

The INFORUM Approach to Interindustry Modeling

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ABSTRACT *INFORUM models are described as internationally-linkable, dynamic, interindustry models which imitate as closely as possible the way the economy behaves. They models are contrasted with classical input-output models, pure econometric models, and CGE models. Their common elements are set out and the common software described. The rest of this issue of this Journal is introduced.*

1. What is INFORUM?

INterindustry Forecasting at the University of Maryland (INFORUM) began in early 1967 with one subscriber and one researcher. By the end of the year, it was up to seven subscribers and four researchers. It has continued as a group devoted to dynamic modeling with input-output detail and forecasting, policy analysis, and research based on those models. Users of its results have been its sole source of financial support, a fact that has doubtless greatly influenced the practical nature of its methods and the direction of its research.

As early as 1970, groups in other countries began to take an interest in cooperating with INFORUM in building models of their own countries. The international group has grown slowly and organically. Each national partner group has had to find its own financing. In 1978-1980, Douglas Nyhus and I were at the International Institute for Applied Systems Analysis (IIASA) in Austria; and the first linking of the various models then available was carried out. That linking system and the individual national models have been developed steadily since that time. I have tried to suggest other, more cosmopolitan, names for the international group; but "INFORUM" has stuck.

The group was pleased to be given a session at the 1989 International Input-Output Conference in Keszthely, and doubly pleased to be invited to put together this issue of *Economic Systems Research*. At the conference session, there were contributions from Austria, China, France, Italy, Korea, Mexico, Poland, Spain, and the USA. An active partner for Germany has since joined the group. There are also well-maintained, USA-built models for Japan and Canada as part of the linked system; a new (USA-built) model of the UK should soon be linked. A model of Armenia is presently underway at the Academy of Sciences of the USSR. A model of CzechoSlovakia is reviving at the Slovak Academy of Sciences. There have also been models of Belgium, Colombia, Hungary, and Kenya; but they do not seem to be presently active.

The basic idea of an INFORUM model of an economy is simple. It is an internationally-linkable, dynamic, interindustry model which imitates as closely as

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possible the way the economy behaves. It is intended for both public policy analysis and business forecasting. Where appropriate, it uses regression analysis to describe the behavior of consumers, producers, exporters, importers, investors, or other economic decision makers. It uses explicit and (usually) changing input-output relations among industries. That use assures absolute accounting consistency, on the product side, among final demands, intermediate use, and production of products and, on the price side, among prices of products, the costs of materials used and the value-added generated in making them. An INFORUM model does not rely upon *ex post* scaling to produce reasonable forecasts, though it may show explicitly statistical discrepancies necessitated by conflicting official data. It builds up macroeconomic totals, like gross domestic product, from industry level variables; it does not -- once it is past the initial stages -- start with aggregate totals and spread them to industries. (Software provides for imposing controls on macro-economic totals, such as imports; but use of these controls should be optional, not a structural part of the model.) The model traces the development of the economy over time and may definitely show business cycles. It does not concentrate on an equilibrium condition at some future date. Finally, the model of one country needs to be linkable with similar models of other countries. In practice, this last condition means that the model should use software that is similar to that used for the other models in the other countries. This software, however, is versatile enough to handle economies as diverse as those of Poland, Mexico, China, and the USA. The models may start as simple as just a constant input-output table and exogenous final demands and grow into a model that integrates outputs, prices, incomes, changing technical coefficients, and dynamic investment functions. There is no attempt to determine centrally the form of the behavioral functions used.

This group of characteristics seems simple, yet it distinguishes this group of models from numerous others. Since such distinctions can be useful in understanding what the models are and what they are not, here is a quick and partial list of other models and how they differ from INFORUM models.

The classical "econometric" models make little or no use of input-output tables, but rely heavily on regression analysis even for relating industry outputs to final demand aggregates. INFORUM models use variable-coefficient input-output tables both in the computation of industry outputs and industry prices.

Classical input-output models make little or no use of regression-based behavioral equations. If they are dynamic, investment is based on "requirements" for future growth, not on any study of the way firms actually determine investment. This "requirements" approach to investment makes current investment depend on future planned output, a dependency which often leads to severe instability problems. The INFORUM models rely heavily on regression-based econometrics for behavioral equations, especially for consumption, investment, export, imports, productivity, profits, and wages. The behavioral approach to investment completely eliminates the non-economic instability of dynamic input-output models. Instead, it introduces the sort of business-cycle fluctuations which are, in fact, observed.

Computable General Equilibrium (CGE) models have concentrated on equilibrium positions rather than on a dynamic time path of an economy that can show business cycles and may never at any moment be in a "steady state" or equilibrium. In their insistence on a complete accounting system and in considering both income and price effects, the CGE's resemble the INFORUM family. CGE's are usually

conducted in the framework of a Social Accounting Matrix (SAM). A complete INFORUM model has all the non-zero elements of a SAM, but does not stress the matrix form of accounting, which, with its many large all-zero matrices, we find conceptually unattractive and practically unworkable. The SAM also seems to breed a certain complacency with the "industry technology" assumption in the input-output calculations, an assumption we find it important and easy to avoid -- see the McCarthy paper in this issue.

Numerous input-output models use aggregate macro-model drivers. The DRI input-output models are well-known commercial examples, though the use of a "row-scalar" technique destroys consistency with the original control totals in these models. Obviously, the real economy has no aggregate driver but builds up the totals from the sum of the parts. The INFORUM models try to work like the real economy.

The HERMES models have in a sense inverted the INFORUM approach to international cooperation. The sectoring plans and the functional forms of the national models were specified centrally and in advance of the actual model building. The software was developed individually by the national partners.

The Cambridge Econometrics model of the UK has all the properties of a model of the INFORUM family but is built with different software, a fact which has made international linking with these models difficult despite the best of intentions on both sides. We consider it an honorary INFORUM model, and its builders graciously accept the title.

In this introduction to this, I shall first explain the general framework of the INFORUM models and discuss briefly the common software which is really the basis of our cooperation. Then I will introduce the following papers to show how they fit together to sketch a complete view of the entire work.

2. The Common Accounting Structure

The basic input-output accounting structure of the INFORUM models is just the usual dual pair of equations

$$\mathbf{q} = \mathbf{A}\mathbf{q} + \mathbf{H}\mathbf{f} \text{ and } \mathbf{p} = \mathbf{p}\mathbf{A} + \mathbf{v},$$

where \mathbf{q} is a column vector of product outputs, \mathbf{A} is a product-to-product input coefficient matrix made by the modified product-technology method which produces a matrix without negative elements, \mathbf{f} is a column vector of final demand by category, \mathbf{H} is a bridge matrix to convert final demand by category to final demand by product, \mathbf{p} is a row vector of prices, and \mathbf{v} is a row vector value added per unit of output of each product. Every vector and matrix in both equations should be thought of as having a time subscript, for all of them change in each year.

The components of \mathbf{f} are many; they include such items as personal consumption by household budget category, equipment investment by purchasing industry, construction by type of construction, inventory investment by product, exports by product, imports by product, government expenditure by budget category. Little or much econometrics may go into the determination of the elements of \mathbf{f} . In a new model, they may be all exogenously specified. In an expanded model, the functions become quite complicated and use relative prices, income distribution, interest rates, and, in fact, any variable which any model could include. Typically, the components of \mathbf{f} representing imports depend on domestic use of the product in the same year, $\mathbf{M}\mathbf{q}$,

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where \mathbf{M} is the import coefficient matrix. \mathbf{M} generally depends on \mathbf{p} , and thus \mathbf{f} depends on both \mathbf{q} and \mathbf{p} for the same period. The same is true for inventory change and investment, which generally depend upon the recent growth in the purchasing industry. The price vector, \mathbf{p} , influences also the personal consumption components of \mathbf{f} . Thus, there is more simultaneous determination in the equations than immediately meets the eye.

The above equations, to repeat, are for products. For value added, however, the modeling should generally be done by industries, which may produce more than one product. To bridge between products and industries, a matrix G is created with rows corresponding to industries and columns to products. The element G_{ij} shows the valued added in industry i per unit of output of product j . Real, value-added weighted output, $\mathbf{r} = \mathbf{G}\mathbf{q}$, then becomes an industry output variable used as a major explanatory variable in explaining the vector of value added by industry, \mathbf{u} . This industry vector \mathbf{u} is then converted back to the vector \mathbf{w} of total value added by product by the equations

$$w_j = \sum_i \left(\frac{G_{ij}q_j}{r_i} \right) u_i$$

The components of the \mathbf{v} vector are then defined by $v_j = w_j/q_j$. In this way, the models do all of the input-output computations at the product level, but model value added by industries, if appropriate.

This accounting structure is common to all the models and is built into the common software, though it can be modified to suit particular countries. There is, however, no attempt to make the econometrics within the various models uniform. Functional forms may be different in different countries; estimating techniques may be different. Nor need the sectoring plans of the tables or their base years be common. The best available in each country should be used. Our concern is to make it as easy as possible for economists in the national partner groups to concentrate on economics rather than software to build the best possible model of each country.

3. The Common Software

National partners are strongly encouraged to use the common software, for its use is necessary to make the linking mechanism possible and to keep the operating manual which the user of the linked system must know within reasonable bounds. Its use also makes it possible for one partner to help another easily. The fact that there are several users stimulates documentation of the software. If the person who works on the software at the programming level for one partner leaves for a new job, it is possible for other partners to step in and help the replacement learn to use the model.

There are two parts of the software presently available. One part, the G regression and data handling program, prepares banks of data, manipulates data in numerous ways, displays it graphically, performs regressions with a number of variations, and writes out the results of the regression in exactly the form needed for use in the forecasting model. G was developed for personal computers and shows the influence of what PC users have come to expect of fun-to-use, interactive programs. It has on-line help and extensive and easy use of graphs. Its particular strength, among regression programs, is its handling of the large data banks, compact representation of series in the data banks, ease of use of "soft" or "stochastic" constraints, and ability to

build models, not just do regression. A sister program, called Build, builds aggregate models directly from the G-estimated equations. Small input-output models may also be built with the G-Build combination. The model of China reported here by Kang Chen was built in this way.

The second part of the software, known as Slimforp, solves the dynamic interindustry models. It is still in Fortran and shows signs of its mainframe origins. It is not hard to use for one accustomed to computers, but it does not have the "friendliness" that personal computer users have come to expect. One prepares matrices of coefficients and arrays of the parameters in equations. At designated points in the program, the user must supply the Fortran code to interpret the parameters of the equations which he has estimated. The programs already written read in the data, perform the input-output calculates, apply modification factors to behavioral equations, provide scaling to control totals if desired, step the model through the periods of the forecast, write the results into data banks, and make tables and (with G) graphs from those banks. The additional code which the user writes to interpret his particular equations seldom gets to be more than a few percent of the total code.

A defect in the present software is that the model must always be run from the same starting date. This limitation is being overcome in a new set of software designed to replace Slimforp in the near future. It allows the user to work on the matrices and time series of vectors as if in a spreadsheet program such as Lotus 1-2-3 but with much greater power for doing the sorts of computations we have found are frequently needed. The two-dimensions of the screen may be the two dimensions of a matrix or they may show one column in a series of years or one row in a series of years. Graphs will be easy to make, the interface with G should be very smooth. The user will need to supply C code for special calculations, but most of the usual vector and matrix operations will be available as functions.

Since data organization is such an important part of input-output modeling, it may be a pardonable digression to mention a use to which the G program is being put. A large portion of G has been put in the public domain under the name PDG and is being used for data dissemination. Its highly compact form of its data banks (just over 2 bytes per observation), its ease of use, and its facility in updating banks make it well suited for this purpose. Most of the regular banks of time-series economic statistics for the USA are available as G banks; these include the National accounts, Flow of funds, Industrial production, Business conditions indicators, Employment and earnings, Producer prices, and more. We sell these data banks at \$20 per diskette. The Italian national accounts have been released in G-bank format, and diskettes bearing Italian-speaking PDG and the Italian quarterly accounts have gone out in the economic weekly *Il Mondo*. PDG is available in English, French, Italian, Spanish, Russian, and Chinese versions.

4. What is in this Issue?

Appropriately, the first article, by Javier Lantero and Jeffrey Werling, describes the initial stages of building an INFORUM model. It is based on their recent experience building the model of Spain. This paper will be of particular interest to anyone considering starting the construction of such a model in a country for which no similar model has ever been built. The precise data problems they encounter may be particular to Spain, but every group has gone through more or less similar trials.

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Following the paper on the youngest INFORUM model comes Margaret McCarthy's description of the eldest, the one for the USA. It conveyed an idea of the range of national modeling possible in the models. This account, the reader will quickly discover, differs from most model descriptions in that it gives as much attention to data as to equations. This balance in emphasis reflects the fact that at least half of the work and perhaps more than half of the value of building a model lies in the organization of data. The USA has several rich data sources, but official statistics hardly begin to organize them as needed for timely analysis of economic issues. The fact that INFORUM does so is one of our main contributions. The behavioral relations described in the second part of McCarthy's summary account reflect the experiments of a dozen or so Ph.D. dissertations which have gone into the USA model. Space does not permit describing in detail any of the specific results of the USA model. Suffice it here to say that they are in constant use by business and government.

Once the national INFORUM models are built, they are applied to numerous national issues. The paper by Bardazzi, Grassini, and Longobardi represents such work. Their concern is the treatment of the value-added tax (VAT) in the Italian table and EEC tables in general. This issue has recently come to the center of attention because of the problem which diverse VAT rates in different countries and different industries pose for a "Europe without borders" by the end of 1992. The present conception is that VAT is a tax on consumption and depends on where the product is consumed, not on where it is made. Administration of the scheme which implements this conception depends on tax declarations and spot checks as goods move across borders. Input-output analysis seems the natural approach to simulation of the effects of changing the rates, or the concept, or the implementation. Before using it, however, it is necessary to understand the treatment of VAT in the published tables. In the most usual EEC tables, those with the flows evaluated "exclusive of deductible VAT", that treatment turns out to disrupt the most fundamental economic calculation with input-output tables, namely, summing across the row. The authors of this paper make a strong case for the publication of not just this one table but also of a table showing how much VAT is in each flow. The whole issue shows how an accounting scheme which is perfectly satisfactory from the point of view of the national accounts statistician -- there is a place for everything and everything balances -- is wholly unsatisfactory for analysis. The present paper deals only with conceptual issues; empirical work on this subject by the authors is forthcoming elsewhere.

Besides public policy issues such as changes in VAT, INFORUM models are regularly applied in industrial forecasting for private companies. In such industrial application of INFORUM models, we have often had the experience that a potential user will say, "Your model is wonderfully detailed in all industries except mine. There it is hopelessly aggregate." The paper by Lorraine S. Monaco is about how to deal with this situation. In the particular case she reports, the user made synthetic resins - - the stuff from which plastic products are made. INFORUM's 420-sector Detailed Output Model got no closer than the whole synthetic resin industry. We thought that was pretty detailed, but our client need detail by individual chemical resin. How we expanded to the model to provide that detail is described in the paper.

At this point, the reader of this issue, will have seen samples of the newest model and of the most developed, of applications to public policy and to private forecasting. Next it seems appropriate to emphasize the international linking of the models. The paper by Douglas Nyhus sets out the linking mechanism. It is a linking by trade and prices at the sectoral level. For modeling the exports of a given product by one

country it uses a weighted sum of the imports of that product by all other countries. In forecasting imports of a given product into a particular country, it compares the price of the product in that country with a weighed average of the prices in other countries. It stops short, however, of giving bilateral trade flows (e.g. Exports of automobiles from Italy to France). Such bilateral flows would be very desirable, and we hope to push the model in that direction.

At the time of the Keszthely conference, the linked system included Japan, Canada, USA, Italy, France, Germany, and Belgium. Nyhus concludes his paper with a brief summary of an application of this linked system to study the effects of a protectionist trade war. In it, the four European countries, the two North America ones, and Japan each try to keep out the products of the other two blocks. The results are instructive, to say the least.

Following the description of the linked system come three papers on national models not yet members of the linked system which each have such interesting individual features that they deserve special attention. First comes the Austrian "satellite" model described by Josef Richter. This paper is instructive in how a small country which is heavily dependent on exports can make good use of the system without having the model fully linked. The satellite model draws on the linked system in making its projections of exports and imports but does not feed back any information to the linked core. As a postscript to this paper, I should note that Austria (along with Mexico and Korea) lost its satellite status in 1990 and is now a fully linked model. The paper, however, loses none of its relevance, for other models can now step into the satellite position.

The paper by Kang Chen on a model of the People's Republic of China is a remarkable example of modeling when the data do not fit into the convenient accounting schemes to which we have become accustomed. He has an input-output table, but almost all of the time series on its elements are missing. He has, however, other time series which, by ingenious bridging and hard work with the data, he combines into a model which not only reproduces the recent history of China but makes plausible forecasts into the future.

The report by Witold Orłowski and Łucja Tomaszewicz on the INFORUM model of Poland deals with what were once "unusual" problems, but now those problems occupy many countries. The model is explicitly demand-oriented and looks to the future market economy of Poland. At the same time, it must be based on data which do not reflect market-clearing prices but chronic shortages. The authors deal very consciously with problems posed by this situation. How to model a future market economy on the basis of a former planned one is clearly a central concern for economists in a large part of the world.

The final article is a brief report by Alberto Ruiz-Moncayo and Clopper Almon on a study of a possible free trade treaty between Mexico and the USA. Such a treaty is now definitely a political possibility. Methodologically, the study was the first to develop specific bilateral trade flows between two INFORUM models, and this is the center of attention in the report here. (This paper was not presented in Keszthely. Two reports presented in Keszthely, Alberto Ruiz-Moncayo on software and Paul Salmon on data organization did not lend themselves well to journal articles. I discuss the software briefly below; the Lantero-Werling and McCarthy papers discuss data organization.)

Finally, I should like to thank all the contributors for their diligence and tolerance of my editing.