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CGE VERSUS INFORUM MODELLING APPROACH

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Introduction

The analysis of what is in common and what makes the difference between quantitative economic models has been the object of a number of articles. Here, characteristics of Computable General Equilibrium (CGE) models and Inforum type models are compared. These models have been already examined together with other modelling approaches.

In front of numerous impact studies undertaken in Australia, being the majority of them based on an input-output framework, West (1995), for example, compared the characteristics of three groups of models. The first group was called the 'conventional input-output model', the second was identified by the acronym IOE, which stands for input-output plus econometric, and the third was the CGE model. Asked by Resources for the Future to be on a panel discussing alternative modelling strategies used to analyse the economic effects of proposal to limit greenhouse gas emissions, Monaco (1997) compared "types of models that try to explain or account for all parts of the overall economy"; he distinguished a) an input-output calculator, b) Applied General Equilibrium Models (where AGE is synonymous of CGE), c) Macroeconomic Models Linked to I-O Tables and d) Interindustry-Macro Models. Any comparison between these types of models includes the I-O model. West calls it 'conventional input-output model', Monaco prefers to call it 'input-output calculator'. The latter definition is similar to that implicitly given by Richard Stone in the Summary of the Proceedings of the Seventh International Conference on Input-output Techniques held in 1979. He wrote that

In the early stages the I/O model consisted of a matrix of intermediate product flows bordered to the right by one or more vectors of final demand and below by one or more vectors of pri-

mary inputs and other production costs such as provisions for depreciation and indirect taxes. Input coefficients were calculated, as a matter of simple arithmetic... They could be arranged in a matrix, usually denoted by A, from which the Leontief inverse, or matrix multiplier, (I - A)-1 could be calculated, though with a good deal more time and trouble than is involved nowadays. In the quantity version of the model this inverse transforms final demands into total outputs; in the price version, its transpose transform primary input and similar costs per unit of output into total costs per unit of output, or prices" (Stone, 1984).

But, he added, *"The development of the I/O model seems to be leading in directions in which its I/O core is becoming less and less discernible*. This is as it should be, because it shows the possibility of improving the very simple relationships which were used initially.

Inforum and CGE models represent, let us say, an 'improvement' of the simple relationships of the 'input-output calculator'.

However, the development of the I-O model has followed many ways; some of them have led to the abstractions of mathematical economics; others have produced interesting quantitative enrichments of the original model based upon empirical data. Inforum and CGE models belong both to the second group.

Modellers may even refer to data, such as national accounts; then, they may consider or ignore them simply focusing on the mathematical properties of their formalization. For better or for worse, Inforum and CGE modellers are forced to use data; they not necessarily look at them with the same care.

In this paper, instead of proposing a definition of these modelling approaches, it was preferred to adopt the definitions given by the model builders practising them.

1. A definition of CGE

An authorized history of the Computable General Equilibrium is available in a number of contributions by J.B. Shoven and J. Whalley (1982, 1994) who have been actively working in the field for decades. A recent contribution by P. Dixon and B.R. Parmenter in the *Handbook of Computational Economics* (1996) edited by Amman, Kendrick and Rust can be considered

an updated description of CGE modelling along with its history. Considering the Shoven and Whalley's lifelong project experience and that the Dixon and Parmenter's paper has been written for a handbook, although the sample is small, the historical references gleaned among their contributions seem to cover very well the common recognition of the main sources of CGE.

Dixon and Parmenter (1996) produce the following definition of CGE models grouping their *'distinguishing characteristic'* as follows:

> *i) They include explicit specification of the behaviour of several economic actors (i.e. they are general). Typically they represent households as utility maximisers and firms as profit maximisers or cost minimizers. Through the use of such optimizing assumptions they emphasize the role of commodity and factor prices in influencing consumption and production decisions by households and firms. They may also include optimizing specifications to describe the behaviour of governments, trade unions, capital creators, importers and exporters.*
>
> *ii) They describe how demand and supply decisions made by different economic actors determine the prices of at the least some commodities and factors. For each commodity and factor they include equations ensuring that prices adjust so that demands added across all actors do not exceed total supplies. That is, they employ market equilibrium assumptions.*
>
> *iii) They produce numerical results (i.e. they are computable). The coefficients and parameters in their equations are evaluated by reference to a numerical database. The central core of the database of a CGE model is usually a set of input-output accounts showing for a given year the flows of commodities and factors between industries, households, governments, importers and exporters. The input-output data are normally supplemented by numerical estimates of various elasticity parameters. These may include substitution elasticities between different inputs to production processes, estimates of price and income elasticities of demand by households for different commodities, and foreign elasticities of demand for exported products.*

This definition largely matches the CGE models which are encountered in related studies.

The definition of 'maximizing economic actors' clearly evokes the structure of a theoretical general equilibrium model where the number of economic agents is specified. When we move from the theoretical to the computable model, the number of economic agents is determined by available statistical information about a given economy. In other words, the implicit one-to-one representation of the economy taken for granted in the world of abstract concepts is absent. Thus, a CGE model builder should be aware that the usually available quantitative description of the economy is not a suitable basis for applying the tools offered by the micro-economic theory.

While some macroeconometric models may refer to a single good economy, CGE models are fed with a detailed description of the economy; but the detail is halfway between micro and macro variables. The level of detail may be labelled as 'meso'; that is, the level which policy makers are interested in. Therefore, CGE models fall short of the theoretical representation of the economy suitable for a general equilibrium model, but match the requirements of the policy maker.

This limit seems well perceived in the second point of the above definition: CGE models, it is said, *determine the prices of**, at the least**, some commodities and factors* which means that these models are less than General. However, they may still focus on important issues.

The third point explains what 'computable' means: CGE models *produce numerical results*. Thus, any estimated econometric model can be labelled computable. Furthermore, a CGE model is characterized by a database which 'usually' contains input-output account(s) and a set of 'normally' supplemented numerical estimates of various parameters. The role of such a database will be discussed later on.

2. A definition of the Inforum model

The name Inforum originally stood for "INterindustry FORecasting at the University of Maryland" and is now used by teams in different countries that work with the Maryland group to give evidence of the basic structure of the country model. A more illustrative name of the nature of these models might be Interindustry Macroeconomic (IM) models ─ "Interindustry" to

stress the presence of an input-output structure and a number of industries in the models and "Macroeconomic" to stress that all of the normal variables of macroeconomics (GDP, inflation, interest rates, employment, and unemployment) are covered. Like macroeconometric models, they use regression analysis of time-series. They do not, however, begin from a macro projection to allocate it to industries. Rather, the macro totals are obtained by summing the industry details: total employment is calculated by summing up the employment computed for each sector, and so on.

The *distinguishing characteristics* of an Inforum model can be summarized as follows.

i) The construction of a model should begin with establishing the accounting system. This accounting system is, in fact, already a model but with many exogenous variables; addition of econometrically estimated equations just reduces the number of exogenous variables. Without these behavioural equations, the model would be all framework with little content; without the identities, the content could be self-contradictory.

ii) A country I-O table can be regarded as cornerstone of such country models. As far as the multisectoral structure of the model, from the accounting identities the Inforum model embodies the real and price sides of an input-output model, that is to say

$$q = Aq + f$$
$$p = A'p + v$$

where A is the well known technical coefficient matrix, q and p are, respectively, the output and price vectors, f is the final demand vector and v is the value added per unit of output vector.

iii) An Inforum model provides the endogenization of many final demand and value added components; these are gathered into vectors f and v; the primitive real and price sides take now the form

$$q = Aq + f\left(q, p, z_R\right)$$
$$p = Hp + Tp^m + v\left(p, q, z_P\right)$$

where z_R and z_P are, respectively, the exogenous variables in the real and price sides of the model; H' and T' are, respectively the domestic and imported inputs per unit of output: H+T=A'; p^m is the vector of import prices. Now, we can see that having modelled final demand and value added components, the dependence of both of them on total output and prices is established; so, the Inforum model has prices and quantities fully integrated. Furthermore, all vectors and matrices have the index t which denotes the time index.

iv) An IM model, such as the Inforum one, must also include a number of macroeconomic equations. Various types of income – wages, depreciation, profits, and so on – originate in industries and are then added up over the industries to give totals of these types of income. They are allocated to different "institutions" such as families, business, and governments. Taxes are then "collected" from families at the aggregate level, without regard to the industry in which the wages were paid. Likewise, subsidies are paid at the aggregate level. The personal savings rate is also established and total household expenditure is derived. There may – or may not – be extra equations to construct in detail all the flows of the institutional accounts of the Standard National Accounts. Other variables, such as the total unemployment rate or interest rates may be determined in the macroeconomic part of the IM model. Thus, the Inforum models integrate completely the sectoral and aggregate aspects of the model. There is no macro-economic driver model, and no need for one. In so far as possible, the Inforum models are built from bottom up and use aggregate equations where it would make no sense to have sectoral equations, as for example the personal savings rate.

3. Do Inforum and CGE models have a common data base?

How to bridge theoretical and observable economic variables is a well-known problem which tormented many economists long before the systematic production of national accounts and related by-product statistics begun. Haavelmo (1944) in his seminal work "The Probability Approach to Econometrics", which placed econometrics into the statistical inference framework, commenting on "Abstract Models and Reality" stressed the distinction between "ob-

servable", "true" and "theoretical variables"; he concluded the discussion with the following advice:

> *...one should study very carefully the actual series considered and the conditions under which they were produced, before identifying them with the variables of a particular theoretical model.*

Later in the 1940s, the production of national income accounts flourished all over the world (mainly in the more developed market economies); under the guidance of the manual entitled System of National Accounts, published by the United Nations in 1953 and updated in 1968 and 1993, national accounting has been progressively implemented.

The production of national accounts is not simply a matter of diligent data collection. The statistics have to respond to theoretical requirements and, in a way, the system of income-production accounts may be considered a set of equations of a theoretically founded economic model[1]. It is obvious that there is an enormous amount of statistical information about the economic activity, but *"No amount of searching in primary records...in the books of a firm or individual, will enable us to detect the income that has been made. To ascertain income it is necessary to set up a theory from which income is derived as a concept by postulation and then associate this concept with a certain set of primary facts"* (Stone, 1951, p. 9). On the other hand, *"statistical information is always collected with some theory in mind and the concepts adopted in the process of collecting the statistical material determine the range of models, for which this information can be used in a meaningful way"* (Rainer, Richter, 1989, p. 235). Given this view, since the System of National Accounts 1993 aims at showing *"the economic behaviour of the economy's participants, their interrelationships and the results and their economic activity"*, one may question which economic theory is behind national accounting. Certainly, the macro economic variables of the Keynesian model have inspired the national accounts statisticians and this is also well preserved in the input-output accounts. An

[1] Stone (1951) gives an example in which, in the construction of social accounting, four variables - income, consumption, saving and asset formation - are related by two independent relationships. Almon (1995) shows that the Standard National Accounts, the accounting system used in the United States, involves some 150 items connected by 40 identities; these may be used as the cornerstone for the so called *identity-centred* modelling.

economic theory may guide the social account statistician only if the theory states a sufficiently clear relationship between economic variables and observed facts. For example, whereas the firm's accounting books are considered to be the basic economic statistics, the economic theory must be well suited to the firm's economic environment.

As mentioned above, in the definition of a CGE, Dixon and Parmenter revealed that a CGE modeller is aware that the model falls short of being general; however, he refers to a micro economic representation of the economy and does his best to match the observed economy with his own point of view. While macro economists have clearly influenced the structure of economic national accounts all over the world, micro economic general equilibrium economists have had a very modest influence on designing the collection of economic data. This fact was underlined by Mansur and Whalley (1984):

> *... The detailed information presented in most national accounts, although clearly of enormous value to economists, nonetheless is largely a by-product of the process of assembly of macro aggregates and typically does not aim at consistency in various areas of detail that general equilibrium analysis requires.*

In order to bridge the gap between the 'theoretical variables' and those available, they suggested a reorganization of the available economic statistical data within the 'spirit' of the general equilibrium theory:

> *In practice, benchmark equilibria are constructed from national accounts and other government data sources. In general, the information will be inconsistent (e.g., payments to labour from firms will not equal labour income received by households), and a number of adjustments are required to the basic data to ensure that equilibrium condition hold. Some data are taken as correct and others are adjusted to be consistent in the process of generating a benchmark data set.*

The treatment of profits is a good example of the suggested adjustment of the economic statistics. The neoclassical paradigm implies that at the equilibrium firms realize zero profits. In national accounts, profits are not zero; this is not due to the fact that the observation of the economy is done out of the equilibrium. On average, profits are strictly positive and this is good for all of us. This fact does not shock a CGE modeller who looks at the economy

through data bases specifically manipulated to match his needs. "*In fact, the assumption of an 'observable' equilibrium leads directly to the construction of a data set that fulfils the equilibrium conditions for some form of general equilibrium model"* (Showen, Whalley, 1984). Although the '*detailed information presented in most national accounts... [have] enormous value to economists'* (Showen, Whalley, 1984), some adjustments ***'are desired'***.

In other words, the theoretical foundations of the CGE are not adequate to represent the real world; hence, the available representation of the world has to be modified. The CGE modeller does not reject the model; he rejects the data giving rise to the peculiar profession of the CGE data maker.

An Inforum modeller attempts to represent the real world as it really is. He is aware of the 'theoretical foundations' standing behind the national account statistics and does not force them to fit contradictory theoretical frameworks.

4. Theoretical foundations and functional forms

In the definition given by Dixon and Parmenter (1996), CGE models

> *include explicit specification of the behaviour of several economic actors (i.e. they are general). Typically they represent households as utility maximisers and firms as profit maximisers or cost minimizers. Through the use of such optimizing assumptions they emphasize the role of commodity and factor prices in influencing consumption and production decisions by households and firms. They may also include optimizing specifications to describe the behaviour of governments, trade unions, capital creators, importers and exporters.*

Indeed, CGE modellers confine the human behaviour to the domain of the neoclassical theory and use behavioural equations derived from the optimization of well defined functional forms. The maximization procedure could start from a utility function (or production as well as a cost function) with a given analytical form and a complete set of parameter values. Unfortunately, these functions are rarely estimated so that the economic 'literature' does not provide an adequate amount of estimated functions to be used to get quantitative behavioural equations as solutions of optimization problems. The standard practice is to choose a function with

a known analytical form; then, behavioural equations are obtained with a maximisation procedure; at this stage, the modeller must give numerical values to the parameters of the obtained analytical functions.

This procedure does not necessarily lead to acceptable results. For instance, from a textbook's point of view, one can assume a utility function shaped as a Cobb-Douglas function or as the utility function implied by the Stone-Geary's linear expenditure system.

The Cobb-Douglas utility function implies a set of demand curves with all own-price elasticities equal to -1.0, all cross-price elasticities equal to 0, and all income elasticities equal to 1.0.

The Stone-Geary's utility function leads to a linear expenditure system where, in order to determine all price elasticities, is sufficient to specify the income elasticities and one price elasticity. It is clear that there is no room to study seriously the effects of price.

One can say that this approach may turn out to be unsatisfactory. It is a matter of fact that this procedure fully matches the first characteristic of a CGE model, according to the Dixon and Parmenter's definition. In the widespread application of the CGE modelling approach, this is a common practice; the obedience to the neoclassical paradigm dominates the plausibility of the form of the behavioural equations.

An Inforum modeller aims at functional forms with desirable properties and capable to interpret and to describe the working of the observed economy. He is aware that the utility maximization process does not necessarily lead to useful demand systems. However, the neoclassical approach to the consumer theory (i.e., the utility maximization postulate) allows us to derive interesting operational restrictions which can be profitably used in shaping a system of demand functions. In other words, the utility maximizing postulate can be matched through the indirect utility function approach which permits the exploitation of the consumer theory restrictions, and the imposition of those economic properties which the model builder thinks a demand system should have.

A good example of this approach is given in Almon (1979) who was looking for a system of demand functions for medium-long run projections in the framework of a multisectoral model

for the United States economy. He posed a typical Inforum modeller's question: What Should a Functional Form Offer? He gave the following answer in ten points:

> *1. ..., a functional form should offer the possibility of expressing either substitution or complementarity between goods.*
>
> *2. It should permit some goods to have close substitutes and high price elasticities, while other goods, with no close substitutes have low elasticities.*
>
> *3. It should be homogeneous of degree zero in all prices and income, that is, doubling all prices and income should not affect consumption. Homogeneity is a necessary property for individual demand functions; the assumption that everyone's income changes in the same proportion makes it necessary for aggregate demand also.*
>
> *4. It should add up, that is, the amount spent in all goods plus the amount saved must equal income, or some predetermined fraction of income.*
>
> *5. It should be possible to use the assumption of Slutsky symmetry to reduce the number of parameters to be estimated. While this symmetry is by no means necessary for market demand functions, it is not implausible that it should hold closely enough to help us economize parameters.*
>
> *6. As income increases any asymptotic proportions of amounts consumed or of the budget shares should depend upon prices or at least this dependence should not be ruled out a priori.*
>
> *7. Marginal propensities to consume as income rises must be capable of being different for different goods. They should also depend upon prices in a way to be estimated.*
>
> *8. It should be easy to include effects of variables other than prices and income, such as stocks of durables, interest rates, lagged price and income, and time trends. The magnitude of these effects should be affected by prices.*
>
> *9. The parameters of the system should not be vastly numerous or difficult to estimate.*

10. Price changes alter the effect of income and non-income determinants of demand – such as stock of durables, interest rates, or time trends – in approximately equal proportions. Some forms concentrate all their attention on how prices affect marginal propensity to consume out of income; other forms just shift the consumption-income function (Engel curve) up or down without affecting the marginal propensity to consume out of income. Each has strange implications.

As it is well known, the direct utility function has a great intuitive appeal, but the indirect utility function is not without interest as it is endorsed by the above ten points; Almon respected the fundamental restrictions that come from the utility maximization, and suggested and estimated functional forms (Almon, 1979, 1996) that match the requirements above. One could ask about the analytical form of the correspondent utility function. I think that this answer can be left to mathematicians playing with challenging integration exercises. It is widely recognized that the knowledge of such utility functions does not give new light to the real working of the economy.

5. The choice of parameter values.

An Inforum modeller takes econometrics seriously. He starts with collecting data. He collects input-output tables, supply and use matrices if available, import flows matrices, non-deductible VAT flows (where this tax is applied) matrix, converter matrices for personal consumption expenditure and investments; then, he collects time series of sectoral components of the final demand (personal consumption expenditure, investments, exports, imports, public and collective consumption, etc.) and of the value added (wages, social securities, indirect taxes, amortisation, gross operating surplus, etc.). The data collection includes the institutional sectors' accounts; some of them overlap those contained in the input-output tables as well as in the final demand and value added time series; others provide the income distribution among firms, households, government and the rest of the world; these accounts represent the fundamental piece to introduce behavioural equations which concur to determine macro variable such as disposable income and government budget balance. Given this volume of

data, the Inforum modeller selects those matrices and institutional account to set the basic identities of the model.

The time series are used to estimate sectoral behavioural functions. Each item of personal consumption expenditures is explained by means of an estimated equation; the behaviour of each investor is modelled by means of an investment equation; sectoral import flows or shares are explained at sectoral level; wages, social contributions and other sectoral value added components are described by means of an estimated equation.

The choice of the analytical forms is determined by the Inforum modeller's economic wisdom; the estimated equations are tested through the model performance. This practice has been suggested by the experience accumulated within the Inforum modellers group. In fact, theoretically founded analytical forms (like those used in CGE models) or mere empirical correlations can turn out to be inadequate once introduced into the model. No matter the standard statistical tests, numerical trouble met during the model solution or non sense simulation results force the modeller to rethink and modify the quantitative equations used to enrich the basic set of accounting identities.

By definition, this work is ignored by a CGE modeller. In fact, Dixon and Parmenter stated, in the above definition of CGE models that: *"The coefficients and parameters in ... [the] equations are evaluated by reference to a numerical database"*. In fact, the CGE modeller does not estimate functional forms; he simply calibrates them picking up parameter values from data banks which in turn are made up with information collected from the (economic) literature. But the calibration procedure and the optimization postulate force the CGE modeller to deduce, for example, the demand functions from the analytical form of the utility functions. The procedure is well-known; once the first order conditions of the maximization of a *convenient* analytically specified utility function are obtained, the analytical structure of the demand functions is easily derived. Afterwards, the demand function parameters are 'calibrated'. The CGE modeller likes such a demand system, being an orthodox fruit of the neoclassical theory.

Hence, the CGE modeller likes to draw 'parameters' from the economic literature. The common practice is to draw parameters from data bases where 'parameters' are collected from the 'literature'. It is clear that while CGE modeller stays very close to the neoclassical paradigms, this practice takes him very far from the economic data. Available data bases containing se-

lected parameters from the literature together with manipulated national accounts put the CGE modeller far from the observed facts; he may even not be aware of the economic content of the data used in model building.

6. The *numeraire* and the observed prices

In the general equilibrium framework, there is a unit, named *numeraire*, used to express all the other unit values in the model. CGE models embody this measurement unit. The presence of a *numeraire* tells us that in CGE only relative prices matter; unfortunately, relative prices are not observable. Furthermore, the meaning of the *numeraire* seems to be largely misunderstood.

The national products and income account in the benchmark data are usually produced in value terms and many economic data can be separated in terms of price and quantity. As mentioned above, a General Equilibrium quantitative model is much less than General in the sense that the real world is not observed at the level of micro economic agents, and goods and services are not clearly defined[2]; in fact, economic statistics are collected at various levels of aggregation, and when the separation of the price and quantity components of the relative flows is possible, it is necessary to have to deal with indexes. The unclear argument suggested by Showen and Whalley is then surprising (1984): *"A commonly used units convention … is to choose units for both goods and factors so that they have a price of unity in the benchmark equilibrium"*. Kehoe and Kehoe (1994) are much more clear about this point; first, they realize that their model is going to be built on aggregates (*"apples and oranges have been aggregated into the primaries goods"*); second, they suggest that one should "*think of these variables as price indexes, which are naturally set equal to one in the base case"*.

Benchmark data (input-output tables, social account matrices, national accounts, etc.) are available in value terms; in fact, many variables in these data set have only nominal measure which – according to the double book-keeping principle – balance with all the other variables in the accounts; but some of them can be split into price and quantity. Prices may be made available only for those variables which are physically measurable (tons, litres, dozens, hours,

[2] *clearly defined* means that no mix is allowed

denumerable objects, and so on). Anyway, these variables are aggregates; so, the appropriate measurement of their prices is done by means of indexes related to a base year. Hence, rather than to say that we adhere to a *'common used units convention'*, it is convenient to make the benchmark year and the base year the same, so that at the base year all price indexes are equal to one[3].

This choice combined with the homogeneity of degree zero in prices and income of the demand equations implies that in the calibration process price elasticities are necessarily drawn from the 'literature'. In other words, in the calibration process, observed prices are mostly uneffective; the performance of a CGE model is largely independent from benchmark data as the price components are concerned.

Following the attention paid to prices in CGE modelling, it clear that prices are not considered front line variables. Production, exports, imports are well described in the aggregates in sectoral detail; often, there are no prices in the tables dedicated to simulation results. Prices are hidden in the welfare indexes that play an invading role, while this detail should deserve central attention and visibility. Kehoe and Kehoe (1994) inform about a *'typical practice'* which is *'to normalize prices so that a certain price index remains constant'*. It is surprising that the declared perfect elegance of the neoclassical theoretical background of the general equilibrium theory does not suggest anything better than a *typical practice* for modelling prices in CGE models.

An insight into price modelling in CGE models can be inferred from Hoffmann (2002). He states that *"economists normally view the field of imperfect competition in general equilibrium models as an open Pandora's box of theoretical problems"*; nevertheless, *"an increasing number of policy questions require that we incorporate imperfect competition"* in CGE models. In fact, considering that competition policy cannot be analysed in the traditional models with perfect competition, the implementation of these models turns out to be on the top of the CGE user agenda.

[3] Needless to say that the choice of the base year is conceptually not equivalent '*to assume that quantity units for all composite commodities are chosen so that their initial purchasers' prices are unity*' (Dixon and Parmenter, 1996).

Firms in imperfect competition are not price takers; their strategy is summarized in the choice of a mark-up. Indeed, CGE models with a mark-up on prices are numerous, but, in general, the implication of this amendment to the general equilibrium framework is not clearly considered. The CGE benchmark data set contains a modified national account system where profits have been removed in honour of the General Equilibrium Paradigms. Hoffmann (2002) rightly underlines the relevance of imperfect competition which implies that profits have to be put back into the benchmark data set. The inclusion of profits in the value added implies production function specifications which differ from those based on of the zero profits assumption. Of course, a specific benchmark data set may be designed for CGE model with imperfect competition. In other words, different theoretical specifications of a CGE model are tackled by building different benchmark data sets. What comes out from this practice is that the CGE modeller has disregard for the economic facts.

Hoffmann (2002) revisits the problem of choosing the *numeraire*. He considers previously published contributions on the importance of the choice of *numeraire* underlining its influence on the measurement of welfare gains. Indeed, he refers to Ginsburgh (1994) who claimed that there might be *"more welfare gain from changing the numeraire than eliminating imperfections in the applied general equilibrium model"*. But the problem is that the equilibrium solution gives only relative prices which are not observable, and he dares to "*argue that choosing the numeraire freely is economically meaningless"*.

Inforum modeller takes the same year for benchmark and prices, so that at the base year all price indexes are equal to one. He is aware to deal with price indexes, but he uses time series to estimate behavioural functions, such as personal consumption expenditure demand functions, involving prices. Hence, no matter the degree of these functions, prices enter the estimation procedure supporting the determinations of parameters such as price elasticities. Of course, the estimated parameters are immediately used to test the equations adequacy to mimic the observed economy, both standing alone and within the multisectoral model. The Inforum modeller does not send his estimates to the 'economic literature' where the CGE modeller should observe the economy. Indeed, as known from the Dixon and Parmenter's definition and from the practice described in the 'literature', the CGE modeller uses 'second hand' parameters taking them from databases which contain only those chosen by the 'database-maker'.

7. The Inforum type model and the Inforum system of models. The Bilateral Trade Model (BTM)

An Inforum type model has its own analytical and theoretical framework as described in Almon (1966) and Almon *et al*. (1974) and, recently, in Grassini (1998). An Inforum type model becomes a member of the Inforum system of models when it runs together with all the other country models which make the Inforum system. In fact, these models turn out to be a distinctive feature. They are driven by a world commodity trade model, the Bilateral Trade Model (BTM) created and originally estimated by Qiang Ma (1996). The basic idea underlying this trade model was originally stated many years ago (see Armington (1969a, 1969b) and Rhomberg (1970,1973)); subsequently, a number of studies tackled estimation problems involved in the construction of this kind of trade models (see, for example, Nyhus (1975), Fair (1983)). These researches mainly focused on modelling trade shares by using relative prices as explanatory variables; the BTM model shares the basic characteristic of earlier works and contains interesting innovations.

First of all, BTM is based on a bilateral database, WTDB, released by Statistics Canada. This database provides high quality as well as updated data on commodity trade, which covers all the world commodity trade and makes the bilateral model genuinely 'global'. The raw data set has been submitted to two aggregations. One concerns the commodity classification where the large number of commodity flows has been reduced to a set of 120 trade flows. The second is geographical so that the number of trading countries has been reduced from 200 to about 60; they include the countries of the system of multisectoral models and other countries or groups of them countries (for instance, the transitional economies in the Eastern Europe, OPEC countries, South Africa, other developing Asian countries, and major South American countries). The data allow to construct bilateral trade flows matrices for 120 commodity groups. Each matrix has a number of rows and columns which are related to the above 60 countries. The BTM database is ready for hosting this huge number of countries which can be easily added to the existing country models in the system.

The BTM works as follows. It takes the sectoral imports from each country model and allocates them to the exporting countries within the system; this allocation is done by means of import share matrices computed from the trade flows matrices; imports demanded to a coun-

try turns out to sum up to its exports. Hence, this model ensures the balance of imports demanded to a given country with its exports; this balance is obtained for each commodity group.

Then, the key work of the model is to calculate the movement in 120 import-share matrices. First of all, imports by product, prices by product, and capital investment by industry are collected from the national models. Then the model allocates the imports of each country among supplying countries by means of the import share matrices mentioned above. In any one of these matrices, which we denote by S (for share), the element S i j t is the share of country i in the imports of country j of the product in question in year t. (t is 0 in 1990). The equation in the BTM for this typical element is

$$S_{ijt} = \beta_{ij0} * \left(\frac{P_{eit}}{P}\right)^{\beta ij1} * \left(\frac{K_{eit}}{K}\right)^{\beta ij2} * e^{\beta ij3\,Tt}$$

where,

P_{eit} = the effective price of the good in question in country *i* (exporter) in year *t*, defined as a moving average of domestic market prices for the last three years;

P_{wjt} = the world price of the good in question as seen from country *j* (importer) in year *t* (see description below);

K_{eit} = an index of effective capital stock in the industry in question in country *i* in year *t*, defined as a moving average of the capital stock indices for the last three years;

K_{wjt} = an index of world average capital stock in the industry in question as seen from country *j* in year *t* (see description below);

T_t = Nyhus trend variable, set to zero in the base year, 1990.

β_{ij0}, β_{ij1}, β_{ij2}, β_{ij3} are estimated parameters.

The world price, P_{wjt}, is defined as a fixed-weighted average of effective prices in all exporting countries of the good in question in year *t*:

$$P_{wjt} = \sum_i S_{ij0} P_{eit}$$

$$\sum_i S_{ij0} = 1$$

and the world average capital stock, K_{wjt}, is defined as a fixed-weighted average of capital stocks in all exporting countries of the sector in question in year $_t$:

$$K_{wjt} = \sum_i S_{ij0} K_{eit}$$

The fixed weights in the definition of the world price and the world average capital stock, the S_{ij0}, are the trade shares for the base year 1990. The use of the fixed weights ensures that the share equation satisfies the 'homogeneity' condition as suggested by the demand theory. For example, if all effective domestic prices, P_{eit}, are doubled, then a doubling of the world prices as seen by each importing country (or its import prices) leaves the price ratio unchanged.

The idea behind a relative capital stock as explanatory variable is that (new) investments contain embodied technical progress. A capital stock which contains more recent investments may make the industry more competitive. In other words, an industry can increase its market shares by investing. In order to stress this assumption, capital stock is computed from investments, and the depreciation rate is consequently chosen as strategic variable.

This idea may have been taken from the following statement (European Commission, 2002):

> *Developments in productivity are the result of many different factors, but depend largely on investment performance, which determines the structure and size of the capital stock and enables the penetration of the new technologies in the economy. A higher rate of investment growth raises the capital available per worker and thereby - ceteris paribus - labour productivity... A high rate of innovation in a context of strong investment growth increases also the quality of the capital stock.*

which is contained in the "2002 Broad Economic Policy Guidelines" prepared by the Economic and Financial Affairs Department of the European Council; this statement does not refer to any economic paradigm; anyway, although it is rooted in the economic common sense, it does not prevent any attempt to give it a theoretical framework, including the neoclassical one. In this sense, this statement may surely be provided of theoretical foundations.

8. Conclusions

The above descriptions of the CGE and Inforum modelling approaches are far from being exhaustive. They are mostly taken from Grassini (1998, 2004). The description of the multisectoral Inforum model stems from the author's experience who, within the Inforum system of models, has built and maintains the country model for Italy. On the contrary, the CGE modelling approach has been detected from the literature. Since, Computable General Equilibrium modelling, for better and for worse, has become 'mainstream' economics, the minor contributions deviating from this mainstream have been intentionally ignored. The reader is invited not to use them to critique the following statements:

- The CGE is based on the neoclassical paradigms. The optimization principle is applied to a short number of well defined analytical forms of utility, production and cost functions. The choice of these forms is up to the model builder. The model builder does not care about the 'economic' implications of such choices.

  The Inforum modeller considers the 'economic' performance implied by any analytical function in order to be aware of the expected performance of the model once it is used for simulation purposes.

- CGE model hinges on a single equilibrium year and it has no way of incorporating a dependence of anything on a growth rate.

  Inforum models embody equations estimated by using time series, so that the specification of the equations is not bounded by this restriction.

- The simulations done by using CGE models are basically used for comparative static analysis. The CGE models may be declared static or dynamic, but they are both focussed on steady state equilibria;

  Inforum models are explicitly dynamic; they refer to real dates for each year's solution, rather than referring to an equilibrium at some unspecified time.

- CGE models are timeless. The dynamic CGE models are based on dynamic optimization processes, but the outcome sequence which links two equilibria does not refer to the calendar time. In fact, the outcome sequence time index is rightly named 'period'

by the dynamic CGE modellers. The 'period' is not much different from the 'iteration step' in the static CGE model.

The Inforum models strictly refer to the calendar time; each solution is related to a specific, for example, year.

- CGE models do not refer to the observed economy. They are based on data collected in special data bases which contain manipulated economic data. The manipulation aims to suit the observed economy to the neoclassical paradigms (for example, the zero profit assumption in the perfect competition environment implies the removal of profits from the national product and income accounts). Different assumption concerning imperfect competition regarding different industry sectors, must refer to different quantitative representation of the same economy.

  Inforum modellers take economic data seriously. They are aware about the theoretical foundations supporting the primary data collection as well as the compilation of the national accounts.

- Besides the reference to the fiction *numeraire*, CGE models may consider only relative prices which have a didactical and theoretical appeal but are not observable and hence not applicable; anyway, they are not necessary to give the quantitative picture of the economy at the equilibrium base year.

  In the Inforum models, relative prices play an important role in econometrically estimated equations such as personal consumption expenditure demand system, import equations, import shares in the BTM. Wherever relative prices are expected to be important explanatory variables, their impact is carefully evaluated and they influence the model performance.

- CGE models do not consider what happens outside the equilibrium.

  Inforum models allow disequilibrium, for example, in employment, just as the real economy allows disequilibrium.

- A detailed representation of the economy (mainly based on input-output tables and institutional accounts) is a necessary and important foundation to build macroeconomic models tailored for policy simulation and forecasting, and useful for policy making.

Even the CGE modellers work on this ground, but they produce nothing more than a giant representation of the practice to prepare textbook exercises.

On the contrary, (Almon, 1996):

Inforum models are capable of true forecasting. Then, they can be wrong. And from being wrong, they can be improved. Put otherwise, they are testable scientific hypotheses. Since most CGE's cannot proved wrong, their principal value is in showing the consequences of their builder's assumption. This is a very considerable value, for in economics the consequences of assumptions are often far from obvious. Yet the scientific status of a CGE which cannot be proven must remain questionable.

No Inforum model has ever been complete, finished, and totally satisfactory. Building and working with them is a continuous adventure. It is, in our slightly immodest opinion, the most extensive effort in the world today to understand how modern economies work, to record that understanding in a form which makes it applicable and testable, and then to apply it to questions of policy and forecasting. Any immodesty in this opinion is quickly counteracted in practice by an acute awareness of how imperfect the models still are. Much, much remains to be done.

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