MACRODYNAMIC INFORMATION SYSTEM TO SIMULATE TARIFF POLICY IN THE ELECTRICITY SECTOR

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Abstract

The system aims to provide interactively the following:
- construction of macroeconomic scenarios,
- evolution of the impact of tariff policy and investments on the dynamic equilibrium of the main macroeconomic variables (prices, employment, income, consumption, import-export, national debt, interest rates).
The system is based on a "partial adjustment" dynamic model formed by 14 variable equations with the objective of evaluating the variable paths taken in adjustment process towards a new equilibrium point.
The system encompasses a sector by sector dynamic model to evaluate the effects of electricity tariff policy on the economy.
The system permits the simulation and forecasting of macroeconomic variables by means of the interactive use of input data (exogenous variables), changes in parameters and chance to transform dependent variables into exogenous ones.
The system has been implemented using the SAS System (6.08 0S/2 version) and in particular the following modules: ETS for simulation, AF for interface user procedure and GRAPH for graphic display of the results.

1. Introduction

The changes underway as part of the process of opening up the market in the Italian electricity sector have emphasized the primary importance of tariffs in relation to the problems of optimal allocation of resources and improvement in efficiency and quality of service.

As a consequence there has been a rising interest in evaluating the impact of price dynamics of electricity on principal components of the national economic system and the need to place tariff policies within economic scenarios themselves in a state of rapid evolution.

The macroeconomic system for tariff simulation presented below has been realized by Enel’s tariff division.

After lengthy research aimed at developing new methods of analysis and tools for evaluation, the construction and the implementation of a simulation tool capable of giving an evaluation of Enel’s investment and tariff policies was arrived at based on the dynamics of macroeconomic variables.

The information system is able to manage a macroeconomic model (formed by 14 behavioural equations) and a sector by sector price dynamics simulation model.

2. General outline of the information system

The tool has been realized using only SAS (6.08 version) in OS/2 setting referring in particular to the following modules:
- ETS (Proc Model, Proc Expand) for simulation;
- AF for the construction of the interface procedure user;
- GRAPH (Proc Gplot) for the graphic representation of the results.

The information system has some functions which permit the easy use of the “Proc Model” in simulation and help the user in the input of data and in the steps of the simulation path. In particular we should point out:
- the interactive guide, permanently available on screen, regards both methodological and system use aspects;
- a panel that permits us to input the data and connect it with an algebraic operator for variables and for selected observations;

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--- a printing function of the results that sends instructions directly to the printer;
- the transfer of results in a file form that can be read on an electronic sheet;
- recording the simulations.

The entire system is organized into three main branches that permit: access to the simulation menu on macro model, to the sector by sector price dynamics model and to the management menu of the data-bank.

The methods used for econometric evaluation of the two models and the form of the simulation system are shown below.

3. Methodology

3.1 The macrodynamic model of the Italian economy

3.1.1 Data base

The model is based on a data-bank in three monthly series from 1970 to 1993, originating from the following sources:

- three monthly national accounts (ISTAT);
- Economic Accounts of Public Administration (ISTAT);
- International Financial Statistics, monthly bulletin (International Monetary Fund);
- Economic and statistic bulletin (Bank of Italy);
- Economic Outlook (OECD);
- Direction of Trade Statistics, Yearbook (OECD).

To process this data in a historical sequence two SAS procedures were used: the “Proc Expand” to put into three monthly blocks the sum of the annual series, and “Proc X11” to deseasonalize the variables taken from the sources as rough data. All the variables are expressed at constant 1985 prices.

Moreover for the stock variables, to eliminate several problems of econometric nature due to the contemporary presence of stock and flow variables, the following transformation was adopted:

\[ X^*_t = \frac{1}{2}(X_t + X_{t-1}) \]

3.1.2 Econometric evaluation

The model that has been developed is one of those small size ones which due to own characteristics permits both an econometric check based on full evaluation and information methods as well as a better control since it contains a relatively small number of parameters and as a result is more easily interpretable in the simulation phase.

It is a dynamic model formed by 14 behavioural equations and includes identity equations which permit the balancing of national accounts. In particular reference to the behavioural equation of the following macroeconomic variables is made:

- Income
- Domestic consumption
- Imports
- Exports
- Domestic prices
- Export prices
- Money
- Domestic rates of interest
- Salaries
- Employment
- Capital
- Public expenditure
- Nominal taxation
- Capital debt

for each one the specification is given in an equation, known as “partial adjustment” in economic literature, that is with a variable \( y \):

\[ y_t - y_{t-1} = (1 - \lambda)(y^*_t - y_{t-1}) \]

where the variable \( y^* \) can be represented by the following equation:

\[ y^* = \phi(x) \]

or more completely:

\[ y^* = \alpha + \beta x_t \]
and represents the desired variables of the function. In other words the model represents the behaviour of the variations of the variable y with the speed of adjustment \((1 - \lambda)\) of the distance from the variable \(y_{\text{opt}}\) compared to the variable y delayed \(y_{t-1}\).

For more specific details about the equations please consult the appendix.

The exogenous variables of the model are listed below:

- Import prices
- Competitor prices
- Income from the rest of the world
- Exchange rate
- Monetary reserves
- International interest rates
- Time

For the evaluation and layout of the model the procedure “Proc Model” was used (version 6.08 SAS). This permits the utilization of the FIML (Full Information Maximum Likelihood).

For each behaviour equation an error model AR (autoregressive) or MA (Moving Average) was used.

3.2 Dynamic model of sector by sector prices

3.2.1 Data base

This model has been based on the sum of 18 sector of the intersectorial table of the Italian economy (TEI). They are:

1 - Agriculture
2 - Oil and natural gas
3 - Electricity
4 - Other energy products
5 - Minerals and ferrous and non ferrous metals
6 - Minerals and non ferrous ore products
7 - Chemical and pharmaceutical products
8 - Mechanic and metal products excluding means of transport
9 - Means of transport
10 - Food products, drinks and tobacco
11 - Textile products, clothing, leather products, shoes
12 - Wood, rubber, paper
13 - Other industrial manufactured products
14 - Construction and public works
15 - Retail, hotels, shops
16 - Transport and communication
17 - Credit, insurance and other services
18 - Non-market services

The data base is formed by technical coefficients based on TEI '85 totalled from the eighteen sector listed above, which form the technological base and by three monthly expenditure coefficients calculated on technical coefficient bases and updated every three months, by price indexing using the formulation specified further on, by import price indices sector by sector, by deflation of value added for the production cost, by salary indices based on the gross earnings of three monthly economic accounts.

3.2.2 Econometric evaluation

As for the macro model the sectorial one is also shown by the “Partial adjustment” form. In this specific case, the partial adjustment approach describes the behaviour of the variable price of the sector compared to the desired price.

This latter is hypothesized based on the production factors which can be defined following the well known Leontevine hypothesis as:

\[
P^*_i = \sum_{i=1}^{n} a_{ij} p_j + a_{VA_i} \text{VA}_i
\]

It can be demonstrated that the desired price of each sector is a function of the prices of all the goods and amount of value added in the sector. The parameters \(a_{ij}\) represent the technical coefficients of the matrix \(A\) the sum of which is equal to \((1-a_{us})\) in the hypothesis that the price must reflect the costs of production and the costs of labour and capital.

If the model is extended to an economy open to foreign trading the desired price becomes:

\[
P^*_i = \sum_{i=1}^{n} a_{ij} p_j^m + \sum_{j=1}^{n} a_{ij} p_j^m + a_{VA_i} \text{VA}_i
\]
where the subindices \( n \) and \( m \) indicate the flow of domestic production and imports respectively.

In that specific case the parameters \( a_{ij} \) are found in the Input/Output tables at fixed prices formulated by the methods used in the system of tariff simulation based on TEI already realized by ENEL.

The model for econometric evaluation is this:

\[
\Delta p_i = \alpha_i \left( p_i^* - p_{i,t-1} \right) \\
\Delta p_i = \alpha_i \left( \sum_{j=1}^{\infty} a_{ij}^n p_{i,t-1}^n + \sum_{j=1}^{\infty} a_{ij}^m p_{i,t-1}^m + \nu_{i,t} - p_{i,t-1} \right)
\]

In practice the only parameter estimated econometrically is \( \alpha \) which represents the speed of the adjustment to which the prices of the sector \( i \) are adjusted to the desired level, or in other words the price level which reflects the cost structure following well known leontevine hypothesis.

We should remember that the model is based on technical coefficients and it is necessary to reformulate the previous equations so as to take account of the effects of the price which gradually changes and transforms the structure of the sector costs. It’s necessary therefore to use expenditure coefficients \( b_{ij} \) which can be defined in the following formula:

\[
b_{ij} = \frac{a_{ij}^n \cdot p_{jt-1}}{\sum_{j=1}^{\infty} a_{ij}^n p_{jt-1}^n + \sum_{j=1}^{\infty} a_{ij}^m p_{jt-1}^m + \nu_{ij} \cdot w_{i,t-1} + \pi_{i,t-1}}
\]

where \( a_{ij} \) are the technical coefficients (at fixed price), \( \nu \) \( \pi \) \( w \) \( \pi \) represent salaries and capital remuneration.

The speed of adjustment \( a_i \) has been estimated using a method of Full Information Maximum Likelihood (FIML).

4. The simulation system

4.1 General structure

The scope of the system is to evaluate the effects of the impact of macroeconomic policies on the nation’s economy based on structural relations between the main macro variables, given by model equations and evaluated parameters. In particular the model has been produced to respond to specific problems regarding the effects of Enel’s investment and tariff policies as well as to be a cognitive instrument of the economic reality in which ENEL operates.

Several simulation paths are necessary for this. They must permit both the formulation of forecasting scenarios of short to middle term as well as realizing “what if” type scenarios.

The system is formed from the two management nuclei of the above mentioned models: the macro and price dynamics ones.

The first nucleus of the system is constituted by the macro model equation and the “Proc Model” procedure containing the information relating to the relationships among the variables. All the structure revolves around this centre permitting the modification of relationships between the exogenous variables in each equation system.

In other words it is possible to subdivide the simulation possibilities of this model into two blocks:

- the first concerns exclusively the forecast for endogenous variables on the hypothesis of future scenarios for the exogenous variables;
- the second is dedicated to the “what if” analysis subdivided into three simulation routes:
  - modifying the scenario hypothesis of exogenous variables;
  - modifying the system parameters;
  - transforming into exogenous the endogenous variables.

The second nucleus of the system is represented by price dynamics sectorial model aimed at understanding the dynamics between different sectors and analysing the impact of Enel’s tariff policies which foresee two simulation routes:

- modification of exogenous variables to the model;
- the variation a electricity sector prices. For both the macrodynamic and price model the procedural structure system is the same and can be shown as follows:

Both nuclei can be considered as one and so are finalized toward one result or can be considered independently according to their respective functions. In fact the macro model even though gives the possibility of connecting to the price model, must be considered as a single block. The price model is used to supply data on sector dynamics separately from that of the macro.

4.1.1 Structure of macro model

Before entering into detailed description of the system’s functioning it’s opportune to define some terms which can be used in the course of the explanation:

- scenario hypothesis: projection of exogenous variables on trend (in the system data bank several hypotheses are contained)
- basic simulation: is the result of the application of the model with a specific scenario hypothesis;
- final simulation: is the result of “what if” analysis that is real simulation (the result is presented in comparison to the basic simulation);
- simulation method: the “Proc model” is used as this permits the use of three different methods (Jacobi, Newton, Seidel);
- simulation range: the period to which the simulation refers.

Returning to the functioning of the system, the management of the simulation foresees that for the simulation route only the principal panel is used to supply the necessary information to the system: that is the scenario hypothesis, the range, and simulation method.
SELECT OPTIONS TO START THE SIMULATION

- RECORDED SIMULATIONS -
- CURRENT SCENARIO -
- ENDOGENOUS -> EXOGENOUS -
- SIMULATION PARAMETERS -

Jacobi  Newton  Seidel

Simulation starting year  1JAN1993
Simulation final year    1APR2001
The interaction between the operational procedure and the necessary steps towards the functioning of the simulation can be shown in the following diagram.
4.1.2 Structure of dynamic price model

The dynamic price model too is operated entirely by the principal simulation panel from which the user supplies the necessary information to the system: the scenario hypothesis, the range and the simulation method.
The dynamic price model has been designed to perform simulation tasks within the electricity sector, and is structured as the diagram below shows.
4.1.3 Connection between the two models

As we have already mentioned, the two models can be considered as two parts of the same section. The connection between these is guaranteed by the same scenario hypothesis as indicated in the diagram below:
4.2 Macro model simulation

The simulation of the macro model is aimed basically at evaluating the impact of macroeconomic policies. It is possible for example to evaluate the effects produced by financial policy adjustments, monetary policy, employment policy, containing public expenditure, ENEL’s investment and tariff policy, and exogenous shocks to our economy on dynamic equilibrium of the main macroeconomic variables.

The simulation hypothesis can be transferred as information to the system through the 3 different simulation routes, defined in point 4.1 or through a combination of the 3.

4.2.1 Modification of exogenous variables

The specification of the structural relationship of a macroeconomic model establishes which among the variables used (selected from a group I_t) must assume the endogenous role and which the exogenous one. Obviously the choice is dictated by economic theories and the availability of statistical data.

When the economic theory defines certain structural relationships between the variables, so that some of them can be seen as endogenous and some exogenous, a specific causal relationship is established. Thus the variation of exogenous X is one of the causes of the variation of endogenous Y, but it itself is not influenced by variations in some of the other endogenous variables.

The forecast/simulation of Y_t+k is an output of the system if it receives the information input is formed by the predetermined values in relation to time t+k. The quality of the forecast depends on the plausibility of the future values assigned to exogenous variables.

These future values of exogenous variables are indicated in the simulation system as scenario hypotheses. Some of these have been realized by hypothesising particular economic reference viewpoints. These have already been implemented and recorded in the relevant data bank as a type of preconstituted menu from which to choose the most appropriate hypothesis at the beginning of each simulation. In particular there is a optimistic and pessimistic hypothesis which indicates both a favourable trend of exogenous variables in our economy and a less favourable one.

To implement the simulation modifying the exogenous variables of the model signifies evaluating the effect that a variation in one or more variables of the whole produces on the endogenous variables as a whole compared to a basic hypothesis.

It’s possible for example to evaluate what the effect of variation in exchange rate would be on the country’s economy.

4.2.2 Modifying the parameters

The information system foresees the possibility of modifying parameters estimated for a certain period of time within the simulation period. It’s possible to attribute different values for different intervals to each parameter up to a maximum of ten intervals. This type of simulation responds to particular needs and particular simulation hypotheses which indicate behavioural changes. We can hypothesize for example that in the future an employment policy is introduced for which there is a high mobility of labour. This hypothesis can be transferred into the system raising the parameter referring to the speed of adjustment of the equation relevant to employment. Elsewhere, due to a block of the “sliding scale” and the lack of adjustment of salaries in face of rising prices, we could say that the established (estimated) relationship of the past is no longer valid and so the parameter, in the salary equation linked to prices, would assume a lower value.

4.2.3 The transformation of the endogenous variables

The third route permits the exogenization of endogenous variables, in particular this route permits the evaluation of the impact caused by the variation in prices of electricity and so makes variable domestic prices seen a exogenously determined variable. This possibility has been foreseen for all the endogenous variables, but for prices the option to access to a data bank of price variation hypotheses coming from a dynamic price model has been inserted. The exogenization of a variable means that as a consequence it does not suffer from any variation of other variables but itself causes this like any other exogenous variable. So in the case of prices the trend of the variable can be caused by intersectorial relationships of the price model and not by structural relationships of the macro model.

The option in question moreover permits us to
hypothesize that the chosen variable would maintain constant values and not suffer from the influence of variations in the other variables in the simulation phase.

4.3 Simulations on dynamic price model

The sectorial dynamic price model allows the evaluation of the impact of price variations of electricity on the general level of production prices, by transferring the increase in costs on prices. The simulations in this nucleus of the system are compared with the basic simulation where for basic simulation we intend the result of the application of the dynamic price model on a specific scenario hypothesis (exchange rate, import prices, salary indices).

In keeping with this the price model refers to the same scenario hypothesis intended for the macro model but since it is a sectorial model, before calculating the basic simulation it is necessary to detach sector by sector the various exogenous variables present in the aggregated data bank.

This model indicates two simulation routes: the first route can be applied for example in the hypothetical event of variations in the exchange rate to evaluate the repercussions of such a shock on sector prices. The second route, specifically for the electricity sector, indicates the transformation of sector variables from endogenous to exogenous. In other words when the simulation is implemented we presume that the price of electricity is determined exogenously and that it does not suffer from effects of variations in the production costs but itself causes variations in the costs of other sectors.

The data bank of this model contains about 1,400 variables relating to expenditure and technical coefficients of domestic production as well as importation. In the model every expenditure coefficient has an equation in the system controlled by the same procedure (Proc Model) and in dynamic simulation all the equations are worked out contemporaneously with the sector price equation.

The result of the simulation can be recorded in variation percentage terms compared with basic simulation and used for the macro model to implement another simulation considering the trend of domestic prices determined by the price model as exogenous.

4.4 The management

The system foresees the management of the data bank and is sub-divided into three modules:

- scenario;
- simulation;
- domestic price hypothesis.

In the first two modules it is possible to renominate and/or eliminate the scenario hypothesis or simulation from the data bank. In the third, since the connection with the macro model foresees that the simulations refer to the same period, next to the name of the hypothesis about prices we find the simulation range indicated.
Appendix

The equations of the model

The model, as we have said, is formed by 14 equations which describe the behaviour of the exogenous variables. This appendix list the mathematical breakdown of those equations followed by a brief description of these variables. The parameters are indicated by the letter $a$ and the respective sub-index indicates the number of the equation and it’s position. The parameters relating to the explicable variables are indicated by $b$. The constants are indicated by $d$.

Private consumption equation

\[
\Delta \log C_t = a_{11} \log \left( \frac{y_t - v_t}{p_t} \right) + a_{12} \log \left( \frac{\pi_t E_t}{p_t} \right) - a_{13} \log \left( \frac{\exp \left( b_{14} r_{itt} (y_t p_t^{b_{15}}) \right)}{M_{t-1}} \right)
\]

Capital accumulation equation

\[
\Delta \Delta \log K_t = a_{21} \log \left( \frac{k^*}{k_{t-1}} \right) + a_{23} \Delta \log H + a_{24} \Delta \log A
\]

\[
k^* = \left( \frac{b_{23} Q_t}{K_{t-1}} \right)^{d_{21}}
\]

Import equation

\[
\Delta \log (IM_t) = a_{31} \log \left( \frac{IM^*_t}{IM_{t-1}} \right) + a_{32} \log \left( \frac{S^*}{S_{t-1}} \right) + a_{33} \Delta \log (P_i E)
\]

\[
IM^*_t = \left( \frac{\pi_t E_t}{P_t} \right)^{b_{32}}
\]

\[
S^*_t = \exp^{d_{31}} y_t \exp^{b_{37} y_t}
\]

Price equation
Public expenditure equation

$$\Delta \log (p_t) = a_{41} \log \left( \frac{p_t^*}{p_{t-1}} \right) + a_{42} \Delta \log (M_t)$$

$$p_t^* = d_{41} \left( \frac{\nu t^* a_1 w^* a_2 \Pi_t^* a_3 Q_t^{-1}}{a_1 + a_2 + a_3} \right)$$

Employment equation

$$\Delta \log (G_t) = a_{51} \log \left( \frac{G_t^*}{G_{t-1}} \right) + a_{52} \Delta \log (y)$$

$$G_t^* = \left( \frac{y_t}{b_{51}} \right)$$

Domestic income equation

$$\Delta \log (N_t) = a_{61} \log \left( \frac{w}{\nu} \right) - b_{61} \left( \frac{w}{P_t^* E} \right) - b_{62} \left( \frac{Q_t}{b_{63}} \right) + a_{62} \Delta \log (K_t)$$

Tax equation

$$\Delta \log (T_t) = a_{81} \log \left( \frac{T_t^*}{T_{t-1}} \right)$$

$$T_t^* = d_{81} \left( \exp \left( \frac{d_{81}}{82} Y_t \right) \right)$$

$$Y = y_t p_t$$

Monetary authorities reaction equation
\[
\Delta n = a_{91} \log \left( \frac{m_t}{m_{t-1}} \right) + a_{92} \Delta \log H_t + a_{93} \Delta \log R_t \\
\Delta n^* = \left( \exp^{d_{91}} \exp^{b_{91} \Delta \text{rit}} \exp^{b_{92} \Delta \log(3p)} \right)
\]

Export equation

\[
\Delta \log(X_t) = a_{111} \log \left( \frac{X_t^*}{X_{t-1}} \right) + a_{112} \Delta \log(A) \\
X_t^* = \left( d^{111} (P_f)^{b_{111}} \left( \frac{P_x}{E} \right)^{b_{112}} (Y_{ext})^{b_{113}} \left( \frac{\hat{K}}{K_{t-1}} \right)^{b_{115}} \right) \\
\hat{K} = b_{22} Q
\]

Export price equation

\[
\Delta \log(P_x) = a_{121} \log \left( \frac{P}{(P_f E)^{b_{121}} \left( \frac{Q}{N} \right)^{b_{122}} \left( \frac{Q}{N} \right)^{b_{124}}} \right)
\]

Money wage equation

\[
\Delta \log(w) = a_{151} \log \left( \frac{w^*}{w_{t-1}} \right) \\
w^* = b_{151} \left( \frac{Q}{N} \right)^{b_{152}} \exp^{-b_{153} t}
\]

Production equation

\[
Q = \exp^{d_S} (y)^{b_5}
\]

Rate of interest equation

\[
\Delta \log(\text{rit}) = a_{162} \log \left( \frac{\text{rit}_t}{\text{rit}_{t-1}} \right) - a_{163} \Delta \log M_t + a_{164} \Delta \log R_t \\
(\text{rit})^* = \left( \exp^{d_{161}} \exp^{b_{161} \text{rest}} \exp^{b_{162} \Delta \log E} \right)
\]

State capital deficit equation
\[ \Delta \log(DHI) = a_{141} \log \left( \frac{\exp^{d_{141}} H_{t} \exp^{b_{41} \text{ri} t} \exp^{b_{143} \Delta(i \rho)}}{\log(DHI)_{t-1}} \right) \]

Stock of bank advances equation
\[
\Delta \log(A) = a_{171} \log \left( \frac{\exp^{b_{171} \text{ri} t} (M_{t}^{b_{172}})}{A_{t-1}} \right) \]

Identity equation
\[
Ds = y_{t} - c_{t} - X_{t} - G - \Delta K_{t} + IM_{t} \]
\[
H = H_{t-1} + \Delta H_{t} + DHI \]
\[
S = S_{t-1} + Ds \]
Brief description of the variables:

- All the variables, excluding specified exceptions, are indicated at constant 1985 prices.
- All the variables have been deseasonalized using the X11 software method SAS except those already available in the National Accounts New Series 1970-1992.
- All the variables are expressed in logarithmic terms.

\( C_t \)  Family consumption. Represents the family consumption plus the collective consumption of private institutions.

\( IM_t \)  Import of goods and services.

\( G_t \)  Public expenditure, seen as current expenses of Public Administration.

\( X_t \)  Export of goods and services.

\( DK_t \)  Capital accumulation or net investments (net depreciation).

\( Ds \) Inventories variation.

\( y_t \)  Income. The criterion to reduce the model equations was adopted and so it was decided to include income with depreciation to guarantee a supply and demand account identity.

\( p \)  Domestic prices or de-inflation coefficient of GNP obtained by comparing GNP to current deseasonalized prices and GNP at deseasonalized constant 1985 prices.

\( S \) Inventories defined as accumulated from an annual base in the inventories variations (from the article by Gandolfo Padoan “The Italian Continuous time model”).

\( T \)  Tax. Includes direct taxation as well as indirect taxes, social burdens, less the contributions to production and social factors indicated at current deseasonalized prices.

\( M_t \)  Money seen as M1 + M2 and therefore in circulation plus deposits in current accounts plus deposits in savings accounts at the bank.

\( H \)  Public debt, from the accumulated net total requirement from base year 1960 indicated in Gandolfo Padoan’s article “The Italian Continuous Time Model”.

\( DHI \) Exogenous component of Public requirement formed by passive interest less active interest plus investment expenses less other current revenue.

\( PI \)  Import prices in foreign money obtained from the relationship between imports at deseasonalized current prices and imports at deseasonalized constant prices.

\( PX \)  Export prices, obtained from the relationship between exports at current deseasonalized prices and exports at constant deseasonalized prices.

\( r_{itt} \)  Domestic nominal rate of interest (rating of government bonds)

\( restt \)  International rate of interest indicated as short term rate of interest by USA treasury.

\( pf \)  Index of prices of competitors from Italian exports indicated as:

\[
Pf = \frac{\sum_{j \neq i}^{18} w^*_{ij} X_{ij}}{\sum_{j \neq i}^{18} w^*_j} \frac{\sum_{k \neq i}^{18} w^{*}_{jk} M_{jk}}{\sum_{k \neq i}^{18} M_{jk}}
\]

where

\[
w^*_j = \frac{X_{ij}}{\sum_{j \neq i}^{18} X_{ij}}
\]

\[
w^{*}_{jk} = \frac{M_{jk}}{\sum_{k \neq i}^{18} M_{jk}}
\]

\( X_{ij} \) Represents the Italian exports.

\( M_{jk} \) Importation of goods and services from country j to country k.

\( Yest \) International income intended as income expressed in dollars of OECD countries.

\( R \)  Monetary reserve evaluated as accumulation of sales on balance of payments (monetary movements).

\( E \)  Exchange rate Lira-dollar
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