

## A new Interregional Input-Output Software approach to generalised interregional input-output endogenisation, linkage, multiplier and impact analysis

D. Stelder, J. Oosterhaven & G. J. Eding  
 Department of Economics  
 University of Groningen  
 PO Box 800  
 9700 AV Groningen  
 The Netherlands  
 tel: +31-50-363.3740  
 fax: +31-50-363.7337  
 email: stelder@eco.rug.nl

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### Abstract

Demo-economic model building normally proceeds along a series of ad hoc extensions of the standard Leontief model. Current input-output software concentrates on guiding the construction process of single-region tables and automating applications of standard type I and type II income and employment multipliers. What is lacking is InterRegional Input-Output Software that automates model construction and application of more advanced and flexible extensions of the Leontief model for a flexible number of regions, including a flexible set of impact variables. IRIOS is a software package that does precisely that. The package centers around the following generalized solution:

$$\mathbf{V}_{111} + \dots + \mathbf{V}_{ief} + \dots + \mathbf{V}_{IEF} = (\hat{\mathbf{c}}_1 + \hat{\mathbf{c}}_2 + \dots + \hat{\mathbf{c}}_I) (\mathbf{I} - \mathbf{A} - \mathbf{Q}_1 - \mathbf{Q}_2 - \dots - \mathbf{Q}_E)^{-1} (\hat{\mathbf{y}}_1 + \hat{\mathbf{y}}_2 + \dots + \hat{\mathbf{y}}_F),$$

with:

- $\mathbf{V}_{ief}$  = interregional endogenous effects matrix for impact variable  $i$  via relation  $e$  from impuls  $f$ ,
- $\hat{\mathbf{c}}_i$  = diagonalized matrix with input coefficients vector for impact variable  $i$ ,
- $\mathbf{A}$  = interregional input-output coefficients matrix,
- $\mathbf{Q}_e$  = interregional expenditure coefficients matrix for endogenous relation  $e$ ,
- $\hat{\mathbf{y}}_f$  = diagonalized matrix with exogenous final demand vector for impuls  $f$ .

IRIOS provides all kinds of flexible aggregations of the above formula. The paper will concentrate on the economics involved in the building of models and the doing of linkage, multiplier and impact analysis with IRIOS.

## 1. History and background

The Netherlands has a long tradition in national and regional i-o table construction and analysis going back to 1948 when the first national table was constructed by the Central Bureau of Statistics (CBS). The first interregional i-o table for three regions was constructed by Oosterhaven (1981), followed by a series of biregional tables for mainly the Northern Dutch regions (Oosterhaven, Piek & Stelder, 1986; Boomsma and Oosterhaven, 1992; Eding et. al., 1995; Eding, Stelder & Oosterhaven, 1995). In 1996 the Dutch Central Bureau of Statistics and the University of Groningen started a new project to construct regional supply and use tables for 14 regions, covering the whole country (see figure 1). This co-operation has resulted in the publication of a unique set of bi-regional sector-by-sector input-output tables for each region in 1999 of the full-information type in which both region and industry of origin and destination are fully specified (Eding et. al. 1999).

**Figure 1. New biregional i-o tables for 14 regions for the Netherlands**



Given this new large i-o database the need was felt to develop a standard table format and a software package that would be easy to use for regional government officials, research institutes etc. in order to make the standard i-o analysis accessible for scholars and less trained users. There are not many easy accessible i-o software packages internationally available, most of them are quite specifically developed for the data situation of the country in question (e.g. IMPLAN), for national or single region tables only, or have a strong content of table construction and updating (e.g. IO7). In addition, as an institute with a well known i-o reputation, we of the University of Groningen were increasingly confronted with many research questions of a quite straightforward i-o kind that would imply mostly standard i-o research work which is not really that task of a University.

For these reasons we have developed IRIOS in cooperation with the software agency DIGIMOTIONS. The first version IRIOS 1.0 is now available that contains most of the commonly used tools of i-o analysis.



The example illustrates that an interregional table thus consists of four quadrants with four different types of purchases:

- I purchases that are **regional in terms of both origin and destination (R-R)**: the intermediate purchases and the *regional* final demand categories with  $r \times i$  rows and  $r \times (i + f1)$  columns.
- II purchases that are **only regional in terms of origin (R-N)**: the *other* final demand categories with  $r \times i$  rows and  $f2$  columns.
- III purchases that are **only regional in terms of destination (N-R)**: the primary costs belonging to quadrant I, with  $k$  rows and  $r \times (i + f1)$  columns.
- IV purchases that are **exclusively national (N-N)**: the primary costs belonging to quadrant II, with  $k$  rows and  $f2$  columns.

IRIOS can work with an i-o table without the regional dimension (for example, a national table) as a table with regional dimension  $r = 1$ . An  $r = 1$  table may also be an *intra-regional* table in which the trade with other regions is only represented by a few columns (included among the  $f$  final demand categories) and a few rows (included among the  $k$  primary cost rows).

In IRIOS, the  $k$  dimension has been broadly defined as *all rows in the table that do not belong to the intermediate part*. From a strictly economic point of view, the “foreign import” row, for example, is not a primary cost category. Nevertheless, it does not belong to the intermediate part and it is therefore one of the  $k$  rows in IRIOS.

The  $f1$  categories are defined in terms of *regional destination*, such as, for example, regional private consumption and regional investment. The  $f2$  categories (foreign exports, change in stocks, etc.) are categories that have not been defined in terms of regional destination.

The  $f1$  regional final demand categories, therefore, are present in all regions, the  $f2$  other final demand categories only once. *Therefore, the total number of final demand columns  $f$  in an interregional table equals  $(r \times f1) + f2$ .*

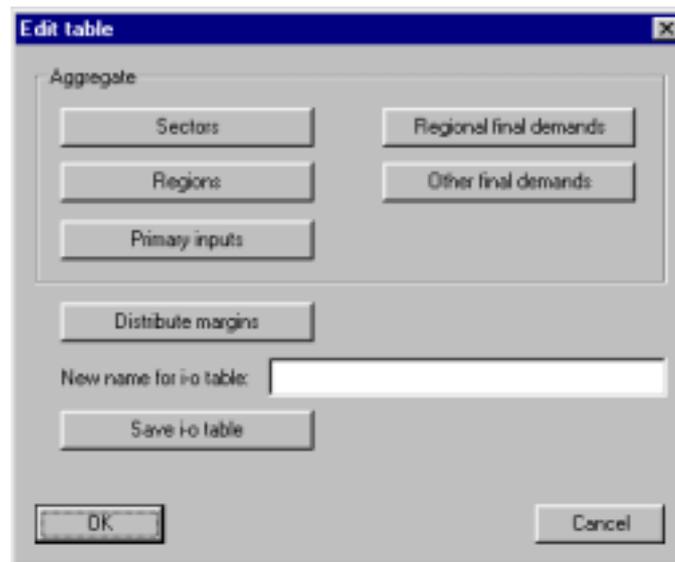
Note that in a national table this distinction does not exist and all final demand categories will belong to block II. In IRIOS a national table will therefore have the dimension  $f1=0$ .

Finally, multiregional tables with no off-diagonal blocks, which are used often in the US, will have the structure of figure 2 also, but with all off-diagonal blocks set to zero.

### 3. IRIOS table-files

In IRIOS a clear choice is made for i-o modelling only assuming that the user has a table to work with, in other words, **IRIOS does no table construction whatsoever**. The main reason for this decision is that table construction and updating, RAS etc. is always a very specific ad-hoc process depending strongly on the data availability and pragmatic choices made by the constructor. In our long history of Dutch regional table construction, even within the Netherlands and within our own institute, no table construction process for any table has ever been exactly the same.

Of course, there is always one exception to the rule: IRIOS has the practical option to **aggregate** the table over all five dimensions separately:



For example, aggregating over any dimension, like sectors, is done for all blocks at the same time. Very practical also for making a **national table out of the interregional one**.

The **Distribute margins** option shown above is the second and last option to edit the table which will not be discussed here<sup>1</sup>.

The i-o tables IRIOS uses are kept in a simple text format (CSV, or Comma Separated Values) that can be loaded and saved directly by all standard spreadsheets like Excel, Lotus, Quattro etc. For larger tables CSV format is easily generated by scientific software like GAUSS or MATLAB. Because of this format, **IRIOS can work with as large tables with as many sectors and regions that your desktop RAM memory can handle!** We would like to note that even the latest spreadsheet software releases still cannot handle more than 256 columns in a one-sheet i-o table (the wellknown and notorious rightmost column IV).

#### 4. IRIOS model files

IRIOS works with a model file of a specific binary format that contains, apart from the table used, all information that you use in a i-o modelling exercise. In many cases this will be extra exogenous information like various **impulses** for impact analysis, extra production-related **variables** like employment, and extra endogenizing functions called **relations** for type II, III or IV multipliers. A model file can hold a whole range of extra variables, functions and impulses in stock that can each be switched on or off separately. We will discuss the extra variables, the extra relations and the impact impulses in the sections below.

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<sup>1</sup> This option has to do with the specific Dutch data situation, but we have left it in for possible use by users from other countries. It is specifically intended for i-o tables measured in basic prices in which you can indicate which row in block III and which column in block II (see Figure 1) contain the trade and transport margins that you wish to distribute to produce a table expressed in manufacturers' prices (including trade and transport margins)

## 5. Model specification

By default, IRIOS works with the standard demand-driven Leontief model<sup>2</sup>, which is referred to as the “basic model” in various IRIOS windows:

$$\mathbf{V} = \mathbf{E} \mathbf{x} = \mathbf{E} (\mathbf{I} - \mathbf{A})^{-1} \mathbf{F}. \quad (1)$$

This basic model contains gross production  $\mathbf{x}$  and all primary cost categories  $\mathbf{V}$  related to gross production through the primary cost coefficients  $\mathbf{E}$  that are included in the table in block III of figure 2 by default (these are always referred to as “variables” in the IRIOS menus).

Any other information that is not part of a standard i-o table can be put into the model as an extra variable extending matrix  $\mathbf{E}$  to  $\mathbf{E}^*$  and  $\mathbf{V}$  to  $\mathbf{V}^*$  respectively. A vector of employment coefficients is the most obvious example, but one can also think of a vector of carbondioxide coefficients per sector per region for environmental implementations. The standard  $\mathbf{V}$  or you own extended  $\mathbf{V}^*$  thus contains the endogenous variables of the model *without feedback to output*.

In addition, you can extend the model to any kind of type II multipliers by specifying an extra endogenous variable *with feedback* (these are always referred to as “relations” in the IRIOS menus):

$$\mathbf{V} = (\mathbf{E} + \mathbf{Qe}) \mathbf{x} = (\mathbf{E} + \mathbf{Qe}) (\mathbf{I} - \mathbf{A} - \mathbf{Q})^{-1} \mathbf{F}^{\text{ex}} \quad (2)$$

The  $\mathbf{Q}$  matrix establishes an additional relation between the sales of sector  $\mathbf{a}$  and a spending category  $\mathbf{b}$ . The  $q_{ab}$  coefficient in a  $\mathbf{Q}(\mathbf{a}, \mathbf{b})$  matrix represents the additional sales of sector  $\mathbf{a}$  per unit of gross production in sector  $\mathbf{b}$ . In the most commonly used example of a consumption function,  $\mathbf{a}$  relates to the sales of consumer goods by sector  $\mathbf{a}$  to the households in sector  $\mathbf{b}$  per unit of production unit in sector  $\mathbf{b}$ . In the latter case, the causality of the additional relation could, for example, be as follows: increased production in sector  $\mathbf{b}$   $\rightarrow$  increased earned income in sector  $\mathbf{b}$   $\rightarrow$  increased total household consumption in sector  $\mathbf{b}$   $\rightarrow$  increased consumer spending on goods supplied by sector  $\mathbf{a}$  to these households.

The  $\mathbf{Qe}$  matrix in (2) is needed for the following reason. Since a variable is defined as a row with coefficients per unit of gross production  $\mathbf{e}$ , variable  $\mathbf{v}$  in the basic model may be computed as  $\mathbf{v} = \mathbf{e} (\mathbf{I} - \mathbf{A})^{-1} \mathbf{f}$ . However, in a model extended with a relation  $\mathbf{Q}$ , the link between a variable  $\mathbf{v}$  and a relation  $\mathbf{Q}(\mathbf{a}, \mathbf{b})$  should be specified. This link is referred to as the  $\mathbf{Qe}$  matrix and consists of  $k$  rows (for each variable  $k$ ) and  $i \times r$  columns. In the same example of a  $\mathbf{Q}$  matrix representing the endogenous consumption, the cell  $Qe_{ki}$  represents, for example, the foreign imports of consumer goods (variable  $k$ ) by households per earned income unit in sector  $i$  per gross production unit in sector  $i$ .

The final model will thus have the following general form:

$$\mathbf{V}^* = (\mathbf{E}^* + \mathbf{Qe}_1 + \mathbf{Qe}_2 + \mathbf{Qe}_3 \dots + \mathbf{Qe}_n) (\mathbf{I} - \mathbf{A} - \mathbf{Q}_1 - \mathbf{Q}_2 - \mathbf{Q}_3 \dots - \mathbf{Q}_n)^{-1} \mathbf{F}^{\text{ex}}. \quad (3)$$

In order to compute impacts and/or projections with the basic model or the extended model, various exogenous impulses for the  $\mathbf{F}^{\text{ex}}$  matrix may be specified.

IRIOS now produces the results according to the generalised equation (3) but with the option to switch each variable and/or relations and/or impact impulse on or off.

<sup>2</sup> See J. Oosterhaven in: Leontief versus Ghoshian Price and Quantity Model. *Southern Economic Journal* 62/3 (1996), pp. 750-59, for the alternative supply-driven model, the standard cost-push price model and the alternative demand-pull price model.

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