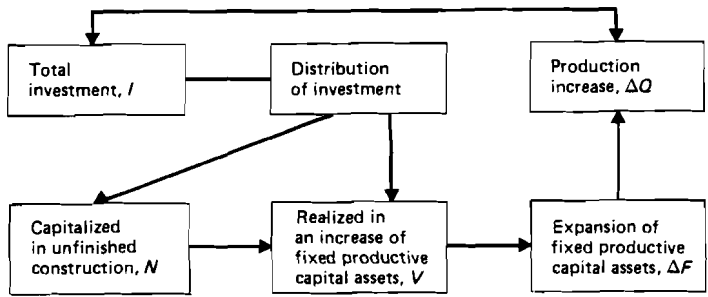
FIGURE 3 A sequence of models developed to simulate investments.

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:

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

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

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.

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

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

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) $\quad$ 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) $\quad q = q(p',p_a,L)$

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

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

The compensated asset price effects are of the traditional kind.

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

The complete substitution matrix may be written in partitioned form

(8) $\quad K = \begin{bmatrix} K_p & \vdots & K_{p_a} \end{bmatrix}$ of dimension $(n+2) \times (n+1)$.

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

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

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

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

$$dp = \hat{p} \, d\log p, \quad \text{"}\hat{\ }\text{" denotes a diagonal matrix,}$$

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

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

$$+ \hat{\pi} q_L (d\log L - \frac{x'\hat{p}}{L} \, d\log p - \frac{A^+ p_a}{L} \, d\log p_a).$$

Defining

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

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

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

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

$$d\log L^+ = d\log L - \sum_{j=1}^{n} w_j \, d\log p_j - w_A d\log p_a, \text{ the growth rate of real}$$

resources (in view of the price of money being the numeraire),

we can write in simpler notation

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

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

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

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

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

Considering the commodity demand subsystem

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

the symmetry condition

(18) $S_{ij} = S_{ji} \quad$ 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 $i=1,\ldots,n$ holds.

From the negative semidefinitness of K_{xp} under the specific utility hypothesis (10) follows the negativity of the S_{ii} elements for $i=1,\ldots,n$. 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 $t=1,\ldots,T$, 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 $i=1,\ldots,n+2$ and $t=1,\ldots,T$.

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	.089	.146	-.398	.232	-.667	.013	1.782
and services	(.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	.169		-.245	.066	-.480	.005	
and services	(.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
	ML	281.655	12.502	9.371	7.204	-"-	inference
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:

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

where $n_i = B_i/\bar{w}_i$, $\sigma_{ij} = S_{ij}/\bar{w}_i$, $\sigma_{ia} = S_{ia}/\bar{w}_i$ 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.

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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 ear-
nings of government workers in relation to the general income develop-
ment. 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 (STATISTI-
SCHES 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 Statisti-
cal Office. The data are disaggregated by a 51 sector classification of
the production sectors, which is given by the table opposite.

The Preliminary Data Analysis.

One problem, which has to be solved, consists of finding adequate
methods to get an overall picture of the development of the multisecto-
ral 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 regres-
sion 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

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

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 omit 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 deve-
lopment 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 consis-
tency 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 employement 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 intercorrela-
tion 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)

Employment (in 1000)

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

Employment (in 1000)

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

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   deter-
mination. 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 inter-
preted 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 coeffi-
cient 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 conser-
vative 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 parame-
ters. 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	Lande	1961.330	187.1	188.10400	232.4	0.170	0.8493
2	Elektrw	-643.949	48.3	544.81000	512.7	0.111	0.9499
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	0.9446
5	Kohlenbb	3387.140	252.5	281.42900	263.4	0.283	0.8969
6	Ubr.Bo	430.657	111.4	16.00520	54.6	0.287	0.6823
7	Chemie	266.764	13.8	1350.00000	974.7	0.214	0.9564
8	Mindl	213.810	40.1	96.10370	226.5	0.409	0.9512
9	Kunststv	-533.428	52.5	317.33200	378.2	0.268	0.9328
10	Gummi	369.715	57.5	185.26000	378.6	0.548	0.9741
11	Steinerd	1524.860	161.2	332.41600	441.2	0.494	0.9591
12	Feinker	302.953	71.8	67.22000	199.9	0.404	0.9492
13	Glas	266.000	48.9	121.77200	281.2	0.465	0.9645
14	Eisenscn	3184.950	256.5	450.54500	485.7	0.425	0.9585
15	NE-Met	331.667	63.4	135.99900	326.0	0.995	0.9766
16	Giesser	877.382	114.6	168.37700	274.6	0.485	0.9330
17	Ziehrerei	890.762	81.7	342.96100	439.2	0.339	0.9558
18	Stahlbau	984.430	105.3	251.93300	338.4	0.534	0.9538
19	Maschbau	1513.200	66.4	1952.09900	1075.9	0.247	0.9400
20	BM,ADV	-189.657	25.6	218.42900	349.8	0.567	0.9644
21	Str+zbau	-2916.650	82.2	1706.26000	876.5	0.195	0.9527
22	Schiffb	369.429	62.8	165.68500	221.4	0.487	0.9585
23	Luft+zb	-318.206	43.7	118.86500	204.6	0.189	0.8946
24	Eltechn	329.957	14.4	1891.79000	1039.9	0.224	0.9572
25	Feinmch	-183.381	16.6	317.23400	361.4	0.145	0.9285
26	EBM	1151.750	185.2	474.38400	544.4	0.382	0.9658
27	Mus,Splw	248.238	59.9	69.67700	229.5	0.238	0.9598
28	Holzbear	386.524	96.2	69.88310	218.3	0.327	0.9695
29	Holzver	1149.348	99.9	392.18200	428.2	0.208	0.9575
30	Zellst	512.429	116.7	80.42860	229.7	0.497	0.9672
31	Papierv	321.144	53.3	172.49300	359.4	0.526	0.9774
32	Druck	818.477	105.3	329.14300	531.8	0.465	0.9806
33	Textil	3385.650	396.8	306.23400	441.9	0.537	0.9666
34	Leder	1249.480	302.4	58.66240	178.3	0.651	0.9526
35	Bekleid	1873.430	385.2	228.68000	463.7	0.927	0.9837
36	Ernahrung	2298.950	163.3	930.85200	829.3	0.175	0.9739
37	Tabakver	256.524	72.4	332.74000	116.1	0.185	0.9208
38	Bauh-gew	7739.480	337.1	1662.36000	909.3	0.602	0.9442
39	Ausbau	214.284	13.8	786.88500	638.2	0.194	0.9482
40	Grosshd	1766.010	83.8	1573.87000	971.0	0.249	0.9498
41	Einzelhd	-1475.050	57.3	2848.81000	995.0	0.128	0.9415
42	Eisenbahn	2690.760	186.3	618.85300	531.2	0.275	0.9358
43	Schiffrt	625.238	108.8	82.72730	198.8	0.192	0.9144
44	Ubr.Verk	1.432	0.1	775.45400	626.7	0.155	0.9440
45	Bupost	336.811	22.8	825.05200	791.3	0.198	0.9644
46	Kreditin	-1587.000	84.6	1977.65000	734.6	0.148	0.9429
47	Versich	-502.427	43.3	475.93300	514.5	0.148	0.9548
48	Wohnvers	-148.667	24.9	104.13000	231.8	0.121	0.9479
49	somst.Die	-1473.140	52.3	2178.41000	968.3	0.105	0.9273
50	Stat	-6178.960	130.0	7380.47000	1949.0	0.133	0.9477
51	Priv.HH	499.951	25.6	1621.69000	648.4	0.126	0.9289
52	Summe	29224.000	295.9	35924.10000	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	Lande	7.749	57.0	0.04497	4.2	0.257	0.9099
2	Elektrw	7.121	70.2	0.11288	14.0	0.339	0.9951
3	Gas	4.916	38.0	0.09575	9.3	0.512	0.9824
4	Wass	5.608	42.7	0.10406	11.1	0.384	0.9998
5	Kohlenbb	8.285	51.7	0.04168	3.2	0.339	0.8136
6	Ubr.Bo	8.123	40.0	0.02957	2.1	0.348	0.6484
7	Chemie	8.389	80.7	0.09717	11.7	0.985	0.9928
8	Mindl	8.673	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	0.04718	7.0	0.682	0.9777
12	Feinker	6.137	60.6	0.04681	8.2	0.891	0.9862
13	Glas	6.364	52.9	0.08172	8.5	0.667	0.9819
14	Eisenscn	8.333	67.7	0.08374	5.7	0.785	0.9585
15	NE-Met	6.597	53.8	0.08970	8.4	0.667	0.9810
16	Giesser	7.149	52.5	0.06232	5.8	0.895	0.9508
17	Ziehrerei	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	6.148	34.4	0.12017	8.5	0.550	0.9603
21	Str+zbau	8.261	71.5	0.11312	12.3	0.904	0.9919
22	Schiffb	6.425	47.2	0.07250	6.7	0.543	0.9629
23	Luft+zb	5.041	36.5	0.13899	12.6	0.948	0.9890
24	Eltechn	8.714	70.6	0.09786	10.0	0.657	0.9860
25	Feinmch	6.802	65.3	0.10138	12.2	0.619	0.9953
26	EBM	7.700	75.3	0.07891	9.6	0.990	0.9893
27	Mus,Splw	6.173	76.8	0.07604	11.9	0.990	0.9957
28	Holzbear	6.285	58.1	0.06316	7.3	0.783	0.9902
29	Holzver	7.701	71.6	0.07316	8.5	0.552	0.9856
30	Zellst	6.524	63.6	0.05740	7.3	1.110	0.9819
31	Papierv	6.642	54.5	0.06507	8.8	0.381	0.9824
32	Druck	7.391	66.5	0.08110	8.3	0.559	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	69.4	0.05489	6.1	0.678	0.9699
36	Ernahrung	8.435	95.3	0.07913	11.0	0.588	0.9937
37	Tabakver	5.798	48.6	0.05269	5.5	0.273	0.9579
38	Bauh-gew	9.312	58.1	0.06965	5.7	0.496	0.9581
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	8.577	85.9	0.10466	13.4	0.552	0.9949
42	Eisenbahn	8.302	58.3	0.04902	6.1	0.304	0.9518
43	Schiffrt	6.698	51.5	0.05297	5.1	0.331	0.9431
44	Ubr.Verk	7.805	83.8	0.09771	13.2	0.428	0.9954
45	Bupost	7.929	64.8	0.09616	9.9	0.325	0.9966
46	Kreditin	7.719	62.6	0.11965	12.0	0.282	0.9994
47	Versich	5.999	61.7	0.11384	12.6	0.396	0.9926
48	Wohnvers	5.377	47.7	0.11812	13.1	0.435	0.9952
49	somst.Die	8.681	91.9	0.10593	13.8	0.455	0.9956
50	Stat	9.817	84.3	0.10910	11.8	0.341	0.9918
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 re-
sult, that the development of sectoral incomes follows a growth trend
over the last 21 years is not very surprising, but the degree of homoge-
nity 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 relation-
ships 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 re-
lated 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 explana-
tory variable than the time trend. In its the aggregate so many diffe-
rent developments are mixed up, that it is does not fit into any secto-
ral development very well. The significance of time trends in the secto-
ral 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 recove
ry, 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 explana-
tory variable for all sectors. In the average performance the logarith-
mic 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 discri-
mination between both would only be possible, if the economic develop-
ment 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)

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	Lande						
2	Elektrw						
3	Gas						
4	Mass						
5	Kohlenbb						
6	Ubr.Bb						
7	Chemie						
8	Minbl						
9	Kunststv						
10	Gumi						
11	Steinerd						
12	Feinker						
13	Blas						
14	Eisenach						
15	NE-Met						
16	Blswar						
17	Ziehwrei						
18	Stahlbau						
19	Maschbau						
20	BM,ADV						
21	Btrfzbau						
22	Schiffb						
23	Luftfzb						
24	Eltechn						
25	Feinmech						
26	EBM						
27	Mus.Sple						
28	Holzbear						
29	Holzver						
30	Zellst						
31	Papierv						
32	Druck						
33	Textil						
34	Leder						
35	Beklelid						
36	Ernährung						
37	Tabakver						
38	Bauh.gew						
39	Ausbau						
40	Grosshd						
41	Einzelhd						
42	Eisenbahn						
43	Schiffrt						
44	Ubr.Verk						
45	Bupost						
46	Kreditin						
47	Versich						
48	Wohnvera						
49	sonst.Dle						
50	Staat						
51	Priv.HH						

Wages and Salaries in mill.DM

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

Wages and Salaries in mill.DM

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

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 condi-
tions, 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 presen-
ted in this paper, which started to demonstrate the usefulness of preli-
minatory data analysis. If we end here to ask new questions without
having them in mind when we started the analysis, this shows the suc-
cess of this approach. The relation to economic theory is still not
explained. The question, of how to relate this way of analysis to stan-
dard 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 rela-
tions, 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 investiga-
tion 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 informa-
tion, 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...

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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

	Purchasers						
		Final demands					
	44	40	23	4	1	1	1
Products	A Intermediate	C Consumption	B Capital equipment	G Government and non-government expenditure	Inventory change	Exports	Imports
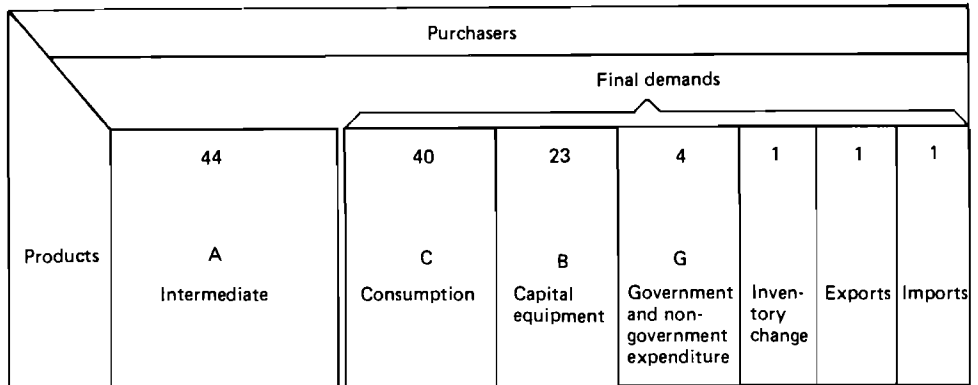
FIGURE 1 The real side of INTIMO.

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
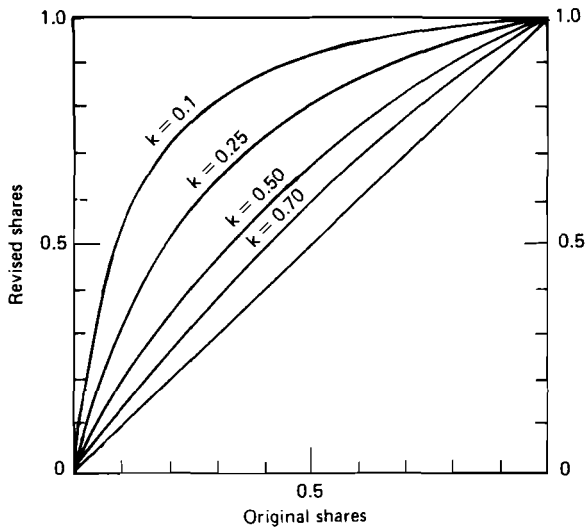
FIGURE 2 Share revision function.

and q_i represents the current sectoral output in base-year prices. The sec-
toral 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 cor-
rect 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, im-
parting to each component of the matrix the rate of change forecast by the
behavioral equation of the corresponding value added component. Schematic-
ally, the price side of INTIMO is shown in Figure 3.

Prices	Inter-mediate 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:

$$\log (WM/EM) = a_1 \log PRODM (t) + a_2 \log PRODM (t-1)$$

$$+ a_3 \log P(t) + a_4 \log P(t-1) \tag{4}$$

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

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

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 (- 5.76)	- 0.44 (- 0.58)	- 0.09 (- 0.28)	- 0.03 (8.60)	0.90	0.85
2 - Coal	1.03 (2.53)	- 0.86 (- 1.63)	- 0.07 (- 0.64)	- 0.00 (- 0.12)	0.04	2.04
3 - Coke	2.46 (4.98)	0.42 (1.90)	- 0.03 (- 0.13)	- 0.01 (- 3.06)	0.42	2.26
4 - Petroleum,gas,refining	1.12 (2.89)	0.26 (0.21)	0.32 (2.92)	- 0.00 (- 0.59)	0.46	2.45
5 - Eletricity,gas,water	4.48 (7.97)	- 1.44 (- 1.41)	0.15 (0.38)	- 0.46 (- 6.36)	0.90	0.97
7 - Non Ferrous ores	2.28 (19.39)	0.04 (0.23)	- 0.02 (- 0.73)	- 0.01 (-11.14)	0.94	1.95
8 - Non metal min,min prod.	0.21 (1.18)	0.42 (0.88)	- 0.20 (- 1. 51)	0.01 (4.23)	0.70	1.59
9 - Chemical products	1.41 (3.58)	- 0.13 (- 0.17)	- 0.01 (- 0.05)	- 0.00 (- 1.18)	0.03	1.58
10 - Metal products....................	1.66 (7.77)	0.01 (0.02)	0.11 (0.73)	0.00 (- 3.03)	0.60	1.52
11 - Agricul and indus. machinery	1.43 (8.84)	- 0.18 (- 0.43)	0.04 (0.44)	- 0.00 (- 2.68)		
12 - Office,precis,opt. instruments	0.63 (4.12)	- 0.21 (- 0.92)	- 0.09 (- 1.78)	0.00 (2.34)	0.31	1.23
13 - Electrical goods	1.99 (10.97)	- 0.95 (- 2.53)	0.31 (2.71)	- 0.01 (- 5.40)	0.32	1.05
14 - Motor vehicles	2.91 (12.02)	0.68 (1.60)	- 0.14 (- 0.62)	- 0.02 (- 7.02)	0.87	1.72
15 - Other transport equipment	2.36 (15.38)	- 0.52 (- 2.29)	0.16 (3.03)	- 0.01 (- 8.50)	0.88	1.71
16 - Meat	0.10 (0.39)	0.25 (0.29)	- 0.41 (- 1.44)	0.01 (3.37)	0.62	2.20
17 - Mill	0.25 (0.90)	2.93 (2.32)	- 0.63 (- 3.27)	0.00 (2.44)	0.68	1.96
18 - Other foods.......................	- 1.08 (- 2.57)	- 2.62 (- 1.09)	0.20 (0.06)	0.02 (4.81)	0.70	1.17
19 - Non alcohol,alcoh.beverages	- 0.38 (- 0.97)	- 2.20 (- 1.43)	- 0.09 (- 0.55)	0.01 (3.37)	0.53	2.63
20 - Tobacco	3.70 (3.24)	- 0.28 (- 0.57)	0.00 (- 0.03)	- 0.03 (- 2.40)	0.81	2.27
21 - Textiles and clothing	0.50 (3.47)	- 0.16 (- 0.37)	0.04 (0.66)	0.00 (3.56)	0.53	2.75
22 - Leather and shoe	- 0.76 (- 3.67)	0.57 (0.61)	- 0.14 (- 1.59)	0.02 (8.64)	0.93	2.06
23 - Wood and forniture	0.45 (1.59)	0.62 (0.59)	- 0.11 (- 1.03)	0.00 (2.10)	0.48	2.79
24 - Paper and printing prod.	1.77 (10.61)	0.63 (1.17)	- 0.01 (- 0.31)	- 0.01 (- 4.70)	0.82	1.68
25 - Rubber and plastic prod.	0.41 (0.95)	1.48 (2.79)	0.04 (0.62)	0.00 (1.43)	0.51	2.25
26 - Other manufact prod.	1.05 (3.53)	- 0.32 (- 0.85)	- 0.02 (- 0.26)	- 0.00 (- 0.17)	- 0.28	1.29
27 - Construction	1.37 (5.29)	0.73 (1.62)	- 0.17 (- 1.20)	- 0.00 (- 1.53)	0.10	1.99
28 - Recovery and repair serv.	0.70 (4.26)	- 0.07 (- 0.39)	- 0.60 (- 2.54)	0.00 (1.60)	0.39	2.05
29 - Trade	0.75 (6.34)	0.38 (1.41)	0.22 (- 1.25)	0.00 (1.81)	0.43	2.78
30 - Hotels and restaurants	- 0.51 (- 3.30)	0.76 (2.06)	- 0.08 (- 0.35)	0.01 (9.53)	0.92	1.77
31 - Inland transport	2.88 (5.88)	- 1.91 (- 0.79)	- 0.59 (- 0.75)	- 0.02 (- 3.83)	0.61	1.72
32 - Sea and air transport	5.41 (31.52)	0.57 (1.16)	- 0.96 (- 3.56)	- 0.05 (-25.83)	0.98	3.15
33 - Transport services	1.12 (7.82)	0.60 (1.69)	- 0.92 (- 3.82)	- 0.00 (- 0.94)	0.61	2.02
34 - Communication	3.81 (3.93)	0.26 (0.17)	1.53 (1.90)	- 0.03 (- 3.04)	0.75	2.81
35 - Public Services	4.38 (16.03)	0.81 (1.05)	0.36 (0.54)	- 0.04 (-13.93)	0.96	1.83
36 - Other Services	3.54 (3.02)	1.22 (0.13)	2.60 (0.99)	- 0.30 (- 2.66)	0.80	0.80

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            regres-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                   0.157725        0.405885        0.3886        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, gas, 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                 0.262463        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	0.0031?0	-7.3210	75.5000
wagr14	dependent variable - - - - - - - - -			1.03110

date	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	
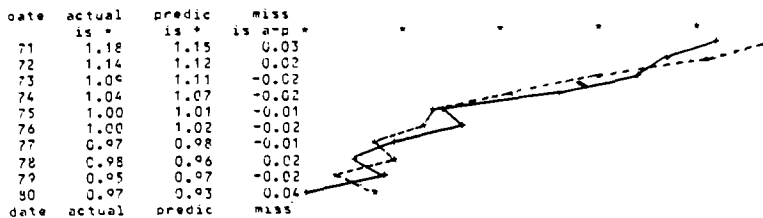
sector 17 mill

	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
wagr17	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	predic	miss	
	is *	is +	is a-p *	
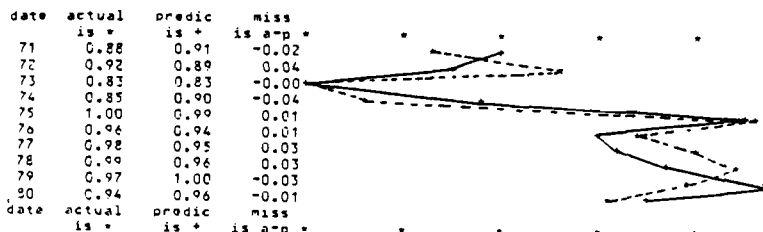
sector 19 beverages

	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	0.97	0.96	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 *	

0.852   0.883   0.914   0.944

TABLE 2 (continued).

---

sector 23 electrical goods

see = C.011C rsur = 0.9304 rbarsqr = 0.8206
rho = 0.374 dw = 1.292 aape = 0.95

variable	regres-coef	std.error	t-value	mean
intercept	1.990422	0.181489	10.9700	1.0000
vpemp	-0.958200	0.378322	-2.5330	0.0165
vpq	0.318775	0.117383	2.7156	0.0821
time	-0.012977	0.002402	-5.4014	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 *

0.980   0.999   1.017   1.035

---

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 *

0.938   0.951   0.964   0.977

---

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 *

0.924   0.974   1.024   1.075

TABLE 3 Simulation results for sectoral wage index.

PREVISIONE: BRANCHE DI O	ITALIA 17 DEC 1981					SERIES		INDICI DEI SALA		
	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	2.22	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	1.17	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) <u>real side GDP sectors,</u>
(b) <u>nominal side value added components.</u>

(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	17.66
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	12.97	14.94	13.72
IVA SULLA PRODUZION	15.96	16.47	13.37	12.11	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

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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

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[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

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[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:

$$e = f (pe_w, c, dw) \tag{1}$$

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

$$m = f (pm, c, dd) \tag{2}$$

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,

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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 pe_i partly to 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, how- ever, 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 struc- ture.

There are several ways in which capital costs could be taken into consi- deration. 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 com- petitive 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:

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

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

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

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:

$$\cfrac{\cfrac{1}{r} \cdot \cfrac{\sum\limits_i pe_i \cdot exp_i}{\sum\limits_i exp_i} \bigg/ \cfrac{\sum\limits_i pc_i \cdot exp_i}{\sum\limits_i exp_i}}{\cfrac{1}{r} \cdot \cfrac{\sum\limits_i pm_i \cdot imp_i}{\sum\limits_i imp_i} \bigg/ \cfrac{\sum\limits_i pc_i \cdot imp_i}{\sum\limits_i imp_i}}$$

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:

$$\cfrac{\cfrac{1}{r} \cdot \cfrac{\sum\limits_i pe_i \cdot exp_i}{\sum\limits_i exp_i}}{\cfrac{1}{r} \cdot \cfrac{\sum\limits_i pm_i \cdot imp_i}{\sum\limits_i imp_i}} \quad\text{x}\quad \cfrac{\cfrac{\sum\limits_i pc_i \cdot imp_i}{\sum\limits_i imp_i}}{\cfrac{\sum\limits_i pc_i \cdot exp_i}{\sum\limits_i exp_i}}$$

$$\text{price terms of} \qquad\qquad \text{cost terms of}$$
$$\text{trade} \qquad\qquad\qquad \text{trade}$$

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 c o s t 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 able 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 diffe-
rences 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	0.009	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

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

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.

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 im-
portance of machinery in Hungarian exports indicate that demand is more im-
portant 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 pro-
duction 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 Hun-
garian 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.

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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:

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

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 considera-
tion.

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 abscence 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_{ik}^t of this
matrix can be calculated by

$$yd_{ik}^t = y_{ik}^t \cdot (1-mfs_{ik}^t) \tag{4}$$

mfs_{ik}^t 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 interme-
diate 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 de-

mand and the market shares of imports in both final demand <u>and</u>
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 <u>Data</u>

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 tech-
nology.
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 con-
stant 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 avai-
lable 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 <u>Calculating structural factors</u>

The general approach of the study was to calculate hypo-
thetical 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

$$mf^{t*}_{ik} = y^{t}_{ik} \cdot mfs^{b}_{ik} \tag{7}$$

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

$$ad^{t*}_{ij} = a^{t}_{ij} \cdot (1 - mms^{b}_{ij}) \tag{9}$$

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 chang-
ing 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 argu-
ment 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 (cor-
responding to input-output sectors) with estimates for imports
obtained by applying constant import share matrices as dis-
cribed 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

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In general the use of the 1976 import share matrices leads
to an overestimation of the imports in 1970 and to an under-
estimation 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 (com-
modity specific) global import share that can be explained by
the changing composition of demand.
The analysis of commodity specific import shares was limi-
ted 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 concen-
trating on commodity groups with high import shares.

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

| Selected | 1970 | | 1981 | | Share of the structural |
sectors	Obs.	Hyp.	Obs.	Hyp.	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 im-
ported goods shows that for all these sectors the market shares
of imported goods vary significantly across receiving indu-
stries.
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 de-
mand 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 hypo-
thesis was chosen although it is obvious that changes in tech-
nology 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 in-
corporate at least the information available on total output at
constant prices. In order to make use of the observed develop-
ment of total output by industries equation (11) had to be
modified to

$$MM^{t***} = MC^b \cdot X^t \tag{12}$$

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 difficul-
ties 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		1981		Share of the structural factor[b]
	Obs.	Hyp.	Obs.	Hyp.	
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 overestima-
tion of intermediate imports, any overestimation of final de-
mand 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 con-
siderably 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 de-
mand for imports. The empirical analysis indicates that struc-
tural 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 in-
corporation 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.

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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 = MODFIQ(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
C      PART = (SUM -YM)/(1. -A(I,I) +A(I,I)*AM(I,I))
C      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:NYR,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 con-
sider the evolution of various economic aggregates. If we compare consump-
tion and investment in two periods and find that in the earlier one invest-
ments 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 ag-
gregate. 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 invest-
ment process--leads to different merceological patterns in the demand of in-
vestment goods, which in turn stimulates, to a variable degree, the output
level of the respective producing sectors. Thus, the quality of the invest-
ment process, in other words, the quality of a final demand component, repre-
sents 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 re-
ported 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

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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 inter-
national linking structure, but can and should be specific as regards domestic
structural equations, such as those for consumption, investment, labor produc-
tivity, 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 composi-
tion 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 re-
sults 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 avail-
able 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 sec-
ond revision--a significant change in the coding of commodities with less
relevant items being grouped together and others that are growing in import-
ance in international trade being split--defines the commodities trade data
from 1978 to the present. An item-by-item investigation has led to the defi-
nition 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 ag-
gregation 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 adop-
ted (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 prod-
uced, unfortunately only for the most recent years, by ISTAT (Italian Statis-
tical 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 im-
perfect transmission,etc.

3.   THE STRUCTURAL CHANGES

Italian foreign trade is firstly analyzed considering the economic aggre-
gates 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 materi-
al 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 ex-
port performance but with a worsening of the balance of payments which led to
a restrictive economic policy and the subsequent recession in 1977. In gen-
eral, 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 notice-
able 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 prod-
ucts and oil represented 57% of the imports in 1965; at the end of the peri-
od considered their share was reduced to 26%. Consequently, many items
tended to record increasing shares during the period; among the most notice-
able 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 im-
portant, 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 required 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

$$p_t = \Sigma_{r=0}^{R} w_r (p^m_{t-r}/p^d_{t-r})$$

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

$$P_t = \Sigma_{r=0}^{R} w_r (p_{t-r}^E / p_{t-r}^W)$$

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 ELASTICITY ESTIMATE	A PRIORI	CONSTANT(A)	DEMAND(D)	DEMAND ELASTICITY	RHOMEQ	80 IMPORTS
1AGRICULTURE,FOR.,FISHERY	-0.59	-0.50	598.1 (0.10)	0.256 (5.55)	1.14	0.605	268?.
4OIL AND REFINING	-0.50	-0.20	307.6 (9.19)	0.409 (3.72)	1.06	0.532	24735.
7FERROUS NON FERROUS ORES	0.0	-2.00	278.7 (1.19)	0.258 (10.74)	0.92	0.874	7024.
8NON METAL MIN.MIN FROD	0.0	-2.00	421.6 (4.62)	0.196 (10.40)	1.50	0.865	1226.
9CHEMICAL PRODUCTS	1.00	-2.00	1122.1 (9.01)	0.340 (20.07)	1.57	0.969	7577.
11AGRIC.& INDUS.MACHINERY	0.0	-2.00	654.8 (2.50)	0.56 (5.63)	1.66	0.642	4916.
12OFFICE,PRECIS,OPT INSTR.	0.20	-2.00	219.8 (5.08)	0.699 (5.03)	1.11	0.770	3118.
13ELECTRICAL GOODS	0.0	-2.00	1116.7 (4.52)	0.433 (9.46)	1.59	0.859	3951.
14MOTOR VEHICLES	-1.00	-1.00	2095.11 (7.98)	0.668 (12.46)	1.71	0.881	6991.
15OTHER TRANSPORT EQUIPMENT	0.0	-2.00	51.0 (0.09)	0.216 (6.14)	0.99	0.683	1357.
16MEAT	0.55	0.50	511.0 (4.89)	0.202 (16.10)	1.79	0.890	2761.
17MILK AND DAIRY	-0.50	-0.50	152.2 (2.22)	0.339 (11.77)	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)	1.80	0.923	391.
20TOBACCO	0.0	-1.00	535.9 (-5.37)	0.406 (6.04)	4.65	0.691	425.
21TEXTILES & CLOTHING	-1.70	-1.50	2125.3 (-3.53)	0.279 (5.15)	2.32	0.792	3694.
22LEATHER & SHOE	-1.50	-1.50	98.8 (-1.76)	0.147 (4.02)	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	-453.7 (-1.90)	0.157 (11.16)	1.15	0.879	1030.
25RUBBER & PLASTIC PROD.	-1.00	-1.00	-428.0 (6.51)	0.237 (12.08)	1.57	0.911	1287.
26OTHER MANUFACT. PROD.	0.0	-1.50	14.8 (0.28)	0.193 (3.50)	0.95	0.410	87?.

SUMMARY OF TIME EQUATIONS INC(IMPORTS) = A + B*(TIME + CUMULATIVE PRICE

SECTOR	PRICE ELASTICITIES	CONSTANT(A)	TIME (B)	RHORSO	IMPORTS
3COKE	-1.40	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	DEMAND ELASTICITY	RHOBAR	1989 EXPORTS
1 AGRICULTURE,FOR.& FISHERY	0.50	0.50	27.1 (-0.12)	9.170 (3.79)	1.627	0.469	2102.
3 COKE	1.50	0.75	26.2 (2.06)	9.37 (4.51)	1.404	0.484	80.
4 OIL AND REFINING	0.0	2.00	235.4 (0.73)	19.640 (4.49)	0.040	0.384	5576.
7 FERROUS NON FERROUS ORES	0.0	-2.00	818.2 (-1.87)	17.767 (4.04)	1.678	0.474	3208.
8 NON METAL MIN.MIN PROD.	0.0	-2.00	1418.1 (8.02)	12.459 (13.46)	1.886	0.914	3152.
9 CHEMICAL PRODUCTS	0.40	-2.00	101.4 (1.09)	19.534 (19.45)	1.045	0.965	4111.
10 METAL PRODUCTS	2.00	-2.00	-69.8 (-0.38)	15.773 (8.06)	1.037	0.961	4471.
11 AGRIC.& INDUS.MACHINERY	2.00	2.00	2448.1 (-11.21)	58.954 (24.96)	1.503	0.963	19173.
12 OFFICE,PRECIS.OPT INSTR.	0.40	2.00	-430.1 (-3.34)	16.798 (7.81)	1.447	0.817	2348.
13 ELECTRICAL GOODS	0.80	-2.00	914.1 (4.62)	22.787 (10.10)	1.496	0.885	3421.
14 MOTOR VEHICLES	2.00	-2.00	-329.4 (-1.91)	21.453 (12.13)	1.141	0.942	4763.
15 OTHER TRANSPORT EQUIPMENT	0.20	-2.00	-219.2 (-2.35)	7.526 (7.51)	1.329	0.793	1418.
16 MEAT	-0.50	-0.50	-168.4 (5.23)	2.602 (7.50)	2.394	0.757	341.
18 OTHER FOODS	-0.65	0.75	-477.8 (-3.67)	11.908 (8.56)	1.551	0.855	1703.
19 NON ALCOHOL.ALCOHL.BEVERAGES	-1.00	-1.00	-119.5 (-8.10)	2.043 (12.93)	1.997	0.896	277.
21 TEXTILES & CLOTHING	0.0	-1.50	-4309.4 (-6.21)	63.104 (9.25)	2.137	0.833	7547.
23 WOOD & FURNITURE	0.0	-1.00	550.9 (-3.08)	10.412 (5.40)	1.840	0.623	2044.
24 PAPER & PRINTING PROD.	-1.00	-1.00	-464.2 (7.00)	8.524 (12.12)	1.838	0.889	1143.
25 RUBBER & PLASTIC PROD.	-1.00	-1.00	199.2 (2.71)	7.412 (9.34)	1.980	0.844	1305.

SUMMARY OF TIME EQUATIONS   LN(EXPORTS) = A + B*TIME + C*RELATIVE PRICE

SECTOR	PRICE ELASTICITIES	CONSTANT(A)	TIME(B)	RHOBAR-SQ	EXPORTS 1989
22 LEATHER & SHOE	-2.42	0.5 (0.27)	0.175 (5.12)	0.657	41.3.

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.

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APPENDIX

Bridge between NACE-CLIO and SITC classifications before 1977.

NACE.CLIO											STIC									
	11	12	13	14	15	19	251	252	341	342	343	344	350	360	371	372	411	412	421	422
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	2129	2221	2231	2242	2322	2234	2223	2235	2234
	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	2880	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	5052	3352	2665	2666	2667
	2671	2672	2711	2712	2713	2714	5111	5112	5113	5114	5121	5122	5123	5161	5162	5137	5138	5139	5132	5133
	5146	5147	5148	5154	5155	5156	5157	5169	5221	5222	5223	5224	5225	5231	5232	5233	5239	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	5902	5903	5989	6516	6517	6518	6531
	6532	6534	6539	6535	6536	6538	8821	8822												
10	8951	6911	6912	6924	6931	6932	6940	6951	6953	6954	6121	6124	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	7152	7133	7138	7139	7187	7188	7211	7212	7213	7223	7231
	7219	7371	7372	7373	7244	7245	7246	7247	7248	7243	7251	7252	7259	7263	7269	7264	7267	7258	7271	7161
	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	7429	7329	7442	7449	7441	
12	7511	8811	7512	7521	7522	7523	7524	7525	7528	7518	7591	7599	8841	8842	8710	8813	8720	8740	8732	8723
	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	7640	7641	7642	7643
	7751	7752	7754	7757	7758	7741	7742	7781	7782	7761	7762	7763	7764	7768	7783	7788	7784	7631	7638	8943
	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	8111	8113					
17	224	223	230	240																
18	460	470	481	482	483	484	488	582	583	586	589	561	564	565	611	612	615	616	612	639
	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	2615	2631	2632	2633	2634	2640	2651	2652	2654	2655	2659	2690	6130	6541	6543	6549	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	8469
	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	6530	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	5036	5837	5838	5839	2331	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	8990
	8996	8999	9110	9610	9710															

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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	3310	3321	3322	3323	3325	3326	3329												
5	3412	3510	3411																	
6	5151	5153																		
7	2813	6759	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	8429					
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	8721
	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

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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 macro-economic 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).
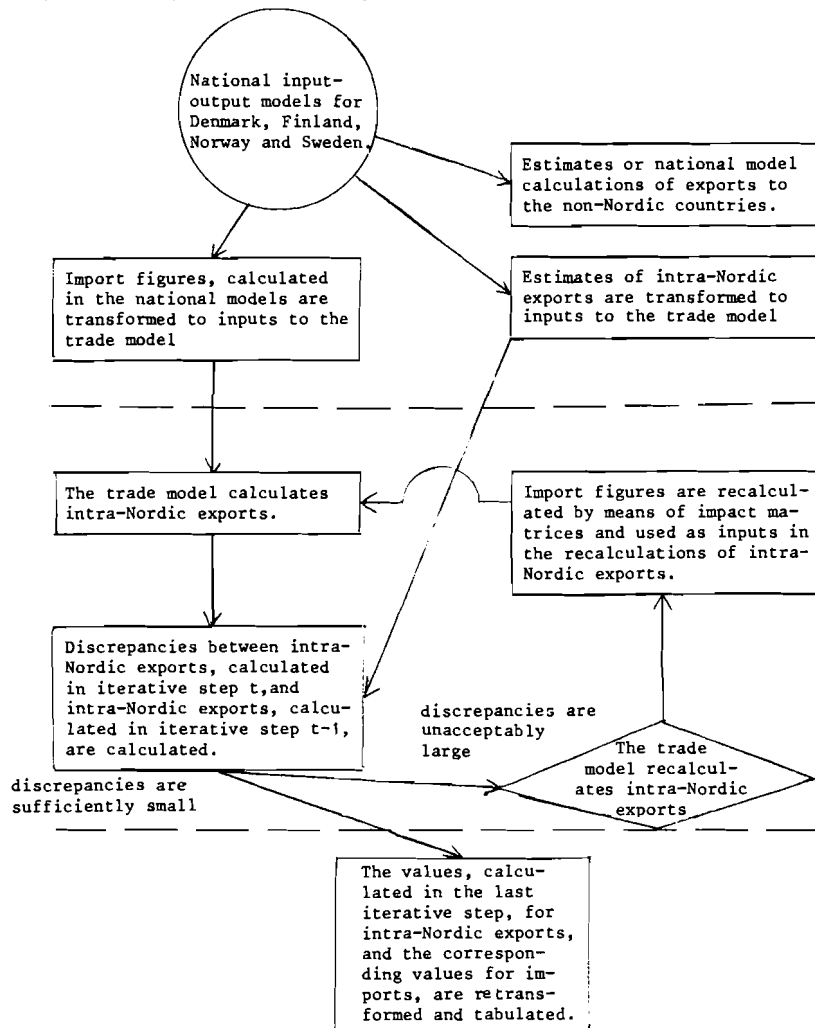
a more comprehensive model system established during the last 5-6 years on
the basis of an initiative made by IIASA (International Institute for Applied
Systems Analysis, Austria) and INFORUM (International Forecasting project,
University of Maryland, USA).

Financially supported by Nordisk Økonomisk Forskningsråd, a <u>first version</u>
of the NORDHAND model system is now established. In the paper at hand, a
technical description of the first version is provided.

3. <u>TECHNICAL DESCRIPTION OF THE NORDHAND MODEL SYSTEM</u>

3.1. <u>A brief outline of the model system</u>

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,

National input-
output models for
Denmark, Finland,
Norway and Sweden.

Estimates or national model
calculations of exports to
the non-Nordic countries.

Import figures, calculated
in the national models are
transformed to inputs to the
trade model

Estimates of intra-Nordic
exports are transformed to
inputs to the trade model

The trade model calculates
intra-Nordic exports.

Import figures are recalcul-
ated by means of impact ma-
trices and used as inputs in
the recalculations of intra-
Nordic exports.

Discrepancies between intra-
Nordic exports, calculated
in iterative step t,and
intra-Nordic exports, calcu-
lated in iterative step t-1,
are calculated.

discrepancies are
unacceptably
large

The trade
model recalcul-
ates intra-Nordic
exports

discrepancies are
sufficiently small

The values, calcu-
lated in the last
iterative step, for
intra-Nordic exports,
and the correspon-
ding values for im-
ports, are retrans-
formed and tabulated.

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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) $\quad X^k \; = \; \Gamma^k \; o \; \underset{l \neq k}{\Sigma} \; (M^{kl} \; o \; \Lambda^{kl} \; o \; B^l) \quad$ [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: $Z = X \; o \; Y$, where X and Y are vectors (of the same order) means that $Z_i = X_i \cdot Y_i$ for all i.

X^k = vector[1] of intra-Nordic exports of NORDHAND-commodities[2] from country k; constant (1980-) prices; US$.

$\lceil^k$ = vector of correction parameters for intra-Nordic exports of NORDHAND-commodities from country k;

$M^{kl}(k \neq 1)$ = vector of market shares by (NORDHAND-) commodity of country k in country l's imports[3].

$\Lambda^{kl}(k \neq 1)$ = vector of parameters for exogenous adjustments of the market shares by (NORDHAND-) commodity of country k in country l's imports;

B^1 = vector of imports of NORDHAND-commodities to country l; constant (1980-) prices; US$.

The parameters for exogenous adjustments, the elements of $\Lambda^{kl}(k \neq 1)$, are initially given by

$$(2) \quad \Lambda^{kl} = e^{4)} \qquad\qquad k \neq 1$$

and is introduced to be able, in a simple way, to adjust the intra-Nordic market shares. Instead of adjusting the elements of $M^{kl}(k \neq 1)$ directly, we substitute the initial values of the elements of $\Lambda^{kl}(k \neq 1)$ by alternative values, different from 1[5].

Given the particular role of $\Lambda^{kl}(k \neq 1)$, (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 $\lceil^k$) 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 $\lceil^k$, 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 classi-fication of the trade model is 36, and in this paper, except where it is explicit stated not to be the case, all vectors are of order (36 · 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 $\Lambda^{kl}(k \neq 1)$.

$$(3) \quad \Gamma^k = X^k(T=0) \text{ o INV } \sum_{l \neq k} (M^{kl} \text{ o } \Lambda^{kl} \text{ o } B^l(T=0)) \quad [1]$$

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

$$(4) \quad X^k_t = \Gamma^k \text{ o } \sum_{l \neq k} (M^{kl} \text{ o } \Lambda^{kl} \text{ o } B^l_{t-1})$$

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:

$$(5) \quad \dot{X}^k_t = \widehat{X^k_{t-1}}^{-1} \cdot (X^k_t - X^k_{t-1})^{[3]}$$

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:

$$(7) \quad B^k_t = (V^k \cdot \dot{X}^k_t + e) \text{ o } B^k_{t-1}$$

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: $Y = \text{INV } X$, 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

$$X^{k}_{t-1} = X^{k}_{o}$$

(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_{ij}^{Ak}, 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):

$$(9) \quad T_{Ak} \cdot e = \tilde{A}_N^k$$

where

$\tilde{A}_N^k$ = exports, from country k, of those components of the commodities of the national model of country k that are classifiable in terms of SITC-commodities[1]; 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.

$$(11) \quad T_{Mk} \cdot e = \tilde{M}_N^k$$

where

$\tilde{M}_N^k$ = 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 matrix[3], the typical element of which, w_{ij}^k, representing

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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

$$A_N^k = \text{exports, from country k, of the commodities of the national model of}$$
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):

$$(16) \quad V^k = \widehat{M^k}^{-1} \cdot T'_{Mk} \cdot U^k \cdot \widehat{\overline{A}^k} \cdot \widehat{A^k}^{-1}$$

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 de-
fined 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) $\quad T_{SAk} \; = \; T'_{Ak} \; \cdot \; \overset{\frown}{INV \; \tilde{A}^k_N} \quad \text{1) 2)}$

(18) $\quad T_{SMk} \; = \; T'_{Mk} \; \cdot \; \overset{\frown}{INV \; \tilde{M}^k_N} \quad \text{3) 4)}$

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 model[5] 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, applies[6]:

(19) $\quad X^k_o \; = \; c^k \cdot T_{SAk} \cdot \bar{\tilde{A}}^k_{No} \quad \text{7)}$

where

c^k = units of US\$ per unit of the national currency of country k; figures for the year under consideration.

$\bar{\tilde{A}}^k_{No}$ = 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, $\overset{\frown}{INV \; \tilde{A}^k_N} = \overset{\frown}{\tilde{A}^k_N}{}^{-1}$. 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 $\overset{\frown}{\tilde{A}^k_N}{}^{-1}$ 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, $\overset{\frown}{INV \; \tilde{M}^k_N} = \overset{\frown}{\tilde{M}^k_N}{}^{-1}$. 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 $\overset{\frown}{\tilde{M}^k_N}{}^{-1}$ 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.

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$\tilde{M}^k_{No}$ = 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 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:

$$(21) \quad \tilde{A}^{k*}_{N(fin)} = \frac{1}{c^k} \cdot (T^{*\Delta}_{SAk})^{-1} \cdot X^{k\Delta}_{(fin)} \quad [4]$$

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

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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 $\tilde{A}^{k*}_{N(fin)}$, 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 $\tilde{A}^k_{N(fin)}$ 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 inter-relations 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].

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1) If the vector $\tilde{M}^{k*}_{N(fin)}$, defined by (22) 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_{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 $(n^{k*} \cdot n^{k*})$, 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 model calculations of imports (<u>not</u> classifiable in terms of SITC) to country k; the commodity classification of the national model of country k.

National input-output models for Denmark, Finland, Norway and Sweden

Estimates or national model calculations of country k's exports to the non-Nordic countries and of intra-Nordic exports (<u>not</u> 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

$$X_t^k = \lceil^k \; o \; \sum_{l \neq k} (M^{kl} \; \bullet \; \Lambda^{kl} \; \bullet \; B_{t-1}^l)$$

where

$\lceil^k$ = 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

$$B_t^k = (v^k \cdot \dot{X}_t^k + e) \; o \; B_{t-1}^k$$

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

$$\dot{X}_t^k = \widehat{X_{t-1}^k}^{-1} \cdot (X_t^k - X_{t-1}^k)$$

$|\dot{X}_t^k| \leqq \epsilon \cdot e$ is not satisfied

The vector X^k is recalculated

$|\dot{X}_t^k| \leqq \epsilon \cdot e$ is satisfied

where ϵ is the acceptability limit for discrepancies.

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.

The vectors $\bar{\bar{A}}^{k*}_{N(fin)}$ and $\bar{\bar{M}}^{k*}_{N(fin)}$ are calculated by

$$\bar{A}^{k*}_{N(fin)} \;=\; \frac{1}{c^k} \cdot (T^{*\Delta}_{SAk})^{-1} \cdot X^{k\Delta}_{(fin)} \quad \text{and}$$

$$\bar{M}^{k*}_{N(fin)} \;=\; \frac{1}{c^k} \cdot (T^{*\Delta}_{SMk})^{-1} \cdot B^{k\Delta}_{(fin)},$$

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 $\bar{A}^{k*}_{N(fin)}$ and $\bar{M}^{k*}_{N(fin)}$ are calculated, the vectors $\bar{A}^k_{N(fin)}$ and $\bar{M}^k_{N(fin)}$ are easily obtained in the way described in section 3.4.

The vectors $\bar{A}^k_{No}$ and $\bar{M}^k_{No}$ are substituted by the vectors $\bar{A}^k_{N(fin)}$ and $\bar{M}^k_{N(fin)}$, 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

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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 <u>first version</u> 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 coun-
tries/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 de-
fines so as to be aggregates of the 119 commodity groups defined in
the IIASA/INFORUM project. The data have in all cases been estab-
lished 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 coun-
tries, 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) fur-
ther 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 transform-
ation 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

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Table 6   The Danish share in the total imports of the other Nordic countries 1970, 1975 and 1981 (based on figures in current prices)

	Finland			Norway			Sweden		
	1970	1975	1981	1970	1975	1981	1970	1975	1981
1	2.39	3.04	3.53	42.27	3.62	4.98	4.60	6.29	7.17
2	8.19	3.90	3.62	43.17	37.79	30.47	37.54	37.13	37.80
3	.07	.02	.02	1.16	5.81	5.12	32.75	33.05	33.76
4	.00	.00	.00	1.47	4.12	1.82	21.43	8.38	2.06
5	.00	.00	.00	9.55	4.30	1.01			6.15
6	.03	.00	.00	.00	.00	.00	.07	.00	.00
7	.92	.72	.71	6.94	7.38	9.76	.37	.01	.02
8	16.72	.00	.00	.00	.00	9.37	64.56	.00	9.30
9	.42	.05	.72	.72	.69	.78	1.83	2.11	1.69
10		13.95							
11	5.74	6.46	9.25	17.21	23.87	22.84	26.05	20.10	14.96
12	5.14	3.42	11.53	15.04	15.16	15.53	17.36	18.85	18.18
13	8.69	3.50	23.94	20.45	13.12	16.67	19.22	10.45	9.47
14	2.78	1.38	13.72	5.81	17.24	3.56	8.67	13.10	6.20
15	8.17	3.45	4.64	22.32	17.39	28.37	18.54	10.80	18.67
16	16.06	3.04	2.03	11.71	8.06	8.45	12.93	10.40	8.42
17	5.07	3.04	1.03	3.33	5.44	1.35	17.75	14.81	7.90
18	4.39	5.03	4.92	18.30	14.56	13.24	22.30	15.38	12.68
19	2.12	1.73	2.71	4.12	3.72	4.27	5.00	3.54	2.81
20	3.05	3.04	2.68	2.47	3.08	4.92	30.80	3.07	3.85
21	5.08	4.84	4.57	13.02	14.21	12.40	0.80	14.06	11.69
22	5.71	2.75	2.32	14.97	7.84	6.95	11.98	14.38	12.80
23	.43	.98	1.33	3.61	2.53	3.18	2.76	4.62	5.83
24	.90	1.92	4.24	2.02	2.72	3.77	1.62	1.41	2.43
25	3.86	1.08	4.92	8.79	6.63	7.86	7.62	6.39	7.26
26	4.50	4.21	4.03	7.17	6.53	5.29	8.61	6.32	5.92
27	.50	.49	.51	.62	1.64	1.65	1.26	1.13	1.68
28	8.95	3.39	.60	3.11	5.74	1.94	4.67	3.50	6.24
29	.92	1.24	.78	1.11	5.98	3.26	7.45	11.52	5.71
30	3.34	1.20	3.61	13.40	12.23	3.35	3.03	7.89	
31	9.29	14.03	9.82	13.90					
36	.00	.00	.56	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		
Exporting country:	1970	1975	1981	1970	1975	1981	1970	1975	1981	1970	1975	1981
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		
Importing country:	1970	1975	1981	1970	1975	1981	1970	1975	1981	1970	1975	1981
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 be-
tween 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 pro-
ducts. 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

$$PXk = PXk(\frac{1}{Ek}, \bar{P}Xk, QXk; CXk) \tag{1.1a}$$

(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).
$\overline{P}Xk$ is a weighted average of the competing countries export unit prices for
the given good measured in the numeraire currency:

$$\overline{P}Xk = \sum_{l \neq k} \beta_l PXl \qquad\qquad (1.1.b)$$

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. $\overline{P}$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. $\overline{P}$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.

  The demand for imports is determined in two steps. This approach pre-
supposes 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.

  In the first step 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:

$$SMlk = SMlk(\hat{PM}l1,\ldots,\hat{PM}lL) \qquad (1 \neq k) \qquad (1.2')$$

Here "$\hat{}$" 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:

$$SMlk = SMlk(\hat{PM}l1/El, \ldots ,\hat{PM}lL/El)$$

$$= SMlk(\underset{\neq}{PM}l1, \ldots , \underset{\neq}{PM}lL) \qquad (1 \neq k) \qquad (1.2)$$

  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:

$$\sum_{k \neq 1} SMlk = 1 \qquad\qquad (1.3)$$

  In the second step 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 (PM1) for the good:

$$M1 = M1(D1,PH1/PM1)$$
$${+}{+}$$
$$\text{(1.4)}$$

The index of import prices for each good is defined as a function of all prices of imports of the good from different countries:

$$PM1 = PM1(PM11,...,PM1L) \qquad\qquad (1.5)$$
$${+}{+}$$

Total imports of the good to country 1 from country k (M1k) is given by

$$M1K = SM1k \cdot M1 \qquad\qquad (1 \neq k) \qquad (1.6)$$

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:

$$Xk = \underset{1 \neq k}{\Sigma}\ M1k \qquad\qquad\qquad (1.7)$$

The model is completed by assuming a relation between the unit price of imports to country 1 from country k (PM1k) and the unit price of exports from country k(PXk):

$$PM1k = PM1k(PXk) \qquad\qquad (1 \neq k) \qquad (1.8)$$
$${+}$$

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
PXk	– Weigthed average of unit prices of eksports from countries competing with country k on the export market	L
SM1k	– Country k's share of country 1's import	L(L-1)
PM1k	– Price per unit of imports to country 1 from country k	L(L-1)
M1	– Volume of total imports to country 1	L
PM1	– Index of unit prices for imports to country 1	L
M1k	– Volume of imports to country 1 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
D1	– Volume of domestic demand in country 1	L
PH1	– Unit price of domestic production delivered to the domestic market in country 1	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 M1k(1=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:

$$PMlk = \theta^{lk} \cdot PXk \qquad\qquad (l \neq k) \qquad\qquad (2.1.a)$$

where - l=D,F,N,S
      - k=D,F,N,S,W

Combining (2.1.a) and (1.2) gives

$$SMlk = SMlk(\theta^{l1}PX1,\ldots,\theta^{lL}PXL) \qquad\qquad (l \neq k) \qquad\qquad (2.1.b)$$

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 re-sidually determined by using the condition that market shares must sum to one:

$$SMlW = 1 - \sum_{k \neq 1} SMlk \qquad\qquad (2.1.c)$$

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:

$$Xk^N = \sum_1 SM1k \cdot M1 \qquad (3.1)$$

where $1,k = D,F,N,S$

$$SM1k = SM1k^*(PX1,\ldots,PXL) \qquad (1 \neq k) \qquad (3.2)$$

where $1,k = D,F,N,S$

$$SM1W = 1 - \sum_{k \neq 1} SM1k \qquad (3.3)$$

where $1,k = D,F,N,S$

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
SM1k – Country k's share of country l's imports (1≠k) (k=D,F,N,S,W and 1=D,F,N,S)	16

Exogenous variables:

M1	– Volume of total imports to country 1 (1=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):

$$PXk = PXk(\frac{1}{Ek}, \bar{PX}k, QXk; CXk) \qquad (3.4)$$

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):

$$\epsilon PX^k = \begin{cases} 0 \text{ no effect} \\ -1 \text{ full effect} \end{cases} \quad (3.5)$$

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).

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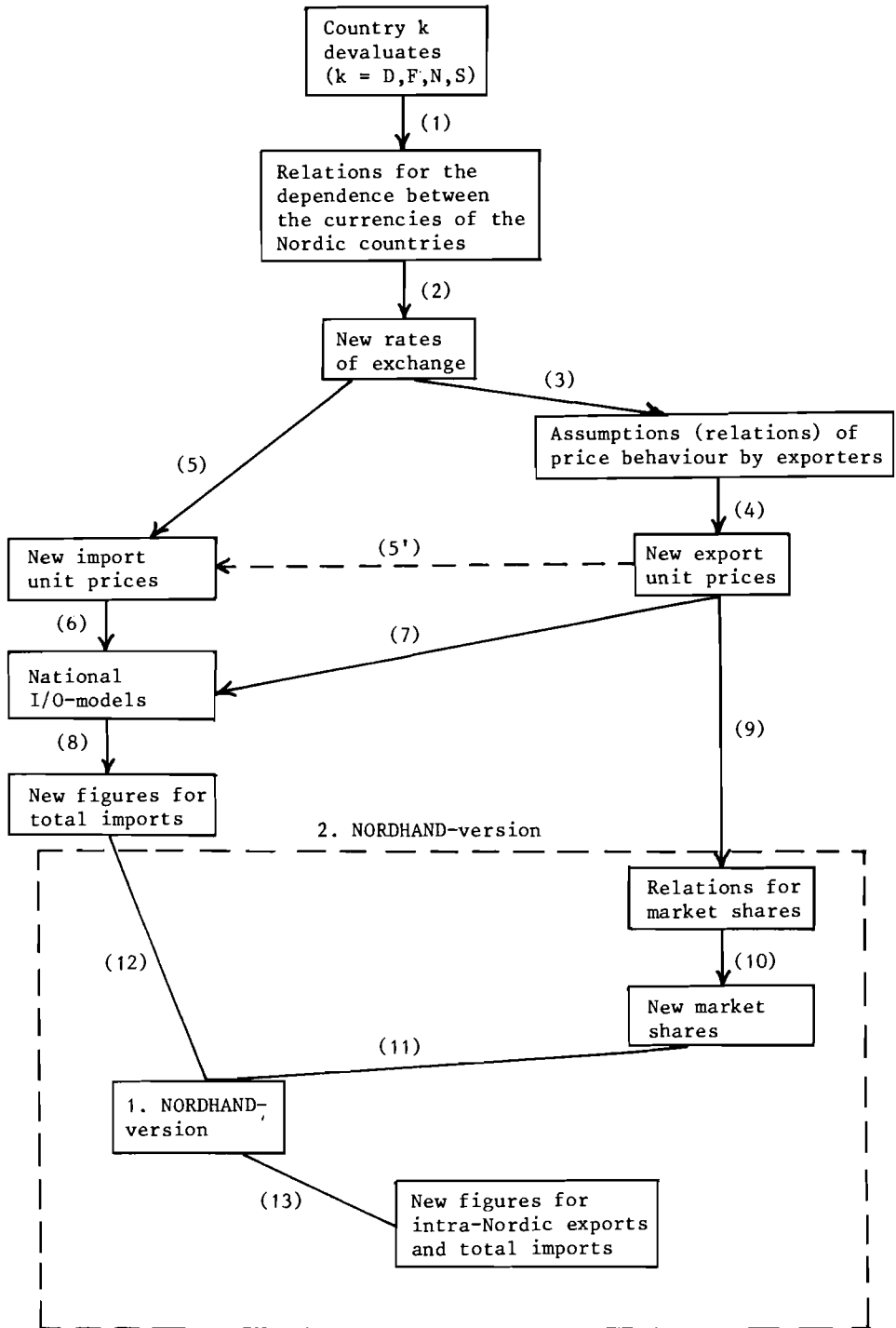
EFFECTS OF A SWEDISH DEVALUATION ON TRADE AND PRODUCTION IN THE NORDIC COUNTRIES: CALCULATIONS USING THE NORDHAND MODEL SYSTEM

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 <u>some</u> increase in Swedish profit margins, limiting the rise in relative <u>import</u> 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 mark-

et, 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 <u>less</u> 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.

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,...,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:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log(\bar{x}/p) \tag{2.1}$$

where P is the price index defined by

$$\log P = \alpha_0 + \sum \alpha_k \log p_k + \tfrac{1}{2}\sum_k\sum_\ell \gamma_{k\ell} \log p_k \log p_\ell \tag{2.2}$$

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:

$$\frac{e_{jM}^C}{x_j^M} = f^M\left(\frac{s_{kj}^C}{\sum_{C'} w_{C'M} \cdot s_{kj}^{C'}} \; ; \; \bar{x}_j^M\right) \tag{2.3}$$

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 $w_{C'M}$).

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[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:

$$w_{CM}^i = \alpha_i + \sum_k \sum_{C'} \gamma_{CC'}^k \log S_C^k + \beta_C \log (X_i^M / P_i^M)$$ (2.4)

where k represents the kth 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

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[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.

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procedure[4] total sales by each of the competing producers in the different markets.

i.e. $y_{iM}^C = w_{CM}^i \cdot x_M^i$ (2.5)

and total sales in all markets determines total sales of industry i

$y_i^C = \sum_M w_{CM}^i \cdot x_M^i$ (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.

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[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

$$w_{CM}^{i} = \alpha_C + \beta_C \log(\frac{\bar{x}}{P^*}) + \sum_k \gamma_{CC'}^{k} \log \frac{s_{Ci}^{k}}{\sum_{C'} w_{C'} s_{C'i}^{k}} \qquad (3.1)$$

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).

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[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 compet-
itiveness (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).

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*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

regressors:	Fed. Rep. Germ.			France		
	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   F.R.G.

	YT	LUR	XR	Interc.	$\bar{R}^2$	DW
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

	YT	LUR	XR	Interc.	$\bar{R}^2$	DW
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 (4.1)	−.068 (9.5)	−.778 (5.3)	.466 (4.0)	.982	3.1
5. Minerals	−.088 (1.5)	−.066 (3.3)	−.421 (2.0)	.912 (1.6)	.974	1.3
6. Chemicals	−.07 (4.5)	−.034 (7.0)	−.152 (1.5)	.774 (4.8)	.930	2.5
7. Metal Pds.	−.079 (3.3)	−.044 (5.0)	−.135 (2.2)	.779 (3.4)	.993	2.7
8. Mach.	−.115 (10.1)	−.517 (9.9)	−	1.08 (10.2)	.995	2.4
9. Office Mach.	−.123 (3.8)	−.046 (3.6)	−.069 (.598)	1.06 (3.9)	.839	2.2
10. Electr. Gds.	−.068 (3.7)	−.041 (6.1)	−.083 (1.2)	.662 (3.8)	.992	2.0
11. Transp. Eqn.	−.057 (3.1)	−.023 (2.6)	−	.576 (3.2)	.962	2.2
12. Food, Dr., T.	−.078 (2.4)	−.052 (5.8)	−.398 (5.8)	.85 (2.6)	.940	2.1
13. Text., Cl., L.	−.048 (.31)	−.094 (1.6)	−.581 (1.1)	.492 (.31)	.970	1.3
14. Paper & Print.	−.058 (1.5)	−.550 (3.5)	−.409 (3.7)	.593 (1.6)	.970	2.6
15. Rubber & Plant.	−.068 (2.8)	−.048 (7.2)	−.179 (2.0)	.678 (3.2)	.982	2.0
16. Other Manuf.	−.125 (2.0)	−.089 (4.4)	−.491 (2.3)	1.28 (2.1)	.976	1.6

U.K.

	YT	LUR	XR	Interc.	$\bar{R}^2$	DW
4. Metals	−.048 (3.0)	−.02 (3.3)	−	.544 (3.0)	.880	2.1
5. Minerals	−.056 (1.8)	−.045 (5.5)	−.222 (3.6)	.568 (1.9)	.955	1.8
6. Chemicals	−.054 (.94)	−.036 (2.8)	−.276 (.78)	.609 (.96)	.857	1.0
7. Metal Pds.	−.014 (.28)	−.028 (1.9)	−.230 (3.9)	.177 (.38)	.903	2.2
8. Mach.	−.015 (.26)	−.048 (2.4)	−.563 (4.4)	.213 (.44)	.822	2.4
9. Office Mach.	−.35 (5.8)	−.138 (7.0)	−.397 (6.4)	2.99 (6.1)	.895	1.6
10. Electr. Gds.	−.04 (.626)	−.042 (2.5)	−.363 (3.1)	.437 (.74)	.795	2.7
11. Transp. Eqn.	−.039 (.34)	−.028 (.59)	−.364 (1.9)	.541 (.526)	.169	1.6
12. Food, Dr., T.	+.013 (.466)	+.011 (3.9)	−.353 (3.0)	.148 (.44)	.758	1.5
13. Text., Cl., L.	−.044 (1.0)	−.028 (1.95)	−.218 (3.4)	.52 (1.3)	.631	2.0
14. Paper & Print.	−.159 (8.2)	−.075 (11.6)	−.332 (9.0)	1.6 (9.1)	.963	2.5
15. Rubber & Plant.	−.05 (1.4)	−.038 (3.6)	−	.475 (1.4)	.985	1.5
16. Other Manuf.	−.076 (5.1)	−.045 (11.1)	−.24 (6.6)	.774 (5.6)	.961	2.1

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 indus-
tries 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 absorp-
tions 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.

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[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.

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[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.

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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

$$y_t = (I-A)X_t \qquad\qquad (1)$$

where: $y_t = \left[y_{it}\right]$ is a vector of final output,

$X_t = \left[X_{it}\right]$ is a vector of gross output,

$A_t = \left[a_{ijt}\right]$ 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 $\left\{a_{ijt}\right\}$ 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.

$$d_{ij}^{(1)} = a_{ij} = \frac{X_{ij}}{X_j} \quad , \tag{2}$$

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

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[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.

$$d_{ij}^{(2)} = \frac{X_{ij}}{\sum_i X_{ij}} = a_{ij} \frac{X_j}{\sum_i X_{ij}} \ , \qquad (3)$$

$$d_{ij}^{(3)} = h_{ij} = \frac{X_{ij}}{X_i} = a_{ij} \frac{X_j}{X_i} \ , \qquad (4)$$

$$d_{ij}^{(4)} = a_{ij} \frac{X_j}{\sum_j X_{ij}} \qquad (5)$$

can be also considered with some generalization of these measures

$$d_{ij}^{(5)} = \sqrt{a_{ij} h_{ij}} \ = \frac{X_{ij}}{\sqrt{X_i X_j}} \ , \qquad (6)$$

$$d_{ij}^{(6)} = \frac{X_{ij}}{\sqrt{\sum_i X_{ij} \sum_j X_{ij}}} \ . \qquad (7)$$

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

$$a_{ij} = f_{a_{ij}}(t) \ .$$

The measure of importance of coefficients could be the derivative of this function in point $t = T$ /T - forecasting period/

$$d_{ij}^{(7)} = \frac{df_{a_{ij}}(t)}{dt} \ . \qquad (8)$$

Taking into account the results of the application of the other measures of importance it seems possible to consider as a

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[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, $m = n \times n$ - the number of elements of matrix A.
The sum of ranks obtained by a given element with respect to all criteria, i.e.

$$R_i = \sum_{k=1}^{K} R_i^{k} \qquad\qquad i = 1, \ldots, m. \tag{10}$$

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.
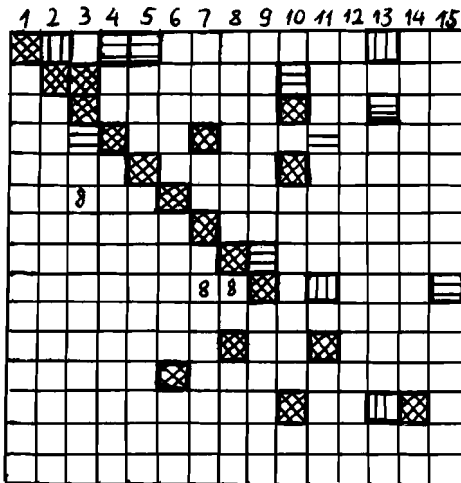
FIGURE 1   Important coefficients
1971
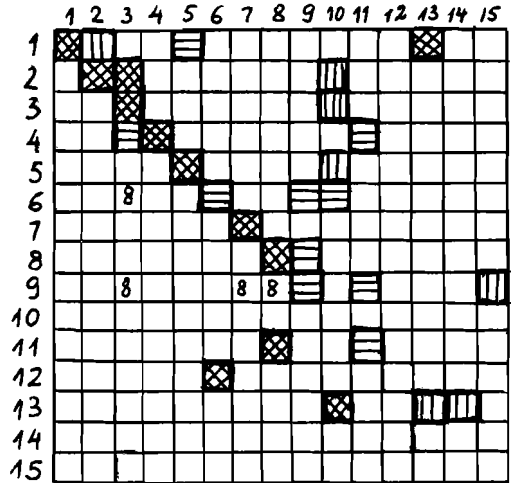
FIGURE 2 Important coefficients
1975

[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.
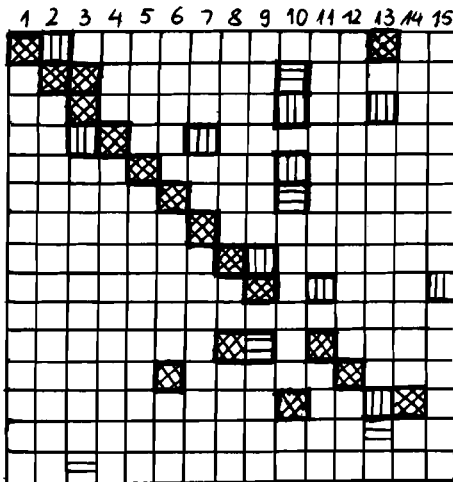
FIGURE 3 Important coeffi-
cients 1980
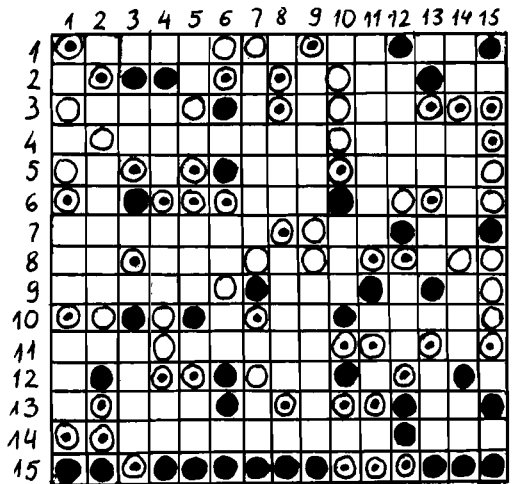
FIGURE 4 Trends of coeffi-
cients

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 $(1,0.9\rangle$, ◉ – in the interval $(0.9,0.8\rangle$, ○ – in the range $(0.8,0.7\rangle$.

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 de- voted especially to the analysis of trend functions of coeffi- cients.

Analysing Figures 1, 2, 3 it can be concluded that the most important coefficients are placed first of all on the main dia- gonal /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 co- efficients 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 coef-
ficients.

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 estima-
tion 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 $\qquad a_{ijt} = \alpha_0 + \alpha_1 t,$

II/2 $\qquad a_{ijt} = \alpha_0 + \alpha_1 t + \alpha_2 t^2,$

III/3 $\qquad \ln a_{ijt} = \alpha_0 + \alpha_1 t,$

IV/4-6 $\qquad \ln a_{ijt} = \alpha_0 + \alpha_1/(t+\vartheta),$

V/7-9 $\qquad \ln a_{ijt} = \alpha_0 + \alpha_1 \ln(t+\vartheta),$

VI/10-12 $\qquad \ln a_{ijt} = \alpha_0 + \alpha_1/(t+\vartheta) + \alpha_2 \ln(t+\vartheta),$

$$\vartheta = 0, 5, 10.$$

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 deter-
mination 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 characteri-
zed 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 coeffi-
cients 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 ob-
served 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 (0.8,0.7)	
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^2 value /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 ten-
dency to change in time. To determine the scale and tendency of
these changes the above-mentioned measure of changes being sup-
plementary 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 adjust-
ment of coefficients are the techniques based on some base mat-
rix 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 bi-
proportional RAS-type methods and techniques of mathematical
programming. In the case when many input-output tables are avail-
able, 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 eco-
nometric forecasting techniques based on trend functions /or re-
gression 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 re-
lation 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 me-
thods of forecasting the input-output coefficients and especial-
ly 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 applica-

tion 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.

$$A = RA^O S,$$

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

$$\sum_{j=1}^{n} r_i a_{ij} s_j = a_{i.} \; ,$$

$$\sum_{i=1}^{n} r_i a_{ij}^O s_j = a_{.j} \; .$$

The values of $a_{i.}$ and $a_{.j}$ being the sums in rows and columns of

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[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]

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5 The adaptation of SLIMFORP/INFORUM system to computers in Poland is led by Dr.A.Tomszewicz, 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.

$$\Sigma_j x_{ij}(t)\left|\ln(a_{ij}(0)/a_{ij}(t))\right|/\Sigma_j x_{ij}(t) \qquad (2)$$

$$\Sigma_i a_{ij}(t)\left|\ln(a_{ij}(0)/a_{ij}(t))\right|/\Sigma_i a_{ij}(t) \qquad (3)$$

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.

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[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: $[E(t) - E(0)]B(t)y(t)$ $(7d)$

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[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 corre-
lation between causes exists, the effects of different causes are hard to
indentify from empiral data. The size of input coefficient may be deter-
mined by the following function (Forssell, 1972).

$$a_{ij}(t) = f_{ij}(K_j, L_j, M_j, N_j, u_{ij}) \tag{8}^5$$

Substituting this equation for the input coefficients in an open static
input-output model gives the following model

$$x_i(t) = \Sigma_j f_{ij}(K_j, L_j, M_j, N_j, u_{ij})x_j(t) + y_i(t) \qquad (i=1, \ldots, n) \tag{9}$$

The parameters of these equations could be estimated by simultaneous esti-
mation 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 esti-
mation. 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 change %	1956-coefficients			1959-coefficients		1963-coefficients
	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 coeffi-
cients are remarkable. Relative changes of small coefficients are greater
than changes of great coefficients.

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[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:

$$(\text{median})^2 = 0,0074t^{0,8} \tag{10}$$

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 diffe-
rent 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 commo-
dity-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 conc-
luded that about two thrids of the explained dispersion of input coeffi-
cients 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/0-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		the average error	
	all the coefficients changed	22 coeffi- cients constant	all the coefficient changed	22 coeffi¬ cients 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 remar-
kably 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 tech- nology	+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.

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These causes of changes in input coefficients were analysed for 21 manu-facturing industries[6] related to forestry sector 1954-1965 (Forssell, 1972).

The correlation between input coefficients and the share of the princi-pal 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 coeffi-cients 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 in-puts. 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 coeffi-cients concerns first of all technological development which is closely related to expected changes of relative prices. Both causes have substi-tution effects among inputs. Time-paths of substitution processes due to tehnological development trends are then central research objects in the furure.

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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

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[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:

$$v_i(t) = \sum_j v_{ij}(t) \tag{1}$$

The total output of the industry is given as

$$q_i(t) = \sum_j q_{ij}(t) \tag{2}$$

Thus, a commodity-related input coefficient can be defined as

$$a_{ij}(t) = \frac{v_{ij}(t)}{q_{ij}(t)} \tag{3}$$

With given product-mix coefficients

$$c_{ij}(t) = \frac{q_{ij}(t)}{\sum_j q_{ij}(t)} \tag{4}$$

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]:

$$\text{Model 1:} \quad b_i(t) = \sum_j a_{ij}(t) \cdot c_{ij}(t) \tag{5}$$

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]:

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[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

$$a_{ij}(t) = a_{ij}(0) \cdot \exp(r_i \cdot t) \qquad (t = 1, 2, \ldots, 17) \qquad (6)$$

and

$$\text{Model 2:} \quad b_i(t) = \sum_j c_{ij}(t) \cdot a_{ij}(0) \cdot \exp(r_i \cdot t) \qquad (7)$$

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.

$$\beta_i^*(t) = (c_{11}(1)\alpha_{11} + (1-c_{11}(1)\alpha_{12})) \exp(r \cdot t) \tag{8}$$

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:

$$\Delta\beta_i = [\beta(1) - \beta^*(t)] + [\beta^*(t) - \beta(t)] \tag{9}$$

$$\underbrace{\quad\quad\quad\quad}_{\text{technology effect}} \quad \underbrace{\quad\quad\quad\quad}_{\text{product-mix effect}}$$

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

$$b_i(t) = p_i(t)^{\gamma_i} (c_{i1}(t) \cdot \alpha_{i1} + (1-c_{i1}(t))\alpha_{i2}) + \varepsilon_i(t)$$

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

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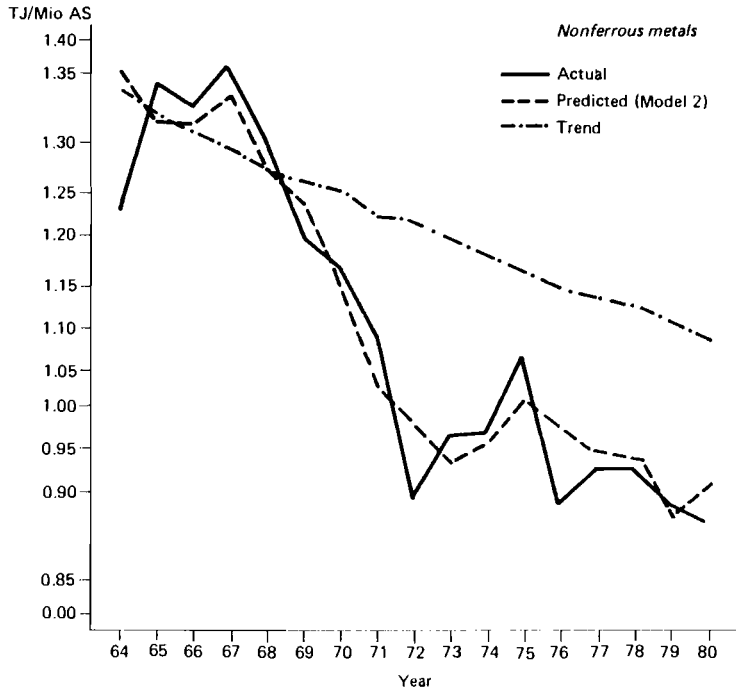[1] For an extended analysis the use of real prices instead of nominal prices should be considered.
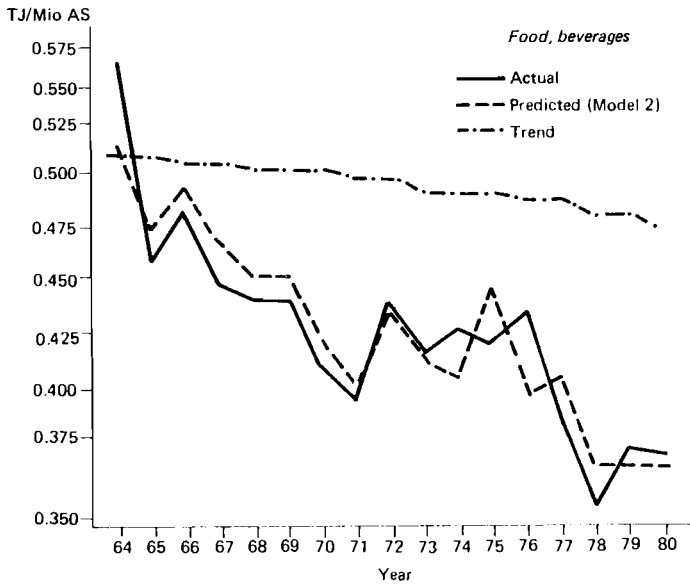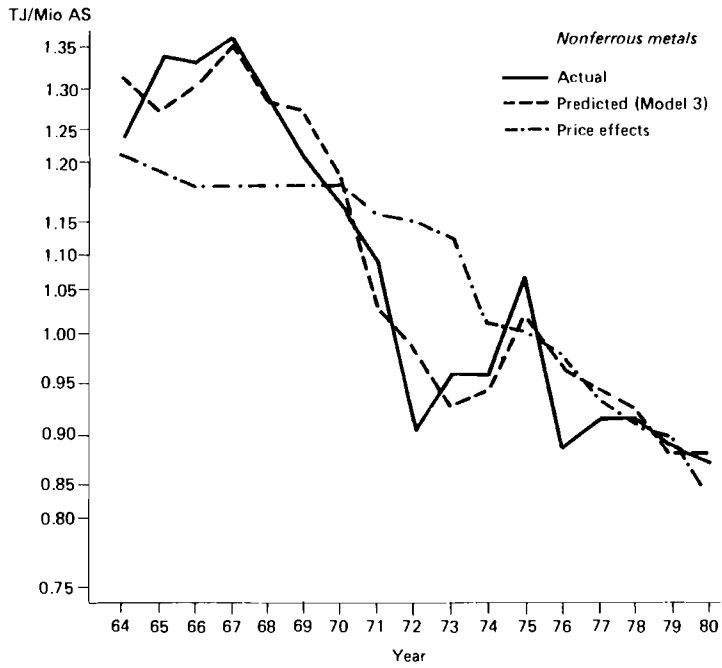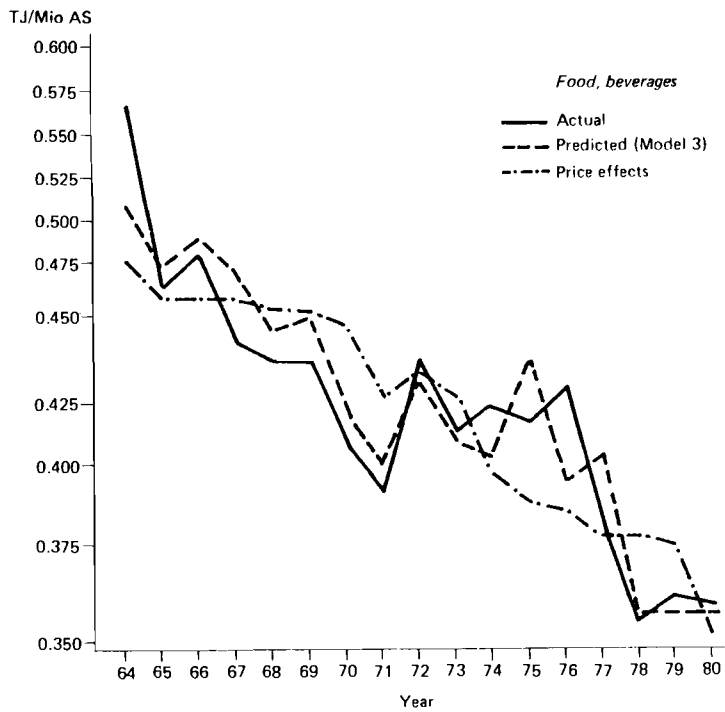
FIGURE 1

FIGURE 2

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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.

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APPENDIX

Table A1 Model 1: $b_i = \sum\limits_{i} c_{ij} \cdot a_{ij}$.

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: $b_i(t) = \sum\limits_{j} c_{ij}(t) \cdot a_{ij}(0) \cdot \exp(r_i \cdot t)$.

Industry	Commodity	Estimate[a] $a_{ij}(0)$ (TJ/Million AS)		r_i		R^2
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)		
	Rest of output incl. bricks	0.13 (1.8)	−0.21 (0.09)	0.997
Pulp, paper	Pulp	4.1 (0.36)		
	Paper	1.8 (0.16)	−0.14 (0.03)	0.999
Nonferrous metals	Nonferrous metals (electrolytic)	3.15 (0.25)		
	Other output	0.05 (0.16)	−0.31 (0.12)	0.997
Chemicals	Fertilizers, rubber products, basic chemicals	3.08 (1.01)		
	Rest of output	0.60 (0.65)	−0.85 (0.28)	0.980
Food, beverages, tobacco	Sugar, beer	2.29 (0.41)		
	Rest of output	0.06 (0.09)	−0.03 (0.06)	0.998

[a] Standard errors in parentheses.

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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 – to-
gether 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 count-
ries: 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 con-
sequences 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 inten-
  sity
- to restructure the national production to achieve lower ener-
  gy 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 produc-
tion has consequently got into the center of the general in-
terest in the analizing and internationally comparing the de-
velopment of the economy for the present time and for the fu-
ture 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 mul-
tiplied 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

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the different energy intensities of the industry branches (pro-
ducts) can and has to be evaluated only on the level of the na-
tional 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 in-
tensity itself - low or high - alone doesn't give the possibi-
lity to decide how to develop the economy in the future.)
        This study deals still only with the different energy in-
tensity 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 cor-
rect meaning and using of the energy intensity factors detai-
led 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 conver-
sions'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),
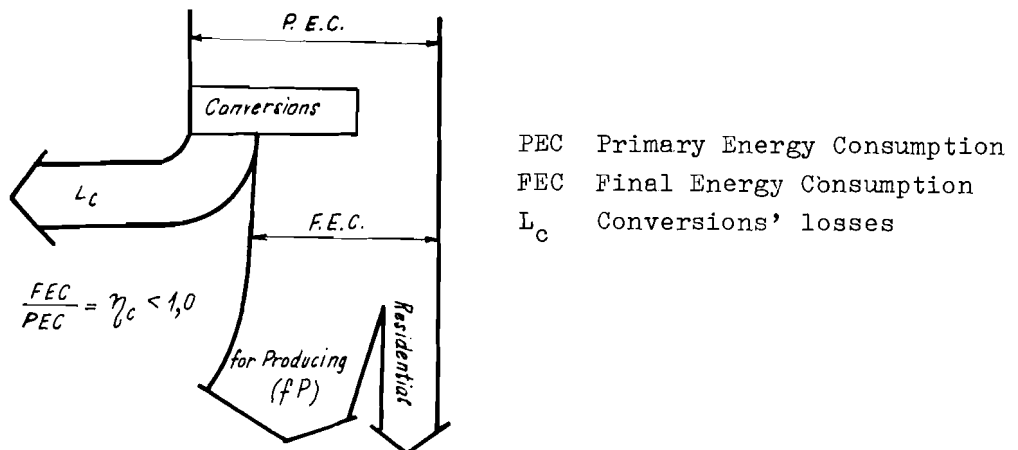without the residential consumption.

$$\frac{FEC}{PEC} = \eta_c < 1,0$$

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

$$E = P \cdot e_a = \sum_i P_i \cdot e_i = P \cdot \sum_i s_i \cdot e_i \qquad\qquad s_i = P_i/P$$

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 <u>E energy consumption depends at the same time on the quantity and the structure of the P production</u>. 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, <u>we can be constrained to analize only the structure of the industry</u>. 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 <u>how to ensure the consistency between energetics and economy</u>, 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.
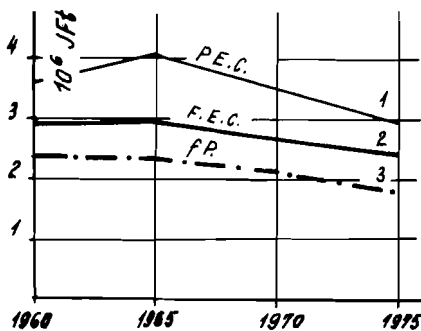
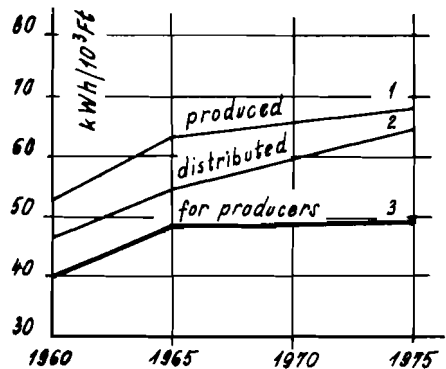FIGURE 2   Global energy intensity factors

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.
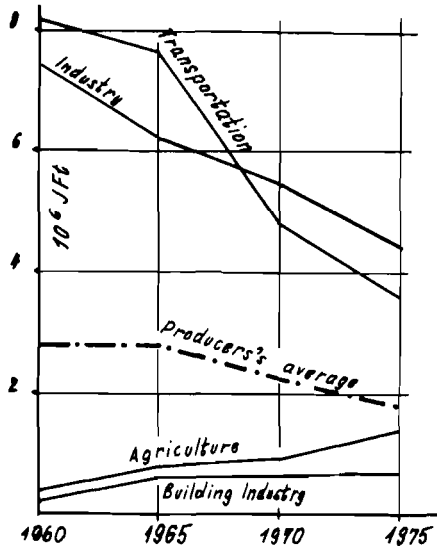
FIGURE 4   Intensity of sec-
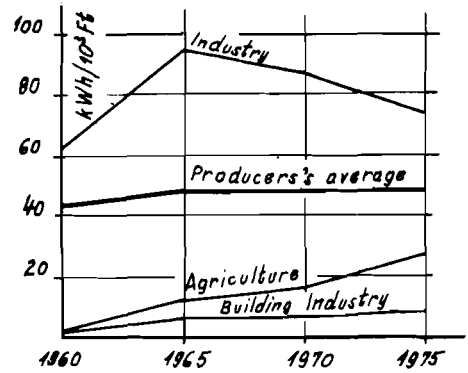   tors

FIGURE 5   Electric intensity
             of sectors

However, these sectors are not homogeneous from the as-
pect 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 grea-
ter details, more and more homogeneous grouping.
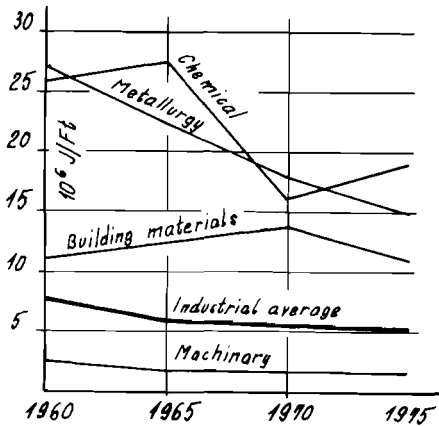
FIGURE 6   Intensity of bran-
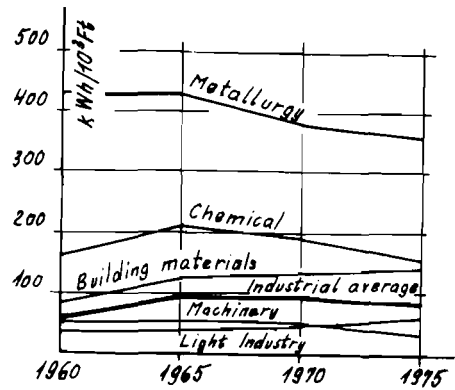   ches

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)
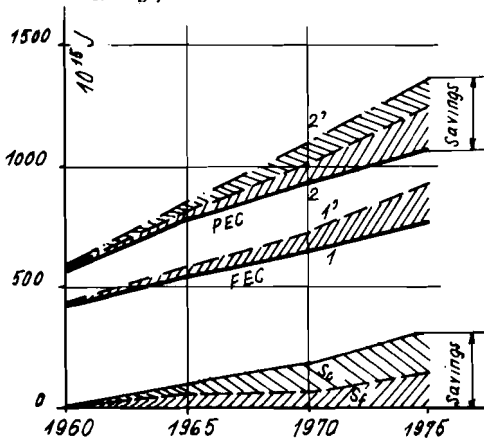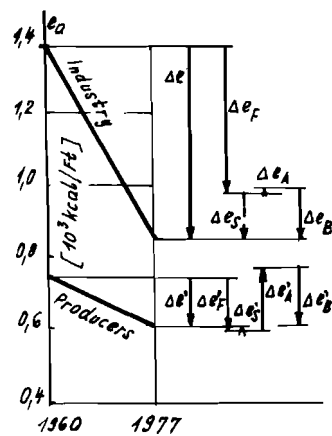

FIGURE 8   Shaping of FEC and PEC

FIGURE 9   Changes of energy intensity

On the base of the diagram it may be expressed for the past in-
vestigated 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 ($\triangle e_A \cong 0$)
- concerning the whole economy, the rate of the industrial
  production increased, this situation increased the global
  energy intensity factor (the arrow of the $\triangle e_A^*$ goes upwards)
- the internal structure change of the investigated industry
  branches ($\triangle e_B$) has essential effect onto the e_a change.

<u>Other types of energy intensity factors</u> (related to va-
lue). 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.

<u>Energy intensity of smaller producing units</u>. The investi-
gated industry branches are not homogeneous. That means that
the smaller units inside them are of different energy intensi-
ties, 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 spe-
cific 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 va-
lues. 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 respec-
tively 0,30-0,90 Ft/Ft output.
It has to be emphasized that these values will deteriorate (in-
rease) in the future because of further rise of energy prices
in the CMEA countries towards the world market prices. Therefo-
re 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 con-
tent 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 diffe-

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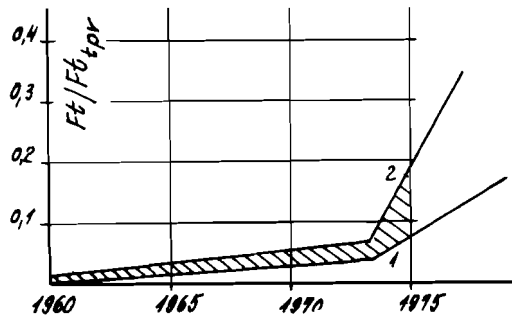rent for the branches in function of their energy intensity.

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 measu-
ring the energy intensity of the branches. These new factors of
Ft energy/Ft branch have the meaning how much additional ener-
getical 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-deve-
lopment. By the formula, the condition is expressed - summari-
zing 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 ge-
neral 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

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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 cal-
culate only the direct connections instead of using complica-
ted models, which have to be worked out in the most cases in
the future.

4.5. Elasticity Factors

     The fundamental relationships between E energy consump-
tion and P production - explained in the Chapter 3.2. - are
valid in the case of growth of E and P parameters i.e. for
$\triangle$ E and $\triangle$ P. It means that the connection between $\triangle$ E and $\triangle$ P
is created by the energy intensity of the $\triangle$ P production
growth structure. Therefore the growth rates and also the va-
lue of r = ($\triangle$ E/E):($\triangle$ P/P) elasticity factors depend on the
production structures of P and $\triangle$ P, i.e. on the energy inten-
sity 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 ca-
se often occurs internationally too. Table 6 shows approxima-
tely both elasticity factors between 1960-1982 in 5-years pe-
riods (national in PEC, the other in FEC). Because of the
specialities of the years after 1980 it has no sense to calcu-
late the factors to those years. Still the effects of these
extraordinary events can be evaluated by comparing the r fac-
tors of 1975-1982 to those of 1975-1980.

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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 calcu-

lated 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 establish-
ment 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 tra-
ditional 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 consump-
tion 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 tech-
nology that involves only goods and services produced in Denmark (en-
dogeneous 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 possi-
ble 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 im-
ports (i.e. the import matrix is separated out)

1) $x=(I-A)^{-1} \cdot D \cdot d$

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 con-
tains the proportions delivered from industries into each category of
final demand.
d is a column vector for the absolute level of final demand by cate-
gory.

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) $e \times x = e \times ((I-A)^{-1} \cdot D \cdot d)$

where e is a vector for the energy consumption per unit of output.

The symbol $\times$ denotes element multiplication whereas $\cdot$ 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) $e_t \times x_t - e_{t-1} \times x_{t-1} = e_t \times ((I-A)_t^{-1} \cdot D_t \cdot d_t) - e_{t-1} \times ((I-A)_{t-1}^{-1} \cdot D_{t-1} \cdot d_{t-1})$

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: $e_t \times ((I-A)_t^{-1} \cdot D_{t-1} \cdot d_{t-1}) - e_{t-1} \times ((I-A)_{t-1}^{-1} \cdot D_{t-1} \cdot d_{t-1})$

5) Demand: $e_t \times ((I-A)_t^{-1} \cdot (D_t \cdot d_t - D_{t-1} \cdot d_{t-1}))$

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: $e_t \times ((I-A)_t^{-1} - (I-A)_{t-1}^{-1}) \cdot D_{t-1} \cdot d_{t-1}$

Changes in energy-coefficient $(e_t - e_{t-1}) \times ((I-A)_{t-1}^{-1} \cdot D_{t-1} \cdot d_{t-1})$

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) $\quad e_t \times (I-A)_t^{-1} \cdot (D_t \cdot (d_t + d^{\ast} - d^{\ast}) - D_{t-1} \cdot d_{t-1})$

6) can be split into 2 components:

Changes in the composition of final demand: $e_t \times ((I-A)_t^{-1} (D_t \cdot d^{\ast} - D_{t-1} d_{t-1}))$

Changes in the level of final demand $\quad : e_t \times ((I-A)_t^{-1} \cdot (D_t \cdot d_t - D_t \cdot d^{\ast}))$

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 compo-
nent 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.

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TABLE 3   Changes in industrial energy consumption 1966-79 (TJ)

| | DEMAND | | | TECHNOLOGY | | | Indu-strial struc-ture | Total change |
	Total	Compo-sition	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		Total	TECHNOLOGY		Total change
	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	20018	-1121	3140	804	282	522	2823
18 TRANSPORT AND STORAGE	26942	-2299	24643	2788	-2739	5528	29730
19 COMMUNICATION	22384	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	-1431	-72	-1203	815
24 RECREATIONAL AND CULTURAL SERVICES	582	-129	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	140589

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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)

Period	DEMAND			TECHNOLOGY			Total change
	Total	Compo- sition	Level	Total	IO- coef.	Energy coef.	
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 conserving 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.

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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) $e_t*x_t - e_{t-1}*x_{t-1} = (e_t - e_{t-1})*x_{t-1} + e_t*(x_t - x_{t-1}) = A+B$

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 $x_{t-1} = (I-A)_{t-1}^{-1} \cdot D_{t-1} \cdot d_{t-1}$ 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 coef-
ficient 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 rela-
tion between domestic production and imports. Firstly a substitution be-
tween Danish production and imports will affect the Danish energy consump-
tion. 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 influ-
ence 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 cal-
culated 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	Compo-sition	Level	Total	IO-coef.	Energy coef.	Total change
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.

	Ana-lysis	DEMAND			TECHNOLOGY			Total change
		Total	Compo-sition	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) $EC = e \times ((I-A)^{-1} \cdot D \cdot d$

9) $EEC = e \times ((I-A_x)^{-1} \cdot D_x \cdot d$

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 consump-
tion 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 dome-
   stic 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 respec-
tively.
In the periods 1966-70 and 1970-73 the relative importance of the de-
mand 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 com-

ponent 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.

	Ver-sion	DEMAND			TECHNOLOGY			Total change.
		Total	Compo-sition	Level	Total	IO-coef.	Energy coef.	
1966-70	F	89.4	-21.1 (-23.6)	110.5 (123.6)	10.6	-6.5 (-61.3)	17.1 (161.3)	100.0
	N	89.3	-17.4 (-19.5)	106.6 (119.5)	10.7	-4.4 (-41.1)	15.1 (141.1)	100.0
1970-73	F	150.9	-35.9 (-23.8)	186.8 (123.8)	-50.9	-12.9 (25.3)	-38.0 (74.7)	100.0
	N	149.6	-28.1 (-18.8)	177.6 (118.8)	-49.6	-0.4 (0.8)	-49.2 (99.2)	100.0
1973-75	F	50.2	-101.6 (-202.2)	151.7 (302.2)	49.8	-12.2 (-24.5)	62.0 (124.5)	100.0
	N	42.4	-49.5 (-116.6)	91.8 (216.5)	57.6	-1.5 (2.6)	59.1 (97.4)	100.0
1966-75	F	147.8	-27.2 (18.4)	175.0 (118.4)	-47.8	-6.6 (13.8)	-41.2 (86.2)	100.0
	N	154.4	-14.2 (-9.2)	168.5 (109.2)	-54.4	-3.6 (6.6)	-50.8 (93.4)	100.0

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 dif-
      ferent 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 chan-
ges 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-tab-
les. If the coefficients tend to be more stable in the new tables the re-
lative importance of the changes caused by changes in the branch compo-
sition 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.

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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.

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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 summa-
rized 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 es-
  timate 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 simu-
  lation 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 par-
ticular production activities are missing, for instance the production of
coal in Italy, the Netherlands, and Denmark. All missing production activi-
ties 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 in-
verse), Y the matrix of final demand, while B represents one topic of econo-
mic 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 re-
sults 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 cumul-
ative (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 necess-
ary 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:

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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).

$$E^{TJ} = D(I-A)^{-1} \tilde{Y} + \tilde{T} \tag{2}$$

$$= \begin{bmatrix} D_1 & \vdots & D_2 \\ \cdots & \vdots & \cdots \\ 0 & \vdots & 0 \end{bmatrix} \cdot \begin{bmatrix} I - \begin{pmatrix} A_1 & \vdots & A_2 \\ \cdots & \vdots & \cdots \\ A_3 & \vdots & A_4 \end{pmatrix} \end{bmatrix}^{-1} \cdot \begin{bmatrix} \tilde{Y}_E \\ \cdots \\ Y_{NE} \end{bmatrix} + \begin{bmatrix} \tilde{Y}_E \\ \cdots \\ 0 \end{bmatrix}$$

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)

$\tilde{Y}$ = diagonal matrix of final demand (DM)

$\tilde{T}$ = 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:

$$(I-A)^{-1} = I + A + A^2 + \dots = \sum_{i=0}^{\infty} A^i \tag{3}$$

Figure 2: Physical Energy Requirements of Commodities
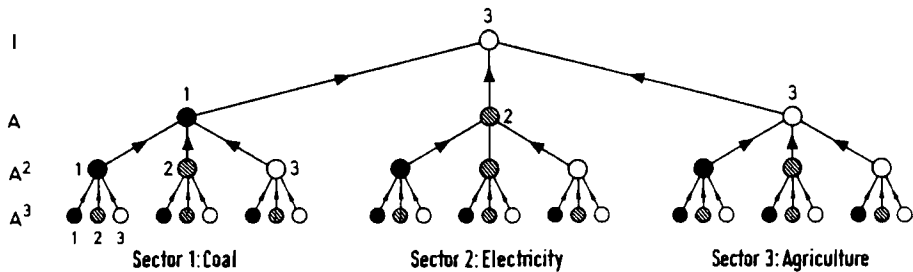
The expansion of the Leontief - inverse in (3) reveals also the reason why we have to add the matrix $\hat{T}$ in calculating the total physical energy requirements.Premultiplying by A leads to eliminating all commodities leaving intermediate production.

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).

$$E^{TJ} = H(I-A)^{-1} \hat{Y} + \hat{T} \tag{4}$$

$$= \begin{bmatrix} F_1 & \vdots & D_2 \\ \cdots & \vdots & \cdots \\ 0 & \vdots & 0 \end{bmatrix} \cdot \left[I - \begin{pmatrix} F_1 & \vdots & D_2 \\ \cdots & \vdots & \cdots \\ G_3 & \vdots & A_4 \end{pmatrix} \right]^{-1} \cdot \begin{bmatrix} \hat{J}_E \\ \cdots \\ Y_{NE} \end{bmatrix} + \begin{bmatrix} \hat{J}_E \\ \cdots \\ 0 \end{bmatrix}$$

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:

$$E^{TJ} = H(I-K)^{-1} Y + T \qquad \text{Total physical energy requirements} \qquad (5)$$

$$= H_d(I-K_d)^{-1} Y_d \qquad \text{Domestic energy for domestic production}$$

$$+ T_d \qquad \text{Domestic energy for final demand}$$

$$+ H(I-K)^{-1} K_m(I-K_d)^{-1}Y_d \qquad \text{Foreign energy for foreign production of intermediate imports}$$

$$+ H_m(I-K_d)^{-1} Y_d \qquad \text{Foreign energy imported for domestic pro-duction}$$

$$+ H(I-K)^{-1} Y_m \qquad \text{Foreign energy for imported commodities of final demand}$$

$$+ T_m \qquad \text{Foreign energy directly imported for final demand}$$

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.

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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	FRA	ITA	GBR	BEL	NED	DEN
	(1)	(2)	(3)	(4)	(5)	(6)	(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.

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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 2   Technical coefficients of energy conversion in Austria, 1976.

		Hydro-electr. Plants	Thermal Power Pl.		District Heating Plants	Gas Gener.	Gas Works	Blast Furn.	Coke Ovens	Refineries
			Utili-ties	Manuf. Ind.						
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 prices 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.

	ENERGY CONVERSION INPUT PJ	OUTPUT PJ	EFFICIENCY COEFFICIENT %	DIRECT INPUT COEFFICIENT
J55	296.5	241.0	81.3	1.2303
J56	306.8	247.9	80.8	1.2377
J57	319.2	263.8	82.7	1.2099
J58	294.5	245.6	83.4	1.1992
J59	302.3	246.5	81.6	1.2260
J60	322.6	263.5	81.7	1.2247
J61	338.4	270.9	80.0	1.2494
J62	366.3	293.0	80.0	1.2501
J63	393.2	311.5	79.2	1.2622
J64	428.4	338.1	78.9	1.2672
J65	438.2	357.4	82.0	1.2195
J66	455.2	372.1	81.7	1.2233
J67	464.6	382.3	82.3	1.2152
J68	502.8	414.2	82.4	1.2130
J69	537.8	434.5	80.8	1.2377
J70	590.3	495.8	84.0	1.1907
J71	655.3	547.3	83.5	1.1973
J72	685.6	575.4	83.9	1.1915
J73	741.0	620.8	83.8	1.1936
J74	720.7	608.4	84.4	1.1846
J75	692.5	582.0	84.2	1.1881
J76	753.1	617.4	82.8	1.2197
J77	716.5	595.8	83.1	1.2027
J78	766.7	643.9	84.0	1.1907
J79	819.5	690.6	84.3	1.1866
J80	806.4	680.1	84.3	1.1858
J81	742.8	621.5	83.7	1.1953
J82	690.8	575.1	83.3	1.2012

TABLE 6 Production mix in electricity generation (%).

	THERMAL POWER PLANTS			HYDRO-ELECTRIC PLANTS
	UTILI-TIES	MANUFACT. INDUSTRY	TOTAL SHARES	
J55	17.2	9.3	26.5	73.5
J56	16.8	9.2	26.1	73.9
J57	16.2	9.0	25.2	74.8
J58	13.2	8.5	21.7	78.3
J59	17.4	8.4	25.8	74.2
J60	16.9	8.7	25.6	74.4
J61	20.8	9.1	29.9	70.1
J62	23.3	8.6	31.9	68.1
J63	26.2	9.0	35.2	64.8
J64	26.4	8.9	35.3	64.7
J65	19.7	8.0	27.7	72.3
J66	20.4	7.4	27.2	72.8
J67	20.2	7.4	27.6	72.4
J68	21.9	7.4	29.3	70.7
J69	27.7	8.8	36.5	63.5
J70	21.1	8.2	29.3	70.7
J71	32.0	9.7	41.7	58.3
J72	31.0	10.3	41.3	58.7
J73	28.6	10.2	38.8	61.2
J74	23.6	9.5	33.1	66.9
J75	24.0	8.5	32.6	67.4
J76	32.5	9.4	41.9	58.1
J77	25.2	8.8	34.0	66.0
J78	25.8	8.8	34.6	65.4
J79	22.2	8.8	31.0	69.0
J80	22.5	8.2	30.7	69.3

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 7 Direct input coefficients of electricity generation.

	TOTAL	COAL	PETROLEUM PRODUCTS	GAS	ELECTRICITY	HYDRO-POWER	OTHER ENERGY SOURCES
J55	2.0948	.6266	.1680	.2966	.0800	.9235	.0000
J56	2.0934	.5710	.1445	.3652	.0841	.9785	.0000
J57	2.0483	.5695	.0938	.3612	.0846	.9393	.0000
J58	1.8887	.4037	.1134	.3019	.0801	.9836	.0000
J59	1.9840	.4989	.1684	.3123	.0803	.9321	.0000
J60	1.9451	.3999	.1536	.3800	.0767	.9349	.0000
J61	2.0454	.5439	.1830	.3600	.0774	.8811	.0000
J62	2.0523	.5351	.2653	.3208	.0756	.8554	.0000
J63	2.1249	.5750	.3354	.3160	.0772	.8143	.0071
J64	2.0943	.5360	.3811	.2883	.0698	.8130	.0062
J65	1.8956	.3759	.3988	.2279	.0683	.9083	.0064
J66	1.8835	.3982	.2481	.2497	.0674	.9140	.0061
J67	1.8684	.3792	.2752	.2316	.0661	.9096	.0066
J68	1.8882	.3759	.3143	.2348	.0679	.8883	.0071
J69	2.0151	.4415	.3613	.3396	.0680	.7971	.0077
J70	1.8484	.2653	.2117	.4101	.0662	.8882	.0068
J71	2.0379	.3697	.3634	.4989	.0664	.7326	.0069
J72	2.0269	.3126	.4241	.4776	.0615	.7368	.0083
J73	1.9752	.2621	.4090	.4590	.0668	.7683	.0099
J74	1.8375	.2639	.2319	.4309	.0615	.8402	.0090
J75	1.7958	.2171	.2726	.3884	.0627	.8472	.0078
J76	1.9193	.2859	.3775	.4563	.0614	.7294	.0088
J77	1.7688	.1658	.2765	.4268	.0605	.8290	.0102
J78	1.7745	.1443	.3078	.4057	.0615	.8213	.0139
J79	1.7576	.1382	.2815	.4009	.0580	.8626	.0165
J80	1.7164	.1811	.3226	.2663	.0582	.8665	.0216

TABLE 8 Cumulative input coefficients of secondary energy.

	COKE	PETROLEUM PRODUCTS	TOWN GAS	BLAST-FURNACE GAS	COKE-OVEN GAS	WORKS GAS	DISTRICT HEAT	ELECTRICITY
J55	.8189	1.0078	2.7539	.9132	.8291	1.0982	.	2.2908
J56	.8320	1.0659	2.5394	.9226	.8424	1.0972	.	2.2519
J57	.8566	1.0132	2.4164	.9709	.8667	1.1099	.	2.1860
J58	.8677	1.0177	2.0746	.9867	.8784	1.1293	.	1.9750
J59	.8849	1.0067	1.8165	.9902	.8923	1.1060	.	2.0725
J60	.9144	1.0007	1.7608	1.0355	.9190	1.1633	.	2.0281
J61	.9299	.9903	1.7161	1.0601	.9332	1.2103	.	2.1360
J62	.9026	1.0045	1.7618	.9994	.9062	1.2283	.	2.1404
J63	.8974	1.0044	1.7964	.9885	.9006	1.2521	.	2.2232
J64	.9134	1.0141	1.7476	1.0011	.9193	1.2731	.	2.1900
J65	.9342	.9954	1.6569	1.0214	.9342	1.2273	.	1.9644
J66	.9422	.9957	1.6470	1.0265	.9450	1.2717	.	1.9571
J67	.9455	.9937	1.5497	1.0323	.9492	1.2952	.	1.9331
J68	.9701	.9941	1.4802	1.0482	.9740	1.2022	.	1.9553
J69	1.0231	.9928	1.3151	1.0812	1.0272	1.1468	.	2.0956
J70	1.0653	.9785	1.1693	1.1245	1.0737	1.1015	.7999	1.9170
J71	1.0563	.9807	1.1477	1.1665	1.0649	1.1354	.6743	2.1163
J72	1.0740	.9806	1.1344	1.1627	1.0819	1.0741	.7551	2.1074
J73	1.0721	.9853	1.1368	1.1612	1.1155	1.0737	1.4081	2.0585
J74	1.0189	.9825	1.1312	1.1818	1.0835	1.0740	1.5277	1.9035
J75	1.0928	.9824	1.1365	1.1843	1.0982	1.1682	1.4111	1.8547
J76	1.0841	1.0089	1.1424	1.1994	1.0890	1.1734	1.3780	1.9956
J77	1.0948	1.0073	1.1498	1.1792	1.1005	1.1641	1.2719	1.8320
J78	1.0883	1.0067	1.0967	1.1238	1.0938	1.1741	1.3169	1.8370
J79	1.0962	1.0076	1.1028	1.0958	1.1022	1.3300	1.2860	1.8184
J80	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.

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TABLE 9   Cumulative primary energy content (PJ).

	MANUFACT- URING INDUSTRY	TRANSPORT- ATION	SMALL USERS	NON-ENERGY CONSUMPTION	OWN CONSUMPT- ION	TOTAL CONSUMPT- ION	INVENT- ORY	EXPORTS	IMPORTS	DOMESTIC PRODUCTION
J55	163.8	57.9	152.9	7.6	27.2	411.3	-23.6	83.4	166.4	351.9
J56	175.6	66.6	153.1	8.3	27.5	430.9	8.0	93.4	172.3	349.0
J57	177.5	68.9	160.5	10.4	28.1	441.4	-7.4	76.5	188.4	336.8
J58	172.3	67.6	152.4	10.4	28.4	431.1	-5.9	67.5	180.6	323.9
J59	180.2	70.5	144.6	14.1	27.4	436.8	4.5	70.7	187.6	315.4
J60	200.2	77.2	152.5	15.6	27.9	473.4	-8.1	68.0	221.9	327.6
J61	203.9	80.0	154.5	18.1	28.2	485.6	3.5	57.7	219.3	320.0
J62	201.8	88.3	177.0	21.6	30.4	519.1	-.2	52.4	245.5	326.1
J63	204.9	95.7	204.8	23.1	32.8	561.3	-6.6	54.3	280.5	341.7
J64	220.8	101.7	196.3	25.7	33.7	577.6	-9.2	38.7	279.8	345.8
J65	216.2	105.0	196.9	29.5	30.8	578.4	-17.3	42.8	279.3	359.2
J66	217.9	112.5	194.0	33.3	30.1	587.8	-25.0	44.1	294.9	362.0
J67	212.7	115.0	210.1	34.7	29.5	602.0	-6.1	44.4	305.4	347.1
J68	223.7	122.2	227.8	37.3	31.4	642.4	-11.1	47.0	363.2	337.3
J69	249.1	127.9	249.4	43.9	35.4	705.8	13.0	48.6	419.2	322.2
J70	255.5	138.5	280.3	51.2	38.1	763.6	-18.9	55.0	479.7	357.8
J71	270.3	145.0	285.1	52.9	43.4	796.8	1.8	46.0	513.9	327.1
J72	219.7	158.8	300.4	55.1	46.5	840.6	-4.5	46.7	563.0	328.9
J73	292.2	172.4	336.4	59.4	46.9	907.8	-17.3	47.8	617.9	354.5
J74	304.6	161.4	307.5	61.5	44.2	879.0	-24.9	53.6	603.3	354.2
J75	276.1	164.5	309.5	59.6	42.1	851.9	-.1	56.2	554.3	353.9
J76	298.6	169.5	316.8	67.0	49.4	921.2	-12.8	53.0	661.4	325.6
J77	282.5	174.5	331.2	69.2	45.9	903.2	-7.1	54.0	612.0	347.3
J78	289.5	184.0	355.1	68.0	50.1	946.6	-34.1	50.4	677.7	353.1
J79	306.6	191.8	374.7	73.1	48.7	995.0	-40.3	54.0	725.7	363.5
J80	297.5	193.1	371.1	73.2	56.2	991.1	-29.9	56.1	729.0	398.0

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:

$$(1) \quad \begin{pmatrix} \phi & \phi & U_{pt} \\ \phi & \phi & U_{st} \\ \phi & V_{ts} & \phi \end{pmatrix} \cdot i + \begin{pmatrix} l_p \\ l_s \\ l_t \end{pmatrix} + \begin{pmatrix} y_p \\ y_s \\ \phi \end{pmatrix} - \begin{pmatrix} m_p \\ m_s \\ \phi \end{pmatrix} = \begin{pmatrix} q_p \\ q_s \\ g_t \end{pmatrix} \qquad \begin{pmatrix} y_p \\ y_s \end{pmatrix} = \begin{pmatrix} E_{pj} \\ E_{sj} \end{pmatrix} \cdot i + \begin{pmatrix} k_p \\ k_s \end{pmatrix} + \begin{pmatrix} c_p \\ c_s \end{pmatrix} + \begin{pmatrix} d_p \\ d_s \end{pmatrix} + \begin{pmatrix} x_p \\ x_s \end{pmatrix}$$

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:

$$(2) \quad \left(\frac{B_{pt}}{B_{st}}\right) = \left(\frac{U_{pt}}{U_{st}}\right) \widehat{g}_t^{-1}$$

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:

$$(3) \quad (g_t - l_t) = D_{ts} q_s$$

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.

$$(4) \quad \left(\begin{array}{cc|c} L_{pp} & \phi & \phi \\ \phi & L_{ss} & \phi \\ \phi & \phi & L_{tt} \end{array}\right) = \widehat{\begin{pmatrix} l_p \\ l_s \\ l_t \end{pmatrix}} \cdot \left[\widehat{\begin{pmatrix} q_p \\ q_s \\ g_t \end{pmatrix}} + \widehat{\begin{pmatrix} m_p \\ m_s \\ \phi \end{pmatrix}}\right]^{-1}$$

Using (2), (3), and (4) the identity (1) can be rewritten.

$$(5) \quad \left(\begin{array}{cc|c} \phi & \phi & B_{pt} \\ \phi & \phi & B_{st} \\ \phi & D_{ts} & \phi \end{array}\right) \cdot \begin{pmatrix} q_p \\ q_s \\ g_t \end{pmatrix} + \left(\begin{array}{cc|c} L_{pp} & \phi & \phi \\ \phi & L_{ss} & \phi \\ \phi & \phi & L_{tt} \end{array}\right) \cdot \left[\begin{pmatrix} q_p \\ q_s \\ g_t \end{pmatrix} + \begin{pmatrix} m_p \\ m_s \\ \phi \end{pmatrix}\right] + \begin{pmatrix} y_p \\ y_s \\ \phi \end{pmatrix} - \begin{pmatrix} m_p \\ m_s \\ \phi \end{pmatrix} = \begin{pmatrix} q_p \\ q_s \\ g_t \end{pmatrix}$$

The diagonal matrix of efficiency coefficients is given as

$$\left(\begin{array}{cc|c} W_{pp} & \phi & \phi \\ \phi & W_{ss} & \phi \\ \phi & \phi & W_{tt} \end{array}\right) = \left(\begin{array}{cc|c} I-L_{pp} & \phi & \phi \\ q & I-L_{ss} & \phi \\ q & \phi & I-L_{tt} \end{array}\right)$$

Using these efficiency coefficients (5) yields

$$(6) \quad \left(\begin{array}{c|c|c} W_{pp} & \phi & -B_{pt} \\ \hline \phi & W_{ss} & -B_{st} \\ \hline \phi & -D_{ts} & W_{tt} \end{array} \right)^{-1} \left[\begin{pmatrix} y_p \\ y_s \\ \phi \end{pmatrix} - \begin{pmatrix} W_{pp} \cdot m_p \\ W_{ss} \cdot m_s \\ \phi \end{pmatrix} \right] = \begin{pmatrix} q_p \\ q_s \\ g_t \end{pmatrix}$$

Through partitioned inversion, the demand form of the Leontief model can be obtained:

$$(7) \quad \left(\begin{array}{c|c|c} M_{pp} & M_{ps} & M_{pt} \\ \hline M_{sp} & M_{ss} & M_{st} \\ \hline M_{tp} & M_{ts} & M_{tt} \end{array} \right) \left[\begin{pmatrix} y_p \\ y_s \\ \phi \end{pmatrix} - \begin{pmatrix} W_{pp} \cdot m_p \\ W_{ss} \cdot m_s \\ \phi \end{pmatrix} \right] = \begin{pmatrix} q_p \\ q_s \\ g_t \end{pmatrix}$$

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):

$$M \quad [y \ - \ W \cdot m] \ = \ q$$

or in partitioned form

$$\left(\begin{array}{c|c} M_{pp} & M_{ps} \\ \hline M_{sp} & M_{ss} \end{array} \right) \left[\begin{pmatrix} y_p \\ y_s \end{pmatrix} - \begin{pmatrix} W_{pp} \cdot m_p \\ W_{ss} \cdot m_s \end{pmatrix} \right] = \begin{pmatrix} q_p \\ q_s \end{pmatrix}$$

where

$$(8a) \quad M_{ss} = (W_{ss} - B_{st} \, W_{tt}^{-1} \, D_{ts})^{-1}$$

$$(8b) \quad M_{ps} = W_{pp}^{-1} \, B_{pt} \, W_{tt}^{-1} \, D_{ts} \, M_{ss}$$

$$(8c) \quad M_{pp} = W_{pp}^{-1} = (I - L_{pp})^{-1}$$

$$(8d) \quad M_{sp} = \phi$$

The supply form of the model is obtained through the re-inversion of matrix M and the separation of the identity matrix

$$(9) \quad (I \ - \ A^T) \quad q \ = \ y \ - \ W \cdot m$$

or in partitioned form

$$\left[\left(\begin{array}{c|c} I & \phi \\ \hline \phi & I \end{array} \right) - \left(\begin{array}{c|c} A_{pp}^T & A_{ps}^T \\ \hline A_{sp}^T & A_{ss}^T \end{array} \right) \right] \cdot \begin{pmatrix} q_p \\ q_s \end{pmatrix} = \begin{pmatrix} y_p \\ y_s \end{pmatrix} - \begin{pmatrix} W_p \cdot m_p \\ W_s \cdot m_s \end{pmatrix}$$

The matrices AT correspond to the matrix of input coefficients of the conventional input-output model:

$$(9a) \quad A_{ps}^T = B_{pt} \, W_{tt}^{-1} \, D_{ts} \qquad\qquad (9c) \quad A_{pp}^T = L_{pp}$$

$$(9b) \quad A_{ss}^T = L_{ss} + B_{st} \, W_{tt}^{-1} \, D_{ts} \qquad (9d) \quad A_{sp}^T = \phi$$

A conventional input-output commodity-commodity table for the energy conversion
sector is obtained by multiplying the technical coefficients by the diagonalized
supply vector.

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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 Inoustrial 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.
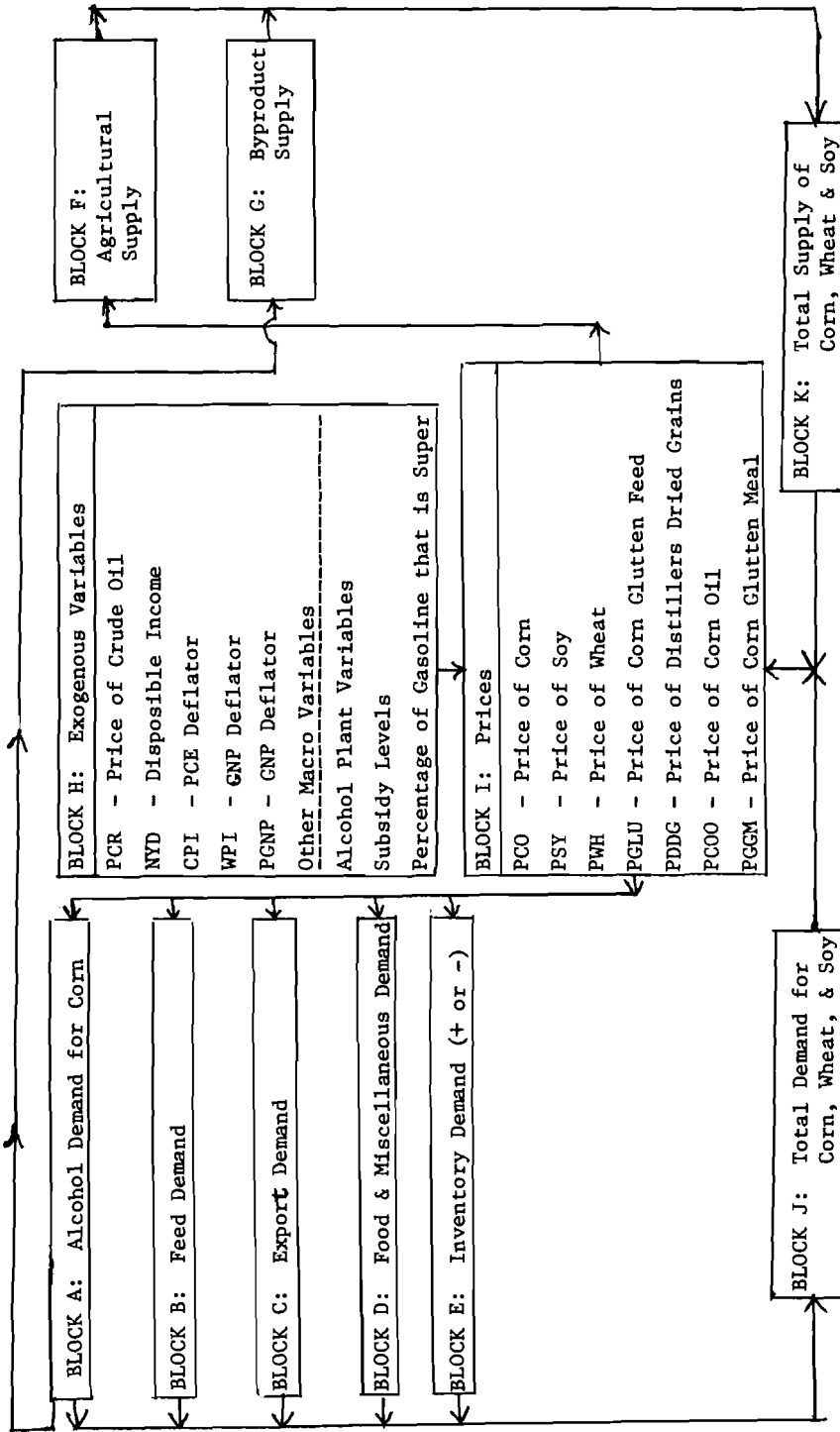
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FIGURE 1

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 unlikely 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

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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 199ว. 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 profitability 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.

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TABLE 1   CAM *** CASE 3 ***   BASE FLAT REAL PRICE OF CRUDE   PAGE 1

CAM *** CASE 3 ***   BASE FLAT   BASE FLAT   REAL PRICE OF   REAL PRICE OF   CRUDE   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 ($/BU)	2.150	2.524	3.299	2.449	2.883	3.762	4.378	5.084	5.695	6.735
PCDCPI	PRICE OF CORN / CPI ($/BU)	2.150	1.953	2.345	1.649	1.868	2.189	2.225	2.229	2.227	2.221
GCOS	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
GCO	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	0.628	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
GCOEQ	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
GDDGCO	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
GCOMCO	COM 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
GCOFCO	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
GCOD	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	0.844
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
GCODALC	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
GCOINV	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
GSYS	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
GSY	SUPPLY OF SOY GROWN (BBU)	1.289	2.270	1.844	2.023	1.965	2.130	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
GSYEQ	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
GDDG3Y	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
GCGMSY	COM 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
GCGFSY	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
GSYD	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
GSYINV	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)	0.735	0.803	0.745	0.798	0.761	0.815	0.834	0.670	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	0.267	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

		1977.0	1980.0	1981.0	1982.0	1983.0	1985.0	1987.0	1990.0	1992.0	1995.0
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

		1977.0	1980.0	1981.0	1982.0	1983.0	1985.0	1987.0	1990.0	1992.0	1995.0
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	0.950	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
QWHALC	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	PGAS+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
DCTPRE	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 ($/GAL)	1.058	1.338	1.627	1.430	1.551	1.863	2.085	2.386	2.596	3.024
PWHALCT	PRICE WET MILL ALC ($/GAL)	1.058	1.373	1.647	1.430	1.551	1.863	2.085	2.386	2.596	3.024
PWHALC	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$/TON)	1.212	1.434	1.702	1.461	1.654	2.018	2.426	2.836	3.287	3.942
PQLU	THE PRICE OF CGF (H$/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$/TON)	2.100	2.369	3.171	2.780	3.132	3.785	4.571	5.348	6.230	7.487
PCDO	THE PRICE OF CORN OIL ($/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
GCGM	QUANTITY CGM	(BLBS)	0.000	0.206	0.313	0.495	0.535	0.622	0.726	0.916	1.068	1.345
GCGF	QUANTITY CGF	(BLBS)	0.000	0.731	1.110	1.758	1.899	2.209	2.578	3.252	3.791	4.776
GCDO	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 econom-
ies. 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 distribu-
tion 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 aggre-
gate output seldom exceeding 3 ÷ 4 percent in real terms, while sectoral
quota under the swift upsurge of new technology and investment options suf-
fer, 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 techno-
logical innovation which requires investment which depends on interest rates
which relate to global economic growth. Assuming zero growth rate of aggre-
gate 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 techno-
logical choice. A set of rival technologies is assumed to exist in each
sector, together with a pre-specified set of investment options and consump-
tion 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 uncer-
tainty embodied in the technology, investment consumption sets will be trans-
ferred 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

$$x(t) = Ax(t) + y(t) \qquad (1)$$

($x \sim$ 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

$$y(t) = Cx(t) + B[x(t+1) - x(t)] \qquad (2)$$

which substituted into (1), yields the model in dynamic closed form (Leontief [6], 1953)

$$Bx(t+1) = [B + I - A - C]x(t) \qquad (3)$$

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 $M[x(t)]$ this region, eq. (3) must be viewed as a point-to-set mapping associating $x(t)$ to

$$x(t+1) \in M[x(t)] \tag{4}$$

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 $A \times B \times C$, a composite finite set collecting all possible options for technology, investment, and consumption. If the innovation rule $t \to \{A(t), B(t), C(t)\}$ 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 $A \times B \times C$. 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 $\overline{(3)}$ 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

$$y \in M[x] \tag{5}$$

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

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[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.

$$S^{n-1} = \langle e_i \rangle_{i=1}^n \qquad (6)$$

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

$$G(M) = \{(x,y): y \in M[x]\} \qquad (7)$$

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

$$G(M) = \langle (x_i,y_i): y_i \in M(x_i) \rangle_{i=1}^N \qquad (8)$$

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

$$\begin{cases} Ax = y \\ \mathbb{1}^T A = \mathbb{1}^T , \quad \mathbb{1}^T = \{11,\ldots,1\} \\ a_{kj} \geq 0; \ k,j \in [1,n] \end{cases} \qquad (9)$$

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

$$y \in \langle A^\ell x \rangle_{\ell=1}^m \qquad (10)$$

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

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[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 $\{x(1), x(2), \ldots\}$ 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 $\{u(1), u(2), \ldots\}^3$. 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

$$\frac{1}{n} \sum_{j=1}^{n} a_{kj}^i$$

while its average value is simply $\frac{1}{n}$.

As inputs to sector k are outputs of other sectors, the difference

$$\Delta_k^i = \frac{1}{n} \sum_{j=1}^{n} a_{kj}^i - \frac{1}{n}$$

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_k^i 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

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[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).

$$r_k^i - n\, a_{km}^i < 1 \tag{13}$$

where

$$a_{km}^i = \min_{\ell,h,j} a_{hj}^\ell \qquad\qquad r_k^i = \sum_{j=1}^n a_{kj}^i$$

For subsequent developments, it is useful to introduce a family of closed convex polyhedra $\{S_\alpha\}$ defined by

$$S_\alpha \triangleq \langle \frac{1-\alpha}{n}\, \mathbb{I} + \alpha e_k \rangle_{k=1}^n, \quad \alpha \in [0,1]$$

with $\mathbb{I} \triangleq \{1\ 1\ 1\ \ldots\ 1\}^T$.

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 $S(\tau,\rho)$. It is then easy to prove that 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 $A_o: S^{n-1} \to 2^{S^{n-1}}$

$$x \to A_o(x) \triangleq \langle A^i x \rangle_{i=1}^m$$

When x is let to vary in S_α, the reachable set is the image of S_α under the set-to-set mapping $A_1: \tau \to 2^{S^{n-1}}$

$$S_\alpha \to A_1(S_\alpha) \triangleq \bigcup_{u \in S_\alpha} \langle A^i x \rangle_{i=1}^m$$

This set is, in turn, contained in a minimal set S_β defined as

$$S_\beta \triangleq \{\bigcap_\gamma S_\gamma: S_\gamma \supset \bigcup_{x \in S_\alpha} \langle A^i x \rangle_{i=1}^m\}$$

and a second set-to-set mapping $A_2: 2^{S^{n-1}} \to \tau$ is established

$$A_2 (\bigcup_{x \in S_\alpha} (A^i x)_{i=1}^m) \triangleq S_\beta$$

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

$$\{ \sum_{i=1}^m A^i u_i x: x \in S_\alpha; \ u \in s^{m-1} \} = \bigcup_{u \in s^{m-1}} (\frac{1-\alpha}{n} \sum_{i=1}^m r^i u_i + \alpha \sum_{i=1}^m a_k^i u_i)_{k=1}^n$$

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 $(\frac{1-\gamma}{n} \mathbb{I} + \gamma e_j)_{j=1}^n$. This yields the condition

$$\sum_{i=1}^m [\frac{r^i}{n}(1-\alpha) + \alpha a_k^i] u_i - \frac{1-\gamma}{n} \mathbb{I} \geq 0 \qquad \forall \ k \in [1,n]; \quad \forall \ u \in s^{m-1} \qquad (14)$$

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

$$\beta = 1 - \min_{ijk}(r_j^i(1-\alpha) + n a_{jk}^i \alpha) = 1 - \min_{ij}(r_j^i(1-\alpha) + n \min_k a_{jk}^i \alpha)$$

Rewrite this expression for $\alpha' \neq \alpha$ and let β' the corresponding β. Then

$$\rho(A(S_\alpha),A(S_{\alpha'})) = \rho(S_\beta, S_{\beta'}) = |\beta - \beta'| = |\min_{ij}(r_j^i(1-\alpha') + n \min_k a_{jk}^i \alpha') -$$
$$- \min_{ij}(r_j^i(1-\alpha) + n \min_k a_{jk}^i \alpha)| \leq (r_m^\ell - n a_{mn}^\ell)|\alpha - \alpha'|$$

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 $S_{\hat\alpha}$.

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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 $S_{\hat{\alpha}+\epsilon}$ goes outside $S_{\hat{\alpha}+\epsilon}$, $\epsilon > 0$.

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

$$S_{\hat{\alpha}} = \langle \frac{1-\hat{\alpha}}{n} \, \mathbb{I} + \hat{\alpha} e_k \rangle^n_{k=1}$$

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

$$A(S_\alpha) \subseteq S_\alpha$$

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 $h = \dfrac{1-\alpha}{n\alpha}$

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[4] A finer topology than τ may improve the situation in this respect.

$$h(r^i - \mathbb{I}) + a^i_k \geq 0, \quad k \in [1,n] \tag{15}$$

As some components of $(r^i - \mathbb{I})$ are negative, the largest in absolute value is upper binding for h. The upper bound $\hat{h}$ is computable as follows.

Let $I \underline{\Delta} \{(m,n)\}$ be the set of index-pairs where

$$\{r^i_\ell : i \in [1,m], \ell \in [i,n]\}$$

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

$$\{a^i_{jk} : (i,j) \in I, k \in [1,n]\}$$

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 $\{a^i_{jk} : (i,j) \in I, k \in [1,n]\}$
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

$$A^1 = \begin{bmatrix} .1 & .3 & .2 \\ .2 & .1 & .4 \\ .7 & .6 & .4 \end{bmatrix}; \quad A^2 = \begin{bmatrix} .5 & .2 & .6 \\ .3 & .2 & .1 \\ .2 & .6 & .3 \end{bmatrix}; \quad A^3 = \begin{bmatrix} .7 & .6 & .2 \\ .2 & .2 & .2 \\ .1 & .2 & .6 \end{bmatrix}$$

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 (11), 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,...,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]

$$\left| \min_i [A_i(1-\alpha) + \alpha a_i] - \min_i [A_i(1-\beta) + \beta a_i] \right| \leq K|\alpha - \beta|$$

Proof. For any i we have $a_p \leq a_i$ and let $A_q \leq A_i$. 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

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$$\left| \min_i [A_i(1-\alpha) + \alpha a_i] - \min_i [A_i(1-\beta) + \beta a_i] \right| \leq (A_p - a_p)|\alpha - \beta| = K|\alpha - \beta|$$
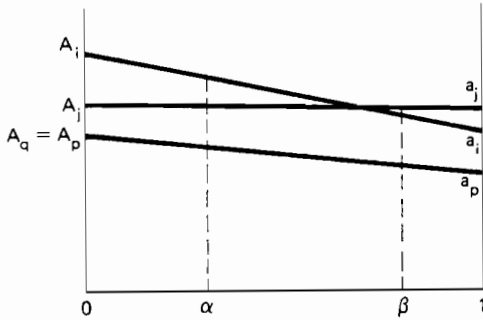

Fig. 1   Fig. 2
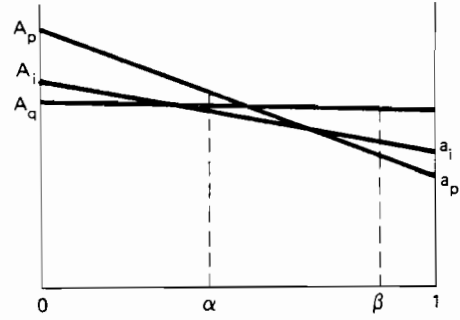
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INPUT–OUTPUT MODELING OF FUEL, ENERGY, AND METAL CONSUMPTION IN CZECHOSLOVAKIA

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 $Z = \| z_{ij} \|$, $i=1,\ldots,n_z$, $j=1,\ldots,n$. 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 $P = \| p_{ij} \|$, $i=1,\ldots,m$, $j=1,\ldots,n$ determined as follows:

$$P = \left\| \begin{array}{ll} p_{ij} = a_{ij} & \text{for } i,j = 1,\ldots,n \\[2em] p_{ij} = h_{ij} & \text{for } i=n+1,\ldots,m, j=1,\ldots,n \end{array} \right\|$$

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, ho-
wever, noted that the overall material requirements of pro-
duction are given by a vector b where $b_j = \sum_{i=1}^{n} a_{ij}$ for $j=1$,
...,n.

The basic production factors are given by the vector of
the capital requirements of production $f=/f_1,...,f_n/$ and by
the vector of labour requirements of production $p=/p_1,...,p_n/$.

The technical and economic production level is represen-
ted by vectors: $u=/u_1,...,u_n/$ - total technical and economic
efficiency /it is given by net production per a worker/, $s=$
$/s_1,...,s_n/$ - structure of capital funds/ is given by the
proportion of productive machines in the total capital funds /,
$v=/v_1,...,v_n/$ - equipment by productive machines /is given by
productive machines per a worker/.

We shall concentrate on investigating the following prob-
lem 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 re-
  quierements for the total material, fuels, energy and me-
  tals, 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 require-
ments 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 struc-
ture 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 investi-
gated if the industries of this group have also similar requi-
rements 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:

$$d_{kt}^2 = \sum_{i=1}^{m} (p_{ik} - p_{it})^2, \text{ for all k and t,} \qquad /1/$$

where d_{kt}^2 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_{kt}^2 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_{kt}^2.

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 $\{1\},...,\{n\}$. 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

$$\{1\},...,\{i,j\} , ..., \{n\} .$$

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:

$$d_{kh}^2 = \frac{n_k + n_i}{n_k + n_h} d_{ki}^2 + \frac{n_k + n_j}{n_k + n_h} d_{kj}^2 + \frac{n_k}{n_k + n_h} d_{ij}^2 \qquad /2/$$

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_n represent the number of elements in clusters $\{i\}^k$, $\{j\}$, $\{k\}$ and $\{h\}$.
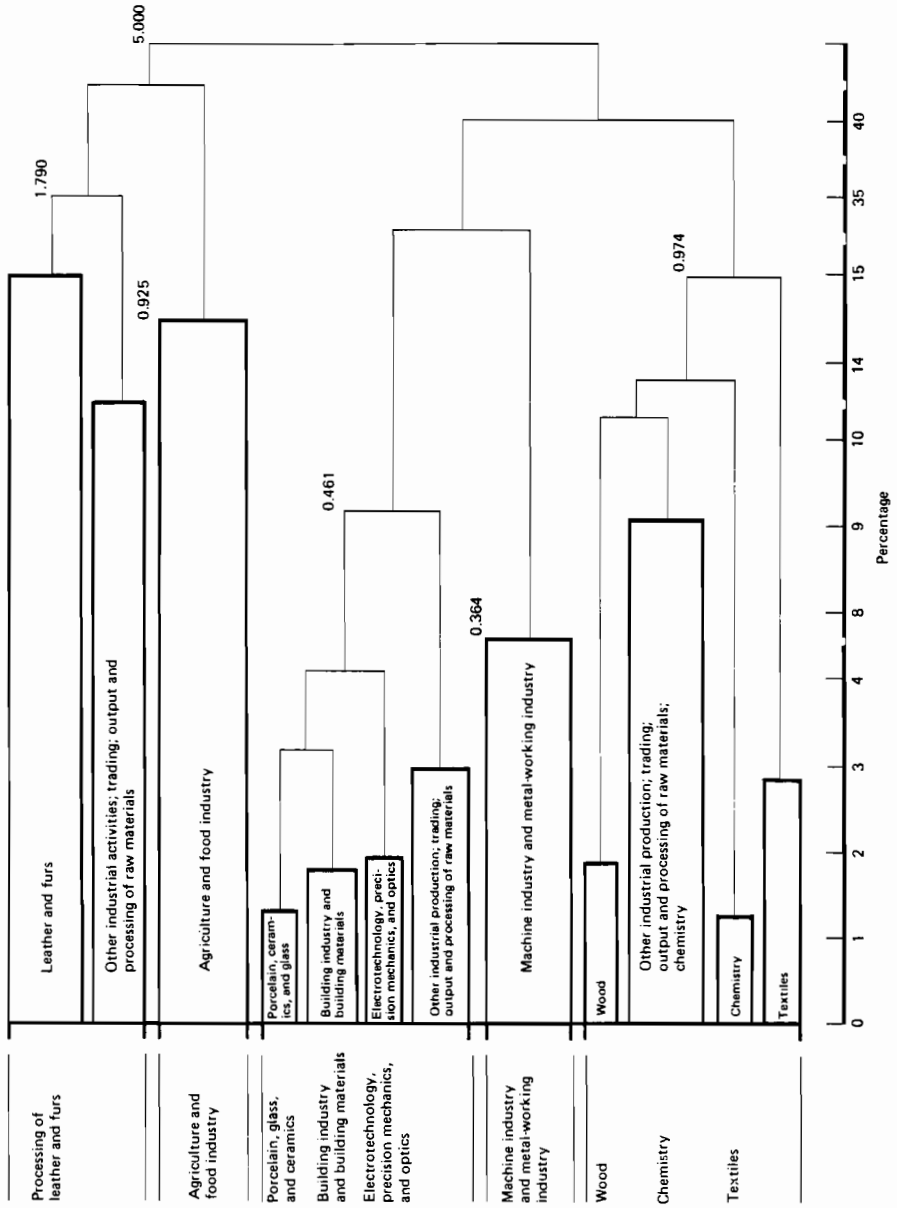
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FIGURE 1 Hierarchy of similarity relations in cost structure of production.

Through applying the given method we have obtained a hie-
rarchy of relations of similarity described by a dendrogram
in Fig. 1 which, apart from absolute values of levels of dis-
tances in creating individual clusters, contains also their
expression in percents.

According to the similarity of cost. structure of pro-
duction five basic clusters of industries are created in na-
tional economy. These basic clusters contain groups of the
appropriate industries groupped into systems of smaller clus-
ters 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 in-
dustries 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, capi-
tal, 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 inves-
tigating 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 ma-
terial, 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:

$$z_k = \max_{ij} |w_i - w_j| \text{ for all } i,j \text{ from each investigated} \quad /3/$$

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
$\max w_i - \min w_i$ 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 hetero-
genity of the degree of difference between the investigated
inputs of the process of production in *industries* with a relat-
ed cost structure of production belonging to the investigat-
ed clusters. Some connections between the similarity of cost

structure of production and the investigated inputs of pro-
duction 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 ma-
terial, metals, energy and fuels whereas they are also charac-
terized by a similar total technical and economic efficiency,
i.e. these characteristics are connected with the mode of pro-
duction 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 econo-
mic 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 identi-
fied.**

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 analogic-
ally as in the previous part. The mutual comparison of these
vectors by means of the cluster analysis resulted in the hie-
rarchy 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 cha-
racteristics as they are manifested in the structure of natio-
nal economy. It means, for example, that in individual indus-
tries 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 effi-
ciency, etc. The distances given in absolute and percentage
expression represent a degree of dissimilarity of the corres-
ponding factors. The high difference between labour and capi-
tal requirements and other investigated factors indicates that
the relation between these requirements and other factors is
very small. The mutual difference between other factors /repre-
sented 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 in-
fluenced, we may presume that the corresponding parts of the
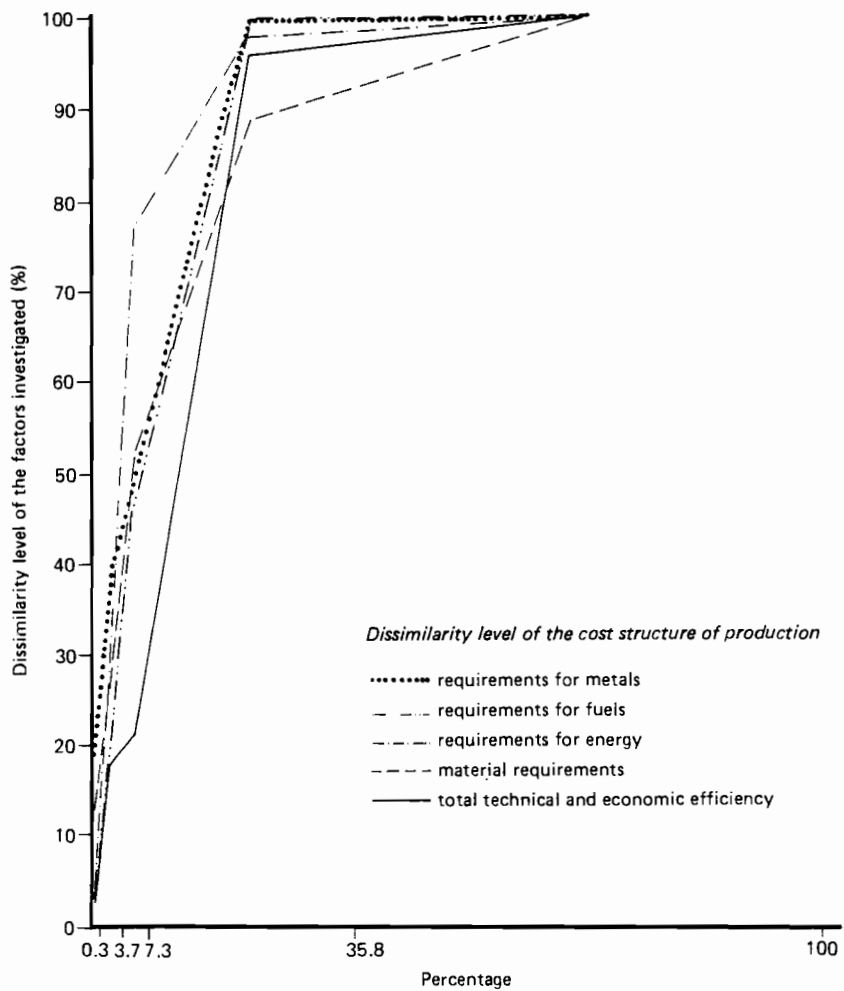subject-matter relations can be expressed by a functional re-
lation:

FIGURE 2 Relation between the mode of production
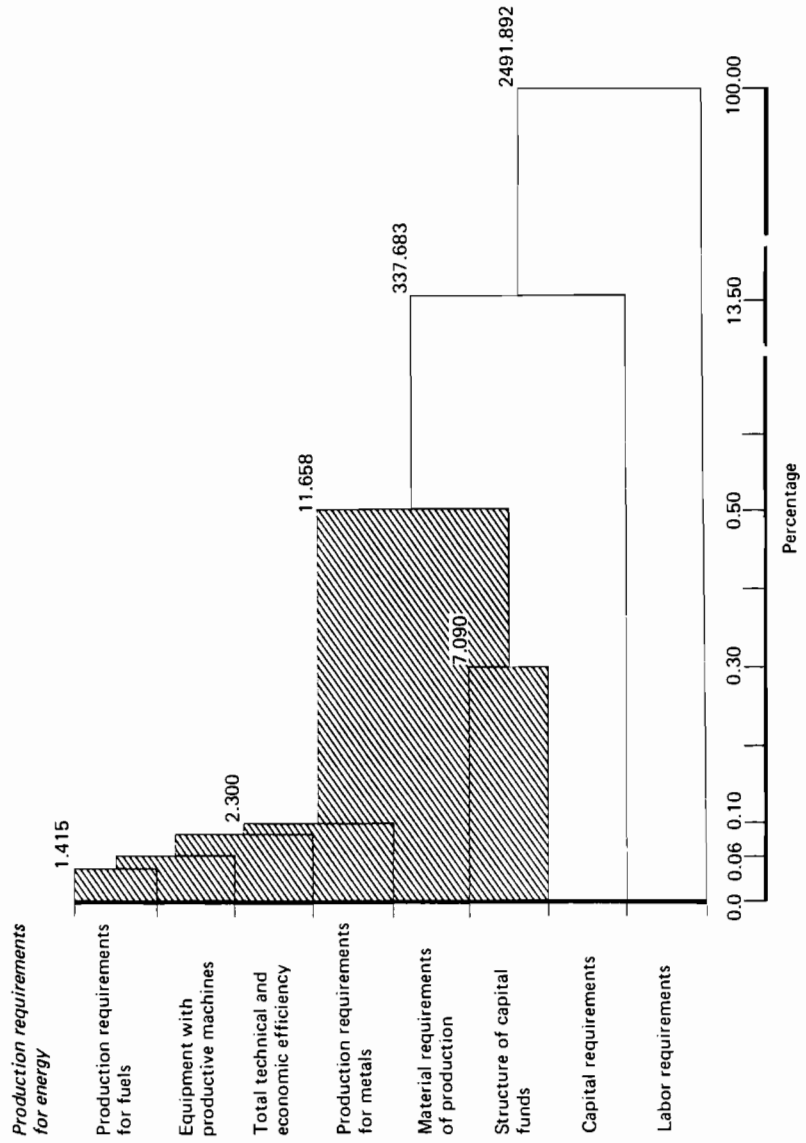and the level of the investigated factors.

FIGURE 3   Hierarchy of similarity relations among the investigated production factors.

$$NE = a_1 NP + a_2 VVS + a_3 TEU + a_4 NK + a_5 MN + a_6 SVF + a_7 FN + a_8 PN \quad /4/$$

where the individual symbols denote: NE - production require-
ments for energy, NP - production requirements for fuels, VVS
- equipment with productive machines, TEU - technical and eco-
nomic efficiency, NK - production requirements for metals,
MN - material requirements of production, SVF - structure of
capital funds, FN - capital requirements, PN - labour requi-
rements. The coefficients $a_1, ..., a_8$ 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 ti-
mes decreased. The relation /4/ represents then by means of
coefficients a_i an expression of the effect of the investiga-
ted factors on energy requirements of production. When inter-
preting 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 require-
  ments of production is identical in all industries at the
  level of national economy as well.

The estimation of parametres of the relation /4/ was per-
formed 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:

$$NE = -0,2271\ NP + 0,3858\ VVS - 0,0557\ TEU - 0,0430\ NK - 0,0291$$
$$MN + 0,0239 \cdot SVF + 0,0036\ FN + 0,0024\ PN, \qquad /5/$$

where the appropriate determination index and the Durbin-Wat-
son 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 ma-
chines and by the structure of capital funds whereas the ca-
pital and labour requirements of production show less influ-
ence 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 ma-
chines. 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 cumu-

lants 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.

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