STUDI E SAGGI

– 121 –

STRUCTURAL ECONOMICS

Titoli pubblicati

Rossella Bardazzi and Leonardo Ghezzi (edited by), *Macroeconomic modelling for policy analysis*
Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future. A tribute to Maurizio Grassini and a selection of his writings*

Economic multisectoral modelling between past and future

A tribute to Maurizio Grassini and a selection of his writings

edited by
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FIRENZE UNIVERSITY PRESS
2013

Economic multisectoral modelling between past and future : a tribute to Maurizio Grassini and a selection of his writings / edited by Rossella Bardazzi. – Firenze : Firenze University Press, 2013.
(Strumenti per la didattica e la ricerca ; 121)

http://digital.casalini.it/9788866554097

ISBN 978-88-6655-408-0 (print)
ISBN 978-88-6655-409-7 (online)

Layout by Alberto Pizarro Fernández - Pagina Maestra s.n.c.
Cover image: © Rolffimages | Dreamstime.com

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Università degli Studi di Firenze
Firenze University Press
Borgo Albizi, 28, 50122 Firenze, Italy
http://www.fupress.com/
Printed in Italy

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PART II
ESSAYS IN HONOR OF MAURIZIO GRASSINI

INTRODUCTION

> Model building is both an art and a science. Science may mostly be transferred by means of traditional vehicles such as articles and books. Art requires other qualities; the experience of model building, the effectiveness of old and new tools used or specifically created, the efforts ended in failure, devices to tackle a number of difficulties, all contribute to the invaluable patrimony of every model builder (Grassini, 2001, p.1).

The words quoted above synthesize the work of an applied economist building macroeconometric models: this is the vision which has inspired Maurizio Grassini's work and which has certainly enabled him to build up a vast 'patrimony' of experience and know-how which this book intends to pay tribute to. Despite being an econometrician, Maurizio Grassini would probably define himself as first and foremost a model builder using econometric techniques to analyze and explain economic phenomena. He has, and continues to dedicate a large part of his professional life to building and developing the INTIMO model (Interindustry Italian Model), transferring the know-how acquired in model building to his university teaching. He has always eschewed the idea of having 'pupils' preferring instead to create relationships with those of independent mind, but I'm convinced that many of the people who completed their training under his guidance, including myself, consider him their mentor for having passed on that wealth of knowledge needed for them to conduct their professions independently. Precisely for this reason, the book does not aim to be a celebration of the past but takes a look at the future of the multisectoral modeling which M. Grassini has contributed so much to and which the selection of his works reprinted here is merely proof of. Colleagues and friends who have encountered M. Grassini in the professional sphere on matters of quantitative economic analysis or still working with him on interindustry models have contributed to this book to look at the future prospects of a research field firmly based on the experience of what has been done so far.

The selection of M. Grassini's works presented in the first part of this volume is mainly devoted to research issues of multisectoral modeling.

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The selected papers have been reprinted in the language of the original publication – Italian or English – and are presented here in chronological order although a unique *fil-rouge* connects all these contributions which are related to the development of a macroeconometric model for the Italian economy, INTIMO. This model has been developed by M. Grassini since the beginning of the 1980s within INFORUM (INterindustry FORecasting at the University of Maryland), a research project founded in 1967 by Clopper Almon. As described by its founder in the introduction of a special issue of *Economic Systems Research* – the official journal of the *International Input-Output Association* – devoted to the INFORUM approach to interindustry modeling,

> […] the basic idea of an INFORUM model of an economy is simple. It is an internationally-linkable, dynamic, interindustry model which imitates as closely as possible the way the economy behaves. It is intended for both public policy analysis and business forecasting. Where appropriate, it uses regression analysis to describe the behavior of consumers, producers, exporters, importers, investors, or other economic decision makers. It uses explicit and (usually) changing input-output relations among industries. That use assures absolute accounting consistency, on the product side, among final demands, intermediate use, and production of products and, on the price side, among prices of products, the costs of materials used and the value-added generated in making them. (Almon, 1991, p. 1).

This modeling approach was first applied to the US economy then, in the early 1970s, groups in other countries began to cooperate with INFORUM in building models for their own countries. One of the first international partners was M. Grassini who was immediately fascinated by the potential of this approach and decided to join the network, devoting himself entirely to building the first version of the Italian model during a research period at the International Institute for Applied Systems Analysis (IIASA) in Austria. At the same time the first linking of the various models was performed by C. Almon and D. Nyhus. That linking system and the country models have steadily developed since then, with changing partners but an ongoing exchange of experiences. The first annual INFORUM World Conference was held at the University of Rennes (France) in 1993 and, since then, this has been an opportunity to exchange new software, new research experiences and techniques through the presentation and publication of papers representing the work of INFORUM activities worldwide. As one of the first international partners to join INFORUM, M. Grassini has actively promoted and organized several of these conferences and participated in the modeling activities of other national groups. In particular, he has been very keen in developing relationships with research groups in the Baltic countries, which fruitfully evolved into a new national model for the Latvian economy.

The basic structure of the INTIMO model is the same as other interindustry models of INFORUM network: however, the beauty and power of this approach allows each model builder to give «a personal touch to the architecture of his country model; institutional peculiarities of a country, availability of statistical economic information, (economic) personal beliefs, all those contribute to making each country model different from any other in the system» (Grassini, 2001, p. 2). A first example is given by the first paper: *A system of Demand Equations for Medium-to-Long-Term forecasting with Input-Output Econometric Models*. The real side of an INFORUM model contains several final demand components (private consumption expenditures, government expenditures, investments, imports and exports, inventory changes) evaluated at any level of desirable disaggregation. Some of these components may be explained by econometric equations to make them endogenous to the system. To this end a system of personal consumption equations was designed and estimated for Italian households over a 40 commodity classification. This early version of a demand system for INTIMO was one of the first steps in developing a modern multisectoral dynamic model – or an input-output (IO) model +econometrics as named by West (1995) – where the basic accounting IO identities are surrounded and enriched by econometric equations with the aim of improving the explanatory potential of the seminal Leontief equation. The role of IO accounting identities and their coexistence with structural econometric equations inspired M. Grassini's paper *Problemi econometrici della modellistica multisettoriale* (Econometric problems of multisectoral modeling). When the input-output model builder decides to implement behavioral equations to explain some economic variables within the IO structure of the model, «the theory which inspired the reference accounting framework abandons the model builder and he cannot but live with the sentence of theoretical eclectism. Indeed, no input-output theory exists for household sectoral consumption, salaries, profits and anything else that might be encountered when enriching the complexity of an IO model» (editor's translation of Grassini, 1991, p. 49). The introduction of structural equations to explain economic variables at a sectoral level brings in several interactions which were not included in the original Leontievian scheme: these interactions connect the price and quantity systems and link variables within each system, such as prices with value added and final demand with total output. These interactions definitely modify the original analytic input-output framework and enrich its explanatory potential. In modeling the price formation, special attention has been devoted to the role of indirect taxes and in particular to value added tax (VAT) as described in the paper *Value-added taxes and indirect taxes in an EEC country model: the Italian case*. Indirect taxes are located in the nominal side of the model as a component of value added, along with depreciation, profits, interest, and labor compensation. They need to be appropriately placed in valuation matrices (see Richter's paper in this volume) and modeled in the price equation as they are not uniform for all products and industries. Moreover, excises also influence industrial international competitiveness as exports are not exempted. In macroeconomic models VAT is usually treated as a final consumption tax which affects only purchasers' prices but non-deductible VAT affects some specific industries and also influences producers' prices. That means that the valuation of the product across the row is not homogeneous and this heterogeneity needs to be appropriately treated both creating a VAT table and modifying the price equation. The solution described in the paper has been applied in several other INFORUM models of European countries. The issue of indirect tax modeling is described in greater detail along with the general structure of a modern interindustry model in the paper *The Core of the Multisectoral INFORUM model.* As stated by the author in the introduction to the book containing this contribution, M. Grassini's main aim in this work is to clearly describe the main features of an INFORUM model to highlight how this approach differs from traditional IO models. The 'interindustry' and 'macroeconomic' characteristics are recalled to explain that all relevant macro variables are obtained by a bottom-up approach, that is by summing up industry level variables. The model is dynamic and business cycles are shown, as it is not concentrated on an equilibrium condition in the future. The model has no assumption of fixed IO coefficients and changes in input-output relationships among industries are explicitly modeled. Finally, these models share a common software to facilitate international cooperation and make the linking mechanism possible.

The main purpose of these multisectoral models is public policy analysis and forecasting. The paper *Methodological Framework and Simulations for Evaluating the Impact of the EU Enlargement on the Italian Economy* shows how the Italian model and the international trade model which links many INFORUM national models may be effectively used to evaluate the economic impact of Eastern EU enlargement. Several simulation scenarios are designed beside the baseline: a higher growth rate of candidate countries, a deeper specialization in their trade structure, a removal of tariffs and non-tariff barriers. The interlinked system of models has made it possible to obtain very original results including the so-called 'indirect effects' or 'second-order effects' of enlargement which for some countries turn out to be more significant than the direct effects. These trade-induced effects can only be estimated by using a model of bilateral trade flows which accounts for economic interrelations of each country with other EU member states. Moreover, the multisectoral approach is particularly useful to evaluate the impact of such scenarios on the structure of Italian industry. The increase in exports produced by enlargement exerts a demand effect so that all industries benefit in varying degrees in terms of output growth. But the removal of tariffs produces effects which are industry-specific and therefore generate 'winners' and 'losers' among economic sectors.

As mentioned above, there are several characteristics distinguishing the INFORUM models from numerous others. In particular, Computable General Equilibrium (CGE) models have become very popular in economic analysis and therefore deserve special attention. The paper *Rowing along the Computable General Equilibrium Modelling Mainstream* is a very interesting analysis by M. Grassini of CGE models' main properties and their ability to assess public policies. This work has been appreciated in the related literature as a clear contribution to the «econometric critique» of CGE modelling (Barker, 2004; Scrieciu, 2007). CGE models do not rely on the econometric approach to estimate equation parameters. In contrast to macro econometric models such as INFORUM models, behavioral and technological parameters are chosen by the modeler through calibration. This method consists of assigning values to equation parameters (elasticities of substitution, income elasticities of demand, supply elasticities, etc.) on the basis of information drawn from various empirical studies in the literature and specific databases. In general CGE models are not validated against historical data in contrast with the INFORUM approach where data play a fundamental role both in the accounting framework and in the time-series equations. Furthermore, CGE concentrate on equilibrium positions: the economy is studied at two different points in time, the benchmark equilibrium and the future counterfactual equilibrium. The transition path toward the future equilibrium where the economy converges is not explicitly modeled. Even the dynamic models cannot tell us about the time it takes to reach the new equilibrium, as the *number of periods* can be known but not *the length of each period* along the transition. M. Grassini criticizes this modeling approach with detailed arguments and concludes that CGE models are not adequate to describe the working of the economy.

The last paper included in this part is an unpublished more recent work by M. Grassini: *Overlapping Leontief: A Boolean approach to economic thought*. Von Neuman, Leontief and Sraffa's economic models are analyzed and compared to argue about the main differences of their work stemming from a common base. The historical environment where these models were developed is firstly analyzed then the development of the models in time is explored to conclude that only Leontief's work was deeply rooted in the observed economy with an empirical approach interacting with a theoretical scheme. The main result of this effort being Leontief's input-output table which is the cornerstone of every multisectoral model. The focus on empirical analysis in Leontief's seminal work is a common feature which can also be envisaged in M. Grassini's research activity and is well described in the words of Leontief himself, which still sound very up-to-date, about the endless circular linkage between theoretical and empirical questions:

> […] this, incidentally, makes untenable the admittedly convenient methodological position according to which a theorist does not need to verify directly the factual assumptions on which he chooses to base his deductive arguments, provided his empirical conclusions seem to be correct. The prevalence of such a point of view is, to a large extent, responsible for the state of splendid isolation in which our discipline nowadays finds itself (Leontief, 1971, p.5).

The second part of the volume contains unpublished contributions in Italian or English by several economists who have deep-seated feelings of friendship, esteem and professional admiration for M. Grassini and have thus decided to take part in this project.

Josef Richter, Stefano Casini Benvenuti and Clopper Almon are among the oldest friends of M. Grassini in the economic profession. They share much of the same approach in economic analysis and the work of model building. As a partner of INFORUM since the early years and builder of a multisectoral model for Austria, J. Richter deals with the issue of *Empirical economics and economic data – some remarks on an uneasy relationship*. As already pointed out, economists should be aware of the nature and content of economic data and their relationship with theoretical models. Economic statistics themselves are the output of a modeling process involving several assumptions at different stages of the production process: a classification of different models used in producing economic statistics and the related issues is proposed by the author. Then the characteristics of input-output data are thoroughly explored along with model assumptions involved in this data generating process. Greater emphasis on the nature of economic data is strongly needed in the economic profession, with a continuous dialogue between the producers and users of economic data to better understand the needs for empirical analyses and the content of the information used.

Clopper Almon is the founder of INFORUM, a prominent economist and, most of all, a very good friend of M. Grassini. His work has inspired the development of multisectoral dynamic models and his generosity and determination has spread the construction of these models worldwide. He has shown endless energy in travelling around to visit national partner groups and helping to develop new INFORUM country models. M. Grassini joined this experience in the early days and never left it since. In his contribution to this volume with the beautiful and evocative title *Regress to revea*, C. Almon deals with the econometric practice of testing in regressions. As a storyteller, he explains the conventional view of regression as the Datamaker Fable who generated many vectors of variables y and X and threw it out into the universe. One of these struck our planet and created the economy we observe. It is the work of economists to compute the b parameters which on average represent the true $\boldsymbol{\beta}$. The derivation of the distribution of regression coefficients, of the t- and F-statistics is beautiful and elegant but it assumes that economists know exactly how the Datamaker works which is very far from what economic model building is about. Then the standard errors of regression coefficients and the other statistics are analyzed as ‘metaphysical’ statistics and alternative and more meaningful statistics are proposed as ‘factual’ in the sense of measures conveying meaningful factual information about regression.

As already mentioned M. Grassini has joined several research groups during his career and one of his most important collaborations which continues today is with IRPET, the Regional Institute of Economic analysis for Tuscany, an Italian region. His contribution to the development of the first IO model for the region is acknowledged by S. Casini Benvenuti when he recalls the early stages of the project at IIASA in Austria and the first contact with the INFORUM group in his paper *Il prof. Grassini e l’IRPET* (*Professor Grassini and IRPET*). The fruitful exchange of ideas and discussions on several modeling issues gives an account of M. Grassini’s generous attitude in sharing his knowledge with others in the continuous effort to progress the understanding of how economic systems work on the basis of an empirically-founded approach. As further testimony of the relationship with IRPET, Leonardo Ghezzi describes the most recent model under construction at the regional Institute in his contribution *DANTE: verso un nuovo modello multiregionale-multisettoriale dell’economia italiana* (*DANTE: towards a new multiregional-multisectoral model for the Italian economy*). DANTE stands for Dynamic Analysis for National and Tuscan Economy, it is a model based on the INFORUM approach applied in a multiregional setting where Italy is divided into 3 regions: Tuscany, Central-Northern Italy and Southern Italy. The input-output table is the core of accounting identities of the model, the structural model is then built with behavioral equations inspired by the «theoretical eclectism» explained by M. Grassini. This model will be linked to the microsimulation models for households and firms already in use at IRPET to simulate the effects of fiscal policies on the economy both at the ‘meso’ (by industry) and at the micro level. L. Ghezzi is one of the researchers inspired by M. Grassini’s teaching and research experience and who is successfully proceeding in his own field grateful for the lessons received.

The system of personal consumption equations applied to Italy in M. Grassini’s 1983 paper has been updated and expanded in more recent years in several directions as described by R. Bardazzi in *Modelling Household Consumption: a long-term forecasting approach*. The emphasis in the title about the ‘long-term’ horizon of the analysis must be kept in mind when evaluating the major characteristics of all enhancements achieved on the basis of the original design of the demand system by Almon in 1979. New issues such as the ageing population, the heterogeneity of consumption behavior for different households and generations, and the availability of new data at the micro level produced a 'virtuous circle' (Leontief, 1971) of new questions, theoretical advances and better data flows which permit new insights from empirical analysis.

Finally, the paper *Inversioni cicliche e previsioni macroeconomiche: Racconto di due recessioni* (*Cyclical turns and macroeconomic forecasts: The story of two recessions*) by Lisa Rodano, Stefano Siviero and Ignazio Visco concludes the volume. M. Grassini has cooperated with the Bank of Italy's Economic Research Department as a member of the Scientific Board for the conferences jointly organized by the Bank of Italy and CIDE, the Interuniversity Centre of Econometrics. Those conferences had as a general theme, quantitative research for economy policy (*Ricerche Quantitative per la Politica economica*) and economists from the Italian Central Bank, the academic world and other institutions were invited to discuss research experiences on relevant economic issues.

Macroeconometric modeling and forecasting activities are carried out within the Bank of Italy with several models and the key issue of the paper is related to the difficulties of models based on historical observations in capturing discontinuities such as those of the recent economic recessions in 2008-2009 (the Great Recession) and 2010-2012 (the sovereign debt crisis). As already mentioned, econometric models are just approximations of a complex reality and they may fail when structural breaks occur and the past may no longer provide reliable guidance. However this does not mean that they are useless and inadequate in describing the mechanisms of an economy: a failure may sometimes offer an opportunity to improve a model by a thorough understanding of the forecast errors. The paper presents a decomposition of forecast errors caused by (i) incorrect hypotheses in relation to exogenous variables; (ii) imprecise initial conditions of the forecast; and (iii) the use of add-on factor adjustments to include judgmental evaluations of the model builder stemming from external information. Results of the study show that forecasting errors of the Bank of Italy's Italy's Quarterly Model were reduced comparing the performance in the first and the second crisis: the largest error component is attributable to the approximation of initial conditions on which the predictions are based, then smaller errors stem from assumptions about exogenous variables, especially concerning the world demand. Instead, the use of model builder's 'judgment' contributed to reducing the errors over the whole period of analysis. Moreover, forecasts during the second crisis showed smaller errors thanks to the use of satellite models which produced external information about the effect of credit crunch on economic activities. One lesson that can be drawn from this experience is that the use of all recent qualitative and quantitative information is crucial to improve the performance of a model and, in structural breaks, additional information from other models to capture mechanisms absent in the main model are valuable as well. Finally, as a last important lesson, it is essential to communicate to the public, including policy-makers, that a particular forecast embodies risks which may be made explicit by the use of fan-charts reproducing the probability distributions of forecasts or alternative methods at present being developed with the final aim of drawing attention to the possibility of alternative scenarios with a reduced but non-negligible probability of occurring.

Rossella Bardazzi

Thanks

To conclude this introduction to the book I would like to thank some people without whom this project would not have got off the ground. First of all Carla Sodini, Maurizio Grassini's wife and esteemed colleague in the History department, who suggested and supported this initiative, offering me the chance to make a small contribution and pay tribute to a person to whom I shall be eternally grateful. Thanks also to the many colleagues who enthusiastically contributed to this book, finding the time despite onerous professional commitments to respond to my requests, patiently taking my calls and reading my e-mails. My greatest thanks, it goes without saying, are lastly to Maurizio Grassini himself for everything he taught me and which he continues to pass on in a professional and human sphere, for having opened up the world of multisectoral modeling to me and made me part of the INFORUM group, generous and fun model-makers known in fact as the *INFORUM family.*

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PART I

MAURIZIO GRASSINI: SELECTED WRITINGS

A SYSTEM OF DEMAND EQUATIONS FOR MEDIUM-TO-LONG-TERM FORECASTING WITH INPUT-OUTPUT ECONOMETRIC MODELS[1]

Maurizio Grassini

1. Introduction

Systems of demand equations have been widely investigated at various levels of theoretical sophistication; this has led ·to the identification of related areas of research such as demand analysis and consumption theory. In general, the end in itself of such research is to produce a system of equations and estimate its parameters for a given economic environment (see Barten 1977, Phlips 1974, Theil 1975, 1976, Vinci 1970).

This paper describes a system of consumption functions proposed by Almon (1979) for use in medium-to-long-term forecasting, and presents numerical results calculated for Italy. This system is specifically designed to be a component of a large macroeconomic model; it should therefore be evaluated largely in terms of the required overall performance of this model.

The macroeconomic model of which this system of consumption functions represents a part is a member of the INFORUM group[2]; INTIMO (Interindustry Italian Model) is the Italian member of this group[3]. The INFORUM models can be described as modern input-output econometric models because of the type of quantitative analysis of final demand and value added components and because of the characteristics of the links between real and price sides[4].

The purely sectoral structure of these models implies a theoretical background determined by the «length» of the bridge thrown from ma-

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[1] Paper published in «Economic Notes», 1983, n. 2, pp. 84-96.

[2] The INFORUM project (Interindustry Forecasting Project, University of Maryland) was founded by, and has since been directed by, Professor Clopper Almon of the University of Maryland, USA.

[3] The INTIMO model is supported by IRPET (Istituto Regionale per la Programmazione Economica della Toscana) and ENI (Ente Nazionale ldrocarburi) and is directed by Professor Maurizio Grassini of the University of Siena, Italy.

[4] The main features of the INFORUM models have been described by Almon and his co-workers (1966, 1981, 1982), and the structure of the Italian model by Grassini (1982).

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croeconomic towards microeconomic theory and reflected in the sectoral detail considered[5].

In this context, the system of equations describing private consumption expenditure must reflect as far as possible the disaggregation imposed by the available I/O table and at the same time should have desirable properties such as «adding-up», homogeneity of degree zero in prices and income, the possibility of substitution or complementarity between goods and, if possible, Slutsky symmetry. Furthermore, the model should be such that, as the forecasting horizon moves far from the sample period price changes should alter the effect of income and non-income determinants; the marginal propensity to consume as income rises must be capable of being different for various goods and not necessarily independent of the price system; budget shares should depend on prices as income increases and, finally, the effect of other variables should be easy to include.

The model is outlined in Sections 2 and 3. In Section 4, the statistical data used and the estimates for Italy are presented and discussed.

2. *The model*

The equations in the demand system have the basic form

$$q_i = f_i(\bullet)\, g_i(\bullet) \quad i = 1, 2, \ldots, n$$

where

q_i	is the per capita consumption of good *i* (in constant prices);
$f_i(\bullet)$	is a function of determinants unrelated to prices; these include real per capita income and its functions;
$g_i(\bullet)$	is homogeneous of degree zero in prices;
n	is the number of commodities.

The determinants unrelated to prices considered here are income, its first difference, and a trend factor. This leads to a function $f_i(\bullet)$ of the following form:

$$f_i(\bullet) = b_{0i} + b_{1i}\,\bar{y} + b_{2i}\,\Delta\bar{y} + b_{3i}\,t$$

where $\bar{y}$ is the per capita income factor (disposable income, total expenditure, etc.) measured in real terms, $\Delta\bar{y}$ is its first difference, t is the trend factor, and the *b's* are parameters to be estimated statistically. $f(\bullet)$

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[5] The concept of a «bridge» between macro- and microeconomic models was introduced by Sylos Labinl (1967) in a presentation of the theoretical foundations of his econometric model for Italy.

includes a deflator which is equal to *1* at the base year (t_0). It is shown later that $g(\bullet)$ is equal to *1* at t_0, and thus the «adding up» condition implies

$$\Sigma_i b_{1i} = K \text{ and } \Sigma_i b_{0i} = \Sigma_i b_{2i} = \Sigma_i b_{3i} = 0$$

where K is the ratio between total consumption expenditure and the income variable used.

The price function takes the following form:

$$g_i(\bullet) = \Pi_j p_j^{C_{ij}} \qquad j = 1, 2, \ldots, n$$

where p_j represents the price of good j, c_{ij} is the price elasticity and the homogeneity condition implies

$$\Sigma_j c_{ij} = 0.$$

We can see that the demand function constructed above has the following properties, at least at the initial point: (a) it is homogeneous of degree zero in prices and income; (b) the adding-up condition is preserved; (c) the marginal propensity to consume depends upon prices.

We now introduce various assumptions which reduce the number of parameters to be estimated while still preserving the desired properties of the system (as is generally done when using utility maximization theory). Away from the initial point, the adding-up condition is obtained by introducing a «spreader», the role of which is explained in detail by Almon (1979). Constraints on parameters are derived from Slutsky symmetry (which is preserved whatever the initial point).

From the analytical forms of $f(\bullet)$ and $g(\bullet)$, the income-compensated derivative of q_i with respect to p_j

$$\left(\frac{\partial q_i}{\partial p_j}\right)_{\text{cost}} = \frac{\partial q_i}{\partial p_j} + q_j \frac{\partial q_i}{\partial y}$$

evaluated at the initial point is

$$\left(\frac{\partial q_i}{\partial p_j}\right)_{\text{cost}} = c_{ij} \frac{q_i^0}{p_j^0}$$

where ^{0} is used to indicate values measured at this base point. (This derivative may also be obtained by retaining the homogeneity property, which implies a constant real income). At the base point, the condition

$$\left[\frac{\partial q_i}{\partial p_j}\right]_{\text{cost}} = \left[\frac{\partial q_j}{\partial p_i}\right]_{\text{cost}}$$

therefore implies that

$$\frac{c_{ij}}{s_j} = \frac{c_{ji}}{s_i}$$

where $s_i = p^0_i q^0_i$ is the budget share of good *i*. Defining

$$\lambda_{ij} = \frac{c_{ij}}{s_j}$$

we have

$$q_i = f_i(\bullet)\Pi_j p_j^{\lambda_{ij} s_j}$$

where we take $c_{ii} = \lambda_{ii} s_i$ for the time being.

The analytical forms and assumptions outlined above yield a system of equations with the properties mentioned earlier, including the possibility of substitutability or complementarity between different types of goods. This substitutability/ complementarity relationship is based on the grouping procedure presented in the next section.

3. *The Grouping Procedure*

The assumption of Slutsky symmetry is made mainly in homage to the theory of consumption behavior and results in a modest reduction in the number of parameters to be estimated. In order to have the possibility of (a) either substitution or complementarity between goods and (b) different price elasticities between substitutes, we adopt a method based on groups and subgroups which is, at the same time, a powerful way of boiling down the number of parameters. We assume a set *C* containing *n* goods; each good *i* belongs to a group C^0 which is a subset of *C;* goods in C^0 are considered strictly as substitutes to goods in $\overline{C^0}$ (the complement of C^0), which is itself partitioned into subsets C^1, C^2,....

In its turn, C^0 can be divided into subsets C^0_1, C^0_2 and so on; within C^0_x, goods can be either substitutes or complements; between a good in C^0_x and goods in C^0_y for $x \neq y$ we can again find either substitution or complementarity. A subset C^0_x can be partitioned still further, with the goods in the newly formed groups being either substitutes or complements to each other, as at the previous level. In this paper the partitioning is stopped at the second stage (C^0_1, C^0_2, …), recalling that in the first stage (C^0, $\overline{C^0}$), only substitution between goods in different groups is allowed.

The grouping is naturally based on the expected complementarity/substitutability of the various goods, and is reflected mathematically in assumptions concerning λ_{ij}. These are

$$\lambda_{ij} = \begin{cases} \lambda_C, j \in C^0 \\ \lambda_0, j \in \overline{C^0} \end{cases}$$

for

$i \in C^0$.

Note that λ_0 is constant over all groups. This leads to the following decomposition of $g(\bullet)$:

$$g_i(\bullet) = \prod_{j \in C^0} {}_j p_j^{\lambda_{ij} s_j} \prod_{j \notin C^0} {}_j p_j^{\lambda_{ij} s_j}$$

Next, we introduce

$$\bar{p} = \prod{}_j p_j^{s_j} \qquad \bar{p}_H = \prod{}_h p_h^{s_h / s_H}$$

where $\bar{p}$ is the general price index (deflator), $\bar{p}_H$ is the group index for goods h ($h = 1, 2, \ldots, H$) in a group C^H, and $s_H = \Sigma_h s_h$ is the budget share of the group C^H. Then, assuming $\lambda_{ij} = \lambda_0$ for $j \in \overline{C^0}$, we obtain

$$g_i(\bullet) = \prod_{j \in C^0} {}_j p_j^{(\lambda_{ij} - \lambda_0) s_j} \bar{p}^{\lambda_0}$$

and taking out p_i *for* $i \in C^0$, inserting $1 = p^{\pm(\lambda_C - \lambda_0) s_j}$; and assuming $\lambda_{ij} = \lambda_c$ for $j \in C^0$ we get

$$g_i(\bullet) = p_i^{(\lambda_{ii} - \lambda_C) s_i} \prod_{j \in C^0} {}_j p_j^{(\lambda_C - \lambda_0) s_j} \bar{p}^{\lambda_0} .$$

Using the definition of the group price index, we obtain

$$g_i(\bullet) = p_i^{c'_{ii}} \bar{p}_C^{\lambda'_C} \bar{p}^{\lambda_0}$$

where $c'_{ii} = (\lambda_{ii} - \lambda_C) s_i$ and $\lambda'_C = (\lambda_C - \lambda_0) s_C$. Then, inserting the homogeneity condition

$$c'_{ii} + \lambda'_C + \lambda_0 = 0$$

we have

$$g_i(\bullet) = \left(\frac{p_i}{p_C}\right)^{-\lambda'_C} \left(\frac{p_i}{p}\right)^{-\lambda_0}.$$

The decomposition can be extended using a nested grouping procedure. We can consider a good i belonging to a set C_1; this is a subset of a set C_2; C_2 in turn is a subset of C_3 and so on, up to a set C_{n-1} which is a subset of C. Then good

$$i \subset C_1 \subset C_2 \dots \subset C_{n-1} \subset C.$$

Following the above procedure, we obtain

$$g_i(\bullet) = \left(\frac{p_i}{p_1}\right)^{-\lambda'_1} \left(\frac{p_i}{p_1}\right)^{-\lambda'_2} \dots \left(\frac{p_i}{p_{n-1}}\right)^{-\lambda'_{n-1}} \left(\frac{p_i}{p}\right)^{-\lambda_0}.$$

In view of the data available, we stop the procedure after dividing C into groups, and some of these groups into subgroups. In this case, we have

$$g_i(\bullet) = \left(\frac{p_i}{p_G}\right)^{-\lambda'_G} \left(\frac{p_i}{p_C}\right)^{-\lambda'_C} \left(\frac{p_i}{p}\right)^{-\lambda_0}.$$

The introduction of the subgroup C_G does not alter the relationship between λ_0 and λ_C; this is clear from the nature of the decomposition procedure. The basic idea (moving from right to left in the above equation) is to first consider goods i, j ($i \in C^0$, $i \in \overline{C^0}$) for which $\lambda_{ij} = \lambda_0$, then goods i, j ($i, j \in C^0$) for which $\lambda_{ij} = \lambda_C$ and finally goods i, j ($i, j \in C_G$) for which $\lambda_{ij} = \lambda_{ji} = \lambda_G$ because of the Slutsky condition inside the subgroup.

In practice, this involves working out the price index for the group C^0, and then considering the impact of transformation involving the parameters of the subgroups (or goods). Given λ_0 and the above definition of λ'_C, the introduction of subgroups leads to the following group (relative) price and individual (relative) price elasticities:

$$\lambda'_G = (\lambda_G - \lambda_C)s_G$$
$$c'_{ii} = (\lambda_{ii} - \lambda_G)s_i$$

where

$$s_G = \sum_{j \in C_G} s_j.$$

The extension of the subgrouping procedure does not introduce any particular difficulties: the values of the λ' and c'_{ii} may be readily derived from the values of the λ and c_{ii}, just as the values of λ and c_{ii} can be easily obtained from the λ'.

We now have two versions of function $g_i(\bullet)$: one indicates the price elasticities of all of the goods in the consumer's basket, the other summarises these elasticities in a small number of parameters, thanks to the assumptions about the values of λ in particular groups. The latter version of $g_i(\bullet)$ is useful for estimation and also introduces an element of simultaneity through parameters common to more than one equation in the given system.

Let us consider the equation for goods *i* and *j* that belong to the same group. We then have

$$g_i(\bullet) = \left(\frac{p_i}{\bar{p}_C}\right)^{-\lambda'_C} \left(\frac{p_i}{\bar{p}}\right)^{-\lambda_0}$$

$$g_j(\bullet) = \left(\frac{p_j}{\bar{p}_C}\right)^{-\lambda'_C} \left(\frac{p_j}{\bar{p}}\right)^{-\lambda_0}$$

from which we can see that, on the price side, the demand equations for goods in the same group have the same parametric structure; furthermore, the individual equations representing any good in the consumer's basket all contain a common parameter, λ_0. In view of this parametric structure, the problem of estimating the system of consumption functions collapses into the estimation of a single equation. By estimating the parameters relative to a given good, it becomes possible to evaluate the performance of the system of equations, commodity by commodity.

A good can be listed as a member of a subgroup, a member of a group, or a member of neither. Wherever a good is located, its presence can be detected through its price and the corresponding price elasticity. Thus, the complete parametric structure of the system of consumption functions can be obtained, yielding for each commodity the price elasticity, c_{ij}, for the good itself, its elasticity when it is in a subgroup, in a group, or in neither. The results for Italy presented in the next section are given in this form.

4. *The Estimates for Italy*

The estimates of the parameters for Italy are based upon annual data on private consumption expenditure over the period 1970-1981 (ISTAT 1982). These data cover 40 commodities and are available in both current and constant prices (base year 1970).

The income elasticities are assumed to be obtained exogenously through an analysis of family budget data; these data, together with the techniques and results, are presented in Grassini (1982). The assumed knowledge of income elasticities gives us an a priori estimate of b_{1i}.

The estimation procedure continues with the minimization (with respect to the unknown parameters) of the residual sum of squares of the linear expansion approximating the given equation. Linearization is achieved using the Taylor series terminated at the first derivative. Given b_{1i}, an estimate of the other *b*'s and λ's can be obtained. These values are then used to recompute the coefficients of the linear expansion and a new estimate of the parameter is considered. This iterative process is continued until the solution converges to within a pre-specified tolerance level. In the present case, convergence was very rapid.

The results obtained for Italy are presented in Table 1. Income and price elasticities (the latter given as individual, group, and general elasticities) are as defined in previous sections. It can be seen from the table that the signs and magnitudes of these elasticities largely correspond to the empirical and theoretical values. For example, all of the individual elasticities are negative; they are low for primary goods and services such as food, housing and health, and higher for luxuries such as fashion goods, transportation, durable and recreation. Looking at the group elasticities, it can be seen that items in the housing, health and food groups are complementary; the complementarity within the food group, although weak, may be interpreted as a basket effect, with substitutability taking place inside the subgroups[6]. However, this effect can be detected only for protein foods, other foods remaining complementary due, perhaps, to the nature of Italian eating habits. Goods in the other groups (alcohol and tobacco, clothing, durables, transportation, education, recreation and the other goods and services considered) show internal substitutability.

Each demand equation has a trend component which should detect changes in the consumption pattern unexplained by income, changes in income, or prices. This trend information, given in the table as a percentage of the endogenous variable in the last year of the sample period, can be used for a posteriori evaluation of the income elasticity estimate. An overestimate (underestimate) of the elasticity actually leads to an underestimate (overestimate) of the trend component, which tends to incorporate the income effect due to the bias. This is the case, for example, for the health commodities: these expenditures are mainly undertaken by the government but are attributed to families in the national account statistics. Thus, if the government increases these expenditures, income elasticities computed on the basis of the outlays recorded in family budgets cannot

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[6] The subdivision is made as follows: (a) bread and cereals, fruit and vegetables, potatoes, sugar, and soft drinks; (b) meat, fish, milk, and cheese; (c) coffee, tea, cocoa, and other foodstuffs.

Table 1 – Income Elasticities, Price Elasticities (Individual, Group, Subgroup and General) and their Average Absolute Percentage Errors (Aape) Calculated for 40 Commodities and Services from Italian Data

Commodity	Income elasticity	time in % of last yr.	price elasticities				aape
			individual	group	subgroup	general	
Foods							
Bread and Cereals	0.114	-0.0	-0.024	-0.007	-.007	0.004	0.8
Meat	0.471	1.2	-0.067	-0.018	0.049	0.010	0.7
Fish	0.004	1.1	-0.111	-0.002	0.005	0.001	4.4
Milk / Cheese	0,230	1.2	-0.097	-0.007	0.019	0.004	1.0
Oils and Fats	0.752	-1.5	-0.019	-0.004	-.007	0.002	2.3
Fruits and Vegetables	0.171	0.1	-0.028	-0.011	-.011	0.006	2.0
Potatoes	0.138	0.4	-0.018	-0.001	-.001	0.000	4.5
Sugar	0.200	1.4	-0.018	-0.001	-.001	0.001	1.4
Coffee / Tea / Cocoa	0.216	0.4	-0.014	-0.001	-.002	0.001	2.0
Other Foods	0.662	-1.1	-0.014	-0.001	-.002	0.001	1.8
Soft Drinks	-0.080	2.3	-0.018	-0.001	-.001	0.000	3.1
Alcohol & Tobacco							
Alcoholic Beverages	0.759	-1.8	-0.164	0.081		0.003	1.4
Tobacco	0.793	2.3	-0.176	0.069		0.002	3.2

Commodity	Income elasticity	time in % of last yr.	price elasticities				aape
			individual	group	subgroup	general	
Clothing							
Clothing Incl. Repairs	1.391	-0.7	-0.312	0.920		0.007	1.2
Shoes Incl. Repairs	1.008	2.5	-1.011	0.221		0.002	2.1
Housing							
Rent	0.355	1.0	-0.063	-0.076		0.010	0.8
Fuel & Electric Power	0.943	2.0	-0.010	-0.023		0.003	1.8
Durables							
Furniture	2.985	1.3	-0.800	0.205		0.002	3.2
Household textiles	1.809	0.3	-0.903	0.102		0.001	3.8
Household Appliances	1.978	0.0	-0.873	0.132		0.001	4.4
Glassware	1.895	3.4	-0.928	0.077		0.001	3.0
Non durable articies	0.928	-2.I	-0.933	0.072		0.001	5.4
Radio / Tv etc.	1.155	2.4	-0.680	0.325		0.003	2.7
Health							
Medical and harm. Prod.	0.504	4.4	-0.079	-0.009		0.001	3.9
Therapeutic Appliances	2.057	3.3	-0.070	-0.000		0.000	6.6
Services of Physicians, Nurses	1.399	2.7	-0.083	-0.013		0.002	5.7
Hospital Care	0.41	-4.4	-0.073	-0.003		0.000	4.2

Commodity	Income elasticity	time in % of last yr.	price elasticities				aape
			individual	group	subgroup	general	
Transportation							
Personal Transport Equipment	3.423	0.4	-0.587	0.177		0.002	5.5
Operation of Personal tr. eq.	1.346	1.5	-0.381	0.383		0.005	1.9
Purchased Transport	1.062	0.3	-0.651	0.113		0.002	3.3
Education & Recreation							
Communication	1.638	0.6	-0.600	0.042		0.001	5.1
Books / Newspapers & Magazines	1.702	-0.7	-0.584	0.058		0.001	4.1
Education Books	1.805	-2.5	-0.626	0.016		0.000	3.9
Entertainment & Recreat. Serv.	1.983	-1.9	-0.521	0.121		0.003	4.6
Exp. in Hotels, Restaurants	1.550	0.6	-0.324	0.318		0.007	3.0
Other Goods & Services							
Domestic Services	1.327	2.6	-0.097	0.002		0.002	6.7
Personal Care & Effects	1.083	1.4	-0.097	0.002		0.003	2.6
Other Goods	1.262	0.1	-0.097	0.002		0.002	4.0
Financial Services	2.127	0.3	-0.099	0.000		0.000	8.5
Other Services	0.836	1.3	-0.098	0.001		0.001	1.9

explain this expansion in terms of income determinants. In this case the trend component prevails over the income effect, but particular care must be taken with forecasts.

Since the equation system is used for forecasting purposes, the statistical index chosen to measure the goodness of fit is the average absolute percentage error (aape); the values obtained for this index suggest that the estimates are generally quite satisfactory. The worst estimates, according to this index, correspond to low-budget-share items and categories not necessarily attributable to households.

It should be noted that we need an assumption on prices to forecast private consumption expenditure. Once the system of equations has been inserted into the macroeconomic model, prices become endogenous. Even if we confine our attention to the real side of the macroeconomic model, we still need an assumption on prices. Due to the homogeneity conditions, our model requires assumptions on relative prices which are less restrictive than those for the price levels. Furthermore, since the ratios of prices of different goods are generally roughly constant, trends in relative prices can be regarded as a reasonable basis for prediction.

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PROBLEMI ECONOMETRICI DELLA MODELLISTICA MULTISETTORIALE[1]

Maurizio Grassini

1. Introduzione

Nella letteratura economica i modelli input-output (IO) si incontrano nei più svariati contesti teorici. Spaziando dall'analisi economica alla politica economica, dalla econometria all'economia quantitativa, percorrendo la selva delle numerose discipline economiche non è difficile imbattersi nella rete dei flussi intersettoriali che caratterizzano lo schema analitico quantitativo messo a punto da W. Leontief. La letteratura sui modelli IO è sconfinata e se – come è ovvio in ogni branca del sapere – è possibile selezionare i contributi seminali che hanno determinato le successive esplosioni degli approfondimenti teorici e degli esperimenti applicativi, la delimitazione dell'interesse al rapporto tra modelli IO e modelli econometrici esorta ad una riflessione più generale sulla natura di quest'ultimi, una riflessione che può successivamente orientare una perimetrazione più puntuale della letteratura pertinente al tema in questione.

È opportuno ricordare, anzitutto, che i modelli econometrici sono marcati, tra l'altro, da due importanti connotati delineati negli anni '40: l'approccio probabilistico e la rappresentazione multiequazionale dell'economia.

Il primo – l'approccio probabilistico – è stato sistemato da T. Haavelmo (1944) in un saggio pubblicato come supplemento dalla rivista «Econometrica». Il secondo – la visione di un'economia attraverso un sistema di equazioni - è il frutto delle attività di ricerca della Cowles Commission animate da T. Koopmans. Il primo approccio – mediato dal lavoro di H. Mann e A. Wald (1943) – ha segnato il taglio scientifico del secondo.

Da allora i cultori dell'analisi econometrica non hanno mai sconfessato queste radici, anzi in molti casi hanno tanto curato la delimitazione dei confini dell'ortodossia da indulgere in manifestazioni di arroganza, fenomeno questo non ascrivibile certo in esclusiva ai cultori di questa disciplina. Anche quando si sono accesi dibattiti di particolare vivacità sui connotati suddetti – come traspare dagli scritti raccolti da Gordon e Klein

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[1] Questa ricerca è stata realizzata con il contributo del Ministero della Pubblica Istruzione (40%). Questo saggio è stato pubblicato in M. Faliva (a cura di), *Il ruolo dell'Econometria nell'ambito delle scienze economiche*, Il Mulino, 1991, pp. 39-56.

Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online),

in Readings in Business Cycle (1966) – non sono messi in discussione i fondamenti metodologici dell'econometria ma – come è accaduto più recentemente con la controversia sulle aspettative razionali – si è dibattuto sulla validità e la fondatezza della teoria economica che dovrebbe ispirare le analisi quantitative (incluso il caso estremo di «misurazione senza teoria»).

L'approccio probabilistico che avvolge lo studio delle equazioni econometriche può essere evocato per tener conto di diversi aspetti del modello teorico e della natura delle variabili osservate; ma preme qui sottolineare l'uso del metodo probabilistico diretto ad accogliere ed a trattare la parte «residuale» di una relazione tra variabili economiche per le quali esiste (per supporto teorico) un collegamento di varia specificazione analitica. Ad esempio, se si aderisce all'ipotesi di una relazione tra consumi aggregati e reddito disponibile come suggerito da Keynes nella General Theory e si formula una relazione analitica necessariamente tesa a stilizzare la relazione ipotizzata, dal confronto con i dati osservati si percepisce l'esistenza di qualcos'altro che oltre al reddito determina i consumi aggregati; lo stesso Keynes ricorda, oltre il reddito disponibile, altre determinanti del consumo. L'esistenza di questi effetti aggiuntivi sui consumi, che compaiono come residui del collegamento analiticamente definito tra reddito e consumo, dà spazio all'approccio probabilistico.

Il trattamento stocastico delle equazioni econometriche ha, infatti, definito – sia nel caso di singole equazioni che nei sistemi di equazioni – il primato delle relazioni dedotte dalla teoria economica che interpretando il comportamento degli operatori producono necessariamente, come conseguenza delle semplificazioni analitiche di cui soffrono i modelli e per la forzata e necessaria omissione di alcune determinanti, la componente residuale che viene poi assimilata ad una variabile casuale.

Questi fondamenti metodologici dell'econometria hanno indotto una gerarchia in generale non dichiarata nella tipologia delle equazioni (che compongono un modello econometrico come sistema di equazioni) suggerita da Koopmans, Rubin e Leipnik (1950). Prima vengono le equazioni di comportamento; esse esprimono il collegamento tra i fenomeni come assunto e dedotto dalla teoria economica; nel confronto con la realtà inevitabilmente compare il residuo casuale. Poi vengono a pari merito le equazioni tecnologiche e le equazioni istituzionali. Le prime sono classicamente esemplificate con le funzioni di produzione. Le seconde sono le equazioni che esprimono regole imposte dall'operatore pubblico come le equazioni che descrivono la relazione tra il gettito di un'imposizione fiscale e la base imponibile. Per entrambe non è difficile trovare i motivi che giustifichino la non esatta corrispondenza tra i dati osservati e le relazioni funzionali proposte; la componente casuale seguita, quindi, a svolgere il ruolo desiderato. Infine compaiono le relazioni contabili che definiscono l'uguaglianza tra il dare e l'avere, tra le entrate e le uscite. Appartengono a questa categoria il conto delle risorse e degli impieghi, la definizione di spesa totale come somma delle spese (prezzo per quantità) per le diverse funzioni di consumo, l'indice dei prezzi all'ingrosso come numero indice sintetico dei prezzi all'ingrosso di varie categorie merceologiche e, soprattutto, di ogni relazione contabile dove una delle componenti è definita a saldo. In queste equazioni, per definizione e per calcolo, non c'è spazio per un residuo e quindi esse non sono provviste del connotato fondamentale per la loro trattazione stocastica. Per questo motivo le identità sono state relegate al margine delle metodologie econometriche, anzi sono state considerate con malcelato disappunto ed eliminate – utilizzandole come criteri di ridefinizione di alcune variabili – ogniqualvolta l'attenzione si doveva concentrare su metodi di stima per i quali i principi dell'inferenza statistica esigevano l'azzeramento di ogni caso che negasse l'esistenza di componenti casuali o desse luogo a variabili casuali con connotati poco desiderati e definite, in molti casi, degeneri. In verità, la costruzione di un modello econometrico non implica la presenza di equazioni del tipo identità, ma queste finiscono per imporsi per motivi contabili. Infatti, se un modello econometrico è disegnato per spiegare tutte le variabili che compaiono, ad esempio, nel conto delle risorse e degli impieghi, non è possibile pensare che sia in sede di descrizione del periodo campionario che di previsione, il modello conduca alla determinazione di una discrepanza tra volume delle risorse e volume degli impieghi. L'esigenza di rispettare questo tipo di coerenza, che è propria di molte informazioni statistiche (ed in particolare di quelle della contabilità economica ispirata, comunque, al criterio ragionieristico della partita doppia), fa riemergere le identità che con prepotenza riaffermano il proprio ruolo cardine nella modellistica econometrica. Si usa allora dire che un modello econometrico non può essere fondato esclusivamente su un insieme di equazioni comportamentali, ma si rende necessario garantirne l'indispensabile coerenza contabile propria delle informazioni statistiche utilizzate per la sua stima, coerenza contabile che viene realizzata attraverso un'operazione di «chiusura» del modello mediante le identità contabili, riconoscendo a queste un ruolo che, pur irrilevante in fase di stima, si conferma essenziale nel momento della predizione. In realtà le equazioni contabili non sono attori che compaiono nella fase di chiusura o completamento di un sistema di equazioni econometriche che vengono così compattate in un modello; esse rappresentano il primo passo verso la costruzione dei modelli. In primo luogo perché le variabili economiche trovano, in generale, nelle identità contabili la definizione del loro contenuto informativo; in secondo luogo perché esse possono essere di per sé sufficienti a rappresentare le relazioni di interdipendenza tra le variabili ed essere quindi utilizzate per analisi metodologicamente equivalenti a quelle compiute con modelli più intrisi di teoria economica e di lavoro econometrico.

2. Le identità di apertura nei modelli macroeconomici

Si consideri il sistema dei conti riportato nella tabella 1. Esso è costituito da 4 identità contabili e coinvolge 8 macroaggregati; le relazioni contabili, per loro natura, hanno nel loro interno (almeno) una variabile a saldo, non ospitano anonimi residui e quindi ricadono tra le suddette identità; ma proprio per questa «flessibilità» dovuta al saldo esse rappresentano uno schema nel quale una o più componenti possono avere la «libertà» di variare dal momento che gli effetti di queste variazioni si scaricano sulle variabili cuscinetto. Ciò consente di indagare su strutture alternative dei macroaggregati; questo esercizio può essere illustrato riproponendo il sistema dei conti come un sistema di equazioni raccogliendo i macroaggregati – le variabili – in un vettore e i coefficienti che definiscono i 4 conti in una matrice, sicché la struttura contabile in esame viene ripresentata nel modo seguente:

$$\begin{bmatrix} 1 & 1 & -1 & -1 & -1 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 & 0 & 1 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & -1 & 0 & -1 \\ 0 & 1 & 0 & 0 & -1 & 0 & -1 & -1 \end{bmatrix} \begin{bmatrix} Y \\ M \\ C \\ I \\ X \\ S \\ R \\ B \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Tab. 1 – Schema generale di contabilità nazionale di un economia aperta

Conti	*Equazioni*
1. Produzione	$Y + M = C + I + X$
2. Reddito e consumo	$C + S = Y + R$
3. Formazione del capitale	$I = S + B$
4. Transazioni internazionali	$X + R + B = M$

dove
Y = Reddito nazionale o prodotto nazionale
C = Consumi
I = Investimenti
M = Importazioni
X = Esportazioni
S = Risparmio
R = Trasferimenti netti dall'estero
B = Indebitamento netto verso l'estero
Fonte: Vincenzo Siesto, *La Contabilità Nazionale*, Il Mulino, 1977, p. 23.

Questo sistema è derivato da un sistema contabile di partita doppia che per costruzione dà luogo ad un sistema di equazioni linearmente dipendenti; ciò può essere rapidamente constatato osservando che l'ultima riga della matrice dei coefficienti è uguale alla somma delle prime tre righe; quindi dal sistema contabile potranno essere derivate non più di tre equazioni linearmente indipendenti. Inoltre, in un sistema di equazioni disegnato per rappresentare un modello economico, l'insieme delle variabili - sulla base di una teoria economica e della realtà che con il modello si vuole descrivere - viene distinto in due gruppi; il gruppo delle variabili «esogene», cioè delle variabili determinate all'esterno della realtà che si vuole descrivere, ed il gruppo delle variabili «endogene» i cui livelli saranno determinati in linea con le interazioni espresse dal modello. Si può supporre, allora, che i Trasferimenti netti dall'estero e l'Indebitamento netto verso l'estero siano determinati esogenamente perché, ad esempio, si vuole sostenere che l'insieme delle altre variabili qui considerate si «aggiusta» rispetto a questi due aggregati e non viceversa; si può ancora assumere che anche le Esportazioni e gli Investimenti siano determinati esogenamente; le Esportazioni possono essere assunte come dipendenti dalla domanda mondiale e gli Investimenti come definiti autonomamente da adeguati strumenti di politica economica. Infine si può assumere che anche la variabile C, i consumi aggregati, sia determinata esogenamente quale risultato di specifiche politiche di distribuzione del reddito. Dal sistema ridotto all'insieme di tre equazioni si può, dunque, ottenere la soluzione di un modello derivato da un semplice schema contabile.

$$\begin{bmatrix} Y \\ M \\ S \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 & -1 & -1 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} C \\ I \\ X \\ R \\ B \end{bmatrix}$$

ovvero

$$Y = C + I - R - B$$
$$M = X + R + B$$
$$S = I - B$$

Questo risultato non è certo importante da un punto di vista econometrico ed è chiaramente modesto rispetto all'apparato analitico utilizzato; questo risultato, del resto, è facilmente raggiungibile con semplici manipolazioni delle equazioni della tabella 1. La costruzione del modello basato su questo piccolo gruppo di equazioni contabili è stata qui compiuta per dare risalto a due aspetti del ruolo da queste svolto nelle analisi quantitative. In primo luogo, si può notare che esse possono dare origine ad un modello. In secondo luogo, nel caso specifico emerge una evidente banalità delle analisi economiche condotte esclusivamente su strutture analitiche fondate su equazioni contabili; a tale proposito ci si può chiedere se è possibile immaginare un modello derivato da quadri contabili capace di offrire spunti intellettualmente più interessanti per l'analisi economica. Questo interrogativo trova una risposta affermativa quando ci si orienta sulle tavole input-ouput quali schemi contabili di riferimento per la costruzione di modelli economici e modelli econometrici.

Una tavola dell'economia che si ispira a schemi leontieviani si fonda sulla iterazione del conto di equilibrio delle risorse e degli impieghi di unità produttive (raggruppate per motivi di rappresentabilità e vincoli di rilevazione in settori o branche). Dalle tavole dell'economia, per esigenze espositive, vengono qui di seguito isolate tre componenti: i consumi intermedi, la domanda finale e la produzione totale.

Sia V la matrice dei consumi intermedi di ordine m x n essendo n le branche individuate nel sistema contabile. Tutte le componenti della domanda finale siano riassunte nel vettore y; y sarà dunque la somma dei vettori dei consumi delle famiglie, degli investimenti, ecc. e del vettore delle importazioni con segno negativo; sia q il vettore delle produzioni totali. Utilizzando il vettore somma h di ordine n, le tre suddette componenti possono essere utilizzate per rappresentare in forma compatta i conti di equilibrio degli impieghi e delle risorse nella forma seguente

$$Vh + y = q$$

Considerando la matrice diagonale, $\hat{q}$, che ha sulla diagonale principale gli elementi del vettore q, si può produrre la seguente trasformazione

$$V\hat{q}^{-1}\,\hat{q}\,h + y = q$$

dove $V\hat{q}^{-1}$ conduce alla determinazione della matrice A i cui elementi

$$a_{ij} = \frac{v_{ij}}{q_j}$$

sono i coefficienti di spesa che possono corrispondere ai coefficienti tecnici leontievani. Usando la matrice A, il sistema dei conti settoriali può essere riproposto come

$$Aq + y = q$$

La presenza della matrice A e l'isolamento dei vettori q e y in ciascuno dei quali sono collezionate n variabili (le produzioni totali nel primo e la domanda finale nel secondo) suggeriscono l'uso del sistema per la determinazione di un gruppo di variabili in funzione dell'altro. Se si assumono note le produzioni totali, si determinano le domande finali

$$y = q - Aq$$

Se si assumono note le domande finali, si determinano le produzioni totali

$$q = (I - A)^{-1} y$$

Ed è possibile, come terzo caso, determinare anche un gruppo «misto» di variabili: parte delle y e parte delle q, in numero pari a quello delle equazioni: questo caso non presenta però alcuna peculiarità essendo in parte riconducibile al primo ed in parte al secondo caso.

Il primo problema non riceve molta attenzione in sede di analisi economica; il secondo problema è decisamente più popolare. Quest'ultimo offre la risposta al quesito: a quale livello debbono essere poste le produzioni totali per soddisfare una determinata composizione della domanda finale? Il primo si limita, invece, a definire la domanda finale in termini residuali con una banalità analitica che non può, come si può notare nella letteratura, attirare molto impegno speculativo. Ciò non significa che il problema non possa avere una sua dignità operativa; se si pone l'obiettivo di garantire specifici livelli occupazionali a livello settoriale (livelli che si collegano alle produzioni settoriali) allora il problema della conoscenza della domanda finale da «programmare» assume notevole rilevanza[2].

Gli schemi contabili che consentono le analisi quantitative ispirate al modello IO hanno, ovviamente, una rappresentazione aggregata nella quale i riferimenti di branca scompaiono (Siesto 1973). In questo caso il conto di equilibrio delle risorse e degli impieghi può essere riproposto nella forma

$$Q = CI + Y$$

dove

$$Q = h'q \quad Y = h'y \quad CI = h'Vh$$

Seguendo lo schema che ha condotto alla formulazione leontieviana, in questo caso si può definire

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[2] Si può qui notare che sulla base di uno schema contabile si possono compiere valutazioni sulla risposta di un sistema economico agli stimoli prodotti da variabili esogene. Si noti che, come in ogni modello economico, il collegamento tra variabili non preclude, in generale, una flessibile articolazione tra grandezze predeterminate e grandezze (endogene) che di conseguenza si aggiustano; è senz'altro vero che un modello basandosi su una teoria economica possa postulare determinanti per ipotesi esterne ai fenomeni considerati (come la domanda mondiale per una piccola economia aperta) ma altre variabili (come il tasso di cambio che può essere posto come vincolo od utilizzato come strumento) possono alternativamente assumere il connotato di determinanti o determinate a seconda dell'esercizio di politica economica proposto. In questo senso, determinare la domanda finale a partire dalle produzioni totali e viceversa sono esperimenti conducibili nell'ambito del modello in esame.

$$a = \frac{CI}{Q}$$

ed ottenere le relazioni

$$Y = Q - aQ$$

e

$$Q = (1 - a)^{-1}\,Y$$

che esprimono i due schemi di analisi del «modello input-output» costruito sui conti aggregati, dove il parametro a rappresenta il coefficiente leontieviano relativo all'«unico bene», Q, prodotto nell'economia. Queste equazioni, ed in particolare la seconda, non si prestano per la loro semplicità ad analisi approfondite paragonabili a quelle che vengono compiute sui sistemi di equazioni derivate dalla contabilità di branca, ma concettualmente i due sistemi sono equivalenti.

3. Dalle identità di apertura ai modelli econometrici

Sia il modello IO che quello «monosettoriale», sopra delineati, possono essere emendati con equazioni che esprimono il divenire interdipendente della (o delle) produzione(i) totale(i) e di una o più componenti della domanda finale. Questo processo, partendo dall'immagine fotografica espressa dalle equazioni derivate dai quadri contabili, conduce alla formulazione di modelli dinamici. Date le formulazioni analitiche delle componenti dinamiche, le variabili (endogene) esprimeranno allora peculiari traiettorie che consentono di riflettere sulle caratteristiche del modello e, quindi, sulle condizioni necessarie per una rappresentazione «realistica» dell'economia. Non è difficile attraverso un'analisi comparata, rilevare anche in questo caso la coincidenza concettuale tra la rappresentazione analitica dei modelli aggregati e dei modelli multisettoriali, fatta salva per quest'ultimi la maggiore complessità algebrica degli strumenti necessari per qualificare i connotati delle soluzioni del modello.

La natura di questo processo di arricchimento può essere esemplificata con una delle rappresentazioni formali del modello di crescita di Harrod. In questa sede non si ripercorre la lettura del saggio che è alla base della teoria della crescita (Harrod 1939), ma si fa riferimento alla illustrazione e soprattutto ai commenti fatti da Sen (1970). Sen dopo aver sintetizzato il modello ed evidenziato le condizioni di steady growth sottolinea la natura dell'instabilità del modello:

> If the investors anticipate more than the warranted rate of growth s/C then the actual growth rate of demand will exceed even the high

> expected growth rate, so that instead of feeling that they expected too much they are likely to feel that they expected too little. Similarly, if they anticipate a growth rate lower than the warranted growth rate, then the actual growth rate will fall short of even the expected growth rate and the investors may decide that they expected too much rather than too little. The market thus seems to give a perverse signal to the investor, and this is the source of Harrod's problem.

Egli riconosce che «there are, of course, problems in interpreting a system like this one», suggerisce alcune linee di riflessione sul modello di crescita in esame e conclude affermando che: «In general, it will be fair to say that the Harrod's instability analysis overstresses a local problem near the equilibrium without carrying the story far enough, and extensions of his model with realistic assumptions about the other factors involved tend to soften the blow» rimarcando immediatamente «Harrod's model of instability is undoubtedly incomplete». Le implicazioni «irrealistiche» che emergono dall'analisi di modelli economici possono, in generale, essere attribuite ad incompletezze e rimosse seguendo due strade. Da un lato, si può cercare di definire forme analitiche più compiacenti per quelle equazioni che risultano essere causa di traiettorie fondamentalmente poco interessanti; quando, ad esempio, si nota che un'equazione alle differenze produce soluzioni esplosive che rappresentano curiosità analitiche con scarso senso economico, si può ricorrere a sfasamenti temporali, che modificando l'ordine dell'equazione, consentono di ristabilire evoluzioni economicamente plausibili, magari provviste di improbabili fremiti ciclici, ma confinate in intervalli economicamente accettabili.

La seconda strada è quella di cercare di completare il modello inserendo quegli elementi che vengono evocati per commentare la non plausibilità dei risultati che si ottengono con una stilizzazione dell'economia giudicata per l'appunto troppo sommaria.

In entrambi i casi si tratta di emendare il modello originario; tuttavia i risultati mantengono i connotati propri della soluzione del problema. Nel primo caso si trovano i contributi più specifici dell'analisi economica; nel secondo, gli arricchimenti possono da un lato rappresentare un opportuno ed anche doveroso completamento della rappresentazione formale di una teoria economica, ma possono anche costituire le trasformazioni ritenute necessarie per fare del modello uno strumento adatto alla descrizione quantitativa della realtà osservabile. Percorrendo la seconda strada e perseguendo quest'ultimo obiettivo si incontrano i modelli econometrici.

I modelli econometrici possono essere ispirati da uno schema teorico ben delimitato come è il caso del modello Klein-Goldberger che ripercorre fedelmente l'insieme delle relazioni tra variabili macroeconomiche suggerite dalla lettura della *General Theory* di J.M. Keynes; ma possono anche essere eclettici nel senso che raccolgono diverse ispirazioni teoriche; caso questo ormai generale della modellistica macroeconometrica (Visco 1987).

4. Teoria economica e modelli multisettoriali

I modelli multisettoriali o input-output sono per loro natura teoricamente eclettici e sono palesemente caratterizzati dalle identità di apertura. Infatti, un modello IO trova la sua base statistica nelle tavole delle immissioni e delle erogazioni come, ad esempio, la Tavola dell'Economia Italiana; l'ispirazione leontieviana di questa base statistica guida con immediatezza verso quelle elaborazioni elementari costituite dal calcolo dei coefficienti di spesa e, quindi, alla produzione della matrice dei coefficienti input-output; i sistemi di equazioni delle quantità e dei prezzi che vengono di conseguenza proposti, sia che si considerino distintamente o congiuntamente, non si discostano nella sostanza dal quadro statistico che ne costituisce la base. Quando da questo quadro si passa alla costruzione del modello econometrico emerge con chiarezza la condanna all'eclettismo teorico che caratterizza i modelli IO. Questa può essere meglio compresa passando per contrasto attraverso l'esempio del più semplice modello keynesiano di determinazione del reddito.

Il modello keynesiano di determinazione del reddito viene proposto nella sua forma più elementare assumendo le condizioni di equilibrio che si esprimono mediante l'uguaglianza tra risparmio e investienti e la conseguente uguaglianza tra domanda e offerta aggregate. Queste assunzioni hanno il riscontro contabile nella relazione che è alla base del conto delle risorse e degli impieghi

$$Y = C + I$$

dove Y è il reddito, C sono i consumi e I sono gli investimenti. Successivamente si considera che le variabili dell'equazione contabile assumono valori determinati dai livelli su cui si attestano altre variabili; in particolare si ricorda che i consumi, secondo i suggerimenti di Keynes, sono determinati dal reddito; allora si propone

$$C = f(Y)$$

e nasce così il modello che spiega simultaneamente la formazione del reddito ed il livello dei consumi per un dato volume di investimenti (autonomi). Questo sviluppo si realizza nell'ambito della teoria keynesiana e può espandersi come nel già citato modello di Klein-Goldberger. Può poi accadere che si giudichi opportuno inserire una curva di Phillips per la spiegazione della dinamica dei salari nominali con la conseguente incrinatura dell'ortodossia keynesiana e la comparsa, perciò, di eclettismo teorico.

Nei modelli IO, confinando l'attenzione per esigenze espositive all'equazione delle quantità, dalla relazione di apertura

$$q = Aq + y$$

riconoscendo alle produzioni totali il connotato di variabili endogene, si può giungere alla «forma ridotta»

$$q = (I - A)^{-1} y$$

ma ancor prima di riconoscerla come il modello che spiega simultaneamente gli elementi del vettore q, nella «costruzione del modello econometrico» si deve dare spazio a spiegazioni quantitative di almeno qualche componente che concorre alla determinazione degli elementi del vettore y. Così come nel modello keynesiano di determinazione del reddito si introduce la funzione del consumo, nel modello IO si deve valutare quali componenti che confluiscono nel vettore y debbono e possono essere interpretate con funzioni suggerite dalla teoria delle interdipendenze settoriali. La teoria che ha ispirato il quadro contabile di riferimento abbandona a questo punto il costruttore del modello econometrico ed egli non potrà fare altro che convivere con la condanna all'eclettismo teorico. Infatti non esiste una teoria «input-output» dei consumi settoriali delle famiglie, dei salari, dei profitti, e quant'altro si può incontrare nell'arricchimento della complessità di un modello IO; ma anche quando si presume l'esistenza di qualche indicazione teorica non è detto che sia necessariamente un sostegno positivo per l'analisi quantitativa. È questo il caso della matrice dei fabbisogni di capitale sulla cui base è stata aperta la porta alla dinamicizzazione del modello input-output ed è stato troppo rapidamente rimosso il problema della teoria degli investimenti. Se in assenza di indicazioni teoriche associate a quelle fondamentali del modello input-output si può considerare libera la scelta degli schemi teorici per la costruzione di un modello econometrico multisettoriale, problemi di ortodossia nascono quando, appunto, sono presenti indicazioni teoriche come quelle sugli investimenti, indicazioni tanto improponibili sul piano operativo quanto esaltanti una produzione scientifica che sorprende per volume e continuità. Si può allora comprendere come accanto a quella di eclettismo teorico, i costruttori di modelli econometrici multisettoriali debbano mettere in conto la più seria condanna di eresia. Infatti è inevitabile lo iato tra la teoria degli investimenti frequentata dagli analisti (di stretta osservanza leontieviana) del modello input-output e le teorie economiche che sono in grado di orientare il costruttore del modello quantitativo: il problema dell'instabilità duale nel quale può concentrarsi l'impegno di un analista economico non desta alcun interesse nel costruttore del modello econometrico che osserva una realtà che non ha mai dato segno di soffrirne.

5. Grandezze economiche aggregate e settoriali nei modelli IO

L'arricchimento econometrico di uno schema IO può essere perseguito a livello di grandi aggregati economici ed a livello di grandezze settoriali. Il collegamento tra le variabili spiegate da equazioni econometriche e l'identità di apertura costituisce un elemento qualificante la tipologia del modello multisettoriale.

Schematicamente, è possibile immaginare due tipi di collegamento. Per illustrare il primo tipo si supponga di voler calcolare la «forma ridotta» descritta nel paragrafo precedente; si assuma, inoltre, per semplicità che esista un'unica componente della domanda finale e quindi le altre variabili del modello siano riassunte nelle componenti del vettore y. Se l'equazione econometrica che si associa allo schema IO è preposta alla spiegazione dell'aggregato domanda finale, si pone il problema della sua traduzione in domande settoriali. Una procedura molto spesso seguita si basa sul trasferimento alle singole componenti settoriali della dinamica dell'aggregato. Essa si sintetizza nelle seguenti fasi:

a) il vettore della domanda finale viene trasformato in quote del totale del vettore y; sia questo totale $\bar{y}$;
b) il modello econometrico della domanda finale predice un dato livello aggregato della stessa ovvero del totale $\bar{y}$; sia $\hat{y}$ il valore predetto;
c) questo livello di domanda finale è allora ripartito nel vettore y secondo le quote suddette;
d) il vettore di domanda finale così «stimato» è utilizzato per calcolare il vettore q.

Se si definisce con α il rapporto tra $\hat{y}$ e $\bar{y}$, il vettore della domanda finale associato a $\hat{y}$ sarà uguale a αy ed il vettore delle produzioni totali che scaturisce dalla forma ridotta sarà αq. In altri termini, si ha che l'estensione di una variazione della domanda finale aggregata a tutte le sue componenti settoriali si risolve in una medesima variazione di ogni produzione totale settoriale. La banalità di questo risultato può essere nascosta ma non rimossa se le componenti della domanda finale sono considerate distintamente. In questo caso se si hanno variazioni diverse per ogni aggregato o anche per un solo aggregato, sarà possibile percepire riflessi settoriali differenti sui livelli delle produzioni settoriali. Se i risultati non ostentano la banalità del caso precedente, rimane, sul piano operativo, il peso della semplicità della procedura. Infatti, per qualunque disaggregazione della domanda finale nelle sue componenti statisticamente osservate e per qualunque ventaglio di variazioni dei corrispettivi aggregati, la struttura dei vettori di ogni singola componente è assunta costante, e quindi non è possibile tener conto degli effetti di quelle modifiche strutturali che un modello multisettoriale dovrebbe evidenziare (non solamente per il vettore delle produzioni totali).

La procedura ora descritta viene seguita quale strada obbligata quando dapprima si costruisce un modello econometrico aggregato e successivamente si cerca di dare evidenza dei riflessi settoriali che possono accompagnare le variazioni dei macroaggregati. In questo caso il modello IO emerge come superfetazione del modello macroeconomico e sebbene sul piano analitico sia possibile affermare che i risultati settoriali così ricostruiti siano provvisti di un loro specifico interesse, solo l'esperienza può dissuadere il costruttore del modello dal seguire questo processo di settorializzazione delle previsioni macroeconomiche.

Il secondo tipo di collegamento tra le equazioni econometriche e l'identità contabile di apertura segue un percorso fondamentalmente opposto: le grandezze aggregate sono ottenute dalla somma delle grandezze settoriali. Ad esempio, equazioni settoriali delle esportazioni producono i valori settoriali delle esportazioni e le esportazioni totali sono ottenute dalla somma delle prime; nel caso precedente, invece, a partire dalle esportazioni totali mediante una ripartizione per quote si producono le esportazioni settoriali. In sintesi, mentre nel primo caso a partire da un modello macroeconomico si ricostruiscono le informazioni settoriali per suddivisione degli aggregati macroeconomici, nel secondo caso quest'ultimi vengono prodotti per somma delle informazioni settoriali.

Nel primo caso il modello IO è totalmente guidato da un modello macroeconomico mentre nel secondo caso è guidato da un insieme di equazioni econometriche preposte alla spiegazione di singole componenti settoriali. Se i modelli IO sono indicati come strumenti di analisi delle modifiche strutturali, quando si articolano con analisi econometriche essi preservano questa caratteristica solo nel secondo caso, cioè quando l'analisi econometrica è diretta non tanto sull'aggregato quanto sulla sua struttura.

6. L'equazione leontieviana residuale

Un ampio uso di equazioni preposte alla spiegazione di grandezze settoriali – uso diretto a tenere in adeguata considerazione le disaggregazioni proprie di una tavola dell'economia – introduce inevitabilmente interazioni non considerate dal tradizionale schema leontieviano; queste interazioni corrono tra variabili del sistema dei prezzi e del sistema delle quantità ed all'interno dei due sistemi rispettivamente tra prezzi e valore aggiunto e tra domanda finale e produzione totale. L'avvento di queste interazioni non può che essere accolto favorevolmente dato che esse esprimono l'effetto dell'eclettismo teorico (teorie che postulano collegamenti tra variabili non considerati rilevanti in ambito leontieviano) congiunto allo sforzo di rendere realistico il modello multisettoriale. Questo sforzo è sollecitato, ad esempio, dal desiderio di poter dare una risposta al quesito: quali effetti (settoriali) sortono i prezzi (settoriali) e le produzioni totali (settoriali) sulle importazioni (settoriali)? Un desiderio che viene generato, ovviamente, dal supporre che le importazioni dipendono dalla competitività di prezzo dei produttori esteri sul mercato interno e dal livello della domanda interna. Se questi collegamenti vengono innestati sulla tradizionale equazione leontieviana, lo schema analitico nel quale essa è usualmente inserita subisce non trascurabili modifiche. Ciò può essere messo in evidenza nel modo seguente limitando l'attenzione al sistema delle quantità ed introducendo semplificazioni analitiche che non compromettono la generalità dello schema.

Data l'equazione leontieviana si consideri il vettore della domanda finale y costituito da k componenti, y_i per $i = 1, 2 \ldots K$, tali che $y = \Sigma_1 y_1$. Si supponga che un gruppo $G \leq K$ di componenti venga spiegato con equazioni del tipo $y_{ij} = g_{ij}\,(x_1\, x_2 \ldots x_L)$ dove j è l'indice di branca, i della componente della domanda finale ed $x_1\, x_2 \ldots x_L$ sono le determinanti di y_{ij}. Le determinanti possono essere contemporanee o ritardate e possono essere diretta espressione delle produzioni totali e di altre componenti della domanda finale. Si assuma l'esistenza di effetti ritardati non superiori ad un periodo e che le $g_{ij}(\bullet)$ siano, per semplicità, funzioni lineari nei parametri e nelle variabili. Se le G componenti della domanda finale vengono organizzate in un singolo vettore f (di ordine $G \times n$) allora il modello multisettoriale avrà $G \times n + n$ variabili endogene ed il sistema di equazioni può essere allora espresso in notazione matriciale nella forma

$$\begin{bmatrix} q \\ f \end{bmatrix} = \begin{bmatrix} A & \vdots & I_1 I_2 I_3 \ldots I_G \\ C & \vdots & D \end{bmatrix} \begin{bmatrix} q \\ f \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ W_1 & W_2 \end{bmatrix} \begin{bmatrix} q \\ f \end{bmatrix}_{-1} + \begin{bmatrix} y_e \\ z_e \end{bmatrix}$$

dove[3] è possibile individuare due gruppi di equazioni

$$q = Aq + y_G + y_e$$

$$f = Cq + Df + W_1 q_{-1} + W_2 f_{-1} + z_e$$

Il primo gruppo è l'equazione leontieviana con la domanda finale ($y = y_G + y_e$) distinta nella somma delle componenti endogene e delle componenti esogene; il secondo gruppo e l'insieme delle $G \times n$ equazioni degli elementi delle G componenti endogene della domanda finale, con C, D, W_1, W_2 sottomatrici che contengono i parametri delle equazioni econometriche con le quali vengono spiegati gli elementi di f. Riordinando a sinistra le variabili endogene, la soluzione del sistema si configura nel modo seguente

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[3] Le sottomatrici di questo sistema di equazioni sono:
A la matrice dei coefficienti tecnici;
I_i per $i = 1, 2 \ldots.. G$, matrici identità di ordine n;
C matrice di ordine $(G \times n) \times n$ dei coefficienti delle produzioni totali nelle equazioni delle componenti (endogene) della domanda finale;
D matrice $(G \times n) \times (G \times n)$ dei coefficienti delle componenti settoriali della domanda finale nelle equazioni delle componenti della domanda finale;
W_1 matrice $(G \times n) \times n$ dei coefficienti delle produzioni totali ritardate nelle equazioni delle componenti della domanda finale;
W_2 matrice $(G \times n) \times (G \times n)$ dei coefficienti delle componenti settoriali della domanda finale ritardate nelle equazioni delle componenti della domanda finale;
z_e vettore $(G \times n)$ degli effetti delle variabili esogene (correnti e/o ritardate) sulle componenti settoriali della domanda finale.

$$\begin{bmatrix} q \\ f \end{bmatrix} = H \begin{bmatrix} y_e \\ z_e \end{bmatrix} + H \begin{bmatrix} 0 & 0 \\ W_1 & W_2 \end{bmatrix} \begin{bmatrix} q \\ f \end{bmatrix}_{-1}$$

dove

$$H = \begin{bmatrix} I - A & \vdots & -I_1 - I_2 - I_3 \ldots - I_G \\ \cdots\cdots & \vdots & \cdots\cdots\cdots\cdots\cdots\cdots \\ -C & \vdots & I_{G\times n} - D \end{bmatrix}^{-1}$$

e proponendo la seguente ripartizione in blocchi

$$H = \begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix}$$

si ha

$$q = H_{11} y_e + H_{12} z_e + H_{12} W_1 q_{-1} + H_{12} W_2 f_{-1}$$

e questa è definibile come «l'equazione leontieviana residuale». Essa è residuale del processo di endogenizzazione delle G componenti della domanda finale, ed ancora echeggia l'equazione leontieviana per quanto concerne la componente $H_{11} y_e$; ed è, infatti, ancora possibile valutare le «attivazioni» delle produzioni totali settoriali causate da variazioni delle domande finali esogene. Sebbene questa valutazione sia possibile è necessario però rilevare che

$$H_{11} = ((I - A) - (I_1 I_2 \ldots I_G)\,(I - D)^{-1}\, C)^{-1}$$

e quindi il collegamento tra domanda finale e produzione totale non è più stabilito dai tradizionali coefficienti di attivazione[4] e inoltre esso perde il carattere che può essere definito di oggettività statistica. Con ciò si intende sottolineare che la costruzione e l'uso di una tavola dell'economia possono e tradizionalmente sono due momenti di ricerca sepa-

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[4] Questa affermazione può forse apparire troppo perentoria dal momento che non è escluso che con adeguate manipolazioni sia possibile imbastire un qualche commento sul concorso delle varie matrici nel calcolo di H_{11}; un tipo di commento peraltro tanto diffuso negli esercizi analitici che caratterizzano le analisi input-output quanto in generale inutile (se non fuorviante). La perentorietà dell'affermazione è qui voluta dall'Autore nel timore di poter essere causa involontaria di spreco di energie intellettuali.

rati: il primo – la costruzione – per sua natura è condotto da istituti che concludono la loro funzione consegnando ad altri ricercatori il frutto del loro lavoro; il secondo – l'uso – è compiuto da ricercatori che se si ispirano ai contributi leontieviani più ortodossi affrontano con certezza il calcolo dei coefficienti di attivazione ed in una evidente situazione di oggettività statistica giungono tutti alle stesse valutazioni quantitative. Se invece i ricercatori innestano analisi econometriche per singole grandezze di una tavola dell'economia, nell'ambito del modello multisettoriale cade ogni possibilità di individuare un qualche riferimento ai coefficienti di attivazione mentre subentrano senza difficoltà i più tradizionali moltiplicatori. Così come scompaiono i coefficienti di attivazione, così perdono d'importanza gli studi sulle proprietà dinamiche del modello leontieviano quando una pur semplificata versione del settore reale (come quella delineata in questo paragrafo) conduce ad un sistema di equazioni che appare pesantemente determinato dall'arte econometrica del costruttore del modello.

7. Modelli aggregati e modelli multisettoriali: specificità e connessioni

Il collegamento tra i modelli IO e i modelli econometrici è definito anche dal tipo di informazioni statistiche di base che concorrono alla determinazione delle sfere di teoria economica che possono ispirare l'analisi quantitativa. I dati della contabilità economica nazionale possono essere riferiti alle unità produttive o ai settori istituzionali (Siesto 1973). Le informazioni riconducibili alle unità produttive consentono la costruzione delle tavole delle immissioni e delle erogazioni che costituiscono lo schema informativo di base per la costruzione dei modelli IO. Le informazioni statistiche che fanno esclusivo riferimento ai settori istituzionali si pongono al di fuori (o al margine) dei modelli IO, e rappresentano il dominio specifico dei modelli econometrici aggregati. Quindi, non è possibile distinguere la modellistica macroeconomica in due categorie separate: la modellistica multisettoriale e la modellistica aggregata. I modelli IO non potendo entrare nella sfera della contabilità dei settori istituzionali rimangono comunque tributari di informazioni essenziali per la definizione di rilevanti variabili di scenario come, ad esempio, il reddito disponibile delle famiglie, il tasso di cambio, l'offerta di moneta, il tasso di interesse, e quant'altro possa concorrere alla determinazione delle grandezze settoriali pur non essendo variabili settorialmente specifiche.

I modelli aggregati possono ispezionare i collegamenti tra variabili che si raccordano alle figure istituzionali ma non possono addentrarsi nelle disaggregazioni proprie dei modelli multisettoriali e per alcuni aspetti rimangono decisamente tributari di quest'ultimi se ad esempio diviene rilevante poter valutare gli effetti della modifica di un'accisa sul livello dei prezzi o le conseguenze della svalutazione di una valuta sulle prestazioni del settore manifatturiero.

Se un modello monetario per sua natura può e deve essere costruito su sistemi informativi «distanti» da una tavola dell'economia, modelli aggregati del sistema reale e dei prezzi sono diretti alla spiegazione di variabili che si incontrano anche nei modelli IO; ma la distinzione dei due approcci non è solo questione di livello di aggregazione. Infatti, un modello IO diviene un modello econometrico quando il sistema informativo di base – rappresentato, ad esempio, dalla Tavola dell'Economia Italiana – viene assunto come identità di apertura per la costruzione di equazioni econometriche che si inseriscono sulle singole variabili definite dalla disaggregazione originaria e la dinamica degli aggregati viene quindi studiata come somma delle dinamiche settoriali e non viceversa. Il piano di lavoro per la costruzione di un modello provvisto di queste caratteristiche comporta necessariamente un evidente eclettismo dal punto di vista della teoria economica e ciò conferisce ai modelli multisettoriali quelle peculiarità che distinguono i modelli IO moderni (Almon 1982).

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VALUE-ADDED TAXES AND OTHER INDIRECT TAXES IN AN EEC COUNTRY MODEL: THE ITALIAN CASE[1]

Rossella Bardazzi, Maurizio Grassini, Ernesto Longobardi[2]

1. Introduction

The Italian member of the INFORUM group, INTIMO (INTerindustry Italian MOdel) has fully integrated real and nominal sides. Because of this integration, it is very important to deal properly with the value added tax (VAT). In this paper we will try to clarify the treatment of these taxes in the Italian tables. Similar treatment is found in most other EEC tables. We will also refer briefly to the treatment of other taxes on production.

INTIMO has been described in a number of papers. The real side of the model is outlined in Grassini (1983b); the system of demand functions modeling private consumption (a set of 40 equations) is presented in Grassini (1983a); the foreign sector is based on 26 equations respectively for imports and exports on commodities and about 11 equations for imports and exports of services; the foreign sector is discussed in Bamabani (1983), Grassini (1983c) and Bamabani, Grassini (1985). The integration of the real and price side is covered in Ciaschini, Grassini (1983). The international linking of the INFORUM system of models is presented in Nyhus (1975). The price side of the Italian model is presented in Grassini (1987); a detailed analysis of the theoretical, analytical and statistical background for dealing with indirect taxes in an IO model is discussed in Bardazzi (1987).

In this paper, the new features of the indirect taxes in the INTIMO model are presented. A major issue in the negotiations for a "Europe without borders" by 1992 is what to do about value-added taxes which are currently remitted on exports at the border. The crux of this issue is the difference between the rates in different countries and in different industries. Clearly, multisectoral models such as INTIMO and other members of the INFORUM group are the right sort of tools for studying this issue. The careful treatment of the value-added tax and other indirect taxes has therefore become of utmost importance.

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[1] Paper published in «Economic Systems Research», 1991, n. 1, pp. 37-47.

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Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online),

2. VAT as a Consumption Tax

The working mechanism of the Value Added Tax (VAT) can be briefly described. Each producer charges VAT to the buyer of his products (goods and services), applying the tax rate to the value of sales. All EEC countries except Denmark have different rates on various categories of goods and services. Generally, necessary goods carry reduced rates, while luxuries bear augmented rates.

The producer's tax liability is given by the difference between the tax charged on his sales and that paid on his purchases of intermediate goods and services. In other words, all firms or professionals (who must be registered as VAT-liable persons) have to pay the VAT collected from their customers to the tax office, but they are allowed a deduction equal to the VAT they have themselves paid on goods and services (other than labor and financial services) bought from other firms. In this way, VAT is collected at every stage of production according to the value added.

The chain of VAT collection comes to an end when products get to final consumption: the final consumer has no way to deduct the VAT paid on his purchases and thus is the ultimate payer of the tax.

It should be clear that in fact firms act as *tax collectors*, while the consumer represents the actual taxpayer. Because VAT on investment goods is deductible in its full amount in the same tax year as it is paid, VAT appears essentially as a tax on final consumption – at least in its initial incidence – and is so considered in the economic literature.

3. Pre-retail Components of VAT

However, specific tax rules may prevent some firms from deducting the entire amount of VAT paid on their inputs. In this event, the chain of VAT collection ends before getting to final consumption; and the legal incidence (if not the economic one) of the tax rests on intermediate transactions and on investments instead of final consumption (Longobardi, 1990).

We can mention three main reasons why firms may not be entitled to full deduction.

Firstly, firms supplying goods and services which are exempted from VAT have no right to deduct the VAT paid on their taxed purchases. In fact, in the VAT system, exemption refers only to the last stage of the provision of goods and services and does not apply to the inputs necessary for providing them. The most important exemptions in the EEC countries concern insurance, financial services, and health services.

It should be pointed out that such a system of exemption is different from one of *zero-rating*, which concerns primarily exports. According to the destination principle, exports are zero-rated, that is, they are not taxed and the VAT which might have been paid at previous stages must be fully rebated. This implies that exporters maintain their full right to deduction.

The second reason why some intermediate transactions may end up tried is connected with the general VAT principle that liable persons should be entitled to full deduction only on purchases which are strictly connected with production of taxable goods and services. For unincorporated businesses and professionals, it is often difficult to distinguish between productive inputs and personal consumption of the entrepreneur and his family. Several countries have therefore chosen to apply some general rules limiting the deduction of VAT paid on particular goods, such as fuels, passenger cars, restaurants and so on. Sometimes this system is also justified simply by the need for revenue. In countries where, as in France, these rules are very strict, some inputs may indeed bear some tax.

Finally, there may exist special "forfeit" (or "standardized") systems to tax small businesses, according to which deductible VAT is determined on the basis of some fixed economic parameters instead of actual expenses. In such cases, firms may bear part of the tax or, conversely, may enjoy a subsidy, according to whether the actual VAT paid exceeds or falls short of the deduction determined by the law.

In EEC countries, all these "impurities" of actual VAT systems seem to be quite important and to keep a consistent share of the tax within the network of intermediate transactions. (The French refer to this share as «les remanences de T.V.A.»). Thus while VAT was originally conceived as the economic equivalent to a retail tax with a different collection mechanism, a non-negligible component of it turns out to be instead equivalent to a pre-retail turnover tax.

Finally, special mention of the treatment of government agencies is necessary. Because they do not sell their services in the market, they cannot recover VAT paid on purchases from the private sector. In fact, VAT laws do not consider governmental bodies as liable persons but instead as final consumers. This provision produces another component of VAT revenue that does not flow from final private consumption.

4. The Agricultural Special System

In principle, farmers do not pay VAT on the value they add, but, unlike the professionals, are allowed to pass on to their customers a VAT credit for the VAT which they paid on purchased inputs. Furthermore, farmers, especially in some countries, are supposed not to be acquainted with the accounting techniques necessary to keep track of the VAT they have paid. A special system is therefore possible within present EEC agreements to simplify the calculation of the VAT credit farmers are allowed to pass on to their customers.

Essentially, farmers are allowed to choose to pass on a VAT credit which is simply a percentage of their sales. This percentage should, in principle, be set at the level needed to yield a sum equal, on average, to the tax paid by farmers on their inputs. With the percentage so set, the system would not produce any loophole in the tax law, because the tax liability would simply pass from the farmers to their customers. However, some countries, like Italy, make use of this system to subsidize the agricultural sector. They establish agricultural special rates which are consistently greater than the average VAT paid by farmers on their purchases. Because farmers do not have to pay VAT, they get a subsidy equal to the difference between the tax billed to their customers and that paid on their own purchases.

5. The VAT in the IO Table

Let's first imagine an "ideal" VAT system in which all the tax revenue derives from final demand. We could then think of two "pure" ways to represent VAT in an IO framework. In the first, all flows would be inclusive of the full amount of VAT. The actual payments of VAT by each sector would appear in the VAT row of the Value-added section of the table. In the second pure representation, no VAT would be included in any flow. Non-zero VAT entries would appear only in the VAT row of the final demand columns or in the VAT row of the columns of industries which cannot deduct VAT paid on inputs. The difference between these two pure tables provides us with the table of VAT flows. With either of these pure tables, the entries across the rows could be meaningfully summed, for they would all be on the same valuation basis, either with or without VAT. This summation, it must be stressed, is the most important operation in analysis with input-output tables. Any accounting scheme which introduces deliberate differences in the valuation of different cells in the same rows invites nonsensical computations.

For better or worse, the Italian tables and those of other EC countries are based on a mixed approach, the so called non-deductible VAT table. In this sort of table, any flow on which the purchaser can deduct the VAT is shown without the VAT. Other flows are shown with the VAT. The difference between this table and the pure table with no VAT on flows shows the location and primary incidence of non-deductible VAT. The difference between it and the pure table with all VAT included shows the flows of deductible VAT.

We will now examine how the non-deductible VATs approach affects the published tables, both for the standard case when all VAT on intermediate products is deductible and when some of it is not. Our basic position is that at least one and preferably both of the pure tables should be published along with the non-deductible VAT table, for without at least one table with uniform units across each row, many computations will be compromised. Alternatively, publication of a matrix of the non-deductible VAT flows would serve the same purpose.

6. VAT Accounting, Tu Collection and the Location of VAT Yield

Let us consider the price information in sector j

$$P_j = \Sigma_i a_{ij} p_i + v_j \tag{1}$$

where
a_{ij} 's are technical coefficients,
p_i is the sector i price (without tax)
v_j is the value added per unit of output in sector j

In what follows, for the sake of simplicity, we will disregard the investment component in the VAT mechanism. If we consider the ideal VAT case, which we shall henceforth refer to as the standard case, where all VAT on intermediate products can be deducted, the amount of VAT per unit of output actually paid to the government by producers in sector j, vat_j, is given by

$$vat_j = p_j t_j - \Sigma_i a_{ij} p_i t_i \tag{2}$$

where t_i is the VAT rate. Equation (2) represents the heart of the VAT account. Each producer compiles such an account and pays its balance to the tax office. This account thus gives the *entrepreneur tax collector rule* within the VAT system. The price equation can then be defined by

$$p_j(1+t_j) = \Sigma_i a_{ij} p_i(1+t_i) + v_j + vat_j$$

which is obtained by rearranging equation (2) and adding it to equation (1).

In order to show the location of VAT yield we consider a two sector economy; q_1 and q_2 are the total outputs of the two sectors; q_{ij} is the amount of good i used to produce good j; c_1 and c_2 are the final consumptions of the two goods; p_1 and p_2 the two prices, v_1 and v_2 the two value added, t_1 and t_2 the two tax rates. By VAT_1 and VAT_2 we denote the direct VAT payments from industry 1 and 2, respectively. If we show the amount of VAT included in each cell of the table at the prices at which the transactions were made, we get a table like this:

	Intermediate demand		Final demand	Total
product 1	$q_{11}p_1t_1$	$q_{12}p_1t_1$	$c_1p_1t_1$	$q_1p_1t_1$
product 2	$q_{21}p_2t_2$	$q_{22}p_2t_2$	$c_2p_2t_2$	$q_2p_2t_2$
VAT payments	VAT_1	VAT_2		
total in column	$q_1p_1t_1$	$q_2p_2t_2$		

Reading the table by row we see that the total tax in each row is the value of the product multiplied by its tax rate.

$$\begin{aligned} q_1p_1t_1 &= q_{11}p_1t_1 + q_{12}p_1t_1 + c_1p_1t_1 \\ q_2p_2t_2 &= q_{21}p_2t_2 + q_{22}p_2t_2 + c_2p_2t_2 \end{aligned} \tag{3}$$

Reading the same table by column we find the sectoral VAT in the standard case as follows:

$$\begin{aligned} \mathrm{VAT}_1 &= q_{11}p_1t_1 + q_{12}p_1t_1 - q_{12}p_1t_1 \\ \mathrm{VAT}_2 &= q_2p_2t_2 - q_{21}p_2t_2 - q_{22}p_2t_2 \end{aligned} \tag{4}$$

Then, by substituting from (3) for the first term on the right of (4), we obtain

$$\begin{aligned} \mathrm{VAT}_1 &= q_{11}p_1t_1 - q_{12}p_1t_1 + c_1p_1t_1 - q_{11}p_1t_1 - q_{21}p_2t_2 \\ \mathrm{VAT}_2 &= q_{21}p_2t_2 - q_{22}p_2t_2 + c_2p_2t_2 - q_{12}p_1t_1 - q_{22}p_2t_2 \end{aligned} \tag{5}$$

which, after canceling out terms, becomes

$$\begin{aligned} \mathrm{VAT}_1 &= c_1p_1t_1 - q_{12}p_1t_1 - q_{21}p_2t_2 \\ \mathrm{VAT}_2 &= c_2p_2t_2 - q_{21}p_2t_2 - q_{12}p_2t_2 \end{aligned} \tag{6}$$

In the standard case the total yield is then equal to

$$\mathrm{VAT} = \mathrm{VAT}_1 + \mathrm{VAT}_2 = c_1p_1t_1 + c_2p_2t_2$$

We can give a matrix representation of the non-deductible VAT flows:

$$\begin{array}{ccc} 0 & 0 & c_1p_1t_1 \\ 0 & 0 & c_2p_2t_2 \\ \mathrm{VAT}_1 & \mathrm{VAT}_2 & \end{array}$$

In this standard case, non-deductible VAT is found only on final demand. Note that in this table the sum of column i is not necessarily equal to the sum of row i. Rather the sum of the entries in the value-added row (the actual payments) is equal to the sum of all other flows (the “locations” of the VAT).

Let’s now consider what happens to this table of non-deductible VAT flows as we move away from the standard case. We limit ourselves to two main sources of deviation: VAT exemptions and particular rules limiting the deduction.

If the product of sector i is exempted, we must have $t_i = 0$. We have noted the rule that firms producing exempted goods and services have no right to get a rebate of the tax they paid on purchased inputs. This rule may be expressed by imposing the condition $VAT_i \geq 0$ and that all the $q_{ji}p_it_i$ become non-deductible VAT. The matrix of non-deductible VAT flows then becomes

0	0	0
$q_{21}p_2t_2$	0	$c_2p_2t_2$
0	VAT_2	

Consider now the case of tax rules limiting the deductibility of VAT on particular goods and services. Let us assume, for example, that VAT on q_1 (e.g. fuel) cannot be deducted. Equations (5) then become

$$VAT_1 = q_{11}p_1t_1 + q_{12}p_1t_1 + c_1p_1t_1 - q_{21}p_2t_2$$

$$VAT_2 = q_{21}p_2t_2 + q_{22}p_2t_2 + c_2p_2t_2 - q_{22}p_2t_2$$

and

$$VAT = VAT_1 + VAT_2 = q_{11}p_1t_1 + q_{12}p_1t_1 + c_1p_1t_1 + c_2p_2t_2$$

The table of non-deductible VAT, i.e. the table of VAT yield, becomes

Fuel	$q_{11}p_1t_1$	$q_{12}p_1t_1$	$c_1p_1t_1$
Product 2	0	0	$c_2p_2t_2$
VAT payments	VAT_1	VAT_2	

We can see that deviations from the standard case have the effect of filling up the intermediate matrix with some positive values.

The case of agriculture is somehow similar to that one of exemptions. The special rules described above may be seen as imposing $t = 0$ for agriculture. The only tax will be that one paid by farmers on their inputs. The Italian tables, following Eurostat's suggestions, locate VAT on agricultural inputs on the final consumption flow.

In our two sector model, supposing that sector l is agriculture, the matrix of VAT yield would be

Agriculture	0	0	$q_{21}p_2t_2$
Product 2	0	0	$c_2p_2t_2$
VAT payments	0	VAT_2	

In such a way the subsidy (that, as we have seen above, is assured to the agricultural sector through the VAT system) does not appear explicitly: it results in an augmented value added in the sector.

Then it is clear that such a table of non-deductible VAT flows is very important for modeling because we need to know the location and the real amount of the yield of (not-deductible) VAT. In fact, equipped only with a table such as those published for EC countries in which the cells include the non-deductible VAT, it is impossible to express the flows in a given row in uniform units. If the units are not uniform across the row, addition across the row is meaningless; but all IO modeling hinges on addition across the row.

7. The Computation of VAT Yield

The VAT yield is a side result of an input-output model with real and nominal sides integrated. In an IO model, we have the matrix A (the input-output coefficient matrix) and we get price, output, and final demand vectors from the solution; having the tax rates for each flow (a scenario set of parameters), we can transform the real flows into nominal flows, and applying the tax rates to each flow and summing up the non-zero VAT yields we get the total net VAT revenue.

8. The Computation of VAT Inflation

The impact of VAT on prices is strictly endogenous and acts in the nominal side of the model. In order to give evidence of this impact we must remember how prices are measured in price equations. In general, for sector i, we can consider a price p_{io} at the. base year and a price p_{it} at time t; price as an index number is then equal to 1 at the base year and to p_{it}/p_{io} at time t. In the nominal side of the model, prices enter as index numbers. When prices include VAT, (as in private consumption), for sector i, we have $p_{io}(l + t_{io})$ in the base year and $p_{it}(l + t_{it})$ at time t where t_{it} and t_{io} are VAT rates. The index number of the price in the base year is still equal to 1, but at time t it will be equal to $p_{it}\,(l + t_{it})/p_{io}(l + t_{io})$. We can see that the price index inclusive of VAT is equal to the price index net of VAT times the VAT factor index, which is given by the ratio $(l + t_{it})/(l + t_{io})$. Then we can move to the consumer prices by applying, in addition to production prices, the VAT factors which are determined by considering changes in the structural tax rates or by designing tax scenarios.

Because of the exceptions that leave some VAT charges on intermediate consumption, VAT factors influence prices through the price equations. Of course, VAT factors apply only when VAT charge is not equal to zero. If the VAT on private consumption expenditure has a direct impact on inflation, VAT on intermediate consumption may be expected to exert an even greater influence on inflation.

9. Excises and Other Taxes on Production in an IO Table

The indirect taxes (other than VAT) are a component of value added. In general, in an IO table there is one row in the VA sector which contains revenues paid by each sector under the item "taxes on production". Each flow derives from a mix of different taxes which have a different behavior and a different impact on inflation according to their nature and bases. First of all, it is convenient to make clear the types of such taxes.

Such taxes are duties on production and imports. The first and most important group consists of

a) taxes on commodities collected in proportion of the quantity (specific taxes) or the value of goods and services (ad valorem taxes) produced in a country;
b) other indirect taxes on production, namely duties affecting the utilization of factors as well as some rights or licenses for resident firms.

Following this classification, in the Italian case we have a very complex set of indirect taxes where we can roughly identify 39 kinds of duties: some of them are very important in terms of yield, such as fuel taxes; some others are irrelevant and represent only an anachronism in the fiscal system, such as the consumption tax on sugar.

We can interpret the production taxes row in the value-added area of an IO table as the column sum of a matrix of indirect taxes where each row identifies a kind of duty and each column represents an industry. While official IO tables contain this production taxes row, in order to make an I-O model that is useful for policy analysis, we must be in the position to evaluate the effects of modifications of rates and types; that is to say, we need not just a row but a matrix.

Some tax revenues may be allocated to specific sectors; others may not. One can try to build the production taxes matrix as far as the first type is concerned; for the case of non-sectoral taxes one must hope for help from official statistical institutions. Thanks to the help of ISTAT (lstituto Centrale di Statistica, the Italian National Statistical Bureau), the Italian model is now provided with a production tax matrix for 45 sectors and 39 kinds of duties.

We can follow two approaches in order to model production taxes in an IO model. To forecast the economy, we need to evaluate such taxes per unit of output at the sectoral level. One can tackle the problem by assuming that taxes can be, on one hand, explained by behavioral equations or, on the other hand, by managing the rates for each kind of tax and for each sector. The two approaches are outlined in the following sections.

10. Behavioral Equations for Indirect Taxes

In this case the attention is focused on the production tax per unit of output ignoring the rate structure of this value added component. In other words, one can proceed without the indirect tax matrix. Anyway, we assume that we have a time series of vectors … ts_{-2}, ts_{-1}, ts_0, ts_1, ts_2 … – where ts_0 is the production taxes row in the IO table. The tax rates are, then, equal to

$$t_0 = \hat{q}_0^{-1} ts_0$$

where
q_0 is the total output vector at the base year, and
$\hat{q}$ is a diagonal matrix with total outputs along the main diagonal.

We can compute the corresponding vectors of tax rates relative to real output

$$t_t = \hat{q}_t^{-1} ts_t$$

at time t. It's important to stress that the vector t is an "average rate" because it shows the average burden on every single sector.

On modelling the evolution of the value added components (Almon 1981, 1983) we compute the tax indexes as

$$d_t = \hat{t}_0^{-1} t_t$$

and we subsequently model vector d_t. The behavioral equations for each component of vector d_t have to take into account the rough distinction of these taxes into two groups: a) specific taxes and b) ad valorem taxes. If we do not inspect how tax laws may have modified tax rates, sectoral tax indexes can be interpreted by means of a simple sectoral price indexation scheme (Bardazzi 1987, Grassini 1987) which, in general, can be referred for sector i as $d_{it} = f(p_{it})$. In the Intimo model this function is simply linear.

When one prefers to model vector d_t by using tax changes and/or designing tax scenarios, then we move to the second approach described in the next section.

11. Tax Rates Scenarios

This case relies upon a production taxes matrix mentioned above. Let us call this matrix U with as many rows as the sectors in the IO table and as many columns as the kinds of indirect taxes considered. The tax rates matrix U_A is given by

$$U_A = \hat{q}^{-1} U$$

The elements of U_A are tax rates and can be divided into a group of excise tax rates and a group of ad valorem tax rates. Matrix U_A must be defined, for each year; one can expect excise tax rates to change more rapidly than the other group of tax rates; in fact we have to consider that the updating of excise tax rates must take place frequently in order to maintain the tax yield in line with inflation; this is not the case of ad valorem indirect tax rates which imply an automatic indexation. In general, we can consider matrix U_A with two columns related to the two groups of production taxes; let t_{iqt} and t_{ivt} be the two tax rates on quantities and ad valorem in sector i. The tax index at time t in sector i is given by

$$d_{it} = t_{iqt} + t_{ivt}{}^{*}p_{it}$$

which is the variable that acts in the price equation. On the other hand, the sectoral yield is given by $q_{it}{}^{*}\ d_{it}$.

12. Final Comments

Indirect taxes affect price formation; therefore, they must be included in an IO model with a developed nominal side. The level of complexity on modeling indirect taxes qualifies the IO model as a policy simulation tool. On computing price vectors (producers' and consumers' prices) by means of a multisectoral model, we must include the effect of production taxes as well as VAT taxes; this can be accomplished by means of simple indexation of production taxes in the producers price equations and applying VAT factors to consumer prices. When an IO model is used as a fiscal policy simulation tool, we need to deal with tax rate scenarios and to evaluate tax yields; in this case we need a model with prices and outputs endogenous to get endogenous nominal flows from which to obtain tax yields by applying structural tax rates or specifically chosen for simulation exercises.

A fiscal policy simulation input-output model must then have a real and a nominal side fully integrated; it must be able to properly mix tax scenarios like the ones described above. INTIMO is such a model.

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THE CORE OF THE MULTISECTORAL INFORUM MODEL[1]

Maurizio Grassini

1. Introduction

In this paper, a formal representation of the skeleton of a standard Inforum multisectoral model is given. The aim of the paper is twofold. Firstly, a compact algebraic representation of the 'common' part of the Inforum model system - the "core" - is presented in order to reveal the theoretical background of this kind of input-output model; this description will show how these models differ from other models using input-output data. Secondly, new users or potential builders of an Inforum model can find here a quick overview of the nature of these models. Each model, of course, has its own particular features; they can be found in articles and books in which Inforum partner models are described (see, for example, Almon *et al*, 1974; Almon, 1997; Antille *et al.*, 1996; Arango *et al.*, 1987; Buckler McCarthy, 1991; Grassini, 1983, 1987; I.T.I., 1996; Orlowski *et al.*, 1991; Richter, 1991; Meyer *et al.*, 1995; Nyhus, 1997; Werling, 1992; Yu, 1997).

The name Inforum originally stood for *INterindustry FORecasting at the University of Maryland* and is now used by groups in many countries that work with the Maryland group to give evidence of the basic structure of the country model. A name more descriptive of the nature of the models might be Interindustry Macroeconomic (IM) models —"Interindustry" to stress the presence of an input-output structure and many 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

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[1] The author wishes to thank Douglas S. Meade, Ralph M. Monaco and Douglas E. Nyhus for their constructive advice and for providing encouragement; I am deeply grateful to Clopper Almon for his comments and suggestions. A preliminary draft was presented at the Twelfth International Conference on Input-Output Techniques in New York, May 1998. Financial support from MURST (the Italian Ministry of the University and Technological and Scientific Research) is gratefully acknowledged. Paper published in M. Grassini (ed.) *Contribution on Multisectoral Modelling*, Dipartimento di Studi sullo Stato, Università di Firenze, Centro Editoriale Toscano, Firenze, 2001, pp. 7-32.

Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online),

projection and 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. In this article, I shall generally use IM when speaking of the nature of the models and use Inforum to describe the group of model builders.

One important ‘common’ aspect of the Inforum models escapes the algebraic description and should be mentioned at the outset. That is the fact that model builders in different countries all work with a largely common software. It must be stressed that a common software is not a simple technical tool undeserving of any intellectual attention. Rather, this software embodies an extensive understanding of what is needed for multisectoral modeling. It makes it possible to build a wide variety of models with relative ease, to penetrate into the working of the model, and to use it flexibly. But a common software is even an essential tool to facilitate international cooperation in the construction of the models and especially to make their linking possible.

No matter how powerful or seductive the software, however, it is necessary to know clearly and theoretically how the model is to work. Studying the code and equations of existing models is certainly one way of discovering their structure, and the author has spent many an hour doing so. Nevertheless the author is aware that setting out in analytic form the structure of this kind of IM models achieves two objects; firstly, a comprehensive representation of a modern input-output dynamic model (or I/O+ econometrics, see West 1995) and, secondly, the connection with the basic input-output table.

2. Historical remark

In the Summary of the Proceedings of the Seventh International Conference on Input-output Techniques, held in 1979, Richard Stone spoke of the development of input-output (I/O) modeling as follows:

> 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 primary inputs and other production costs such as provisions for depreciation and indirect taxes. Input coefficients were calculated, as a matter of simple arithmetic, by dividing the elements in the intermediate product vectors by the corresponding output total. Apart from a certain number of arithmetical and accounting identities, these coefficients constituted the relationship of the model. 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.

If the I/O table and the Leontief inverse represent the cornerstones of the early stages of the I/O model, the evolution of the Inforum models illustrates a trend noted with approval years ago by Richard Stone.

> 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 (Stone, 1984).

This statement is still valid; the I/O core is fading away as time goes by. The basic accounting identities are still there, but model builders surround them with «structural econometric equations»[2] in the process of improving the seminal Leontief equation.

The development of the I/O model has followed many ways; some of them have produced interesting quantitative enrichments of the original model based upon empirical data; others have led to the abstractions of mathematical economics.

As in other scientific fields, lack of communication has all too often wasted intellectual energies in discovering what was already known. It is still not difficult to find those who believe that the I/O framework excludes interdependence between prices and quantities or who believe that an I/O model must be driven by an aggregate macroeconomic model or who suppose that there is a fundamental problem of the stability of dynamic I/O models. In fact, all these problems arise from misconceptions. The Inforum partners, which now work in over a dozen countries, produce dynamic forecasts of multisectoral models, including both industry outputs and prices with significant effects of the prices on the quantities and vice-versa. The models have no trace of an aggregate driver model, and no problems of the instability beyond that which actually appears in business fluctuations.

3. The I/O table and the notation

Let us consider the following four basic components of an I/O table: IC the Intermediate Consumption flows, FD the final demand components, VA the value added (compensation of primary factors and others), TO the total output. These components fill a simple input-output table as

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[2] West (1995) names this kind of «sophisticated models»: IO+ econometrics or IOE. He compares IOE models with the standard IO and CGE models and gives an interesting listing of the model characteristics.

in the following figure.

IC	FD	TO
VA		
TO		

The table summarizes the two fundamental accounting identities, that is to say

Intermediate Consumption flows + Final Demand = Total Output
Total Output = Intermediate Consumption flows + Value Added

These two identities come from traditional double-entry bookkeeping. By equating the two expressions for total output and canceling Intermediate Consumption from both sides, we get that Final Demand is equal to Value Added. If the table represents an economy disaggregated into *n* industries, the final demand into *k* components and the value added into *l* components, then IC is a matrix *nxn*, FD a matrix *n*x*k*, VA a matrix *l*x*n* and TO a vector with *n* elements; using appropriate sum vectors *h*, the two accounting identities can be rewritten as

$$ICh + FDh = TO$$

$$IC'h + VA' h = TO$$

By means of simple algebraic manipulation, the two accounting identities are transformed into two sets of equations which are respectively the basis of the real side and the price side of a multisectoral model. The notation we shall use is shown in the Table of Notation.

Table of Notation

Vectors and matrices of quantities	
q	vector of sectoral total outputs
$\hat{q}$	diagonal matrix with elements of q on the main diagonal
m	vector of imports
f	vector of final demand with net exports
F_i	vector of the i-th final demand component in national account classification
B_i	bridge matrix related to the i-th final demand
Q	matrix of intermediate consumption flows ($Q= Qd+ Qm$)
z_R	vector of exogenous variables in the real side
z_P	vector of exogenous variables in the nominal side

Vectors of prices	
p	vector of sectoral production prices
$\hat{p}$	diagonal matrix with elements of p on the main diagonal
p_m	vector of import prices

Vectors and matrices of nominal flows	
IC	matrix of Intermediate consumption flows (IC= $\hat{p}$Q)
FD	matrix of Final Demand flows (FD= FD^d+ FD^m)
VA	matrix of Value Added components
TO	vector of total outputs
fd	vector of final demand (fd= FDh= $\hat{p}$f)
va	vector of value added (va= VA’ h)
$\hat{va}$	diagonal matrix with elements of va on the main diagonal
v	vector of value added per unit of output (v= $\hat{p}$-1va)

For the moment, we will assume that all the flows along a single row of the table were conducted at the same price. With this assumption, the two identities described above can be written as follows

$$\left[\hat{p}Q\ \hat{p}f\right]h = \hat{p}q \qquad h'\begin{bmatrix}\hat{p}Q\\ va\end{bmatrix} = (\hat{p}q)^1$$

Premultiplying the first set of identities by $\hat{p}$-1, postmultiplying the second set of identities by $\hat{q}^{-1}$, using h= $\hat{q}^{-1}$q, noting that $\hat{p}$q= $\hat{q}$p and defining the traditional technical coefficients

$$A = Q\hat{q}^{-1} = [a_{ij} = q_{ij} / q_j] \text{ for } i,j = 1, 2,\ldots, n$$

we get

$$\hat{p}^{-1}\left[\hat{p}Q\hat{q}^{-1}q\ \hat{p}f\right]h = \hat{p}^{-1}(\hat{p}q)$$

$$h'\begin{bmatrix}\hat{p}Q\hat{q}^{-1}\hat{q}\\ va\end{bmatrix}\hat{q}^{-1} = (\hat{q}p)'\hat{q}^{-1} = p'\hat{q}\hat{q}^{-1}$$

from which we obtain

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

These two systems are the basic equations of an I/O model; more precisely, the two sets are respectively the basis of the real side and of the price side.

4. The accounting identities and the model

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; adding econometrically estimated equations just reduces the number of exogenous variables. Without the behavioral equations, the model would be all framework with little content; without the identities, the content could be self-contradictory.

The accounting identities of the I/O real side are

$$Qh + f = q$$

These n equations can be used to explain n (endogenous) variables; but the system involves $n^2 + 2n$ variables (the n^2 elements of Q and n each of f and q) so a way to reduce the number of unknowns must be found. The usual device is to introduce the «input-output technical coefficients» a_{ij} defined by $q_{ij} = a_{ij} q_j$ where a_{ij} may be a function of time, prices, interest rates, levels of output and so on. (One extreme case is to assume them constant; it is still not rare to find people who suppose that this one possibility is the only one ever used in input-output work and therefore wrongly assert: "input-output assumes fixed coefficients".)

Now, we see that the introduction of «input-output technical coefficients» reduces the number of variables to 2n. In order to solve them, we must in some way determine n of them. There are, in general, three alternatives: (a) q is left endogenous and f is given, (b) f is endogenous and q is given, (c) n_1 components of q and n_2 components of f are endogenous ($n_1 + n_2 = n$) and the others are left exogenous. Although the above three alternatives are all interesting for tackling specific real problems, in the economic literature (a) is practically the only one considered. Likewise, in the price side there are 2n variables, p and v. One can determine v and deduce p, or determine p and deduce v, or determine some elements of p and others of v. If in both cases we choose the first alternative, then, from the I/O table used to build a simple I/O model, it is possible to obtain

$$Q = g(f) \quad \text{and} \quad p = f(\mathrm{v})$$

These are the solutions used to investigate the mathematical properties of the 'static' Leontief model; the solutions of modern input-output models involve yet other variables and equations.

5. The real side of the model

The structure of the real side of the model can be conveniently presented starting from the Leontief equation. An IM model cannot be confined into the narrow set of variables contained into vectors q and f. In fact, final demand components (private consumption expenditure, government expenditure, investments, imports, exports, inventory changes and so on) must be evaluated at a specified level of aggregation. In general, we can state that the final demand vector is equal to the sum of k final demand components

$$f = f_1 + f_2 + f_3 \ldots\ldots f_k$$

Some components of the final demand, let us say r < k, are explained by means of econometric equations because the model builder does not want to consider all of them as exogenous. Private consumption expenditures, investments, imports and exports are usually explained by means of econometric equations; then, these final demand components are no longer exogenous; consequently, new exogenous variables appear in the framework of the I/O model; these new variables belong to the set of the explanatory variables of the endogenized final demand components.

Now, total output and the final demand components represent the set of endogenous variables of the (real side) I/O model. The total output, q, is defined by the Leontief equation; the r final demand vectors require an econometric estimate of their components. This is accomplished as in every econometric model by using time-series and cross-section statistical data. Much of the time-series data usually comes from national accounts. But I/O and national account classifications in many cases do not match. For example, the National Accounts give a structure of household expenditures with categories quite different from the sectors of the I/O table. The differences in classification are due to real statistical problems with interesting economic contents. For consumption expenditures, national account time series generally reflect categories in which consumers are able to think and answer survey questions rather than the sectors in which the industrialist thinks. The modeling of consumer behavior should also be done in these categories, but it is then necessary to convert a vector of consumption in these consumer categories into a vector of consumption in industrial categories. Similarly, if investment decisions are to be modeled, data on investment by user of the investment goods is necessary. The resulting vector of investment by purchaser must be converted into a vector of investment by product purchased. In both cases, the link between variables available in different classifications is done by means of *bridge* matrices which, in general, should be made available by every statistical bureau producing both national accounts and I/O tables. (In fact, these matrices are not always available from the statistical office; the work of constructing them falls on the model builder).

Every bridge matrix has rows corresponding to I/O sectors and columns to the specific national accounts classification. Thus, all bridge matrices have the same number of rows, though their number of columns may be different. We shall assume that such a bridge matrix is available for each final demand vector; this matrix is such that the correspondence between final demand vector f_i and the national account vector F_i is

$$f_i = B_i F_i$$

When there is a perfect correspondence between the two classifications (as it often is for imports and exports) the bridge matrix will be equal to the identity matrix. Using F's instead of f's, the Leontief equation becomes

$$Aq + B_1F_1 + B_2F_2 + \ldots\ldots + B_rF_r + f_{r+1} + \ldots + f_k = q$$

As previously stated, the *r* final demand vectors F_i are explained by econometrically estimated equations; we have, therefore, for vector F_i as many equations as there are elements of this vector. Among the determinants of the F_i may be found elements of the *q* vector and lagged values of *q* (as in the dependence of investment on increases in output) or variables such as personal income which derive from *q*, as we shall see below. F_i may also depend on variables belonging to the price side of the I/O model (mainly prices) and other variables, such as interest rates which are not explicitly shown in the input-output flow table. These other variables may be true exogenous variables or they may be determined in supplementary equations included in the model but not depicted in the I/O accounting scheme. When *q* has been computed the real side goes on to compute labor productivity and, from it and output, employment which will be - as we shall see - an important link between real and nominal sides. In short, we are very far from the simple determination of *q* given *f*.

Apart from the 'identity' equations derived from the input-output table, most of the equations for the final demand components are nonlinear; in fact, in many cases it is hard to assume linear functions whereas, for instance, prices and demand factors influence each other as in the private consumption demand functions, in the import equations and others. The 'identity' accounting equations and the final demand equations unavoidably make up a *non-linear model.* However, a simple representation of the real side of the IM by using trivial matrix notation can be achieved by considering the linear approximation for all the (*non-linear*) equations in the model.

The endogenous variables of the IM model are now grouped in the vector *[q F]'*; if every subvector F_i has n_i elements, the endogenous variables are in number equal to $n + G_i n_i$. Vector q is explained by the equations coming from the input-output accounting identities; elements of vector F are explained by means of econometrically estimated equations; these last equations make the model dynamic because of the presence of endogenous lagged variables. If we consider, without any loss of generality, the case of one lag among the endogenous variables, vector F can be represented as follows

$$F = Cq + DF + W_1 q_{-1} + W_2 F_{-1} + Pz_R$$

Matrix C contains parameters not equal to zero where there is influence of sectoral total output on total final demand components (mainly inventory changes, imports, investments and others); matrix D shows that interactions among final demand components are allowed. Matrix W_1 and W_2 take into account endogenous variables lagged effects; matrix P collects parameters related to exogenous variables, z_R.

The IM model can be now shown in matrix notation as

$$\begin{bmatrix} q \\ F \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} q \\ F \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ W_1 & W_2 \end{bmatrix} \begin{bmatrix} q \\ F \end{bmatrix}_{-1} + \begin{bmatrix} f_{exog} \\ Pz_R \end{bmatrix}$$

and the reduced form of the model turns out to be

$$\begin{bmatrix} q \\ F \end{bmatrix} = \begin{bmatrix} (I-A) & -B \\ -C & (I-D) \end{bmatrix}^{-1} \left[\begin{bmatrix} 0 & 0 \\ W_1 & W_2 \end{bmatrix} \begin{bmatrix} q \\ F \end{bmatrix}_{-1} + \begin{bmatrix} f_{exog} \\ Pz_R \end{bmatrix} \right]$$

If we define

$$\begin{bmatrix} (I-A) & -B \\ -C & (I-D) \end{bmatrix}^{-1} = \begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix}$$

we can still establish a relationship between total ouputs and 'exogenous' final demand components, f_{exog}, that is to say $q = H_{11} f_{exog}$, which can be called the residual Leontief equation. In fact, the Leontief equation allows to get n endogenous total sectoral outputs from n exogenous total final demand components; now, the above equation gives n total sectoral outputs given n *residual* exogenous n final demand components, f_{exog}.

Matrices $(I\text{-}A)^{-1}$ and H_{11} have different economic meaning. The Leontief inverse can be considered as the parameter structure of the reduced form of a tautological model (a model derived from accounting identities) while H_{11} is a usual reduced form of an econometric model. Matrix $(I\text{-}A)^{-1}$ is common to every standard I/O model builder (in the sense that such a matrix is plainly obtained from the I/O table) whereas matrix H_{11} brings the personal touch of the model builder; in fact,

$$H_{11} = ((I - A) - B\,(I - D)^{-1}\,C)^{-1}$$

where the accounting ratios a_{ij} and the bridge matrices B's are merged with matrices C and D which contain parameters of econometric equations.

So far, we have written equations without specifying the years to which they belong. Of course, for different years we have different final demand vectors, *ft*, and input-output coefficient matrices, A_t. Thus, including the time subscript, we would write the real side as

$$q_t = A_t q_t + f_t$$

6. *The price side of the model*

The structure of the price side of the model can be introduced by using the Leontief price equation $p= A'\,p+ v$. Prices are measured as price indexes; the base year coincides with base year of the I/O table. That is to say, all prices are equal to 1.0 in the base year.

In other years, prices vary according to changes in the vector of value added per unit of output, v, and the A matrix. By using the t subscript to denote the time index, the price equation becomes

$$p_t = A_t' p_t + v_t$$

The model must describe an open economy, so we must take into account two sources of goods: domestic and foreign industries. The total output vector is the amount of resources provided by domestic industries; the import vector is the amount of resources provided by foreign industries. Then, we have that $q_{ij}={q^d}_{ij}+{q^d}_{ij}$ from which we get the ratios $h_{ji}={q^d}_{ij}/q_j$ and $t_{ji} = {q^m}_{ij}/q_j$, with $a_{ij} = h_{ji} + t_{ji}$; defining $H= [h_{ij}]$ and $T= [t_{ij}]$ we have $A' = H(h_{ij})+ T(t_{ij})$. While the elements of matrix A can be interpreted as technical coefficients, their division between the H and T matrices is based primarily on commercial rather than technological considerations. They are used here to compute the cost of intermediate consumption when domestic and import prices differ. The price equation becomes

$$p_t = H_t p_t + T_t p_t^m + v_t$$

For a national model, vector p^m is exogenous; in a naive I/O model, the vector v_t is assumed exogenous as well. In an IM model, the value added per unit of output is considered as the sum of l value-added components such as Wages and salaries, Contributions for social insurance, Capital consumption, Profits, Interest payments, and Indirect taxes. These value- added components are partially exogenous and partially endogenous; subsidies are mainly considered as exogenous, while wages are usually (econometrically) explained. One can even find exogenous as well endogenous variables within the same component; for example, if wages in manufacturing sectors are mainly endogenous, wages in Government sectors may be treated as exogenous. The result of modeling these components is an *n*x*l* matrix, *V*, of different types of value added per unit of output. Summing the columns gives the *v* vector.

7. Real side and nominal side cross over

In our presentation, we have artificially separated the real and nominal side for exposition. In actual modeling, of course, there are many cross-overs. In modeling value added components, we may use explanatory variables such as output or investment, from the real side. On the real side, we may use prices in determination of the input-output coefficients or final demands. Some explanatory variables, such as interest rates, may fall entirely outside the I/O table; they may be exogenous or may be endogenized in the overall model by equations in what is generally called the 'macro' part of the model. Lagged values from one side may enter the equations for determination of values in either side. For instance, formal or informal price indexation makes lagged values of prices a good explanatory variable for wages; price formation under fixed or flexible mark-up implies that profits depend on prices; cost of labor depends on labor productivity, that is to say on total outputs and employment, and so on.

8. Do we assume fixed I/O matrices?

We have mentioned repeatedly the concern of the IM model builder with time series of historical data. Usually these are annual series and include at least series for output, *q*, imports, *m*, exports, and the various F_i vectors from the national accounts. Input-output tables, however, are often not available annually. Can we assume that the A matrices derived from them are constant? In general, certainly not. In order to construct a consistent data base for our work, we should try to produce a series of balanced tables using all the data that is readily available to us, including information on individual flows. Some statistical offices, such as the Dutch and French, routinely do this work and release national accounts that are consistent with generally plausible input-output tables. Others do not bother with this check on the consistency of their national accounts data. In the best of cases, the model builder finds that reasonable changes in the input-output coefficient matrices can reconcile data on output, exports, and imports with the national accounts. In other cases, it becomes clear that the national accounts are inconsistent with other official data sources, thus posing a difficult choice for the model builder. To the best of our knowledge, *in no case have we found data consistent with constant input-output coefficients.* Fortunately, there is absolutely no requirement in any aspect of input-output theory that we have used that coefficients should be constant (Rose, Miernyk, 1989). Rather, modeling their changes can be an important challenge.

What has been said here of the *A* matrix applies with even greater force to the H and T matrices which divide A between domestic and imported parts. At least in the case of A there is likely to be some technological reason for stability of the coefficients, but with H and T substitution of imports for domestic goods or vice versa can be rapid. Modeling of changes in these matrices is crucial.

In short, *constancy of input-output coefficients plays no role in an IM model.* The question is not whether they change but how they change.

9. Indirect taxes in an IM model

Changes in indirect taxes have played a prominent role in recent European economic policy, and a Value Added Tax (VAT) is frequently discussed in the United States. It will illustrate nicely how the structure of an IM model can be exploited to look in some detail at the treatment of the indirect taxes. We will see that correct treatment of three types, the excise, the *ad valorem* tax, and the European-style VAT are quite different.

In order to deal with these, we must be aware about their location in the I/O table. Usually, indirect taxes are recorded in the value added sector, VA, of the I/O table. Both accounting definition and economic meaning of such flows can be understood considering the content of each flow in a table with three industries, one value added row (net of indirect taxes), VA, one final demand vector, c, and the 'totals'; we, now, distinguish two kinds of indirect taxes: excise and ad valorem taxes; their input-output location is presented in the next two sub- sections; in the third subsection the indirect taxes model in an Inforum price side model is presented.

9.1 Excise taxes in the I/O table

We consider the case of an I/O table where an excise tax burden is added to each intermediate consumption and final demand flow; tax flows are, then, located as in the following table

$q_{11}p_1+s_{11}$	$q_{12}p_1+s_{12}$	$q_{13}p_1+s_{13}$	$c_1p_1+s^1$	$q_1p_1+s_{11}+s_{12}+s_{13}+s^1$
$q_{21}p_2+s_{21}$	$q_{22}p_2+s_{22}$	$q_{23}p_2+s_{23}$	$c_2p_2+s^2$	$q_2p_2+s_{21}+s_{22}+s_{23}+s^2$
$q_{31}p_3+s_{31}$	$q_{32}p_3+s_{32}$	$q_{33}p_3+s_{33}$	$c_3p_3+s^3$	$q_3p_3+s_{31}+s_{32}+s_{33}+s^3$
VA_1	VA_2	VA_3		
q_1p_1	q_2p_2	q_3p_3		
II_1	II_2	II_3		
qq_1	qq_2	qq_3		

where

$$II_j = s_{j1} + s_{j2} + s_{j3} + s^j \;\; and \;\; qq_i = q_i p_i + II_i$$

First of all, in order to work out an excise tax model to be merged with the price equation, tax burdens (s_{ij}'s and s^j's) from the table have to be removed; of course, after the removal the intermediate consumption and final demand flows turn out to be net of these taxes, but the I/O table is consequently submitted to a clear modification; excise tax flows will no longer affect intermediate consumption and final demand flows, but excise tax flows will still be in the I/O table. In fact, the excise taxes removal can be interpreted like brushing them down to the value added area where the 'new' flows, IA_j and IA^c, contain now the column sums of the excise taxes 'removed' from intermediate consumption and final demand flows

$q_{11}p_1$	$q_{12}p_1$	$q_{13}p_1$	c_1p_1	q_1p_1
$q_{21}p_2$	$q_{22}p_2$	$q_{23}p_2$	c_2p_2	q_2p_2
$q_{31}p_3$	$q_{32}p_3$	$q_{33}p_3$	c_3p_3	q_3p_3
VA_1	VA_2	VA_3		
IA_1	IA_2	IA_3	IA^c	
q_1p_1	q_2p_2	q_3p_3		

where

$$IA_j = s_{1j} + s_{2j} + s_{3j} \;\; and \;\; IA^c = s^1 + s^2 + s^3$$

The excise tax flows, IA_i's, are now correctly computed and located among the costs of production.

9.2 VAT in a I/O table

The *ad valorem* tax considered in this section is the EC value added tax (VAT). The working mechanism of this tax is such that firms act as tax collectors and the consumer represents the actual taxpayer; hence, VAT turns out to be a tax on final consumption as it is generally considered in the economic literature. It is a matter of fact that specific tax rules introduce the so called «impurities» which make this *ad valorem* tax acting like any other tax burden on production (see Bardazzi *et al.*, 1991).

VAT burden in the I/ O table can be considered by adding to each flow the product of it by the tax rate (whereas the impurities make VAT non-deductible); assuming without any loss of generality that the tax rate, t_i, is constant along the row, the VAT tax burdens may be represented as in the following table where it is assumed that the 'impurities' make VAT non-deductible for three flows out of six in the intermediate consumption; VAT is largely charged on final demand and, for sake of simplicity, only one component, c_i, is considered

$q_{11}p_1$	$q_{12}p_1$	$q_{13}p_1$	$c_1p_1(1+t_1)$	$q_1p_1+VATRS_1$
$q_{21}p_2$	$q_{22}p_2$	$q_{23}p_2$	$c_2p_2(1+t_2)$	$q_2p_2+VATRS_2$
$q_{31}p_3$	$q_{32}p_3$	$q_{33}p_3$	$c_3p_3(1+t_3)$	$q_3p_3+VATRS_3$
VA_1	VA_2	VA_3		
q_1p_1	q_2p_2	q_3p_3		
$VATRS_1$	$VATRS_2$	$VATRS_3$		
TOT_1	TOT_2	TOT_3		

Sector 2 and sector 3 are affected by non-deductible VAT, $VATRS_i$ represents the VAT charged along the *i-th* row, and $TOT_i = q_ip_i + VATRS_i$. By brushing away VAT flows from the table, that is to say, deleting the following terms

$$VATRS_1 = c_1p_1t_1$$
$$VATRS_2 = c_2p_2t_2 + q_{23}p_2t_2$$
$$VATRS_3 = c_3p_3t_3 + q_{32}p_3t_3 + q_{33}p_{32}t_3$$

as a consequence of that, *VATRS* row disappears and a new VAT row will take its place; it will contain

$$VAT_1 = 0$$
$$VAT_2 = q_{32}p_3t_3$$
$$VAT_3 = q_{23}p_2t_2 + q_{33}p_3t_3$$
$$VAT^c = c_1p_1t_1 + c_2p_2t_2 + c_3p_3t_3$$

The first three terms are located among the value added components while the forth term falls out of the table; in fact, *VATc* is the VAT yield which is specifically recorded in the accounts related to the Institutions. The I/O table is now

$q_{11}p_1$	$q_{12}p_1$	$q_{13}p_1$	c_1p_1	q_1p_1
$q_{21}p_2$	$q_{22}p_2$	$q_{23}p_2$	c_2p_2	q_2p_2
$q_{31}p_3$	$q_{32}p_3$	$q_{33}p_3$	c_3p_3	q_3p_3
VA_1	VA_2	VA_3		
VAT_1	VAT_2	VAT_3	VAT^c	
q_1p_1	q_2p_2	q_3p_3		

The removal of VAT and excises taxes is now complete and the price equation with indirect taxes can be defined.

9.3 Indirect taxes in the price equation

If the basic I/O table has no tax burdens added to intermediate consumption as well as to final demand flows, from the price equation

$$\begin{aligned}
a_{11}p_1 + a_{21}p_2 + a_{31}p_3 + v_1 &= p_1\\
a_{12}p_1 + a_{22}p_2 + a_{32}p_3 + v_2 &= p_2\\
a_{13}p_1 + a_{23}p_2 + a_{33}p_3 + v_3 &= p_3
\end{aligned}$$

we get the price vector labeled *basic* (ignoring the time index)

$$\begin{bmatrix} p_1\\ p_2\\ p_3 \end{bmatrix}_{basic} = \begin{bmatrix} 1-a_{11} & -a_{21} & -a_{31}\\ -a_{12} & 1-a_{22} & -a_{32}\\ -a_{13} & -a_{23} & 1-a_{33} \end{bmatrix}^{-1} \begin{bmatrix} v_1\\ v_2\\ v_3 \end{bmatrix}$$

Here we assume that $s_{ij}=q_{ij}\alpha_i$, where α_i s the excise rate for the i-th good; we are aware that because of the composition and policy discrimination among industries, tax rate on the i-th good usually differs sector by sector; assuming excise tax rate constant along the row makes the notation easier without seriously compromising the understanding of the excise tax role in price determination.

The amount of this kind of indirect tax per unit of output is given by $a_{ij}\alpha_i$ and the price equation will get the following structure

$$\begin{aligned}
a_{11}p_1 + a_{21}p_2 + a_{31}p_3 + a_{11}\alpha_1 + a_{21}\alpha_2 + a_{31}\alpha_3 + v_1 &= p_1\\
a_{12}p_1 + a_{22}p_2 + a_{32}p_3 + a_{12}\alpha_1 + a_{22}\alpha_2 + a_{32}\alpha_3 + v_2 &= p_2\\
a_{13}p_1 + a_{23}p_2 + a_{33}p_3 + a_{13}\alpha_1 + a_{23}\alpha_2 + a_{33}\alpha_3 + v_3 &= p_3
\end{aligned}$$

from which we see the relationship between basic price and price including the effect of excise taxes (here labeled *excise*)

$$\begin{bmatrix} p_1\\ p_2\\ p_3 \end{bmatrix}_{excise} = \begin{bmatrix} p_1\\ p_2\\ p_3 \end{bmatrix}_{basic} + \begin{bmatrix} 1-a_{11} & -a_{21} & -a_{31}\\ -a_{12} & 1-a_{22} & -a_{32}\\ -a_{13} & -a_{23} & 1-a_{33} \end{bmatrix}^{-1} \begin{bmatrix} a_{11} & a_{21} & a_{31}\\ a_{12} & a_{22} & a_{32}\\ a_{13} & a_{23} & a_{33} \end{bmatrix} \begin{bmatrix} \alpha_1\\ \alpha_2\\ \alpha_3 \end{bmatrix}$$

This equation makes clear how to deal with excise taxes in price determination and shows that in the multisectoral framework indirect taxes produce an additive component of the basic prices.

The presence of non-deductible VAT on intermediate consumption flows leads to the following price equation

$$a_{11}p_1 + a_{21}p_2 + a_{31}p_3 + v_1 = p_1$$
$$a_{12}p_1 + a_{22}p_2 + a_{32}p_3(1+t_3) + v_2 = p_2$$
$$a_{13}p_1 + a_{23}p_2(1+t_2) + a_{33}p_3(1+t_3) + v_3 = p_3$$

As a cost component, VAT is equal to zero in the first equation, equal to $a_{32}p_3t_3$ in the second equation and equal to $(a_{23}p_2t_2 + a_{33}p_3t_3)$ in the third equation; even if non-deductible VAT is located in a small number of flows, its influence is widespread over the three prices according to a non linear function represented by the solution

$$\begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix}_{vat} = \begin{bmatrix} 1-a_{11} & -a_{21} & -a_{31} \\ -a_{12} & 1-a_{22} & -a_{32}(1+t_3) \\ -a_{13} & -a_{23}(1+t_2) & 1-a_{33}(1+t_3) \end{bmatrix}^{-1} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix}$$

In the case of the 'ideal VAT' (that is to say, when non-deductible VAT is not present in any intermediate consumption flow), p_{vat} is equal to p_{basic}; the presence of non-deductible VAT makes p_{vat} different from p_{basic} but it is not possible to represent one in term of the other like in the case of excise taxes.

After the introduction of indirect taxes (excise and *ad valorem*), the price equation for the j-th sector is restated as

$$p_j = \sum_{i=1}^{n} a_{ij} p_i (1+t_{ij}) + \sum_{i=1}^{n} a_{ij}\alpha_{ij} + v_j$$

where v_j is computed as above.

10. Final remarks

We have seen that from the accounting identities it is possible to obtain a very simple model for the real and price sides of an input-output model, that is to say

$$q = g(f) \text{ and } p = f(v)$$

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

$$q = Aq + f(q,p,z_R) \text{ and } p = Hp + Tp^m + v(p,q,z_P)$$

where z_R and z_P are respectively the exogenous variables in the real and price sides of the model. Now, we can see that having modeled final demand and value added components the dependence of both of them on total output and prices is established; then, the Inforum model has prices and quantities fully integrated.

This review has concentrated on the part of the model which involves its multi-sectoral structure. An IM model must also include a number of macroeconomic equations. Various types of income – wages, depreciation, profits, and so on – originates in industries and is then summed over the industries to give totals of these types of income. They are allocated among various 'institutions' such as families, business, and governments. Taxes are then 'collected' from the 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 further equations for a detailed construction of all of the flows in the institutional accounts of the Standard National Accounts. Other variables, such as the overall unemployment rate or interest rates may be determined in the macroeconomic part of the IM model. Thus, the Inforum models completely integrate 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 build from bottom up and only use aggregate equations where it would make no sense to have sectoral equations, as for example the personal savings rate.

Given the attention which has centered in recent years on 'expectations', it is perhaps important to note that the Interdyme software allows the use of future values of any variable as well as the more traditional current and lagged values of variables. It is thus possible to use 'model-consistent' expectations, which it was once fashionable to call 'rational' expectations. In fact, one ancestor of today's Inforum models (Almon 1963) stressed that it employed such 'consistent' forecasting techniques. Most models currently in use, however, employ mainly adaptive expectations because of the more plausible forecasts which they yield.

Finally, it should be clear that builders of Inforum models take data and behavioral equations seriously. In contrast to models with casually chosen parameters that have been 'calibrated' to only one year of data and produce only comparative static results, the Inforum models can be tested over several years of past data and used to forecast specific future years. These forecasts may, of course, prove wrong. But they offer the possibility of learning from mistakes, something you cannot do with models that cannot make mistakes.

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METHODOLOGICAL FRAMEWORK AND SIMULATIONS FOR EVALUATING THE IMPACT OF EU ENLARGEMENT ON THE ITALIAN ECONOMY[1*]

Rossella Bardazzi, Maurizio Grassini[2]

Introduction

This paper examines the economic implications of European enlargement on the European Union and in particular on the Italian economy. Enlargement may be treated as the merging of two countries, that is, the EU15[3] and the Central and Eastern European Countries (CC)[4]. The study has been designed to give evidence of the expected differences of the enlargement effects on each country and on its economic structure[5].

The results of this piece of research as any other need to be carefully read in the context of the instruments applied, the level of aggregation adopted, and the data employed if we are to obtain a correct reading of the analysis.

The availability of a multi-sectoral model of the Italian economy and of a significant group of similar models of key countries has made the present study possible. The Italian model is named INTerindustry Ital-

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[1] Paper published in «Rivista di Politica Economica», 2003, anno XCIII, Marzo-Aprile, pp. 31-78.

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[3] The EU15 is the group of present Member States of the European Union: Austria, Belgium, Denmark, France, Finland, Germany, Greece, Holland, Luxembourg, Ireland, Italy, Spain, Portugal, Sweden and United Kingdom.

[4] The CC are the present Candidate Countries under the Accession Program: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

[5] This paper draws some simulation results from a study commissioned by the EU Directorate General Budget (Grassini M. *et al.* 2001).

Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online),

ian MOdel or INTIMO[6]. The group of the models – including INTIMO – constitute the INFORUM (INterindustry FORecasting at University of Maryland)[7] system of models, all of which are linked by means of an international trade model which makes the countries' multi-sectoral model a 'true' interlinked system. Thanks to this system of models, this paper presents unprecedented results relating to the effects of EU enlargement on a specific Member State, i.e. Italy.

The present study, which spans a period of ten years (2001-2010), refers to a baseline scenario where the applicants follow a growth path not strengthened by the benefits of improved economic integration. In the alternative scenarios, these advantages are assumed to increase the applicants GDP rates of growth by about 2 per cent annually; this is a widespread assumption which makes our simulations easily comparable with those of previous studies (Prodi 2002). Although applicant countries have made considerable progress towards the full participation in a single market under the Europe Agreements, trade is still restricted by the existence of a range of border and non-border measures and a bundle of tariffs mainly concentrated on agricultural and food products. The study investigates the impact of the complete removal of these residual barriers to free trade among the EU15 and the applicants.

The integration of the Italian Inforum model into a family of interlinked models has a number of important advantages for the analysis of the questions under considerations. In contrast to any economic analysis with a 'stand alone model' of a national economy, we were able to consider a number of indirect effects of enlargement within a framework of interlinked national models. The following lists cites just a few of these relevant effects operating through the European economies on a specific Member State:

- changes in the demand for Italian commodities as intermediate products by other EU countries due to additional imports from CC to present EU members other than Italy;
- changes in the demand for Italian consumption goods by other EU countries induced by income effects caused by economic growth in present Member States due to enlargement;
- changes in the demand of Italian capital goods from other EU countries due to the same economic reasons explained above;

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[6] The description of the real side of the INTIMO model is in Grassini M. (1987); the description of the nominal side of the model is in Grassini M. (1987); the introduction of the institutional accounts and their role in a macroeconomic multisectoral model is in Meade D. (1997). In Grassini M. (1998) the institutional accounts of INTIMO are discussed for the three institutions: a) enterprises, b) households and c) government.

[7] The INFORUM works on economic modelling and forecasting is documented at the web site inforumweb.umd.edu. See also Almon C. (1991).

- substitution effects in trade with CC between commodities of EU Member States – Italy included – due to changes in competitiveness caused by the impact of the removal of trade barriers on relative prices.

Recently, similar studies on the impact of European Eastern enlargement on single EU Member States have been carried out. Important examples are Keuschnigg and Kohler (1999), Keuschnigg *et al.* (1999) for the case of Austria and Germany respectively, and Kristensen and Rormose Jensen (2001) for the Danish case. A number of studies consider this impact on the EU as a whole; these studies are mainly based on methodological approach very different from the one used for the Italian case.

In particular, we would like to stress that our approach is innovative with respect to other studies in the field insofar as it allows us to evaluate not only the direct effects of enlargement normally presented in such analyses, but also the indirect effects generally ignored by more traditional models of analysis. In order to make our results comparable with those of other studies, we have produced some ‘intermediate results’ with a first set of simulations. We have, however, devoted much more attention to the results obtained by means of our advanced system of models where the effect of the removal of tariff barriers can be fully appreciated.

This paper is organized as follows. Section 1 describes the national model and the bilateral trade model used to study the economic effects of EU enlargement. Section 2 presents the scenarios designed for several simulations and describes some introductory results. Section 3 displays our main empirical results on the macroeconomic and sectoral variables and the last section concludes.

The Appendix contains a schematic overview of the econometric Italian model.

1. An outline of the model

1.1 General features

In order to appreciate the results, it is essential to be aware of some of the characteristics of the tools used in this study.

The country models used here belong to the Inforum system; it consists of multisectoral models of Western Europe (Germany, France, Spain, Austria, the UK, Belgium, and Italy), the Far East (China, Japan, South Korea, and Taiwan), and Central-North America (Canada, the United States, and Mexico)[8]. Each country model has been constructed by the country part-

[8] There are many contributions to economic analyses carried out using Inforum country models. Here we refer to special sessions devoted to Inforum models at the International Conferences on Input-Output Techniques in 1989 (Kethzely, Hungary)

ner so that it embodies the peculiarities of the economy as observed and understood by the model builder. As described in Grassini (2001), a more descriptive name for these models might be Interindustry Macroeconomic Models (IM) or Multisectoral Macroeconomic Models (MM): 'interindustry' and 'multisectoral' stress the presence of a detailed representation of the industries in the economy, while 'macroeconomic' emphasizes that the usual variables of macroeconomics are covered[9].

In the same way as (any structural) macroeconometric model, Inforum models are rooted in data and use regression analysis on time-series. An enormous database is necessary to support a proper IM model given the underlying belief that a model incorporating as many previous economic outcomes will have a better chance at forecasting or accurately simulating policy changes than a model that incorporates less information[10]. Therefore, parameters in behavioural relations are econometrically estimated using observed economic outcomes and not calibrated or even borrowed from 'black box' databases by the model builder[11].

Inforum models are explicitly dynamic because they include real dates on each year's solution. The researcher also knows the dynamic path by which the new solution is reached, which may have enormous practical considerations for those policy-makers who are often just as interested in the path to equilibrium as they are in the ultimate equilibrium point[12].

A distinctive property of these models is their 'bottom-up' approach; that is, the macro totals are obtained by summing the industry details. Predictions of time paths are naturally computed at the industry level: the macro dynamics are simply the result of the industry dynamics. Fur-

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and in 1998 (New York). Papers presented at the first conference are collected in a special issue of Economic Systems Research, Vol. 3 (1), 1991. Contributions presented at the XII International Conference in New York may be found on the web site on www.iioa.at.

[9] Here, we do not compare the peculiarities of these kind of models with those of other macroeconomic or multisectoral models. However, see West R.G. (1995) for a synoptic presentation of Computable General Equilibrium (CGE) models, Classic Input-output models and Input-output+econometrics models. For a comparison between macroeconomic models see also Almon C. (1991). Furthermore, see Monaco R.M. (1997) who gives an interesting evaluation of different kinds of macroeconomic multisectoral models from the perspective of a model builder and user. As Inforum models are not CGE models, some fundamental differences between them will be underlined.

[10] Indeed, models belonging to the class of CGE do not contain any information related to the observed behaviour of economic agents.

[11] Examples of these practises are respectively Kehoe P.J. and Kehoe J.T. (1994) and Brown D.K., Deardorff A.V. and Stern R.M. (1993).

[12] The results of policy analyses carried out using the CGE model are usually shown in tables where neither the time span required nor the time span expected to reach the new equilibria is referred to. In fact, it is not practicable to translate the fictious time of the CGE models into the calendar time needed by the policy maker.

thermore, sectoral growth paths are not at all steady over time with accelerations, decelerations, recessions, and recoveries occurring along the simulation horizon. Therefore, as in the case of the evaluation of enlargement effects, an analysis based only upon the comparison between two equilibria would be misleading: the model should offer a guidance of how sectors may cumulate gains and losses along the path so that policy makers may consider potential policy actions.

In these models, the foreign trade flows have 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)[13]. The basic idea underlying this trade model was formulated in the late 1960s (see Armington 1969a and 1969b, and Rhomberg 1970 and 1973), and subsequently, a number of studies tackled estimation problems involved in the construction of this kind of trade model (see, for example, Nyhus 1975, and Fair 1984). These analyses focussed 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 which will be discussed later on.

1.2 Some features of the Italian Model

INTIMO begins from the Italian input-output table and the institutional accounts. The input-output table used in the model has 44 sectors, 40 of which represent the private component of the economy, 4 of which represent non-market sectors (3 are governmental and 1 non-profit). The table distinguishes between domestic and foreign production in each cell, and the model preserves this distinction.

The institutional accounts have been aggregated into three sectors: 'enterprises', 'households', and 'government'. In the European System of Accounts (ESA) there are seven institutional accounts:

1) production;
2) generation of income;
3) distribution of income;
4) use of income;
5) capital;
6) financial; and
7) current transactions (with rest of the world).

The input-output table and the institutional accounts are closely linked. Aggregates from the intermediate consumption and value added matrices in the input-output table go into the first two accounts, 'production' and 'generation of income'. INTIMO then models the third and seventh ac-

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[13] This has subsequently been revised and updated with more recent data.

counts – the 'distribution of income' and 'current transactions' accounts – to calculate, among a number of macroeconomic aggregates, disposable income. The 'use of income' and 'capital' accounts allow us to compute macroeconomic variables such as saving, investment, consumption, inventory changes in nominal terms.

1.3 Equations from input-output identities

In an input-output table there are two sets of accounting identities:

$$Aq + f = q \qquad A'p + v = p \tag{1}$$

where q is the (column) vector of sectoral outputs, f is the vector of final demand, the sum of consumption, investment, inventory changes and net exports, v is the value added vector per unit of output, p is the vector of sectoral prices and, finally, $A = [a_{ij}]$ is the matrix of coefficients so that $q_j{}^*a_{ij}=q_{ij}$ where q_{ij} is the flow from sector i to sector j in the input-output table; matrix A is also known as the 'input-output technical coefficient matrix'. The set of equations on the left side are known as the 'fundamental equation in the input-output analysis' or 'the Leontief equation'; the set of equations on the right side are known as the 'Leontief price equation'.

In INTIMO, all these variables should have also a t subscript to emphasize that they vary over time, so that the equation for the determination of output would be

$$q_t = A_t q_t + f_t \tag{2a}$$

In determining prices, the distinction between foreign and domestic products is important. For the price equations, we need to separate the A_t into a matrix of domestic inputs, H_t and imported inputs, T_t, such that $A'_t = H_t + T_t$. The resulting equation for determining domestic prices is

$$p_t = H_t p_t + T_t p^m{}_t + v_t \tag{2b}$$

where p_t^m is the vector of import prices. While the elements of matrix A may be interpreted as 'technical' coefficients, H and T matrices simply distinguish the origin of inputs, a distinction which is useful for analysing the impact of foreign prices on domestic prices but independent of any technological consideration. There are no annual input-output tables for Italy, but we do have historical series on outputs, final demand, imports, domestic prices, and foreign prices. From these series and the input-output table, we have built a series of A, H, and T tables from which we project future tables.

1.4 Behavioural equations

In very general terms, the real and price sides of INTIMO (or any MM model) can be presented in the following form

$$q = Aq + f(q,p,z_R) \qquad p = Hp + Tp^m + v(p,q,z_N) \tag{3}$$

where z_R and z_N are vectors of variables not appearing in the input-output table, such as interest rates, money supply, or population. Note the 'crossovers'; prices appear in the final demands and physical outputs appear in the price equations. We omit the t subscripts which should be understood on each matrix or vector. We have not included a dependence of the matrices on prices because that dependence has not been built into the present version of INTIMO. Although it would create very substantial empirical problems, there is no problem in principle or theory in doing so. Besides these equations, there are others which lack a sectoral dimension, such as those for collecting personal taxes or government accounting. These equations model economic aggregates mainly located in the institutional accounts.

The real side and the nominal side of the model are strictly integrated and this must be taken into consideration when the simulations in this study are used to evaluate the effect of Eastern enlargement of the EU on the Italian economy. Furthermore, the model incorporate a very advanced treatment of indirect taxes (see, Bardazzi 1992, Bardazzi *et al.* 1991, Bardazzi and Grassini 1993, Bardazzi 1996, and Grassini 2001); in particular, the model explicitly shows the impact of the tax burden on the (sectoral) production side and the corresponding impact in terms of revenues on the national budget. For a schematic overview of INTIMO and of the various behavioural equations that make up the *f* and *v* functions, see the Appendix.

1.5 The Bilateral Trade Model (BTM)

BTM is estimated using a bilateral database, WTDB, released by Statistics Canada and made available to the Inforum research center. This database provides high quality and up-to-date information on commodity trade, which covers world commodity trade and makes the bilateral model genuinely 'global'. The raw dataset has been submitted to two aggregations. One concerns the commodity classification where the large number of commodity flows have 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, including the countries of the system of multisectoral models and other countries or groups of countries (for instance, the transitional economies of Eastern Europe, the OPEC countries, South Africa, other developing Asian countries, and major South American countries). The data allows us to construct bilateral trade flow matrices for 120 commodity groups. Each matrix has a number of rows and columns which are related to these 60 countries. If the BTM database is ready to accommodate this huge number of countries, the present working version is tailored to the existing country models in the system[14]. The structure of the data allows us to investigate the trade structure of other countries not yet included in the system of models and, hence, to tackle problems such as those considered in the present research.

The BTM works as follows. It takes the sectoral imports from each country model and allocates them to the exporting countries within the system by means of import share matrices computed from the trade flows matrices. Imports from a country by all its trading partners equal the country's exports. Hence, this model ensures that imports from a given country determine its exports. This balance is obtained for each commodity group.

Then, the key function of the model is to calculate the movement of 120 import-share matrices. First of all, imports by product, prices by product, and capital investment by industry are taken 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), where the element S_{ijt} 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

$$S_{ijt} = \beta_{ij0} \bullet \left(\frac{P_{eit}}{P_{wjt}} \right)^{\beta_{ij1}} \bullet \left(\frac{K_{eit}}{K_{wjt}} \right)^{\beta_{ij2}} \bullet e^{\beta_{ij3} T_t}$$

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*:

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[14] The United States, Mexico, Canada, Japan, South Korea, China, Taiwan, the UK, France, Germany, Italy, Spain, Austria, and Belgium, two areas comprised by the rest of the OECD countries and 'the rest of the world'.

$$P_{wjt} = \Sigma_i S_{ijo} P_{eit}; \quad \Sigma_i S_{ijo} = 1$$

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*:

$$K_{wjt} = \Sigma_i S_{ijo} K_{eit}$$

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[15].

The BTM work begins with the collection of prices, imports and capital investments, but we see that the share equations require capital stock data which are intentionally not collected from the country models, even if they are endogenously computed. Capital stock data made available by official national statistics are largely based on different criteria, and may not always be comparable (as required in the above equation). Consequently, we chose to compute capital stock directly from statistics taken from a 'comparable' perpetual inventory model where comparability is mainly based on the use of a common depreciation rate. The idea behind a relative capital stock as an explanatory variable is that (new) investments contain embodied technical progress. A capital stock which contains more recent investments may render the industry more competitive[16]. In other words,

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[15] It should also be noted that in any forecast period each trade share must be non-negative, and the sum of shares from all sources in a given market must add up to 1 (i.e. $\Sigma_i S_{ij} = 1$ for all j and t). The non-negativity condition is automatically satisfied through the use of the logarithmic functional form, but the adding-up condition is not. A way must, therefore, be found to modify the forecast trade shares so that the adding-up condition is met. Estimates of all the *n* shares are made separately and subsequently adjusted to meet the adding-up condition. In this way, the forecast shares in each market will satisfy both the adding-up condition and the non-negativity condition. In scaling the forecast shares to meet the adding-up condition in each import market, those with the best fits will require less adjustment than those with poor fits. One way to tackle the problem is to use the standard errors of the estimated equations as weights. Thus, the adding-up condition in each import market is imposed by distributing the residual in proportion to the standard error of each estimated share equation.

[16] This approach clearly couples the argument: «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 new technologies in the economy. A higher rate of investment growth raises the capital available per worker and thereby – ceteris paribus – labour

an industry can buy market shares by investing. In order to stress this assumption, capital stock is computed from investments, and the depreciation rate is consequently chosen as a strategic variable[17].

Ma (1996) estimated equations for over 19,000 trade flows. The capital term entered equations accounting for some 60 per cent of total trade flow. We should emphasize that the estimation uses time-series rather than cross-sectional data. Thus, the coefficients showing the effect of investment in Italy on Italian shares in the imports of other countries only reflect the Italian experience and is not based on, for example, the effects of German investment on Germany's exports. Although the procedure described above may appear rather mechanical due to the treatment of the large number of equations involved, we wish to stress that the model is not treated like a 'black box'. Shares different from zero are examined individually for their plausibility throughout the sample period together with the routine forecast horizon. This procedure is carried out annually in order to anticipate any mis-functioning on the part of the model.

2. Simulation Scenarios For EU Enlargement

A baseline scenario has been outlined which assumes exogenous variables to provide a feasible path for the future economic performance of the domestic economy without EU enlargement. Two large sets of simulation scenarios have been designed for our research. With the first set, we have investigated the impact of enlargement on an EU member country with the assumption of a higher growth rate within the applicant countries due to the persisting effects of the Europe Agreements. In this first set of simulations, we do not include any change of prices due to the removal of trade barriers. Thus the economic effects are due both to changes in demand and to an increase in CC imports which will mean an increase in Italian exports. Therefore, for simplicity's sake, we can refer to this first group of simulations – including three different alternatives as explained below – as the CC growth effect scenarios. After this first round of simulations, some conclusions are drawn and additional elements are included in our analysis. With the second set of simulation scenarios, we have investigated the removal of tariff and non tariff barriers to allow the completion of a free trade area among the EU member countries and the applicants. This second set is labelled as the *removal of trade barrier scenarios* and it allows us to fully investigate the impact of the main economic changes implied by the enlargement process.

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productivity. A high rate of innovation in a context of strong investment growth increases also the quality of the capital stock» (European Commission, 2002).

[17] At present, it is equal to 8 per cent.

All simulations span a period of ten years (2001-2010) with year-by-year results.

2.1 The 'baseline' scenario

Without enlargement, the CC's GDP growth is assumed to follow the average growth rate of the other countries in the system. This assumption is justified by arguing that the CC economic integration supported and assisted by the EU – on driving the applicants along their transition towards a market economic structure – has already produced benefits in terms of a higher GDP growth rate. In other words, in the absence of institutional and economic EU supports, the CC 'catching up' process will miss that stimulus which fosters their growth on levels higher than those of the EU Member States.

As explained above, the Bilateral Trade Model forecasts bilateral trade flows by 14 trading partners and two regions covering the rest of the world. Each country's model forecasts sectoral imports and domestic prices. Given each country's imports of a given commodity, BTM decides from whom that commodity will be imported, based on relative prices between countries, and relative growth rates of capital stock for the commodity between countries. After BTM has solved, it provides each national model with forecasts of exports and average foreign prices which are then treated as exogenous assumptions for that model. Hence, for an individual country model of the INFORUM international system, the export projection from BTM is given. As for domestic prices forecasted by the national models and used in BTM, these are adjusted by assumed exchange rates to produce indexes of effective prices. Industry-specific trade-weighted averages of these country prices are then taken as the prices of the two remaining regions (namely, 'other OECD' and 'the rest of the world'). Since all CC fall into one or other of these two regions, the basic assumption of the baseline is that these countries have 'average' prices relative to those in countries in the model, where 'average' is the average over the 14 trading partners. This rather neutral role of prices is not inconsistent with what has taken place in the recent past. When the CC began the transition from their past economic system towards a market-oriented economy ten years ago, there was an acute crisis in their former economic and political system. After an immediate downward plunge, the recovery was characterized by GDP rates of growth higher than those in EU countries. The CC in their transition process immediately aimed at a close economic integration with Western Europe. The countries with the best economic performance took reform seriously and were supported by the EU Commission. Despite the good performance in GDP growth, the depth of the structural changes produced disequilibria that led to high rates of inflation. Present and anticipated inflation would be likely to damage the competitiveness of these countries were it not offset by a drop in the value of their currencies. We assume that this drop will cancel the rise in inflation so that the effective prices of imports from these countries will be about average for the countries in the BTM.

As for Italian government expenditure, we have assumed that the Stability and Growth Pact, which imposes budgetary discipline and improvement on the budgetary procedure, will force national governments to limit their expenditure to a growth rate approximately equal to, or slightly below, that expected for GDP. Considering the volume of the Italian public debt, a low profile growth in government expenditure may be realistic. In the present scenario as well as in the other scenarios designed in this paper, we assume a constant rate of growth of real government expenditure.

The model includes a well-elaborated Demographic Projections Model (DPM). The role played by DPM is to produce projections of population by age and gender (Bardazzi 2000). As with any other demographic model, DPM is tailored to generate medium to long-term projections. DPM relies upon scenarios concerning fertility rates by age, mortality rates from one age cohort to the next, and net immigration by age and gender. The hypothesis regarding net immigration is the most unpredictable of the components of population projections. The working assumption employed here is designed by ISTAT (Italian Statistical Office) and based on the past behaviour of migration flows: this hypothesis does not take into account other potential factors that may heavily influence future migrations such as the enlargement of EU labour market to Eastern countries. Indeed, the accession of the CC to the EU is likely to have a significant impact on the conditions of migration. Not surprisingly, a debate on the consequences of potential migration has provoked the fear in many countries that the increase in EU populations due to Eastern labour flows may lead to a deterioration of the labour-market position of the local workforce and to wage reduction and job losses. These concerns are particularly acute in countries which are likely to be net recipients of migratory flows, such as Germany and Austria[18]. In spite of the central role played by migration in the negotiations on Eastern enlargement, migration research suggests that the overall impact of enlargement on the EU15 labour market will be limited and that migratory flows will be concentrated in specific Member States. Moreover, demographic projections for CC present similar characteristics with those of most Western countries, that is, population decline and population ageing. If these projections are confirmed in the future, applicants will no longer have a positive demographic surplus to export.[19] In addition, the economic situation of candidate countries is expected to

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[18] As argued by EIC (2000), regions bordering the CC may be expected to take the bulk of post-enlargement migration. For a recent report on migration in Central and Eastern Europe, see OECD (2001).

[19] For an analysis of past migration flows between the CC and Italy and some comments on projections following enlargement as in EIC (2000), see Grassini M. *et al.* (2001).

improve thus reducing the incentive to emigrate. Finally, in the past Italy has not been a migratory pole for Eastern migrants, given its geographical location and prevailing economic conditions, and there is little reason to believe that this framework will change dramatically in the near future. Therefore, we have not assumed a change of migration flows in the simulation scenarios. This decision is based on the hypothesis that any potential variation in the number of migrants will be so low as to leave the labour market, and the economy as a whole, largely intact.

Finally, it is assumed that the exchange rates among the key currencies in the baseline as well as in the other scenarios will not to vary much over time. It is expected that the Euro/US$ exchange rate will rise steadily from the present 0.90 to 1.00 by 2010. This is based on the widely held view that the Euro is undervalued. The Euro/Pound ratio remains constant at 0.630. It is expected that the UK will monitor this rate closely and try to maintain it rather than attempting to maintain the Pound/US$ exchange rate. The Euro/Yen ratio rises from 110 to 117 which indicates a slight but progressive weakening of the Japanese currency.

2.2 The first scenario: Italy versus the Candidate Countries

The first group of simulation scenarios (CC growth effect scenarios) does not include any change of prices due to the reduction of trade barriers. In all three alternative scenarios of this group, we assume that EU enlargement takes place and that the improvement of economic integration will result in an increase in GDP rates of growth of about 2 per cent annually with respect to the baseline for the Candidate Countries. This is a widespread assumption which makes our results easily comparable with those of other studies. In fact, as recently explained by the President of the European Commission, Romano Prodi, «depending on the degree of structural reform undertaken, enlargement-induced additional growth for the new members ranges from 1.4% to 2.7%» (Prodi 2002)[20]. Although market integration between the EU and CC has taken place already through the Europe Agreements, full membership of the EU will mean several important further steps for the CC. Besides the removal of all remaining trade tariffs, which will be considered later on in the paper, accession will extend the single market to the CC. This will mean that the processes and reforms undertaken since the transition began will be deepened further, with trade and capital movements enhancing the integration

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[20] Applied studies to this subject may differ in their assumptions about expected growth for CC after accession. Our hypothesis of a growth rate of 2 per cent higher than the EU15 is somewhat in the middle between a more conservative assumption of about 1.5 per cent above the no enlargement scenario as in Baldwin R.E. *et al.* (1997), and a more optimistic scenario of about 2.5 per cent more than the baseline as in CEC-ECFIN (2001).

process and with EU structural and social fund transfers contributing to pro-growth policies.

Since we do not have models for the CC, nothing can be said about the shifts in the composition of their final demand. On the resource side, however, we assume that imports will grow as rapidly as GDP (Grassini 2002), so that the resource structure remains unchanged. Higher levels of imports from the CC will balance with be higher exports for the countries in the model system. The rapid growth of the applicant countries in terms of GDP should be considered an appropriate assumption and EU enlargement clearly assumes that economic integration will also result in the development of the newcomers' economies in line with the EU prosperity level, which means a faster GDP rate of growth for over another decade.

This first alternative scenario – 'Italy versus CC' – only considers the direct effect of the CC increase in imports on the Italian economy in terms of Italian exports to these countries. In other words, given the increase in Italian exports due to the increase in CC demand, *the Italian model is run alone*. No account is taken of the effect of the enlargement on other economies. We are fully aware that this is a 'purely academic case'[21] because it is clear that the impact for each of the EU countries depends on the European market as a whole. This scenario is quickly overcome in the next section.

2.3 The second scenario: EU versus the Candidate Countries

This scenario considers the impact of the increase in CC imports on the export structure of all models in the system. *The model system, including BTM and country-specific models, is run*. In this case, the effect of the growth in exports to the Central and Eastern European countries will affect every model in the system. Each country will be affected by the changes in the outputs, and therefore imports, of every other country. In this case, Italian exports will be determined by changes in demand for imports by all the countries in the system. Basically, in the first scenario the Italian model runs alone, whereas in the second scenario it is run together with its most important trading partners.

2.4 The third scenario: specializing the Foreign Demand of the Candidates Countries

In the 1990s, the CC overcome the deep crisis which occurred after the crash of the socialist economies. During this decade, the trade between

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[21] We thank an anonymous referee for having so defined this scenario. However, in order to make our results comparable with other studies we have been 'forced' to include such simulation in our work. In fact, most of these studies are founded on such scenario and do not evaluate the impact on foreign trade competitiveness excluding price effects (i.e. Keuschnigg C. and Kohler W. 1999).

EU and these countries increased as the 'catching up' of the applicants started[22]. With the transition a positive trend began; the import-export composition was concentrated on a small group of commodities[23]. During the transition, these commodities have maintained and even increased their importance in trade with the EU countries, accounting for about 60 per cent of the total commodity trade[24]. The most important categories for CC's international trade are:

a) Machinery and mechanical appliances;
b) Electrical machinery and equipment; and
c) Motor Vehicles and vehicle parts[25].

Since this specialization persisted during a period of restructuring towards market-oriented economies, in this scenario we will assume that this trend will continue in the near future, that is, over the time span of the present study. Indeed, this specialization may well be the result of the good use that applicants have made of their negotiations with the EU and programs such as PHARE. Other direct advantages will be generated by their access to the Structural Funds; indirect advantages will come from FDI flows which are expected to remain substantial as the policy of the CC continues to focus on integration with the countries of Western Europe. All these elements generate investments. Commodity bundles listed above relate to equipment or its production. The concentration in trade may therefore be related to the accumulation process. Hence, this scenario may be appropriate to investigate the effects of the CC import structural changes on the Italian economic structure and on that of the other countries.

This group of three scenarios (CC growth effect scenarios) is designed as a first step in investigating the effects of EU enlargement. The difference between the first two scenarios is meant to highlight the relevance of the 'indirect effects' or 'second-order effects' of enlargement on a single member country, namely Italy. As already noted, European enlargement affects each Member State directly and indirectly, irrespective of its geographical distance from any given Candidate Country. In other words, where the gravity model approach tends to weaken the bilateral link as the distance increases, we argue that the indirect effects may be even more important than the direct ones. San Marino may have no bi-

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[22] The statistical evidence of this structural change is extensively analysed in Landesmann M.A. and Stehrer R. (2002). For a reference to the trade flows between the Candidate Countries and Italy, see process is well summarized and described in Grassini M. (2002).

[23] Baldone S. *et al* (1997) pointed out this trade specialization pattern emerging in the early 1990s.

[24] See Grassini M. *et al.* (2001), Grassini M. (2002).

[25] For detailed data on import/export shares between Italy and the CC, see Grassini M. *et al.* (2001), pp.19-29.

lateral link with Hungary; but the links between Hungary and Germany and between Germany and Italy may link San Marino with Hungary in unexpected ways. This is an extreme case where only the indirect effects matter. As our results will show in a more likely case, such as the bilateral links among EU15 economies, the interaction of direct and indirect influences amplifies the impact of a shock such as the Eastern enlargement. Finally, the third scenario — to be compared with the second — allows us to see the significance, if any, of the change in the import structure of the Central and Eastern European countries.

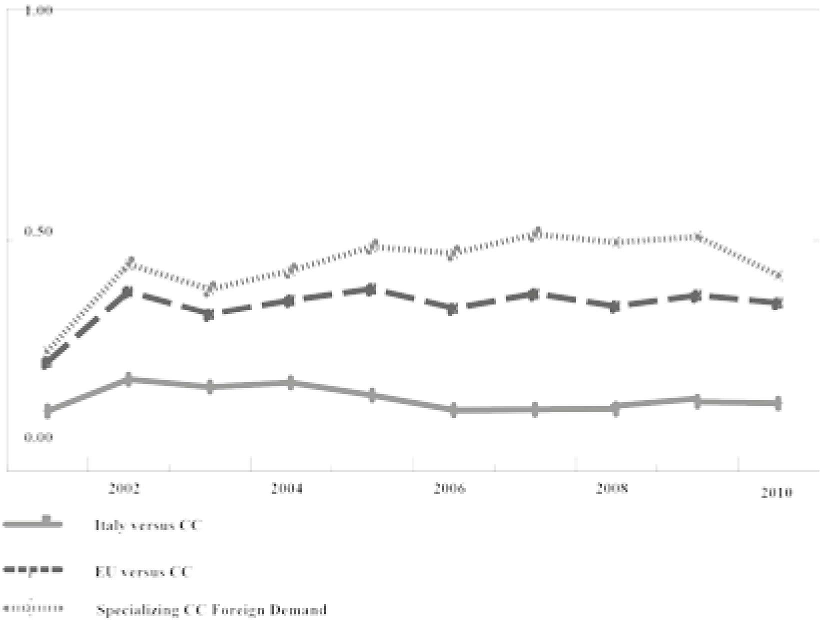
2.5 Some important insights from the first simulations

The GDP growth rates for the three scenarios are plotted in Figure 1 as differences from the baseline scenario. In the scenario 'Italy versus CC', the increase in GDP compared to the baseline is very modest and falls along the simulation interval. In the second scenario 'EU versus CC', the increase in Italian GDP is roughly twice the previous one at the beginning of the simulation interval; the increase in GDP develops smoothly up to a maximum at the end of the period. In the third scenario 'Specialising CC Foreign Demand', where the CC are only assumed to increase their imports for those commodities with the largest shares and covering about 60 per cent of total imports, the increase in Italian GDP is close to 0.5%.

In the product account side, exports and imports reveal the highest difference with respect to the baseline scenario. In particular, taking the third scenario, there is a divergence of over 1 per cent from the baseline for the increase in exports. The increase in imports is much lower, at about 0.6 per cent. The trade balance produces an increase in GDP; consequently, the accelerator pushes investments up and the increase in disposable household income – which results in an increase in household consumption – adds another stimulus to GDP growth.

Given the baseline, these results allow us to draw some preliminary but important conclusions. We have seen that the differences in the scenarios have a clear impact on the results for the simulation. In particular, the first scenario would cause an increase in the GDP growth rate of about 0.15 per cent for the entire the simulation period. The second scenario, which also takes into account the indirect effects of the EU enlargement, generates an increase of GDP close to 0.4 per cent for the period 2000-2010. The third scenario pushes this increase up by another 0.10 per cent. Clearly, the first scenario demonstrates that a comparison of Italy versus the CC is not adequate. The second and the third scenarios provide evidence of the relevance of the detected trade specialization between Italy (but not only Italy) and the most important applicants. It is necessary to remind the reader that, in this set of simulations the magnitude of the impact on domestic prices is expected to be negligible because: a) the CC prices do not change in any scenario; and b) the increase in final demand is in fact

Figure 1 – GDP. Rates of growth (differences from the Baseline)



very modest and possibly it will not sensibly affect the productivity which is – in this case – the main lever influencing the price formation.

At the end of the first round of simulations, we then start to investigate the effect of the second set of simulation scenarios with respect to the third scenario (and, of course, to the baseline).

2.6 The Second Set of Simulations: the Removal of Trade Barriers[26]

This group of simulations is designed to evaluate the impact of a change in trade and non-trade barriers following EU enlargement to the East. In a model, this would mean linking the CC growth effects and trade specialization as assumed in the previous section with a change in relative prices due to the removal of barriers.

Under the Europe Agreements, custom tariffs on EU imports from the CC and on CC imports from the EU have been eliminated for practically all industrial goods with very few exceptions. On the other hand, custom tariffs are still imposed on agricultural products and fisheries both in the

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[26] We thank Elisa Quinto and Alessandro Missale for their contributions to the design of the following scenario variables.

CC and in the EU. The structure of residual custom tariffs residual for agricultural products imposed by the EU on imports from the CC and by these countries on imports from EU have been estimated using data on custom duties to an 8-digit level of detail. To design this scenario, these custom duties for CC have been approximated by the import-weighted average of tariff rates set by the Czech Republic, Hungary and Poland[27]. These computed tariff rates are shown in Table 1.

Since the effects of the elimination of EU tariffs on CC products are equivalent to a reduction in import prices of the same percentage, we model such effects as a reduction in the relative prices of Italian imports in the import equation of the Bilateral Trade Model[28]. This allows us to evaluate the effects, at the sectoral level, of the removal of the remaining tariffs. It is worth noting that we do not consider the potential effects on Italian exports of the removal of tariffs by CC on products originating in Italy. Therefore, the potentially negative impact on Italian output from accession is likely to be overestimated by our simulation.

Non-Tariff Barriers (NTBs) such as
a) quantitative restrictions,
b) price control measures,
c) import licensing,
d) different standards and
e) other technical requirements and custom procedures are impediments to trade.

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[27] First, we have calculated the unweighted average tariff rate on imports originating from the EU for each country at the 4-digit level (data is from the database of the EU available on <www.mkaccdb.eu.int>). Then, for each of the three Candidate Countries the average tariff rates for the 24 agricultural sectors (2-digit sectors), have been computed as a weighted average of the 4-digit rates, using as weights the value of Italian exports to the country (data on Italian exports is from the COMEXT database) in question (see Table 1, first column).The structure by sector of Italian custom tariffs on products originating in the Czech Republic, Hungary and Poland has been computed using data on EU custom duties reported in the TARIC Consultation database (this database can be found at the web site <http://europa.eu.int/comm/taxation_customs/dds/cgi-bin/tarchap> of the European Commission or on <www.finanze.it> of the Italian Ministry of Finance). We have again used the above procedure. First, we have computed the average of custom tariffs at the 4-digit level from the detailed data at the level of 8-digits and, then, the weighted average rate per sector using data on Italian imports for the three countries under examination. In the case of volume duties we have computed total tariff revenues using the volume of Italian imports of the particular product from the COMEXT database and then constructed the ad valorem-equivalent tariff rate. The average tariff rates by sector are reported in the second column 2 of Table 1.

[28] More precisely, a reduction of the average tariff rate per sector from its actual level to zero is considered equivalent to a change in the relative price of imported goods for the corresponding sector.

Table 1 – Average tariffs rates on Italian Trade with the Czech Republic, Hungary and Poland (percentage values).

Sectors	on exports to CZH-HU-POL	on imports from CZH-HU-POL
Unmilled cereals	36	21
Fresh fruits, vegetables	12	13
Other crops	3	6
Livestock	17	12
Fishery	5	9
Meat	32	21
Dairy products and eggs	24	64
Preserved fruits, vegetables	24	14
Preserved seafood	28	16
Vegetable and animal oils, fats	8	1
Grain mill products	18	31
Bakery products	24	16
Sugar	35	18
Cocoa, chocolate, etc	25	11
Food products n.e.c.	17	7
Prepared animal feeds	6	1
Alcoholic beverages	34	6
Non-alcoholic beverages	34	6
Tobacco products	31	29
Paints, varnishes, lacquers	1	1
Scrap, used, unclassified	1	0
Average on above sectors	20	14

Source: EU Market Access Database and TARIC Consultation

It is commonly believed that the effects of the removal of NTBs should be substantial. Unfortunately, available information on NTBs is mostly qualitative and it is difficult to translate it into a quantitative index useful for investigating the impact of NTBs on trade. This explains why it is not uncommon in the literature to model the effect of NTBs by relying on pure judgement. For instance, Baldwin *et al.* (1997) estimate that the elimination of NTBs between the EU and CC would mean a 10 per cent reduction in trade costs, that is equivalent to a 10 per cent reduction in custom duties. Keuschnigg and Kohler (1999) follow the same approach, but opt for a more conservative 5 per cent.

Although our analysis relies on the same kind of judgement as Baldwin *et al.* (1997), our study is innovative in two respects. First, we provide both the estimates for two different scenarios in order to evaluate the sensitivity of trade flows and the results to these alternative hypotheses. Secondly, we take into account that the incidence of NTBs differs across sectors and distinguish between three different ad valorem equivalents of NTBs so as to develop the full potential of our sectoral model.

To evaluate the extent to which EU imports are subject to NTBs in the various sectors, we use 'trade coverage ratios' for each EU sector. Coverage ratios are provided by Wang (2000) who uses information on NTBs indicators contained in the Trade Analysis and Information System (TRAINS) database of UNCTAD. TRAINS provides information for each Harmonized System item (6-digit level) on the presence of NTBs[29]. Depending on the corresponding 'trade coverage ratios' we distinguish between three types of sectors, heavily protected, mildly protected, and unprotected by NTBs (see Table 2).

To estimate the impact of the reduction of the NTBs imposed by the EU we consider two scenarios:

1) A first conservative scenario (see Keuschnigg and Kohler 1999) assumes that the removal of NTBs is equivalent to the abatement of a 10 per cent tariff rate in the heavily affected sectors and to the abatement of a 5 per cent tariff rate in the mildly affected sectors.
2) A second generous scenario (see Baldwin *et al.* 1997) assumes that all sectors are to a certain extent protected by NTBs, whose effect is on average equivalent to a 10 per cent tariff rate. Such scenario assumes that the removal of NTBs is equivalent to the abatement of custom tariffs equivalent to 15, 10 and 5 per cent in the heavily, mildly and (apparently) unprotected sectors, respectively.

3. Selected macroeconomic and sectoral results

In this section, some results of the effects on the Italian economy due to the EU Eastern enlargement are presented. Because of the detailed analysis in terms of variables and economic sectors contained in our econometric model, a selection has been made and the presentation will begin with the most popular macroeconomic variables and will proceed to examine the disaggregated impacts through different sectors. However, we would like to remind the reader that, given the 'bottom-up approach' of our model, the macroeconomic variables are determined as sums of the sectoral variables and not the other way around.

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[29] 'Coverage ratios' for each (2-digit) sector are computed as the percentage of imports (per sector) that are covered by at least one of the following NTBs:

a) Tariff Measures (other than ad *valorem*) such as tariff quota and temporary duties;

b) Price Control Measures countering the damage caused by the application of unfair foreign trade practices;

c) Standards and Other Technical Requirements, including quality, safety, health and other regulations;

d) Automatic Licensing Measures;

e) Monopolistic Measures;

f) Quantity Control measures in EU-CC trade, however absent at present, being lifted by the Europe Agreements.

Table 2 – NTBs Coverage Ratios by Sectors.

Heavily Protected Sectors	NTBs
2 Fruits and Vegetables	34
6 Cotton	53
7 Wool	27
12 Coal	52
18 Meat	19
27 Food Products n.e.c.	64
29 Alcoholic Beverages	20
32 Yarns and Threads	81
33 Cotton Fabrics	52
34 Other Textile Products	88
36 Wearing Apparel	88
49 Synthetic resins, man-made fibres	79
57 Product of coal	52
65 Basic iron and steel	10
67 Aluminium	50
Mildly Protected Sectors	
3 Other crops	1
10 Fishery	6
28 Prepared animal feed	3
35 Floor coverings	1
47 Basic chemicals	3
52 Soap and toiletries	2
53 Chemical products, n.e.c.	1
58 Tyres and tubes	1
59 Rubber products, n.e.c.	1
73 Metal containers	5
75 Hardware	5
93 Radio, TV, phonograph	1
94 Other telecomm. Equipment	1
106 Motor vehicles	2
107 Motorcycles and bicycles	2
108 Motor vehicle parts	2

Source: TRAINS and Wang (2000)

Household consumption response is important in understanding the domestic demand behaviour and some key features of the model. Household consumption is estimated using PADS[30] and population projections for the demand system have been made using the demographic projection model connected to INTIMO. In these equations, the household disposable income and the price term are the most important independent variables. Household disposable income is modelled in the accountant section of the multisectoral model as the sum of 'resources' (such as compensation of employees, property income and transfer payments) minus 'uses' (such as taxes, social security contributions and transfers to others) of the Income Distribution Account for Households. For example, an increase in exports will generate an increase in employment which will in turn boost the compensation of employees and personal consumption expenditure. On the other hand, a price increase will reduce consumption, through a complex price term in the equation.

Turning to our results, Table 3 compares the baseline household consumption growth rates for selected items with two simulation scenarios: the specialization of CC (without changes in trade barriers), and the specialization of CC plus the removal of tariff and non-tariff barriers (according the generous hypothesis)[31]. We can observe an increase in the demand for some goods, such as food products, where the negative growth rate of the baseline reverts to a positive sign, at least for some years. This result may be explained by the reduction of tariffs and prices for some traditionally highly-protected items such as 'bread and cereals', 'meat', 'dairy products', 'fruit and vegetables', and 'tobacco'. We find the same effect, albeit less evident, for 'clothing and footwear' and for 'transport' mainly due to the removal of non-tariff barriers. The household consumption of some services also increases: in this case, an income effect due to the rise of private disposable income prevails over a negligible price effect due to higher income elasticities for these items (Bardazzi and Barnabani 2001). For example, the tendency towards an increased consumption of 'housing' and 'health' services due to population ageing was already apparent in the baseline scenario (Bardazzi 2000). The household disposable income profile is shown in Table 4 for the baseline and the two alternative scenarios. As can be seen, households will benefit from enlargement in both nominal

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[30] This demand system has been designed by Almon C. (1979) and (1996). The implementation of PADS for INTIMO is described in Bardazzi R. and Barnabani M. (2001).

[31] For each sector, the first line shows the rate of growth from year 2003 to 2010; the second line shows the difference from the first line. For example, the total household consumption (TOTAL) growth rate in year 2006 is expected to be equal to 1.47; the 'Specializing CC' scenario suggests a growth rate equal to 1.47+0.23, that is to say a growth rate of 1.7 per cent, while the 'Removal of barriers' scenario produces a growth rate of 1.63 (1.47+0.16). All the tables where results are presented as 'deviations from base values' should be read along these lines.

Table 3 – Household Consumption, Selected Items, Rates of Growth.
Titles of Alternate Runs
Line 1: Baseline
Line 2: Specialising CC Foreign Demand
Line 3: Specialising CC Foreign Demand + Removal of trade barriers (Generous Scenario)
Alternatives are shown in deviations from base values.

	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
TOTAL	1.687	1.460	1.458	1.472	1.359	1.563	1.622	1.596
	0.209	0.210	0.228	0.234	0.251	0.230	0.226	0.178
	0.210	0.397	0.184	0.164	0.239	0.265	0.261	0.220
Foods & Beverages	-0.190	-0.433	-0.404	-0.343	-0.429	-0.175	-0.100	-0.104
	0.209	0.211	0.230	0.238	0.256	0.232	0.227	0.169
	0.211	0.462	0.193	0.171	0.249	0.273	0.267	0.216
Clothing & Footwear	0.577	0.316	0.372	0.408	0.326	0.563	0.646	0.545
	0.200	0.198	0.218	0.227	0.245	0.222	0.224	0.177
	0.202	0.428	0.181	0.165	0.244	0.270	0.239	0.219
Housing	2.529	2.303	2.208	2.113	1.993	2.192	2.212	2.204
	0.229	0.215	0.224	0.235	0.258	0.239	0.242	0.193
	0.232	0.350	0.175	0.161	0.243	0.269	0.276	0.228
Furniture & Services	1.136	0.926	0.948	0.953	0.857	1.033	1.110	1.125
	0.210	0.210	0.228	0.237	0.256	0.233	0.229	0.179
	0.212	0.398	0.182	0.164	0.243	0.266	0.267	0.222
Health	3.191	2.904	2.879	2.733	2.577	2.702	2.743	2.664
	0.219	0.217	0.232	0.235	0.250	0.234	0.233	0.189
	0.220	0.353	0.185	0.161	0.234	0.264	0.265	0.225
Transports & Communications	2.604	2.337	2.379	2.302	2.152	2.283	2.321	2.237
	0.180	0.196	0.223	0.224	0.236	0.214	0.205	0.173
	0.179	0.410	0.185	0.156	0.226	0.249	0.238	0.211
Recreation & Education	2.411	2.160	2.150	2.150	2.066	2.255	2.282	2.236
	0.205	0.211	0.230	0.236	0.254	0.231	0.227	0.182
	0.207	0.379	0.183	0.164	0.243	0.266	0.261	0.222
Other Goods and Services	1.805	1.599	1.537	1.684	1.511	1.725	1.780	1.772
	0.213	0.215	0.235	0.237	0.251	0.231	0.224	0.168
	0.214	0.384	0.190	0.167	0.237	0.266	0.266	0.222

Note: These consumption categories are obtained by aggregation over the 40 consumption items considered in INTIMO. Here follows the list of these aggregated categories with the number of items from which they are obtained: Foods & Beverages (13), Clothing & Shoes (2), Housing (2), Furniture & Services (6), Health (4), Transports & Communications (4), Recreation & Education (4), Other Goods and Services (5)

Table 4 – Household Disposable Income (1988 Prices)
Titles of Alternate Runs
Line 1: Baseline
Line 2: Specialising CC Foreign Demand
Line 3: Specialising CC Foreign Demand + Removal of trade barriers (Generous Scenario)
Alternatives are shown in deviations from base values.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Household disposable income	789	826	863	899	937	973	1011	1050	1093	1137
(Thousands Euros)	1	3	5	8	10	13	16	19	23	26
	1	3	5	6	9	10	13	16	20	23

and real terms, even though, the removal of custom barriers produces a decrease in disposable income with respect to the case of 'Specialising CC Foreign Demand'. We have, however, overestimated the negative effect on Italian output from enlargement, because we do not take the potentially positive effect on Italian exports of the removal of tariffs by CC on Italian commodities into account[32].

A summary of the main macroeconomic variables is shown in Table 6. Here the baseline scenario is compared with the overall simulation of 'removal of trade barriers (generous scenario)'. On the uses side, household consumption benefits from the removal of tariffs although the profile of its aggregate growth rate remains relatively unchanged. The results of this table are obtained by summing up the sectoral estimates presented above: household consumption by category is more variegated, a characteristic which is lost in the aggregate figure. The highest difference between the baseline and the alternative scenario is for exports (with an increase of about 1 per cent at the end of the simulation horizon), while the increase in imports is much lower (about 0.5 per cent). The increase in sectoral outputs and the growth of imports and exports leads to an increase in GDP which is close to 0.5 at the end of the period. The removal of tariffs and NTBs has a distinctive impact on prices: the GDP deflator growth rate decreases compared with the baseline. On the contrary, the Personal Consumption Expenditure Deflator growth pattern is not affected greatly by the alternative scenario apart from the accession year 2004 when the reduction in price growth is about 0.24 per cent. Although this effect on growth rates then vanishes altogether, the levels are permanently affected. These aggregate results clearly show that enlargement has a more significant effect, in terms of prices, on the total domestic product than on the bundle

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[32] For an evaluation of the impact on household welfare see Grassini M. *et al.* (2001).

Table 5 – Household Consumption Deflators, Selected Items, Rates of Growth
Titles of Alternate Runs
Line 1: Baseline
Line 2: Specialising CC Foreign Demand
Line 3: Specialising CC Foreign Demand + Removal of trade barriers (Generous Scenario)
Alternatives are shown in deviations from base values.

	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
Bread & Cereals	2.95	2.85	2.69	2.20	2.15	1.89	1.91	2.16
	0.09	0.04	0.02	0.01	0.01	0.08	0.07	0.11
	0.08	-0.52	-0.03	-0.06	-0.08	-0.04	0.04	0.06
Meat	3.47	3.54	3.33	2.79	2.83	2.65	2.60	2.54
	0.09	0.05	0.02	0.00	0.00	0.04	0.08	0.15
	0.09	-0.75	-0.03	-0.04	-0.03	0.00	0.03	0.10
Fish	3.48	3.68	3.51	2.95	3.04	2.87	2.83	2.85
	0.03	0.01	-0.01	-0.03	-0.04	-0.02	-0.01	0.04
	0.03	-0.19	-0.04	-0.04	-0.06	-0.06	-0.03	0.00
Dairy products	3.35	3.51	3.34	2.84	2.95	2.79	2.74	2.67
	0.02	0.02	-0.01	-0.03	-0.04	-0.02	0.01	0.09
	0.02	-0.51	-0.04	-0.03	-0.06	-0.03	-0.01	0.02
Fruits & Vegetables	3.45	3.65	3.48	2.93	3.02	2.85	2.81	2.82
	0.03	0.01	-0.02	-0.03	-0.04	-0.02	0.00	0.04
	0.03	-0.21	-0.04	-0.05	-0.06	-0.06	-0.03	0.00
Clothing	3.13	3.20	2.96	2.37	2.33	2.09	2.15	2.54
	0.10	0.10	0.07	0.05	0.04	0.07	0.05	0.05
	0.11	-0.29	0.02	-0.01	-0.04	-0.02	0.13	0.02
Shoes	2.94	2.80	2.72	2.30	2.36	2.30	2.27	2.45
	0.04	0.02	0.00	-0.01	-0.02	0.01	0.03	0.08
	0.05	-0.39	-0.01	-0.02	-0.03	-0.02	0.01	0.04
Furniture	2.98	2.93	2.80	2.34	2.32	2.31	2.31	2.41
	0.16	0.06	0.00	-0.01	-0.01	0.03	0.07	0.08
	0.17	-0.18	-0.01	-0.02	-0.05	-0.01	0.04	0.05
Medicines	3.38	3.18	3.08	2.70	2.65	2.52	2.48	2.39
	0.06	0.07	0.06	0.02	-0.01	0.03	0.05	0.08
	0.06	-0.27	0.05	0.00	-0.05	0.01	0.03	0.01
Auto & Cycles	2.89	2.41	2.20	1.88	1.86	1.81	1.88	2.01
	0.20	0.15	0.09	0.08	0.08	0.12	0.15	0.09
	0.20	-0.27	0.06	0.05	0.04	0.10	0.15	0.09

Table 6 – Product Account and Price Indexes
Titles of Alternate Runs
Line 1: Baseline
Line 2: Specialising CC Foreign Demand + Removal of Trade Barriers (generous scenario)
Alternatives are shown in deviations from base values.

	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
RESOURCES								
GDP	2.40	1.67	1.86	1.65	1.42	1.88	1.83	1.77
	0.38	0.39	0.32	0.30	0.48	0.51	0.53	0.43
Imports	6.10	4.58	4.83	4.09	3.60	4.54	4.42	4.39
	0.52	0.64	0.54	0.37	0.56	0.64	0.67	0.54
USES								
Consumption	1.79	1.62	1.62	1.63	1.54	1.70	1.75	1.73
	0.16	0.31	0.14	0.13	0.19	0.21	0.20	0.17
Household Consumption	1.69	1.46	1.46	1.47	1.36	1.56	1.62	1.60
	0.21	0.40	0.18	0.16	0.24	0.27	0.26	0.22
Government expenditure	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Investments	8.69	3.98	4.64	2.83	1.25	3.85	2.98	2.51
	0.56	0.61	0.29	-0.22	0.01	0.27	0.22	0.44
Inventory change	5.87	4.28	4.68	3.72	3.13	4.09	4.08	4.12
	0.82	0.86	0.68	0.60	0.98	1.00	1.04	0.73
Exports	2.77	2.79	3.14	3.16	3.37	3.41	3.68	3.87
	0.82	0.61	0.87	1.03	1.38	1.33	1.40	0.91
GDP Deflator	3.19	3.38	3.36	2.85	2.87	2.76	2.82	2.82
	-0.04	-0.05	-0.03	-0.06	-0.11	-0.11	-0.12	-0.08
PCE Deflator	2.71	2.64	2.65	2.37	2.37	2.29	2.33	2.34
	0.03	-0.24	0.02	-0.01	-0.04	-0.01	0.01	0.01

of goods and services for private consumption. This result is explained by the efficiency gains in terms of productivity combined with the reduction of prices for some imported commodities used in the production process.

At the macroeconomic level, the cumulative impact of the applicants' new prosperity (measured as an increase in import growth rates) on the Italian economy, and the removal of tariffs and non-tariff barriers is clearly positive. Despite the generally positive impact of enlargement, some sectors benefit more than others from the re-shaping of the EU production structure. Moreover, some are directly hit by a reduction of imports prices, that is, 'agriculture' and 'food industries', and suffer a clear, albeit temporary, drop in competitiveness. The disaggregated economic effects of enlargement on the Italian economy are shown in Table 7 where the 'Removal of trade barriers in the 'generous' scenario' is compared with the baseline. If we examine sectoral performance, we find that 'milk & dairy products' suffer an sharp increase in (foreign) competitiveness so that the its performance in terms of total output is negative with respect to the baseline. The sector 'other manufacturing industry' does not appear to have been largely affected by the enlargement and remains a highly dynamic sector. Other sectors tend to decelerate following the removal of trade barriers, but subsequently regain a good pace of growth.

Sectoral growth paths are not steady over time with accelerations, decelerations, recessions, and recoveries which lead to different 'final' scores. Table 8 presents an evaluation of enlargement in two columns respectively headed 'average', which gives – for the TOTAL economy – the percentages of the difference between the cumulated outputs of the 'generous scenario' and the cumulated outputs of the 'baseline' in the interval 2001-2010, and '2010' which reports percentages relative to the difference of total outputs in the last year examined. The sectoral output growth rates are measured as differences with respect to the TOTAL growth rate. The second column reveals our preferences for analysing the simulations by 'level' rather than 'rate of growth' of output; the rate of growth is fully satisfactory for short-term analysis where a single period rate of growth contains all the information about the path for the time interval; but permutations of a rate of growth time series may describe very different paths. The horizon of analysis in this study is a decade so that we are in the presence of long-run simulations where the sequence of growth rates may well be significant; the percentages reporting the difference in total outputs for the last year sum up structural changes over time.

Back to Table 8, column '2010' gives a good picture of the effects of enlargement according to the scenarios considered. In particular, the real effects of enlargement are measured by cumulating the annual gains (or losses) in order to obtain a more accurate impression of the impact in a given year. Although a number of studies conclude that the impact of enlargement (on the EU-15 countries, groups of countries or single countries) is expected to be modest, we should stress that what is most important is its cumulative effect over time. In the case of Italy a relatively substantial expansion will affect some sectors ('agriculture and industrial machinery', 'electrical goods', 'motor vehicles, 'metal products'), whilst others (mainly 'food industries' and 'tobacco') will lose their relative importance. A cumulative output rate of growth difference of over 5 per cent (at the end of the 2000s) will indicate a sizeable sectoral impact.

The anticipated increase of exports generated by the demand of the CC in their process of 'catching up' exerts a clear keynesian demand effect so

Table 7 – Total Output Rates of growth
Titles of Alternate Runs
Line 1: Baseline
Line 2: Specialising CC Foreign Demand + Removal of trade barriers (Generous Scenario)
Alternatives are shown in deviations from base values.

	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
TOTAL	2.40	1.60	1.83	1.55	1.28	1.79	1.74	1.69
	0.45	0.44	0.37	0.35	0.58	0.62	0.65	0.51
1 Agriculture, Forestry, Fishery	-0.24	-0.38	-0.48	-0.41	-0.41	-0.02	0.23	0.39
	0.28	0.09	-0.27	-0.13	0.31	0.31	0.34	0.30
4 Coal, Oil, Petroleum Ref. Products	3.68	1.85	1.46	3.17	4.37	4.95	5.05	4.74
	0.10	0.03	0.38	0.46	0.41	0.26	0.21	0.37
5 Electricity, Gas, Water	1.89	1.36	1.44	1.13	0.93	1.33	1.32	1.32
	0.41	0.43	0.30	0.30	0.51	0.55	0.58	0.46
MANUFACTURING	2.16	1.34	1.64	1.08	0.81	1.36	1.41	1.50
	0.68	0.64	0.58	0.60	0.94	0.99	1.07	0.78
7 Primary metals	3.16	2.10	2.53	1.83	1.51	2.19	2.13	2.13
	0.81	0.50	0.46	0.52	1.02	1.08	1.14	0.97
8 Stone, Clay & Glass products	3.66	2.16	2.76	2.17	1.44	2.22	1.68	1.44
	0.30	0.26	0.16	0.01	0.25	0.32	0.30	0.38
9 Chemical Products	0.71	0.51	0.65	0.38	0.22	0.44	0.54	0.49
	0.38	0.24	0.20	0.24	0.52	0.52	0.59	0.44
10 Metal Products	3.87	1.67	2.08	1.04	0.55	1.58	1.31	1.33
	0.93	0.97	0.85	0.77	1.17	1.29	1.37	0.97
11 Agric. & Indus. Machinery	3.74	1.42	2.23	0.93	0.62	1.61	1.64	2.14
	1.47	1.34	1.60	1.56	2.07	2.22	2.34	1.88
12 Office, Precision, Opt. Instruments	2.00	1.42	1.77	1.48	1.51	1.34	1.66	1.81
	0.65	0.72	0.64	0.62	0.82	0.82	0.90	0.49
13 Electrical Goods	2.66	1.42	1.56	0.75	0.45	0.84	0.71	0.75
	1.15	1.28	1.25	1.30	1.59	1.61	1.69	1.02
14 Motor Vehicles	0.10	0.55	0.17	-0.54	-1.25	-0.65	-0.69	-0.73
	1.35	1.28	1.23	1.42	2.14	2.19	2.45	1.58
15 Other Transport Equipment	3.52	3.92	4.52	4.13	3.96	3.98	4.46	5.02
	0.39	0.29	0.37	0.42	0.48	0.54	0.66	0.39

	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
16 Meat & Preserved Meat	-0.41	-0.51	-0.46	-0.36	-0.41	-0.04	0.18	0.39
	0.22	0.40	-0.11	0.00	0.27	0.29	0.31	0.14
17 Milk & Dairy Products	0.81	0.63	0.66	0.76	0.67	0.92	1.02	1.10
	0.25	-0.60	-0.71	-0.46	0.23	0.26	0.26	0.26
18 Other Foods	0.70	0.61	0.60	0.68	0.62	0.92	1.07	1.08
	0.21	0.39	-0.03	0.05	0.31	0.31	0.28	0.29
19 Alcohol & Non Alcoh. Beverages	1.59	1.30	1.11	1.20	1.11	1.43	1.50	1.53
	0.27	0.30	-0.02	0.06	0.30	0.32	0.34	0.33
20 Tobacco	-2.23	-2.67	-2.97	-3.21	-3.53	-3.48	-3.61	-3.84
	0.25	-0.44	-1.94	-1.26	0.00	0.03	0.03	-0.01
21 Textile & Clothing	0.78	0.85	0.73	0.33	0.26	0.67	1.05	0.91
	0.15	0.10	0.03	0.06	0.34	0.29	0.36	0.40
22 Leather, Shoes & Footwear	-0.36	0.12	0.34	0.47	0.60	1.56	2.36	3.36
	0.17	0.48	0.32	0.35	0.37	0.39	0.55	-0.70
23 Timber, Wooden Product & Furniture	3.46	2.26	2.73	2.00	1.39	1.84	1.70	1.52
	0.18	0.41	0.17	0.08	0.35	0.38	0.39	0.39
24 Paper & Printing Products	1.52	1.14	1.30	1.01	0.91	1.19	1.36	1.43
	0.64	0.47	0.49	0.56	0.86	0.91	1.04	0.86
25 Plastic Products & Rubber	1.98	1.53	1.81	1.46	1.23	1.34	1.37	1.33
	0.81	0.75	0.77	0.83	1.11	1.09	1.21	0.75
26 Other Manufacturing Industry	2.73	3.64	4.46	4.83	5.27	5.51	5.94	6.43
	0.13	0.29	0.21	0.25	0.29	0.22	0.26	0.00
27 Building & Construction	6.26	3.59	4.76	4.05	2.34	3.68	2.57	1.64
	0.19	0.10	0.03	-0.28	-0.15	0.03	-0.12	0.13
SERVICES	2.09	1.53	1.65	1.46	1.24	1.61	1.60	1.57
	0.37	0.44	0.32	0.30	0.46	0.50	0.52	0.41
28 Recovery & Repair Services	0.15	-0.62	-0.67	-1.14	-1.56	-1.35	-1.47	-1.66
	0.48	0.50	0.41	0.42	0.64	0.69	0.73	0.58
29 Wholesale & Retail Trade	1.67	0.98	1.17	0.92	0.67	1.12	1.11	1.07
	0.40	0.50	0.36	0.33	0.52	0.56	0.59	0.47
30 Hotels & Restaurants	2.28	2.02	1.90	2.04	1.84	2.13	2.15	2.14
	0.25	0.41	0.22	0.20	0.29	0.31	0.32	0.25

	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10
31 Inland Transport Services	2.83	1.94	2.23	1.90	1.60	2.16	2.09	2.04
	0.48	0.49	0.42	0.38	0.61	0.66	0.69	0.55
32 Sea & Air Transport Services	0.71	0.54	0.64	0.59	0.57	0.71	0.76	0.80
	0.23	0.21	0.23	0.25	0.37	0.38	0.42	0.32
33 Auxiliary Transport Services	2.18	1.54	1.74	1.50	1.29	1.70	1.69	1.67
	0.41	0.45	0.38	0.36	0.55	0.59	0.62	0.49
34 Communication	3.26	2.79	2.85	2.68	2.51	2.78	2.78	2.74
	0.34	0.45	0.30	0.29	0.44	0.47	0.48	0.37
35 Banking & Insurance	2.37	1.80	1.99	1.79	1.60	1.97	1.97	1.96
	0.42	0.42	0.38	0.37	0.57	0.61	0.64	0.50
36 Other Private Services	2.29	1.46	1.73	1.37	1.06	1.56	1.49	1.45
	0.49	0.48	0.43	0.41	0.64	0.68	0.72	0.56
37 Real Estate	2.62	2.29	2.27	2.17	2.02	2.25	2.25	2.23
	0.26	0.36	0.21	0.19	0.28	0.31	0.32	0.26
38 Private Education Services	2.06	1.68	1.77	1.60	1.52	1.77	1.84	1.87
	0.41	0.48	0.37	0.36	0.52	0.54	0.57	0.41
39 Private Health Services	3.02	2.72	2.68	2.49	2.28	2.40	2.40	2.36
	0.23	0.31	0.19	0.16	0.23	0.26	0.27	0.23
40 Recreation & Culture	1.77	1.51	1.53	1.53	1.44	1.70	1.73	1.75
	0.28	0.39	0.24	0.23	0.34	0.37	0.38	0.30
SERVICES NON-MARKET	2.12	2.11	2.11	2.11	2.11	2.12	2.12	2.11
	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.01
41 General Public Services	1.84	1.84	2.04	2.08	2.21	2.31	2.48	2.62
	0.49	0.41	0.53	0.63	0.85	0.85	0.91	0.64
42 Public Education	2.06	1.84	1.84	1.84	1.83	2.01	2.08	2.06
	0.22	0.37	0.18	0.16	0.24	0.26	0.26	0.22
43 Public Health Services	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44 Non-profit Institutions	1.28	1.08	0.98	1.06	0.87	1.05	1.08	0.96
	0.22	0.40	0.18	0.16	0.24	0.27	0.26	0.22

Table 8 – Generous scenario vs. Baseline-Sectoral output growth rates difference

Sectors	average (*)	2010
TOTAL	2.5	4.9
Sectoral differences from the TOTAL		
Agriculture, Forestry, Fishery	-1.8	-3.3
Coal, Oil, Petroleum Ref. Products	-0.1	-1.2
Electricity, Gas, Water	-0.3	-0.7
MANUFACTURING	1.4	2.8
Primary metals	1.6	3.3
Stone, Clay & Glass products	-1.1	-2.4
Chemical Products	-0.7	-0.9
Metal Products	2.9	5.5
Agric. & Indus. Machinery	6.6	13.6
Office, Precision, Opt. Instruments	1.4	2.2
Electrical Goods	4.7	8.9
Motor Vehicles	5.7	12.5
Other Transport Equipment	-0.5	-0.9
Meat & Preserved Meat	-1.5	-3.0
Milk & Dairy Products	-2.8	-5.1
Other Foods	-1.4	-2.7
Alcohol & Non Alcoh. Beverages	-1.4	-2.6
Tobacco	-3.5	-7.9
Textile & Clothing	-1.6	-2.8
Leather, Shoes & Footwear	-1.1	-2.7
Timber, Wooden Product & Furniture	-1.0	-2.0
Paper & Printing Products	0.9	2.3
Plastic Products & Rubber	2.3	4.3
Other Manufacturing Industry	-1.4	-3.0
Building & Construction	-2.2	-4.7
SERVICES	-0.4	-0.9
Recovery & Repair Services	0.1	0.5
Wholesale & Retail Trade	-0.2	-0.4
Hotels & Restaurants	-1.1	-2.3
Inland Transport Services	0.2	0.4
Sea & Air Transport Services	-1.1	-2.0
Auxiliary Transport Services	-0.1	-0.2
Communication	0.3	-0.9
Banking & Insurance	-1.1	-0.1
Other Private Services	-0.2	0.5
Real Estate	-1.3	-2.3
Private Education Services	-0.9	-0.5
Private Health Services	-2.4	-2.7
Recreation & Culture	0.7	-1.9

Note: (*) averages refer to the period 2001-2010

that all industries benefit in varying degrees in terms of output growth. This is the overall result obtained from the first set of 'CC growth effect scenarios'. Clearly, the removal of tariffs and NTBs interferes with these results. In order to evaluate such interference, we must consider that the removal of trade barriers causes imports from the CC to be more competitive. These imports, which constitute part of the resources, will be used to feed intermediate and final consumption. If we examine import composition, we find that some imports tend to feed intermediate consumption whilst others figure directly in final consumption, such as for example, goods produced for household consumption. Hence, the effect of more competitive imports may vary across sectors.

Figures 2, 3, and 4 may help to highlight the impact of the new prosperity of the CC represented in the 'Specializing CC' scenario and the changes due to the removal of trade barriers in the 'conservative' and 'generous' scenarios. In each sector, the output index (2001=1) shows higher growth in the 'Specializing CC' scenario confirming the positive benefit of the keynesian effect due to the increase in imports for the CC. For 'agriculture, forestry, fishery' (Figure 2), the removal of trade barriers has a negative impact on sectoral performance in term of output, particularly when shifting from the 'conservative' to the 'generous' scenario. In 'milk & dairy product' (Figure 3), the removal of trade barriers is even more severe; all the benefits of the expansion stimulated by higher exports are lost and sectoral output falls below the 'baseline' track until the end of the period when it once again approaches the 'baseline' level. On the contrary, the removal of trade barriers improves the sectoral performance for 'leather, shoes & footwear' (Figure 4); in particular, the 'conservative scenario' stimulates further growth while the 'generous scenario' tends to undermine this stimulus. This means that according to the 'conservative scenario' commodities with reduced import prices generally constitute intermediate consumption for this sector, whilst in the 'generous scenario' the import price reduction is more likely to affect sectoral competition in final consumption products.

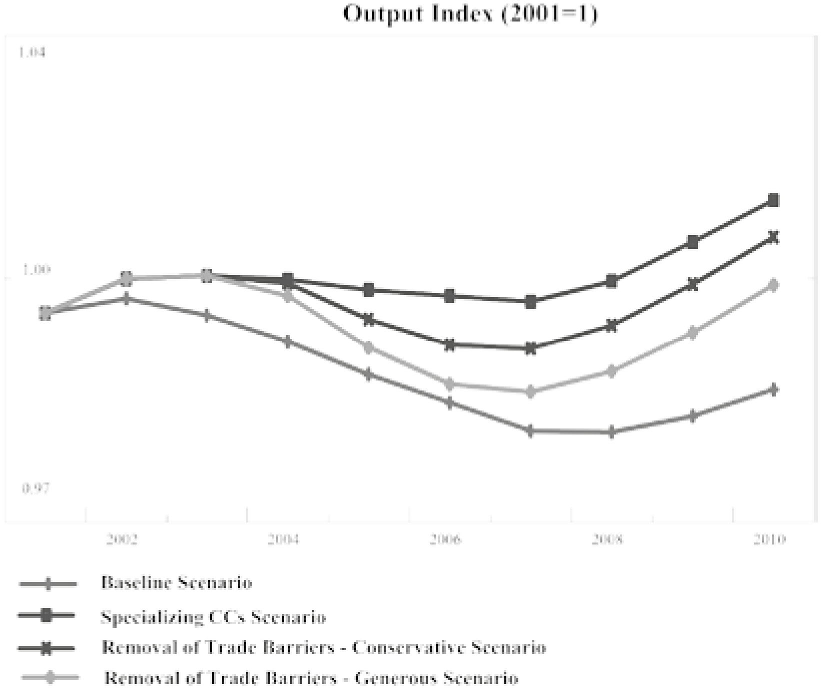
4. Conclusions

The impact of European enlargement on Italy has been evaluated by dismantling the scenarios in order to calculated how Italy is affected by both the new prosperity of the applicants and the removal of existing trade barriers.

The effect of the applicants' new prosperity has been considered in terms of their increased imports from the EU and not in terms of the effect of the enlargement inside the CC economies. This is characteristic of all studies of enlargement viewed exclusively from one side, in this case, the Member States.

As regards the simulation results for the removal of tariffs and non-tariff barriers, two alternative scenarios have been formulated. In the case of non-tariff barriers it is impossible to measure the precise size of their mark-up on price formation. Two scenarios have been designed: one refers to generous effects in terms of Baldwin's hypothesis (Baldwin *et al.* 1997) which assumes an overall reduction of 10 per cent, and the other

Figure 2 – 1 Agriculture, Forestry, Fishery

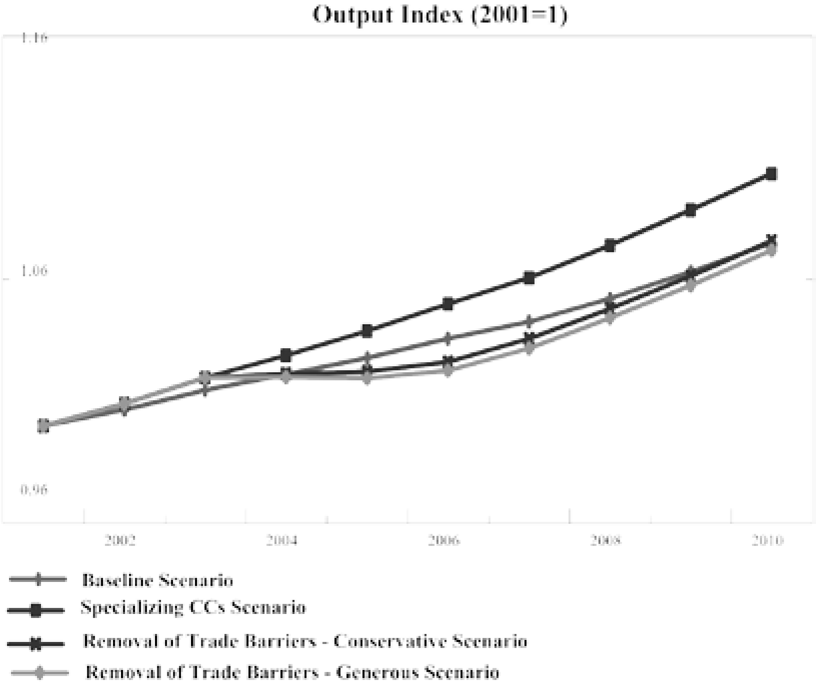


to a conservative hypothesis similar to that proposed by Keuschnigg and Kohler (1999).

Focussing on the Italian economy, the first conclusion reached in the study concerns the evaluation of the direct and indirect impact of the assumed increase in the applicant country's GDP growth rates. Since the econometric model of the Italian economy is a multisectoral macroeconomic model (as is every other model in the Inforum model system), we have used a detailed sectoral representation of the economy to measure the impact of the applicants demand for goods and services; namely, their import structure. Since the historical data on trade between the CC and the EU is concentrated on the import-export flows of a clearly defined number of commodities, we have investigated the effect of this trade specialization on the performance of the Italian economy.

The simulation design has allowed us to compare the impact of the Italy-CC relationship with regard to trade with Italy and the impact on Italy obtained from the more significant impact of the EU15-CC trade. In the first case, we have two countries, Italy and the CC, and in the second case, we have two countries, EU15 and CC, with Italy constituting a single region of the EU. This second case has allowed us to measure the in-

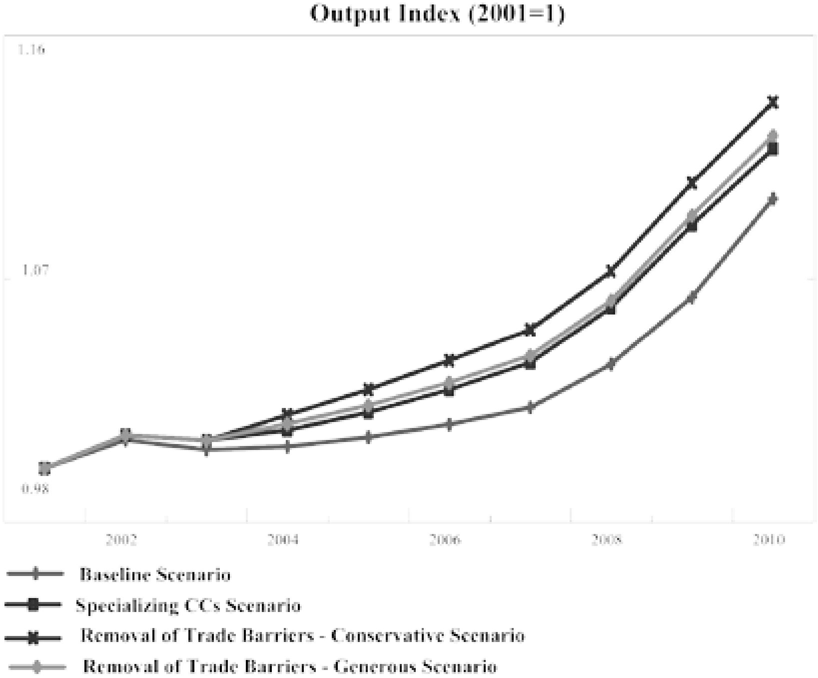
Figure 3 – 17 Milk & Dairy Products



direct effect of the Eastern European enlargement on Italy. Furthermore, there is a third case where the changing composition of the CC imports is considered. This experiment provides evidence that in the case of Italy, which is not on the Eastern EU border but is nevertheless quite near it, the indirect impact on the GDP rate of growth is even more important than the direct one. We can say that the effects of enlargement on the EU 15 as a whole may be even more important than the effect of direct trade which a single Member State has vis à vis the new entrants. Since the effect of the increase on exports induced by a growing demand for goods by the CC is preserved along the simulation period, we can see that the increase is doubled by the indirect effect and that the specialization in CC imports generates a further increase in the GDP rate of growth. This in turn means that the total increase amounts to a factor of approximately 2.6 with respect to that found in the case of Italy-CC.

The sectoral results of our study allow us to detect a group of 'winners' represented by 'agricultural and industrial machinery', 'electrical goods', 'motor vehicles', and 'metal products' which show a remarkable performance with the output growth rates above the economy wide average, even more than 5 per cent. The relative weight of some 'winners' means that

Figure 4 – 22 Leather, Shoes & Footwear



most of the sectors are driven below average; however, among them some 'losers' may be clearly observed: mainly the food industry, 'tobacco', and 'building and construction'. Furthermore, it is important to remember that the removal of trade barriers has been modelled as unilateral, namely only the Candidate Countries benefit from the reduction of their export prices. This has been done in order to emphasize the feared loss in price competitiveness of a Member State foreign trade. Our results show that this loss is more than offset by the increase of foreign demand.

This result clearly demonstrates that the Eastern enlargement is not simply a question of boundaries. In particular, it is clear that – for countries such as Spain, Ireland and Portugal – the indirect effect of Eastern enlargement may be much more significant than the direct effect. Furthermore, the sectoral analysis of foreign trade – together with the sectoral evaluation of its impact – is crucial for understanding the effects of enlargement.

The importance of a sectoral representation of the economy becomes clearer when the removal of tariffs and non-tariff barriers, which mainly concern agriculture and food industry products, have been evaluated. Non-tariff barriers still apply and constitute the bulk of measures hampering international trade between the CC and the EU. Moreover, these measures are concentrated on particular products. For example, the international trade model used in this study examines information on 120 commodities; here, the non-tariff barriers – specifically singled out for simulating their removal – account for about 15 per cent of the range of commodities considered by the model.

In terms of GDP, studies on the impact of Eastern enlargement on a single Member State or on the EU-15 generally conclude that the impact is modest, negligible, or not discernable (see, for example, Baldwin *et al.* 1997, CEC-ECFIN 2001). We cannot confirm such conclusions given that they usually are based on analytical tools which are inappropriate for evaluating the sort of effects examined in this study. It should be noted that the process of enlargement will mean 'the hauling' of the CC economies to the levels of prosperity of the EU15; the hauling is also supported by the CC processes of trade specialization and the removal of commodity-specific tariffs and trade barriers. This in turn requires a 'mesoeconomic' approach where the sectoral representation of the economy may well help highlight the structural changes induced by these factors. The present study demonstrates that macrovariables such as GDP or 'total output' may obscure changes in the structure of the economy which certainly merit policy-makers' attention.

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APPENDIX

A Schematic Overview of INTIMO (INTerindustry Italian MOdel)

INTIMO is a Multisectoral Model (MM) based upon the accounting framework of the input-output table and the institutional accounts of Italy. This table has the intermediate consumption classified for 44 sectors. 40 sectors represent the private component of the economy; 4 sectors represent no-market sectors (3 Government and 1 non-profit).The peculiar representation of Government expenditure in the I/O table (as specified by international statistical standards) commands some changes which lead to the introduction of an extra sector labeled "Government wages"; this sector does not alter the basic accounting structure of the table and the behavior of the model and appears as the 45th sector of the I/O table.

INTIMO Real Side

Component	Sectors	Influences
Output by product sector	45	q=Aq+f
Personal Consumption by expenditure categories	40	Disposable income Size distribution of income Change in disposable income Relative prices Age structure of the population Other demographic variables

INTIMO Real Side

Component	Sectors	Influences
Investment by investing industries	21	Output over the last three years Change in product output
Inventory Change by product sector	27	Product output, inventory stocks
Imports by product sector	41	Import-share equations (ratio of sectoral imports to domestic demand) Foreign prices (supplied by the Bilateral Trade Model)/domestic prices 'Nyhus time trend'
Exports by product sector		Supplied by the Bilateral Trade Model (BTM)
Labour Productivity by product sector	40	Sectoral Output Time trend
Employment	40	Labour productivity
Consumption and Investment by product	45	Final demands by category are bridged to producing sectors
Government Purchases by product sector		Exogenous

INTIMO Price-Income Side

Component	Sectors	Influences
Prices by product sector	45	p = pA + v
Value Added by product sector	45	Value added by industry distributed to products based on product-to-industry bridge
Value added by industry:		
Wages		
Aggregate Wage	1	Personal Consumption deflator Total output/employment
Wage index sectoral/aggregate	42	Rates of growth of employment Output Labour productivity Time trend
Social securities	45	Exogenous

INTIMO Price-Income Side		
Component	Sectors	Influences
Gross operating surplus	42	Sectoral prices Change in sectoral output Sectoral foreign prices for non-sheltered sectors Time trend
Indirect Taxes		Output Prices Exogenous tax rates
Government Subsidies		Exogenous

INTIMO Macroeconomic and Other Variables	
Component	Influences
Population	Supplied by Demographic Projection Model (DPM)
Labour Force	Supplied by Demographic Projection Model (DPM)
Tax Policy	Exogenous
Government Expenditures	Exogenous
Price of crude oil	Exogenous: supplied by BTM
Savings Rate	Exogenous: INTIMO assumption constant to its average in the 90's
Bridge Tables:	
Intermediate coefficients	Across-the-row trends
Personal consumption	Exogenous: supplied at the base year by the Italian Statistical Office
Investments	Exogenous: supplied at the base year by the Italian Statistical Office

ROWING ALONG THE COMPUTABLE GENERAL EQUILIBRIUM MODELLING MAINSTREAM[1]

Maurizio Grassini[2]

1. Introduction

Computable General Equilibrium (CGE) modelling has become "mainstream" economics. Mainstreams, however, are prone to changes in fashion and can lose their popularity. This article explains why such could become the case with CGE modelling.

Keynesian economics has a clear fountainhead in the writings of Keynes, as input-output analysis does in the seminal contributions of Leontief. Walras is widely considered to be the father of general equilibrium theory and is recognized in research which refers to it. Other economic subjects do not have such a clear original set of documents as a source of stimuli for further research. Neoclassical theory and Computable General Equilibrium (as well as Applied General Equilibrium – AGE) are good examples of theories and practices coming from a variety of sources. It is possible to appeal to this kind of theory only when a "synthesis" becomes available; it takes the form of a comprehensive declaration of paradigms collected in one or a few books and articles.

In other words, this kind of subject looks like a river where each branch has its own spring; the tributaries flow together to create the main river; finally, it is claimed that the history of the subject is summarized in the main- stream. Its description assures orthodoxy to whoever wishes to easily row in the right direction of the stream.

An authoritative history of the Computable General Equilibrium is available in a number of contributions by John B. Shoven and John Whalley (1984, 1992) who have been actively working in the field for decades. A recent contribution by Peter Dixon and B.R. Parmenter (1996) edited by Amman, Kendrick and Rust in the *Handbook of Computational Economics* may be considered an updated description of CGE modelling together with its history. Considering the Shoven and Whalley's long project experience and that the Dixon and Parmenter's paper has been written for an

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[1] Paper published in «Studi e Note di Economia», Anno XII, n. 3-2007, pp. 315-343.

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Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online),

handbook, although the sample is small, the historical references gleaned among their contributions seems to cover very well the common recognition of the main sources of CGE.

These sources represent the formalization of the general equilibrium structure by Kenneth Arrow, Gerard Debreu, Frank Hahn, and others in the 1950s, the first CGE model built by Johansen in 1960, the algorithm written by Scarf in 1967 for computing solutions to numerically specified general equilibrium models. Theorists gave the foundations of general equilibrium theory, practical economists tried to look at the real economy using these the- oretical foundations, and mathematicians provided tools to ease the required computations. The diffusion of computing resources supported the dissemination of this kind of modelling. These are the springs which fed the three main branches which significantly determined the CGE river flow.

As in any river basin, it is possible to detect a large number of branches; they are not all the same; some give large contributions to the river flow, others are no more than seasonal streams. Here, these small contributions are intentionally ignored and the reader is asked not to use them to avoid the main questions which will be raised.

2. *A Definition of CGE*[3]

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

i) They include explicit specification of the behavior of several economic actors (i.e. they are general). Typically they represent households as utility maximizers and firms as profit maximizers 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 behavior 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 commodi-

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[3] Kemal Dervis, Jaime de Melo, Sherman Robinson (1982) wrote: «In order to achieve greater policy relevance, it is clear that the fiction of a central command economy must be abandoned in the very specification of the model and be replaced by a framework in which endogenous price and quantity variables are allowed to interact so as to simulate the workings of at least partly decentralized markets and autonomous decision makers». So that «In order to achieve policy relevance», they introduced a class of models they called computable general equilibrium (CGE) models and described their structure. From a practical point of view, this introduction was simply a research project proposal.

ties 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 description 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 the 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 an adequate basis for applying the tools offered by the microeconomic theory.

While some macroeconometric models may refer to a single good economy, CGE models are fed with a somewhat 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 quantified econometric model may 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 data-base will be discussed later on.

3. How to make a General Equilibrium Model Computable

3.1 Social Accounts and Economic Theory

To move from a theoretical to a computable model, measurements of the model variables must be available. How to bridge theoretical and observable economic variables is a well-known problem which tormented many economists long before the beginning of the systematic production of national accounts and related by-product statistics. When commenting on "Abstract Models and Reality", Haavelmo (1944) stressed the distinction between "observable", "true" and "theoretical variables"; he wrote:

> In pure theory we introduce variables… which, by construction, satisfy certain conditions of inner consistency of a theoretical model. These theoretical variables are usually given names that indicate with what actual, "true", measurements we hope the theoretical variables might be identified. But the theoretical variables are not defined as identical with some "true" variables... To impose some functional relationship upon the variables means going much further. We may express the difference by saying that the "true" variables… represent our ideal as to accurate measurements of reality "as it is in fact", while the variables defined in a theory are the true measurements that we should make if reality were actually in accordance with our theoretical model.

and he concluded the discussion with the following advice:

> […] one should study very carefully the actual series considered and the con- ditions under which they were produced, before identifying them with the variables of a particular theoretical model.

Forty years later, in the article where the word "calibration" was defined for economists, Mansur and Whalley (1984) wrote:

> General equilibrium analysis is perhaps the most widely used theoretical framework for economy wide microeconomic analysis, but is only explicitly recognized in the construction of current national income accounts in the aggregate income-expenditure identity, not in any of the subaggregate detail in the accounts… 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 the late 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 Account, 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[4]. 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 and 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. Undoubtedly, 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 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.

3.2 The Social Accounts of the CGE's Economic Environment

In the line connecting "consumption" in an abstract model and the consumption registered by an housewife in a diary given her by a national statistical bureau for primary data collection, the economist usually focuses on statistics located somewhere in the middle of that line. This is because the economist cannot ask the housewife what she really means by consumption expenditure, but he has to use for his purposes the data made available by official statistical institutions. In general, the official statistics yearbooks are the place where economists "observe" the extant economy.

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[4] 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-centered modelling.

As mentioned above, in the definition of a CGE, Dixon and Parmenter reveal 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 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) as mentioned above; 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. Showen and Whalley (1984) wrote:

> 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 labor from firms will not equal labor 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 fulfills the equilibrium conditions for some form of general equilibrium model" (Showen and Whalley, 1984). Although the "detailed information presented in most national accounts [have] enormous value to economists» (Showen and Whalley, 1984), some adjustments "are desired". Then, what happens to the profits? They are simply removed by renaming them as compensation for capital[5]. The rationale for such a manipulation is that profits have a destination. They are distributed to a variety of incomes so that the flow will lose its original character. This rationale may be applied to each item (of the primary distribution) of value added; once the distribution of valued added to the institutions is completed and their disposable income is defined, neither

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[5] Showen and Whalley (1984) are very explicit on this point. Since one equilibrium condition is that «Nonpositive profits are made in all industries», then «This typically involves treating the residual profit return to equity as a contractual cost, as is implicit in most input-output transaction tables». Indeed, this treatment is not at all "implicit".

profits nor any other component of the value added are found in the "use of income" accounts. But profits are well rooted in the primary distribution of value added and are well appreciated as such by the entrepreneur; furthermore, profits may be seen as a buffer variable between costs and revenues which may play the role of a strategic tool in the hand of the entrepreneur. As they are the difference between costs and revenues, profits are strictly related to prices which in turn have a strange location in the CGE models.

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.

4. Static and Dynamic

As it is well known to any model builder, the birth of a "computable" model does not take place in a single step. The model builder may have a rather good knowledge of the model's cornerstones; they can allow him to quickly reach a rough version of the model. Subsequently, the model will be implemented. Firstly, this rough version calls for a refinement. Secondly, the model builder's experience will suggest where to introduce improvements; these largely concern the performance of the model and in particular those distinctive features for tackling particular simulation experiments. A model builder is aware that the refinement and the implementation of a model is an endless process.

A good example of model building experience is offered by "The Michigan Model of World Production and Trade". The modelling framework was originally developed by Deardorff and Stern at University of Michigan in the mid 1970s. This model is still used and implemented; the presentation6 emphasizes that the structure of the model has been extended to include features of the New Trade Theory (imperfect competition, increasing returns to scale, and product differentiation) and many other features to deal with actual and preferential trading arrangements such as the North American Free Trade Agreements, the effects on employment due to the Tokyo Round of Multilateral Trade Liberalization, and many other problems shown in a number of papers listed in the presentation mentioned above. This set of papers is part of the description of the model extensively described in two books by Deardorff and Stern (1986, 1990).

In a recent contribution, Brown, Deardorff and Stern (2001) investigate "the options that two nations have in prospective trade negotiations at the multilateral and regional level" by means of the "Michigan Model" that they "have used for more than 25 years to analyze changes in multilateral

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[6] Its presentation can be found on: www.Fordschool.umich.edu/rsie/model

and regional trade policies". To analyse the multilateral trade liberalization provisions of the Uruguay Round agreements, they use a 20-country/18-sector version of their CGE model. This type of model, as any other model of this kind, requires an immense amount of data. Databases like "The GTAP-5 Database" provided in Dimaranan and McDougall (2002) at Purdue University address this need; the authors are clearly aware that this practice has to be considered largely common to CGE model builders.

Using growth rates forecast for the period 1997-2010, provided by the World Banks's 1999 World Development indicators for various countries, the database was projected to approximate the picture of the world expected in 2005 if the Uruguay Round negotiations had not occurred. Accordingly, the impact of the Uruguay Round induced reduction in tariffs and non-tariff barriers has been analyzed in the course of 10-year implementation period. Once the computational scenarios have been shown in detail, the Authors review the features of the model in order to help the reader to interpret the results. Then, they list a number of expected effects related to the computational scenarios, and warn that "In the real world, all of these effects occur over time, some of them [more] quickly than others" and continue:

> Our model is however static, based upon a single set of equilibrium conditions rather than relationships that vary over time. Our results therefore refer to a time horizon that is somewhat uncertain, depending on the assumptions that have been made about which variables do and do not adjust to changing market conditions, and on the short- to long-run nature of these adjustments. Because our elasticity's of supply and demand reflect relatively adjustments and because we assume that markets for both labor and capital clear within countries, our results are appropriate for relatively long time horizon of several years - perhaps two or three at a minimum.
>
> On the other hand, our model does not allow for the very long-run adjustments that could occur through capital accumulation, population growth, and technological change. Our results should therefore be thought of as being superimposed upon longer-run growth paths of the economies involved. To the extent that these growth paths themselves may be influenced by trade liberalization, therefore, our model does not capture that.

This frank description of the limits of a model is not necessarily astonishing. A model builder is fully aware of the limits of his model; relevant economic questions stimulate him to improve it. However, it is worthwhile to notice that a) the model is static, b) it is based upon a single set of equilibrium conditions *rather than* relationships that vary over time, c) the results refer to a rather uncertain horizon, nevertheless d) the results are appropriate for a relatively long time horizon which surprisingly may be approximately two or three years, and finally e), although the model is tailored for a long time horizon, it does not account for those factors such as capital accumulation, population growth and technological change.

However, the Michigan Model of World Production and Trade was originally developed in the mid 1970s and after more than a quarter of century, it still shows naive limits. These limits are not at all new to macroeconomic modellers who replace them rather quickly by building and implementing macro and multisectoral models. The strange state of art of this CGE model requires further investigation to understand why it still suffers such serious limitations. A few questions are in order. Are they due to the indolence of the Authors? Are they due to the limit of the theoretical background? Is there any way out of such poor representation of the real world? Meanwhile, a further investigation about the properties of other competing CGE models would help to answer these questions properly.

Around the same time, Keuschnigg and Kohler (1999) used a CGE model to evaluate the impact of the European Union Eastern enlargement on Austria. Not constrained by the dimension of an economic journal article, the authors produced a report with a detailed description of the required data for the construction of a "micro-consistent data set" to feed the model, the calibration process, and described and stressed some properties of their CGE model. First of all, the authors let it be known that the "model is best thought of as consisting of a *macro part* which drives dynamic adjustment of the overall economy through time, and a *temporal part* which determines temporal equilibrium at any point in time and which focuses on sectoral aspects"[7]. In other words, Keuschnigg and Kohler largely follow a top-down approach where a "dynamic" macro part drives the sectoral detail of the model.

Since the model is dynamic, "General equilibrium involves market clearing for all goods and factors, plus the fulfilment of an appropriate condition for the government budget at each point in time"[8]. At each point in time there are temporal equilibria which

> [...] are interconnected in two ways. First, sectoral capital stocks as well as the government debt and net foreign assets are inherited from the past. Similarly, the accumulation decisions of the present equilibrium will determine the initial conditions of the subsequent temporal equilibrium. Secondly, any temporal equilibrium is connected to the future through expectational variables. In our case, these are firm values, human capital, and the marginal propensity to consume which incorporates the expected profile of consumer prices. When solving for an adjustment path, we employ the assumption of perfect foresight.

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[7] This statement is in the paragraph about 'A brief description of the simulation model' in Keuschnigg and Kohler (1999).

[8] This is the opening sentence in the paragraph 'Equilibrium in the short-run and in the long-run', Keuschnigg and Kohler (1999).

> More specifically, the calculated sequence of temporal equilibria is characterized by two conditions a) The backward connection of successive equilibria turns out to corroborate ex post the expectations that underlie their forward connection, and b) the sequence leads to steady state where the relevant variables are stationary[9].

Hence, while Brown, Deardorff and Stern point out that the explanatory power of their model is limited by being static, Keuschnigg and Kohler emphasize the dynamic property of the model used in their study. Brown, Deardorff and Stern warn the reader that in their study the time horizon was somewhat uncertain, while Keuschnigg and Kohler talk about starting and ending equilibria and adjustment paths.

The dynamic model solution refers to a time variable; in fact, the solution is provided by an index t which reminds us of its location along the time axis where the time variable is measured. The time variable does not, however, necessarily refer to the calendar time. In an adjustment path, the index t may simply indicate that the variable follows its value at time t-1 and precedes its value at time t+1, where t may refer to an hour, to a month, to a year, to ten years, to a century or to any other fraction of time. This means that a dynamic model may be timeless with respect to the calendar time. In such a case, the dynamic model simply links two "steady state" solutions along a timeless adjustment path; in other words, the model turns out to be useful only for comparative static exercises, as any standard static model[10].

Since they are operating at the same time, the two CGE models considered could represent the state of the art of a classic static computable general equilibrium model and one of the most interesting adventures in the field of the computable general equilibrium dynamic models. In order to evaluate the direction followed and the road covered from the static to the dynamic world, Blaug's comments (Blaug, 1992) may be useful.

Blaug proposes to distinguish General Equilibrium theory from the General Equilibrium model; the theory, deals with the existence of equilibrium, its stability and all the questions purely theoretical; the model, may be expressed as a set of simultaneous equations with a definite empirical content as a wider notion of an economic model. The CGE model comes from this General Equilibrium model's body. The CGE model has gained its own identity through the rich scientific contributions strictly dealing with its function (model selection, calibration, and simulation); however, it cannot exist independently of its theoretical image: the Gen-

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[9] Idem.

[10] Cautiously, Keuschnigg and Kohler (1999) measure the distance between two steady state solutions in terms of "periods". Monaco (1997) notices that CGE models "tell us nothing about the time path to the new equilibrium. Dynamic AGEs [synonymous of CGE] might, but in practice relatively simple cost-of- adjustment functions are assumed, so the path and adjustment speeds are artefacts".

eral Equilibrium theory. On this regard, Blaug cites Franklin Fisher who said (Fisher, 1987):

> […] the very power and elegance of [general] equilibrium analysis often obscures the fact that it rests on a very uncertain foundation. We have no similarly elegant theory of what happens out of equilibrium, of how agents behave when their plans are frustrated. As a result we have no rigorous basis for believing that equilibrium can be achieved or maintained if disturbed.

and Blaug observes:

> This lacuna in GE theory produces the curious anomaly that perfect competition is possible only when a market is in equilibrium. It is impossible when a market is out of equilibrium for the simple reason that perfectly competitive producers are price-takers, not price-makers. But if no one can make the prices, how do prices ever change to produce convergence to equilibrium? This problem is perhaps a minor blemish in an apparatus which has no role for money, for stock markets, for bankruptcies, or for true entrepreneurship.

These considerations about the general equilibrium theory could be seen as a destructive criticism. On the other hand, any attempt to remove one or more blemishes is welcome and serves to reject this unfavourable judgement. Also Blaug offers a way out to his capital sentence by considering the general equilibrium theory as a field with no empirical content, so far from the real world that it could be labelled no more than a *framework or paradigm*. In this case, general equilibrium theory should no longer be judged through the general equilibrium practitioners: the CGE model builders. Indeed, it is hard to find any CGE modeller intentionally disconnected from the theorists' sphere, proud to be backed by the theoretical *framework* which supports the General Equilibrium theory. On the other hand, a CGE model depends explicitly on neoclassical general equilibrium theory, shaped on markets which operate to determine prices, and agents provided by analytically specified utility functions or production functions, who optimize their objective functions under proper constraints. Thinking that this is the authentic picture of the economy, the CGE model builder is pleased to have such *super* theoretical foundations. Many even think that this is the only possible picture of the economy[11].

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[11] It is worthwhile to notice that Blaug's comment on General Equilibrium Theory in *The Methodology of Economics* does not throw any light on the progress made in the direction of a dynamic approach to a computable general equilibrium model. Brown, Deardorff and Stern surely represent the orthodox static CGE modelling; Keuschnigg and Kohler deal with a CGE model with dynamic flavour but their dynamic approach does not seem to add any realistic features to the static version.

5. Paradigms and Functional Forms

Dixon and Parmenter's CGE definition states that households are utility maximizers and firms are *profit maximizers or cost minimizers*. This definition may well be embedded in Lionel Robbins's definition (Robbins, 1935) of *economics* as the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses. We can simply assume that economic agents do their best according to this elementary fact of experience, so that the observed economic phenomena just reflect the outcomes of their behaviour. However, 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. Their strategy may be exemplified to the widespread approach of modelling a system of demand equations in the CGE framework.

The (neoclassical) economist assumes that a consumer maximizes his utility function under his budget constraint. A sceptical observer may question if the utility function really exists. The answer is that it probably does not exist: it is a concept useful to the (neoclassical) economist, not to the consumer. In fact, the (neoclassical) economist is a (social) scientist and as such he builds or simply uses already available models to describe and predict the observed real world phenomena. The consumer behaviour theory based upon the maximizing postulate does not determine the consumer effective purchases on the market, but gives the economist operational hypotheses to figure out a quantitative representation of the consumer behaviour: the demand functions. In this framework, the optimization procedure results take the form of restrictions which are very useful in the (econometric) estimation of demand functions (see Phlips, 1974).

The CGE modeller does not estimate functional forms; he simply calibrates them, picking up parameter values from database 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 obtained. Afterwards, the demand function parameters are "calibrated". The CGE modeller likes such a demand system, being an orthodox fruit of the neoclassical theory. But, we must be also aware of the "economic" properties of these demand functions and the impact of the chosen utility function on the model performance.

5.1. The Economic Properties of a Demand System Obtained from a "Known" Utility Function

From a textbook 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 0.0, and all income elasticities equal to 1.0.

The Stone-Geary's utility function leads to the linear expenditure system which implies that the specification of the income elasticities and one price elasticity is sufficient to determine all price elasticities. It is clear that there is insufficient room to seriously study the effects of price.

Of course, such systems of demand function belong to a group which do not portray the real world; or, at least, out of the textbook environment, they do not deserve any attention.

Hence, the utility maximization process does not necessarily lead to useful demand systems. However, the neoclassical theory approach to the consumer behaviour (that is to say, 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 may 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 put the question: "What Should a Functional Form Offer?" and then 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 B such as stock of durables, interest rates, or time trends B 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 coming from the utility maximization and suggested and estimated functional forms (Almon, 1979, 1996) matching the above requirements. One could ask about the analytical form of the corresponding utility function. I think that this answer may be left to mathematicians playing with challenging integration exercises. It is widely thought that the knowledge of such utility functions does not give new light to the real working of the economy.

5.2. The Choice of Functional Forms Really Matters

McKitrick (1998) decided to revisit the debate about the appropriate methods to construct CGE models. In particular he put the question: calibration or econometric methods? Indeed, he did not get into the debate but focussed on the specific issue of functional form choice. McKitrick underlined the following three points on which he drew renewed attention:

> [First] In the calibration method, some parameters are determined on the basis of a survey of empirical literature, some are chosen arbitrarily, and the remainder are set at values which force the model to replicate the data at a chosen benchmark year [...]
>
> Second, the calibration procedure causes the quality of the model to be at least partly dependent on the quality of the data for an arbitrary chosen benchmark year [...]
>
> Third, the calibration approach tends to limit the researcher to the use of 'first order' functional forms (those in the Constant Elasticity of Substitution (CES) class) all of which embody restrictive assumptions about the structure of the industries being modeled, by imposing a

> single non-negative substitution elasticity across all pairs of goods in the aggregator [...]

McKitrick characterized the literature which emphasizes these points as the ”econometric critique of the CGE modelling”. In truth though, this critique is inside the CGE modelling approach; it concerns the fact that as for any quantitative model, CGE model “embodies three types of information: analytical, functional and numerical”, explained as follows:

> The analytical structure is the background theoretical material which identifies the variables of interest and posits their casual relations. The functional structure is the mathematical representation of the analytical material, and consists of the algebraic equations which make up the actual model. The numerical structure consists of the signs and magnitudes of the coefficients in the equations which form the functional structure.

These three types of information are fundamental pillars of any model builder[12]. Due to the distinctive features of the CGE modeller’s approach, the choice of the functional forms leads to different analytical “behavioural functions” which, in general, figure out varied numerical results once they are part of a model. McKitrick makes a generous working hypothesis; he decided to investigate whether the neoclassical foundations supporting a CGE model are powerful enough to make the choice of the functional forms irrelevant with respect to the numerical results. In the CGE modelling approach, the “solution” at the “equilibrium” is the same for whatever functional form set chosen by the model builder. Out of the benchmark “equilibrium”, different functional forms inevitably produce different “equilibria”. This means that CGE models built on the same data set, but with different functional forms, produce different results in policy simulation experiments; in other words, the “choice of functional form appears to be influential in CGE model performance” [...] ”at both the industry-specific and macroeconomic levels, for large and small policy shocks” (McKitrick, 1988, p. 565 and p. 572).

These results are to be expected; more than supporting the “econometric critique” of CGE modelling, they give this modelling approach the value of textbook exercises. McKitrick’s paper is nonetheless an excellent contribution in the field of comparative modelling which should force CGE modellers to meditate on the quality of their work.

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[12] Here, VAR modellers are not included in the model builder profession, since they do not avail themselves of any economic theory knowledge. In fact, they clearly ignore the first information: *the background theoretical material which identifies the variables of interest and posits their causal relations.*

6. The Choice of Parameter Values

The parameter values of a CGE model are obtained by means of a method which was "officially" named by Mansur and Whalley (1984). They did not invent the practice; they simply named it, and the name became associated with CGE modelling. First, they noted that a standard practice – "calibration" – had evolved among CGE modellers and they claimed that it was much more useful than the "stochastic estimation" later called by Kydland and Prescott (1990) the "system of equations approach". They described the stochastic estimation approach in the form of a cursory review of the most popular estimation methods available at that time. Although the description of the methods is clear, their comments and suggestions reveal their lack of practice with the use of such estimation procedures. In fact, large macroeconomic models are never estimated by means of statistical methods which require time series data inevitably shorter than what is required by the estimation procedure in order to preserve their statistical properties. Every macroeconomic model builder knows that estimation procedures relying upon asymptotic properties, whatever the chosen class (i.e., limited information, full information, instrumental variable and so on), are not practicable for large models, but the alternative is not necessarily the calibration method. At that time a large number of large macroeconomic models were estimated and were running. Observing that models based upon input-output tables involve "dimensionalities which are quite outside those which econometrician are used to", Mansur and Whalley (1984) maintain that "estimation of all model parameters using a stochastic specification and time series data is usually ruled out as infeasible". This is true according to most estimation procedures widely described in econometric textbooks; anyway, Mansur and Whalley seem too confident about their criticism, presenting the calibration as a method with the primacy for parameter selection.

Their description of the calibration method is more clear and interesting in as much as it provides a genuine definition of the method. Before giving numerical value to the parameters of a CGE model, they said that a micro consistent equilibrium data set is constructed using national accounts data sources so as to provide a data base for model calibration. The manipulation of the national accounts is the holy sacrifice of the neoclassical divinity.

The calibration "theory" nested into the neoclassical one leads to a procedure which is efficaciously described in Kehoe and Kehoe (1994) by means of simple numerical examples. Firstly, they calibrate a Cobb-Douglas production function assuming that the entrepreneurs minimize costs and earn zero profits; given the observed measure of primary inputs (labour and capital) and output and assuming that wages and interest rate are equal to one, the production elasticity of one primary input and the scale factor of the production function are computed. This example shows the case of parameters computed using variable observed values at the benchmark (together with a given functional form).

Secondly, Kehoe and Kehoe show that available information on parameters can easily be incorporated into the calibration procedure. This example is addressed to the calibration practice where parameters and elasticities come from the "economic literature". For instance, it may be the case that we have information about, let us say, the numerical value of the elasticity of substitution in consumption. If we do not want to ignore such information, this numerical value can be embodied in a utility function which has it among its parameters. In general, since calibration involves only one year's data (or a single observation however made available), the benchmark data frequently do not identify a unique set of values of parameters in a given model. In this case, it is desirable to have at hand values of relevant elasticities to be used to identify a reliable set of parameters in each equation of the model.

Hence, the CGE modeller is used to regarding the economic literature as the place where the economic life is in evidence; in fact, instead of looking at the economic data, the CGE modeller likes to draw "parameters" from the economic literature. Now, it is a common practice to draw parameters from data bases which in turn have been built selecting "parameters" from the literature. While the CGE modeller stays very close to the neoclassical paradigms, this practice takes him very far from the primary source of economic data. The distance from the observed facts, favoured by the available data bases fed through selected economic literature together with the manipulated national accounts, means that the CGE modeller may not be aware of the economic content of the data used in model building.

7. The CGE Critique of Econometric Modelling

In 1984 Scarf and Shoven[13] edited a book containing a series of papers presented at the Conference on Applied General Equilibrium Analysis held in San Diego in August 1981. The selected papers dealt with a variety of topics. Some of them focussed on methodological issues, others tackled practical problems such as foreign trade, higher energy price effects, taxation impact and its effect on income distributions, and so on. Jorgenson's contribution ranks in the methodological group. Shoven described it in the Preface as "an ambitious and sophisticated attempt to estimate and report on a large general equilibrium model." Jorgenson (1984) noted that "the development of econometric methods for estimating the unknown parameters describing technology and preferences in such [CGE] models has been neglected".

While Mansur and Whalley (1984) went on describing the "calibration" method as one which gives numerical value to any parameter, as an experienced econometrician (which was a member of the team of the Brook-

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[13] See Scarf and Shoven (eds.)(1984).

ing's Quarterly Models of the United States), Jorgenson clearly stressed that the detail of any CGE model was far from the micro economic atomistic world; furthermore, he noticed that the implementation of econometric models is very demanding in terms of data requirements as is well known to macro econometric modellers. Around the same time, Shoven and Whalley (1984) tried to explain why the calibration approach was so widely used; indeed, they underlined: a) that the econometricians require unrealistically large number for observation, b) that the simultaneous estimation approach does not have shortcuts capable of fully incorporating all the equilibrium restrictions, and c) by means of a rather confused analysis of the benchmark data they asserted that it was not possible to have a sequence of equilibrium observations. So, the Jorgenson's econometric approach was rapidly put aside.

Although it is widely said that the calibration is the standard procedure for giving numerical value to the parameters of a CGE model, the so-called econometric critique of the computable general equilibrium modelling still pops up in many studies. Unfortunately this critique is multi-faceted and in many cases is based simply on the assumption that some alternative approaches to making the model computable are declared better than calibration. The critique may have some truth but it requires a better specification of the context.

In the "system-of-equations models" defined in Kydland and Prescott (1990), who refer to Koopmans' Cowles Commission framework, institutional, technological and behavioural equations are given parameters using time series data. The selection of the parameters of the equations is done in order to give the system of equations (at least) the ability to mimic the used time series. In this modelling approach, it is said that behavioural equations are the response of groups of individuals or firms to a common economic environment. These responses may well be theoretically founded[14], but they are also designed on the available statistical information which refer to "groups of individuals or firms", which, by the way, are those also used by any CGE modeller, who believes him/herself to be a microeconomic observer.

It is common to remember that macroeconometric models went into disarray during the 1970s. The oil shocks, which took place at that time, proved that a one-sector model was inadequate to describe and catch the main features of an economy. Many model builders learnt a lot from the failures of their models. Rethinking – thus stimulating scientific advancement – gave rise to interesting improvements in model design. At that time, some criticism was directed towards the "foundations" of the "system-of-

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[14] A good example of macroeconometric model with well defined theoretical foundation is given by Klein and Goldberger (1955); their model is a genuine translation into equations of the content of different chapters of the Keynes General Theory.

equations models" approach. Kydland and Prescott (1990) add a peculiar critique; they say that "[a]nother reason for the demise of this approach was the general recognition that the policy-invariant behavioral equations are inconsistent with the maximization postulate in dynamic settings", due to the advances in neoclassical theory that permitted the application of its paradigms.

So that, in contrast with the econometric critique to the CGE modelling, we have a case of CGE critique to the econometric approach, which is based upon the victory of paradigms. The peculiarity of this critique is not "scientific". Indeed, Mansur and Whalley (1984) declare that they calibrate a model to an equilibrium point combining a data set with a literature search for key parameters, but they practise 'no test of model'; they simply make sensitivity analysis: namely, they simply investigate how different parameter values generate different outcomes.

In this context, the intersection between the "system-of-equations models" and the "calibration" approach turns out to be an empty set. The CGE modeller is unaffected by any criticism, because he already lives in the (neoclassical) heaven and he is not required to make any effort to deserve it. Economists, not yet gifted with faith in the neoclassical theory, may be converted through education. They will examine the CGE literature and inevitably meet the functional form implied by the analytical forms obtained under the assumption of a "revealed" agents' optimization processes. Many analytical forms used in CGE models derived from the agents' optimization processes clearly do not refer to the observed economy, and neither would an economist use them to describe it. Needless to say, this is not an econometric critique of computable general equilibrium modelling.

8. *The CGE auto critique to its quantitative approach*

Shoven and Whalley (1992, p.105) offer a good support of the quantitative economic critique:

> Typically, calibration involves only one year's data or a single observation represented as an average over a number of years. Because of the reliance on a single observation, benchmark data typically does not identify a unique set of values for the parameters in any model. Particular values for the relevant elasticities are usually required, and are specified on the basis of other research. These serve, along with the equilibrium observation, to uniquely identify the other parameters of the model. This typically places major reliance on literature survey of elasticities; as many modellers have observed in discussing their own work, it is surprising how sparse (and sometimes contradictory) the literature is on some key elasticity values. And, although this procedure might sound straightforward, it is often exceedingly difficult because each study is different from every other.

and add an operative justification for using calibration method:

> [...] in some applied models many thousands of parameters are involved, and to estimate simultaneously all of the model parameters using time-series methods would require either unrealistically large numbers of observations or overly severe identifying restrictions... Thus far, these problems have largely excluded complete economic estimation of general equilibrium systems in applied work.

Shoven and Whalley do not seem to be aware that microeconomic studies rarely estimate models that can be applied to the aggregates of the CGE models. More precisely, the economic environments of the microeconomic quantitative analysis and that of CGE are essentially different, and it is not reasonable to apply such parameter estimates to the CGE model. On this point Hansen and Heckman (1996) are very crude:

> Given the less-than-idyllic state of affairs, it seems foolish to look to micro data as the primary source for many macro parameters required to do simulation analysis. Many crucial economic parameters – for example, the effect of product inputs on industry supply – can only be determined by looking at relationships among aggregates. Like it or not, time series evidence remains essential in determining many fundamentally aggregative parameters.

The difference between these points of view is evident, but no debate has taken place. A peculiar case where there is an absence of scientific communication is given by McKitrick's article (1998) mentioned above. Its title refers to the econometric critique to CGE modelling, but it deals with a more substantial question proving that the CGE model performance is seriously influenced by the choice of the functional equations. The critique is a capital sentence for the CGE model as a policy simulation tool. Nevertheless, since then the *Economic Modelling* journal has published a number of articles on CGE modelling, where McKitrick critique is basically ignored[15].

9. 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 modelling only relative prices matter; unfortunately, relative prices are not observable. Furthermore, the meaning of the *numeraire* seems to be largely misunderstood.

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[15] This fact makes the role of the referees unclear.

The national products and income account in the benchmark data are usually produced in value terms and many economic data may be separated in terms of price and quantity components. 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[16]; 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 Shoven 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 are well aware 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 necessarily 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 may be split into price and quantity components. Prices may be made available only for those variables which have a physically measurable component (tons, litres, dozens, hours, denumerable objects and so on); anyway, these variables are aggregates so that the appropriate measurement of their prices is done by means of indexes which are 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[17].

This choice together with the homogeneity of degree zero in prices and income of the demand equations imply that in the calibration process price elasticities are necessarily drawn from the "literature". In other words, in the calibration process, observed prices are largely ineffective; 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 emerges that prices are not considered front line variables. Production, exports, imports are well described in the aggregates in sectoral detail; prices are often absent from the tables dedicated to simulation results. Prices are hid-

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[16] *Clearly defined* means that no mix is allowed.

[17] 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).

den in the welfare indexes which play an invading role when this detail should deserve central attention and visibility. Kehoe and Kehoe (1994) say 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 may be inferred from Hoffmann (2002). He says 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 users' agenda.

In an imperfect competition environment, firms 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 the implication of this amendment to the general equilibrium framework is not, in general, 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 the zero profits assumption. Of course, a specific benchmark data set may be designed for a 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 only gives relative prices which are not observable, and he dares "argue that choosing the numeraire freely is economically meaningless".

10. Provisional Conclusions

Rowing along the computable general equilibrium mainstream, it is easy to detect the presence of other streams. The most important are the theoretical debate stream, the econometric critique stream, the economic quantitative relevance stream and the standard stream (namely, the CGE mainstream).

The theoretical mainstream critique runs parallel to the general equilibrium pillars; old (Kaldor, 1975), recent (Bowles and Gintis, 2000) and permanent (Blaug, 1992) criticism is ineffective. The criticism is directly or indirectly rooted in the "falsification principle", whereas general equilibrium economists indulge in the worship of paradigms. Needless to say, this kind of criticism is ineffective. The general equilibrium economists do not care about it.

The econometric critique is addressed to the poor use of a scarce resource: the available statistical data such as time series data of the national product and income accounts. But, CGE modellers are used to build their model from manipulated data which contains statistical data prepared to match the CGE requirements. In other words, a CGE modeller asks for a data set with data (and parameters) which fit the model, not vice versa.

The economic quantitative relevance stream is strictly related to the previous one. Its criticism focusses on the process of giving numerical value to the parameters in the model. This is the area of conflict between the "calibration" and the "system-of-equation" approaches (Kydland and Prescott, 1990).

The standard stream (that is to say, the CGE modelling mainstream) seems to live in isolation, ignoring both criticisms and the other contributions to multisectoral modelling. Kehoe, Srinivasan and Whalley (2005) edited a book "In Honor of Herbert Scarf" containing contributions presented at a conference held at Yale University in April 2002. They declare that the chapters presented in the book "build on a well-known earlier volume in applied general equilibrium, edited by Herbert Scarf and John Shoven in 1984" (Scarf and Shoven, 1984). This book contains the developments in CGE modelling occurred since the Conference on Applied general equilibrium analysis held in San Diego in August 1981. First, it is worthwhile to cite a very concise definition given by the Editors about the techniques of CGE: "calibrating and benchmarking observed data on economies into an initial equilibrium data set and then doing counterfactual policy analysis". Furthermore, considering key issues in applied general equilibrium modelling, Kehoe, Srinivasan and Whalley reveal that over the years CGE modelling has encountered 'fresh' problems and, on the other hand,

> [...] many question arise, and indeed have been raised, over the empirical plausibility of AGE model results.
> These questions range from the observations that the particular equilibrium structure and functional forms used will, to a large degree, predetermine the results and that the key parameter values used (especially elasticities) are known with little certainty to the claim that there has been little or no ex post validation of model projections. When taken together with the claim that, in practice, actual models are often une-

> asy compromise compared to their theoretically pure parents, such questions have led some to doubt that anything of value can be fount from numerical calculation resulting from these models.

These questions were obviously there twenty years ago and are still at hand. At this point, one could dispute that the CGE model architecture does not permit to find out any adequate answer.

On the other hand, Dixon and Parmenter (1996) are much more aggressive in defending the CGE domain. First they state that "Relative to CGE models, the economy-wide econometric models paid less attention to economic theory and more attention to time-series data". This statement is inaccurate; many economy-wide econometric models are built with a substantial theoretical basis though it is true that CGE models pay no attention to time-series data. Perhaps, their statement becomes clear when they say that in the 1970s "applied economists recognized the power of optimizing assumptions" so that "CGE modelling is now an established field of applied economics" and "graduate students all over the world are engaged in writing CGE theses".

Dixon and Parmenter (1996) fully show their imperialistic impulse by stating:

> Is the field past its peak? Is it in danger of going stale? We don't think so. We think that CGE modelling will generate high-profile academic careers for many years to come. More importantly, it is likely to be increasingly influential in policy making and in business.

So, it is possible to learn that the academic career may fully diverge from that of the economist who wants to learn, to be trained, to understand the working of the economy. On the other hand, thinking of the epistemological problems of economics, it is not common to find such an immoral appeal.

Some peculiarities of the CGE modelling approach detected from the literature may be summarized as follows.

- 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 simulation 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 equilibrium; what happens outside the equilibrium is not explained.
- 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.

- 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).
- CGE models may consider only relative prices which have a didactical and theoretical appeal but are not observable and hence not applicable (nor available in the "special data base" for CGE models).

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 foundation, but they produce nothing more than a giant representation of the practice to prepare textbook exercises.

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OVERLAPPING LEONTIEF
A BOOLEAN APPROACH TO ECONOMIC THOUGHT[1]

Maurizio Grassini

1. Introduction

With regard to John von Neuman's model (1945), Tjalling Koopmans (1964) in his article *Economic growth at a maximal rate* asserts that

> The [von Neuman's] paper contains the first explicit statement, known to his author, of what has subsequently been called activity analysis model of production. This is a model in which there is a finite number of production processes, each of which is characterized by constant ratios of inputs to outputs, hence by constant returns to scale.

Indeed von Neuman (1945) commences the article with another statement. «The subject of this paper is the solution of a typical economic equation system» given specific 'properties'. This 'first explicit statement' identified by Koopmans and subsequently used as a yardstick to classify a number of economic models has also been as a foundation stone to build up the so-called 'theory of production'. This theory starts from that 'explicit statement' seen as a matrix containing commodity flows as the input of industries, (a matrix representing 'methods of production', to use a favourite of Sraffa's) and with the language of matrix algebra and vector spaces there is a lot to play with, so that the 'theory of production' has expanded into a distinctive body of mathematical economics in its own right. Getting back to economic papers using the lens of mathematics, the foundation stone of activity analysis was used to draft a number of economic models. Theory of production specialists used to refer to John von Neuman, Wassily Leontief and Piero Sraffa's economic models as theoretical approaches having a common base. It was from this common base that such models acquired their true economic effectiveness.

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[1] Paper presented the 19th International Input-Output Conference Alexandria, Virginia, USA, 13-17 June 2011; unpublished.

Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online),

2. The historical environment of the models

First of all, let us describe the historical scenario of these models.

In the introduction to readings on *Growth economics*, Amartya Sen (1970) writes:

> The war-damaged economies were trying hard to reconstruct fast, the underdeveloped countries were attempting to initiate economic development, the advanced capitalistic countries being relatively free from periodic slumps were trying to concentrates on raising the long-run rate of growth, and the socialist countries were determined to overtake the richer capitalistic economies by fast economic expansion […]. With this immensely practical motivation it would have been natural from growth theory to take a fairly practice-oriented shape. This, however, has not happened […].

However,

> […] even in these rather esoteric studies growth theory has thrown up issues that are more than theoretical, and the literature is worth reading not merely for intellectual delight (is such are sources of one's delight) but also for noting major questions of importance, even though the answers are usually not very clear.

In this context, von Neuman's model was introduced through the aforementioned article by Koopmans. The title – *Economic growth at a maximal rate* – contains what seems the essence of the economic insight given by this model, described in a paper of 9 pages. As far as references to articles and books reporting the model, it seems that von Neuman did not add any further contributions subsequent to its presentation apart from the association with the turnpike theorem (which is, precisely, a theorem). The economic curiosity supported by this model is that today we could have been better off having preserved the economic structure of our country, let us say, from two centuries ago. In fact, in this model, 'economic growth at a maximal rate' is achieved when all the sectors of the economy grow at the same rate. No one affirms that maximization of economic growth is the basic economic objective; however, in this respect von Neuman's model does not throw any remarkable new light.

In 1943 (and in 1951 for the second edition), Wassily Leontief published *The Structure of American Economy, 1919-1939, An Empirical Application of Equilibrium Analysis*. Dorfman, Samuelson and Solow,(1958) presented Leontief's basic monograph on his input-output approach, writing: «In addition to a statement of the theory, the volume includes input-output tables for the United States for 1919, 1929, and 1939 and three applications for the techniques to current economic problems». Here, it is important to note that Leontief's seminal book on input-output approach contains:

a) 'a statement of the theory',
b) 'input-output tables for the United States' and
c) 'applications… to current economic problems'.

A few years later, Leontief (1953) published *Studies in the structure of the American Economy* containing reports by members of the staff of the Harvard Economic Research Project on a number of aspects of input-output analysis. Among the topics treated was the stability of input-output coefficients over time, a dynamic input-output model, and detailed research into the production functions of a number of industries. Interactions between theory and empirical applications were to characterize the scientific production of Leontief for many years to come.

Sraffa published his *Production of Commodities by means of Commodities* with a meaningful sub-title: *Prelude to a critique of economic theory* in 1960. Sraffa's book is divided in three parts: Part I – *Single-product industries and circulating capital*; Part II – *Multiple-product industries and fixed capital;* and Part III – *Switch methods of production*. The second and third parts offer abundant material for addressing intellectual resources to on purely theoretical and apparently practical problems. The first part is much more interesting, mostly on the grounds of the history of economic thought. In this part, Sraffa makes a basic distinction between *Production for subsistence* (Chapter I) and *Production with surplus* (Chapter II). He considers production for subsistence typical of a «simple society which produces just enough to maintain itself». Commodities are used to produce commodities and part of them (as inputs) are used «as substance for those who work». This society, as opposed to a 'simple' one is what existed before the industrial revolution[2]. 'Production with surplus' characterizes an economy which «produces more than a minimum necessary for replacement and there is a surplus to be distributed»; that is to say, the economy which came to light with the industrial revolution. The innovative event is the novelty of the surplus «because the surplus (or profit) must be distributed in proportion to the means of production (or capital) advanced in each industry»; Sraffa adds that «the rate of profits […] must be uniform for all industries» and affirms that «the system is assumed to be in a self-replacing state». Now, in the prices of commodity equations, the rate of profit plays the role of a mark-up while wages are considered the price of a unit of labour; Sraffa writes:

> We suppose labour to be uniform in quality or, what amounts to the same thing, we assume any differences in quality to have been previously reduced to equivalent differences in quality so that each unit of labour receives the same wage.

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[2] A very effective description of the historical period of that 'simple society' is in Pasinetti (1980).

Subsequently, wages and the rate of profit are assumed equalized between sectors.

«One effect of the emergence of a surplus must be noticed», Sraffa writes. This effect is that «now there is room for a new class of 'luxury' products which are not used, whether as instruments of production or as articles of subsistence, in the production of others' commodities». And it is made clear that «these products have no part in the determination of the system. Their role is purely passive». The distinction between the old class of commodities and the new class, denominated 'luxury' commodities, is crucial to understanding Sraffa's representation of the economic system. He says: «If an invention' modifies the method of production of a luxury commodity this will impact on its price»; however, «the price relations of the other products and the rate of profits would remain unaffected. But if such a change occurred in the production of a commodity of the opposite type, which does enter the means of production, all prices would be affected and the rate of profits would be changed». This statement makes what Sraffa means by the «purely passive […] role» of luxury commodities as far as their impact on prices and the rate of profits, clear. A luxury commodity is defined considering what would happen «if we eliminate from the system the equation representing the production» of it. And in contrast, what happens «if we eliminate one of the other, non-luxury, equation». The elimination of a luxury commodity does not affect the production of non-luxury commodities. If a non-luxury commodity ceases to be produced, the economic system collapses (Sraffa says: «the system would become indeterminate»).

Examples of luxury goods are instructive. Some of them may be used just for their reproduction, like racehorses. Others are used directly or indirectly for their production; the example is given of ostriches which give ostrich-eggs and feathers. An example of an intermediate luxury product is raw-silk. Given these examples, we should assume that the elimination of racehorses, ostriches and silk-worms would not produce any impact on the economic system. It might prove difficult to share this assumption with the people living in Suzhou, China, but then we must not forget that such examples came from Cambridge, UK.

In our time, the example of a non-luxury commodity might be represented by electricity. If electric plants are switched off, the economic system suddenly collapses.

After the introduction of this kind of particular commodity, the distinction between luxury and non-luxury is maintained by renaming commodities respectively as *non-basic* and *basic* products.

Sraffa writes: «We have up to this point regarded wages as consisting of the necessary subsistence of the workers and thus entering the system on the same footing as the fuel for the engines or the feed for the cattle». This approach to wages may be informative about the world represented in *Production for subsistence*. This world was mostly characterized by a labour force of serfs such as the world described by Nicolaj Vasilievich

Gogol in *Dead Souls*; there, the commodities used to maintain and reproduce the workers are properly considered a means of production. But, in production with a surplus,

> We must – Sraffa writes – now take into account the other aspect of wages since, besides the ever-present element of subsistence, they may include a share of the surplus product. In view of this double character of wage it would be appropriate, when we come to consider the division of the surplus between capitalists and workers, to separate the two component parts of the wage and regard only the 'surplus' part as variable; whereas the goods necessary for the subsistence of the workers would continue to appear, with the fuel, etc., among the means of production.

Because of the presence of the surplus, in order to model the price formation of the *basic* products, the amount of labour times the wage per unit of labour (which represents the surplus part of wages) is added to the cost of production. This model aims to draw from some of Marx's ideas. The subsistence located among the means of production is 'wage goods'. The surplus is divided according to the result of the 'class struggle'. However, the part of surplus conquered by the workers spent to buy *non-basic* goods may be considered a capitalistic dissolute attitude, which is in striking contrast with the celebrated virtue of the working class.

The model with a surplus and labor together with the means of production appears suited to tackle the problem of the *Reduction to dated quantities of labor*. This problem is treated in Chapter VI, the last chapter of Part I. Here, the transformation question finds an answer. The economy ahead of us has reached a long-run equilibrium. We do not know how we got it and no scarcity constraints hit the reproduction of input and output; labor – the 'primary factor' – is abundant being available from the Marxian 'industrial reserve army'. In this long-run equilibrium, the rate of profit and wage per unit of labor is the same across industries. Sraffa moves backward along the time axis from this equilibrium to measure the content of labor in the unit of *basic* commodities. The transformation does not give the desired result. In fact, the 'value of labor terms' turns out to depend on the distribution of the surplus. This investigation reveals the peculiar perspective of the Sraffa's modelling approach.

Sraffa' book, Part II and Part III are another story.

3. The modelling perspective. Travelling along the time axis

J. von Neuman left his model in the hands of mathematical economists. They played with it travelling in the forward direction of the time axis. This is why this model is usually found in the field of growth economics. The main contributions supported by von Neuman's model concern the sectoral as well global rate of growth and curiosities such as the turnpike theorem (see Koopmans, 1953).

Sraffa supports his representation of the production of commodities by means of commodities in the presence of a surplus with a group of assumptions; among them, that the rate of profit and the unit labour cost – the wage – are equalized between sectors. Then, he moves backwards along the time axis trying to evaluate the amount of labour embodied in the present prices of commodities. That is to say, the transformation problem of the past into the present in terms of the quantity of labour, representing the primary factor which, according to a Marxian point of view, moves everything.

Leontief skips along the time axis. In his book (Leontief, 1943), he touches on three years, 1919, 1929 and 1939, and takes a picture of the observed economy of the United States. Leontief's research strategy is clearly revealed from the structure of his book. The first edition is composed of three parts. Part I: Quantitative input and output relations in the economic system of the United States in 1919 end 1929; Part II: The theoretical scheme; Part III: Data and variables in the American economic system 1919-1929. The second part – the theoretical scheme – comes after the definition of fundamental concepts of national account items and their statistical application, and before the use of the input-output table for studying price and output reactions, the behaviour of individual industries and structural change investigations. The second edition reproduces the three parts of the first edition 'without any changes' and presents a fourth part: the application of the input-output technique to the American economic system in 1939.

4. The observed economy and the imagined economy.

In von Neuman' article there is no sign whatsoever of an observed economy. In fact, von Neuman declares that the article simply deals with «the solution of a typical economic equation system». Furthermore, he makes it clear that «The present paper was read for the first time in the winter of 1932 at the mathematical seminar of Princeton University. The reason for this publication was an invitation from Mr. K. Menger, to whom the author wishes to express his thanks». As far as the literature quoting this model, von Neuman did not spend any further intellectual energy on this subject. Whereas it is clear that Mr. K. Menger is the sole person responsible for having introduced von Neuman's contribution to the field of economic theory.

Sraffa mentions commodities which can be found in any observable economy: wheat, pigs, iron, coal, ostriches, racehorses, eggs and so on. But Sraffa distinguishes commodities into basic and non-basic. This distinction is crucial to identify a real economy. That is to say, it is not sufficient to list commodities produced in a given economy because we must distinguish those commodities which represent the core of the economy and these basic commodities must be known in advance. Unfortunately, some Sraffians demand economic data describing Sraffa's vision of the (capitalistic) economy. No one has ever seriously been engaged in translating Sraffa's definitions of basic and non-basic commodities into the industrial census classifications. On the other hand, Country Statistical Bureaus are not accustomed or interested, in producing national account data seen through Sraffa's eyes.

Leontief's contributions to input-output analysis are characterized by a rooted empirical approach. His book (Leontief, 1943) inserts the *theoretical scheme* between *fundamental concepts and statistical applications* and the *data and variables of the American economic system*. Later in the *second enlarged edition*, on the basis of this theoretical-empirical approach a fourth Part was added; it deals with the application of input-output techniques to the American economic system *observed* in 1939. The research approach behind Leontief's book (Leontief, 1951) is clearly seen in the acknowledgement in which Leontief affirms that the research was done thanks to the generous support of the Harvard Committee on Research in Social Sciences and writes:

> Maynard Heins, Orville McDiarmid, and Louis Weiner were to a large extent responsible for the difficult task of gathering and organizing the basic statistical material. Whatever deficiencies may be discovered in this part of the work – and doubtless there are many – they certainly are not due to any lack of workmanship or technical ingenuity on part of these skilled statisticians.

While von Neuman delivered and abandoned his *solution of a typical economic equation system* and Sraffa indulged with his economic model to tackle problems concerning the viewpoints of some classical economists intermingled with ideological concepts, behind Leontief's work there was a research group involved in a huge empirical task supported by and interacting with a theoretical scheme.

Hence, one should not be surprised by the fact that Leontief's input-output table soon became popular. Rooted in observable and observed economic phenomena, it attracted every economist and statistician involved in the construction of national accounts. Today, input-output tables are the cornerstone of the national accounts of European Union Member States. Consequently, Leontief's contribution lies behind every multisectoral macroeconomic model structure.

5. The research environment

Von Neuman presented his model in a seminar and wrote the paper (von Neuman, 1945) invited by Mr. K. Menger.

Sraffa in his book declares that he refers to «old classical economists from Adam Smith to Ricardo», stressing that he shunned any «marginalist» interference. Among the contemporaries, only Lord Keynes is mentioned as having read «a draft of the opening proposition of this paper» in 1928 (thirty years before the publication of his book). Afterwards, he worked alone on the subject. He took advantage of A.S. Besicovitch, Frank Ramsey and Alister Watson for «mathematical help over many years […] at different periods». Sraffians flourished only after the publication of the book *Production of Commodities by means of Commodities* and suddenly Sraffa became totally silent, in the sense that he did not even answer those questions posed by "pilgrims" visiting him at Cambridge.

Leontief directed many projects which involved a number of researchers, published many papers related to input-output analysis before and after the publication of the book mentioned above. He trained many students who later became collaborators and academic colleagues.

6. A method of discovering similarities

A method of highlighting the common roots of economic contributions may be represented by a 'Boolean approach' applied to the field of 'economic thought', as follows:
(John von Neuman)& (Piero Sraffa)& (Wassily Leontief) = (Theory of production)

Since then the 'theory of production' has been used as a junction to easily travel from one economic field to another. Educated and living in one of these fields, we may be told that we have close relatives somewhere in the world of economics. At first glance, this is good news; it is largely preferable not to be alone in the universe. This news become less welcome when we are told we are indebted to someone we have never met in our life (by economic literature examined in our area of scientific interest).

Karen Polenske and Anne Carter, two Leontief students and later colleagues, implicitly admit that they ignore the existence of any scientific relations outside Leontief's scientific environment. In the special session in Memory of Wassily Leontief at the 13th International Input-Output Association Conference, Karen Polenske opened her speech on *Leontief's Magnificent Machine and other Contributions to Applied Economics* with the statement: «Wassily W. Leontief was an excellent theorist»; furthermore, she stressed that «he [Leontief] was extremely critical of most economic theorists, especially of those who failed to understand economics as an empirical and applied science». In particular he sharply criticized economists who tended to separate pure theory from empirical investigation as he considered empirical analysis a necessary «descriptive complement of […] theoretical analysis (Leontief, 1954)».

In the Newsletter of the International Input-Output Association (Special issues in memory of Wassily Leontief on occasion of the 10th anniversary of his death, February 2009), Anne Carter wrote that «Leontief's focus was radically different from that of his mainstream colleagues. Some even question whether what he did was truly economics or a different discipline entirely». In fact, «Instead of explaining the market system and its optimizing properties, he simply described the interdependence of sectors in quantitative terms and explored the nature and the consequences of that interdependence».

Karen Polenske remembered that Leontief «expressed dismay that some economic theorists believe they are doing empirical studies». This criticism should be emphasized even more nowadays in the face of the widespread practice of concluding economic papers with the sentence "Some implications for economic policy", such contributions being clearly irrelevant for economic policy. Furthermore, living inside their ivory tower, theorists, who are proud not to have any contact with the observable economy, frequently claim 'empirical evidence' for their theoretical ideas; it is a matter of fact, that such empirical evidence is cited but does not exist or is incorrectly referred to, as is clear to economists who are used to considering observable economic phenomena as the source and support of their theory.

7. Timing, similarities and their relevance

The Joint production problem – one of Sraffia's strong points – deserves a special mention in a Boolean approach to economic thought. Klein-Morishima's debate on production functions and input-output coefficients took place in the '50s (Klein, 1952-1953, 1957, Morishima 1956-1957, 1957), long before the publication of Sraffa's book. First, Klein (1952) observed that

> [...] input-output analysis introduced by Leontief and his followers raises basic questions of economic interpretation. Are the elements of input-output tables structural parameters of an economic system or are they merely ratios of two economic variables? If input-output coefficients are truly structural parameters, can they be identified with well defined technological parameters or are they mixtures of several types of parameters including some that are not purely technological?

Then, he emphasised that «in the standard assumptions of input-output analysis [...] the unrealistic assumption is made that each sector of the economy produces only a single type of output». And «in contrast with other studies», Klein said, «[he] drops the assumption that each sector produces on a single output. We shall allow joint production in each producing sector. This is not to be regarded as a mere refinement since joint production is the rule and not the exception». Morishima (1956) shared this point of view: «the case in which each sector produces only one output is not realistic. In fact, joint production is not an exception but a rule». This awareness is strongly supported by the inclination to look at the observable economy as emerged in Klein's comment (1952) «[…] even if input-output tables are refined to 1000x1000 classifications, the problem of joint production cannot be avoided».

Later, the joint production problem was tackled by splitting the input-output table into two tables named 'make (or supply)' and 'use'. Depending on the constraints satisfied in the data collection process, the two tables are used to deal with the distinction between products and industries, the latter being affected by 'joint production' in terms of products. At present, the input-output framework of the European System of Accounts (ESA 1995) consists of three types of tables:

1) supply tables,
2) use tables and
3) symmetric input-output tables.

The symmetric input-output tables are derived from the supply and use ones. In this process, 'joint production' may cause 'economic inconsistency'. The remarkable inconsistency is represented by the emergence of negative input-output elements. Of course, intermediate consumption input-output flows are constrained to be non-negative and such a non-sense outcome must be tackled by looking into a number of potential sources.

Chapter 11 of the Eurostat *Manual of Supply, Use and Input-output Tables* (2008) contains a detailed discussion (supported by an exhaustive set of numerical examples) on the computation of symmetric input-output tables. Joint production is not stated as a pure theoretical hypothesis; empirical cases are seriously taken into account; different approaches to distinguishing product technologies from the observed industries technologies are presented. Konijn (1994), Thage (2002), Thage, ten Raa (2006)'s contributions are presented with special focus and a detailed presentation of Almon's method (2000) and evaluated as a proposal to overcome the problem of negative input-output flows in symmetric input-output tables derived from supply and use tables. Although 'joint production' is a strong point raised by Sraffians, no contribution from this theorist is mentioned. However, according to the *Sraffian Research Programmes and Unorthodox Economics* listed by Aspromourgos (2004), 'joint production' does not turn out to be among the subjects of the 'Sraffian Project'.

All in all, the absence of the 'joint production problem' among the subjects of the Aspromourgos (2004) 'Sraffian Project' should not be considered an oversight. In fact, some theorists are inclined to create problems, not to solve them.

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PART II

ESSAYS IN HONOR OF MAURIZIO GRASSINI

EMPIRICAL ECONOMICS AND ECONOMIC DATA – SOME REMARKS ON AN UNEASY RELATIONSHIP[1]

Josef Richter[2]

1. Introduction

In contrast to many other empirical sciences those engaged in empirical economics do not make their observations themselves. This is particularly the case for all macroeconomists. Economic reality is primarily perceived through the eyes of the statistical system of the country. Economists have to work with what data are made available by Statistical Offices and with material that was collected with some other purpose in mind. As Zvi Griliches once stated in his Presidential address to the American Economic Association «our understanding of what is happening in our economy is constrained by the extent and quality of the available data» (Griliches, 1994, p. 2). In the same speech Zvi Griliches identified three main sources for what he called the 'data woes'. The first one is that some of the measurement problems are really hard. The second one is that economists have little influence as far as the data-collection activities are concerned and last but not least that economists themselves do not put enough emphasis on the value of data and data collection. In the academic world 'data issues' are not considered to be 'fancy enough'. Or as Zvi Griliches once put it, «it is the preparation skill of the chef that catches the professional attention, not the quality of the raw material which was used to prepare the meal» (Griliches, 1994, p. 14).

The division of labour between data producers and data users would require a permanent and intensive dialogue between these two groups to guarantee the proper use of the data in economic analysis. Unfortunately such a dialogue rarely takes place. As it was pointed out by Robert Eisner in another Presidential address

> […] somehow econometricians, theorists, and economic analysts of all stripes have lost essential communication with the compilers and synthesizers of their data. As a consequence, popular discourse, policymaking, and basic principles of economics have suffered inordinate confusion (Eisner, 1989, p. 2).

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[1] The term 'uneasy relationship' was borrowed from an article by Griliches (1985).

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Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online),

A third quotation from a Presidential address may be considered as another hint that the leading experts in the field are well aware of the problematic relationship between the producers of data and empirical economists: «In too many instances sophisticated statistical analysis is performed on a data set whose exact meaning and validity are unknown to the author» (Leontief, 1971, p. 26).

Unfortunately this relationship seems to be a topic for Presidential addresses only. In the everyday life of many empirical economists the specific nature of economic data and the relationship to the theoretical models is simply ignored. Economists tend to neglect the fact that «there is no such thing as a level of output [...] independent of the statistical operations involved in its measurement» (Arrow and Hoffenberg, 1959, p. 96).

Such a lack of awareness was not always the case. In the early days of econometrics Ragnar Frisch stated: «The connection between statistical and theoretical relations must be thoroughly understood» (Frisch, 1938, p. 2). «The method of econometric research aims, essentially, at a conjunction of economic theory and actual measurements, using the theory and techniques of statistical inference as a bridge pier» (Haavelmo, 1944, p. iii). In his seminal work 'The probability approach in econometrics' Trygve Haavelmo underlined that in the world of empirical research one has to choose 'observable facts' to which the theoretical model is to be applied. He made the important distinction between 'theoretical variables', 'true variables' and 'observational variables'. «The 'true variables' represent our ideal as the accurate measurement of reality while the variables defined in a theory are the true measurements that we should make if reality 'as it is in fact' were actually in accordance with our theoretical model» (Haavelmo, 1944, p. 5). 'Observational variables' are the outcome of the attempts of statisticians to provide the best approximation to the 'true variables'.

This short contribution will touch upon only a very few selected aspects of the empirical foundations of empirical economics.

2. Some characteristics of economic data

2.1 Few direct observations

«In general, the official statistical yearbooks are the place where economists "observe" the extant economy» (Grassini, 2007, p. 320). Economic data as they can be derived from statistical yearbooks and data banks are the outcome of a complex process characterized by a high degree of division of labour and a long chain of subsequent steps. The interesting phenomena are usually neither observed by the statistical authorities themselves nor by the respondents who are approached by the statistical authorities. As regards characteristics such as employment and wages and salaries, the respondent himself relies on information collected by colleagues in the personnel department. As far as the variables covering output and intermediary inputs are concerned, information is derived from the accountants' department. The information provided by these colleagues is in turn based on elementary information collected by different people with a different background and having different (non-statistical) goals in mind. The information that is available at this stage is to a high degree affected by institutional factors, in particular by the tax and the social security systems.

In economic statistics the often quite demanding concepts of economic statistics have to be communicated to everybody involved in this chain of producing the basic information. In this process context borders need to be crossed, and there is always the danger of misunderstandings and misinterpretation. The specific 'language problems' may have a significant impact on what is reported in questionnaires. The raw material resulting from questionnaires or available from administrative sources is then processed by the statistical authorities.

In this process – and in particular on the route from micro to meso data and finally to macroeconomic data – three different types of models are involved, which result in data of quite different cognitive character.

2.2 Models to generate statistical data[3]

i. Models of Type 1. Condensation of information

Once the main procedures of checking and editing micro data are completed then the steps of classification, consolidation and aggregation are done. Each of these steps has a theoretical background; none of them is neutral with respect to the final use of the aggregates. It is worthwhile mentioning that classification and aggregation are also done on the micro level, long before statistical authorities apply their criteria.

Classification and aggregation are inevitable stages in arriving at statistical results. If the processes are well documented, the implications of applying models of this type are quite clear to users.

The design and the calculation of indices of all kinds also fall within this group. Elementary information is condensed with a specific analytical goal in mind. The user has to know the index formula, the weighting scheme and all the other technical details if he/she wants to make appropriate use of the index results. The choice of an index formula, of a base year, a level of aggregation, each of these decisions is of course also theory-laden.

It is not possible to discriminate between various conceptual alternatives on the basis of empirical tests. Sensitivity studies however can provide some insight into the robustness of the results with respect to modifications in the basic decisions.

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[3] For a more elaborate discussion see Richter (2002).

ii. Models of Type 2. Substitution of information – Generating data elements which are observable

Models of this type substitute observations by model results although the target variable could – at least in principle – be observed. Models of this type are based on a functional relationship, in which both the dependent variable and the explanatory variables are observable. Therefore it is – at least under certain circumstances – possible to empirically test the underlying functional relationship and to estimate parameters.

This type of model is primarily used in order to save resources in Statistical Offices and/or to reduce to response burden. Typical examples are:

- Imputations, either in the case of item non-response or unit non-response.
- Sampling instead of collecting data from all the units can be considered as a special case of unit non-response.
- Forecasting models; functional relationships observed and estimated for a past period can serve as the basis of forecasts if one of the variables becomes available earlier than the other. Information on employment is often used to estimate total output or value added. Most flash estimates and updating procedures comprise at least some elements of this model type.
- All kinds of model estimates, so frequently used in the compilation of national accounts data, such as in the following examples:
  - Use of information on purchases instead of information on inputs by products; in such a case a functional relationship is assumed between 'purchases' and 'inputs' to get rid of the inappropriate classification along the time axis.
  - Use of information on stocks instead of data on inputs; data on the number of cars by industries is used to estimate the maintenance cost of cars by industries.
  - Use of information of closely related variables; input of fuel is assumed to be proportional to the input of tyres. Then the known fuel input by industries can be used as explanatory variable for estimating the input of tyres. The parameters could be either derived from engineering information or from a small sample.
- Balancing, reconciliation; models of this class are starting from available but not consistent observations (or model results) with the aim to achieve a consistent solution. It is worthwhile mentioning that in an ideal coherent statistical system with no errors in observation etc, balancing would not be necessary. In all cases in which the entire discrepancy is not allocated to a single element, balancing procedures destroy the direct link between the elementary observation and the resulting aggregate.

All results based on models of Type 2 are dependent on the specification of the underlying functional relationship and on the validity of the parameters estimated. Since it is possible to empirically evaluate these relationships, tests can provide some insight whether the model is adequate and into the robustness of the estimates.

iii. Models of Type 3. Generation of elements which are not observable

In models of this type data elements which are not observable at all are substituted by observed variables. The essence of this approach is a kind of 'relabeling of information'. Models of this type rely on functional relationships, in which the explanatory variables are observable but the dependent variable is not. Therefore it is not possible to empirically test the underlying functional relationship and to estimate parameters. The decision in favour of one of a number of alternatives has to be taken on the basis of a priori considerations.

The aim of such models is always to proceed beyond the limits of observability. Two subgroups can be distinguished:

- Generating data outside the domain
  Models of this type try to generate data outside the domain in which these variables are observable. The treatment of rents in national accounts is an illustrative example. Rents paid are of course observable, as they are based on transactions. The imputed rents for owner occupied houses and apartments have no counterpart in the world of observable transactions. If it is the intention to include these services into the output of real estate, we have to assume some relationship between factors such as size and quality on the one hand and the rent on the other hand. This relationship can be tested within the domain of transactions but not beyond this domain.
- Relabeling information
  Models of this type generate information which is not observable at all. In this case one has to rely on conventions or on a priori considerations. The definition of output of non-market producers as the sum of inputs is a well-known example for a model of this type.

The estimation of capital stock can be seen as a borderline-case between the models of Type 2 and 3. Some assets might be observed directly, the big majority of assets is not observable according the concepts of national accounts. De facto and following the proposals of the System of National Accounts (SNA) capital stock and consumption of fixed capital are calculated on the basis of some version of the Perpetual Inventory Method. As the SNA 2008 acknowledges

> […] estimating the value of capital stock is not a straightforward process. Whereas it is possible to measure all new capital formation un-

> dertaken in a year directly and simply aggregate it, estimating the total value of a stock of assets, even of the same basic type, but with differing characteristics and of different ages, is not simple. Thus measures of capital stock must be derived indirectly and this is conventionally done by making *assumptions* (emphasis added) about how the price of an asset declines over time and incorporating this in a *model* based on the perpetual inventory model (PIM) (SNA 2008[4], 20.8).

Capital stock is the result of *observed* capital formation in the past, adjusted to the price of the current year and many *assumptions* about the decline in price, age-dependent efficiency, estimated life lengths and retirement patterns of assets and the like. Some of these assumptions might be inspired by some empirical background; most of them are mere assumptions. Despite these characteristics capital stock figures enter equations as if they were observations.

2.3 Conglomeration of information of different nature

Most aggregates – even after the first steps – consist of layers of different nature. The size of these different layers is unknown to the user and – in most cases – even to the Statistical Office. What is presented in the publications is by no means homogeneous. It is not only aggregation over different layers of reliability. It is aggregation over elements which are of different cognitive character. From a methodological perspective it is adding up elements that are not commensurate. Aggregation results in conglomeration.

One of the big challenges for users is that usually data of a descriptive nature and the results of models are not shown separately. Instead, they are merged together like 'market output' and 'non-market output'. In a number of industries the share of 'non-market output' in total output is quite high although 'non-market output' and 'market output' considerably differ from a conceptual perspective. Only few Statistical Offices like Statistics Austria provide some numerical insight and publish total output figures distinguishing between 'market output', 'output for own final use' and 'Other non-market output' (Statistik Austria, 2013). In the breakdown according the European standard activity classification NACE Rev. 2 in most industries 'market output' is dominating. On the other hand there are a number of industries such as 'Public administration', 'Education', 'Membership organisations' where the share of 'non-market output' in 'total output' exceeds 90%. And there are industries like 'Real estate' and 'Residential care services' with a share of 'non-market output' in 'total output' around 50%. As might be seen

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[4] European Commission, IMF, OECD, United Nations, World Bank (2009) referred to as SNA (2008) adding the chapter number.

from these few figures, even total output by industries is very inhomogeneous as far as the basic concept behind the figures and the cognitive character are concerned.

2.4 The role of coherence

Coherence is a necessary condition for information from different statistical sources to be meaningfully combined in an analysis. The main criteria to be met are that the data are based on the same statistical units, the same reference period, the same coverage, the same breakdown, the same basic concepts, etc. When some of these criteria are not completely met, the analysis might be limited to a subset of activities covered by all sources or to a level of disaggregation for which a common denominator exists in all the sources. In such an environment, different variables (based on different definitions) in the underlying sources can be combined for analytical purposes.

One of the problems of empirical economics is that the system of economic statistics is the result of a long evolution. The various sub-systems were developed with different analytical goals in mind and a blue-print in the background to guarantee consistency was to a large extent missing. In particular the different statistical units used in the different sub-projects cause severe problems. Because classifications (and a number of variables such as output) are 'unit dependent' many results presented in standard classifications are only seemingly comparable. Only few insiders are aware that basic criteria of coherence are quite frequently violated.

One of the main reasons why national accounts have become the dominating 'language of macroeconomics' is that the system of national accounts is designed as a statistical framework that provides a comprehensive and consistent set of macroeconomic accounts for policymaking, analysis and research purposes. «The central framework of the SNA is consistent in terms of its concepts and its accounting structure» (SNA 2008, 2.159). Users reading such statements assume that all parts of the system can be combined in analyses without any difficulties and worries. The coherence achieved by national accounts has its price. The system often proceeds beyond the frontiers of the domains in which direct observation is given. In order to arrive at a comprehensive picture, data belonging to different categories of information are combined.

Data belonging to different categories of information can also often be identified in time series. In many cases the last elements in a series are based on some model of Type 2, whereas all the other elements result from models of Type 1. In particular politicians and business cycle analysts strongly argue in favour of 'up-to-date' information. Statistical Offices are forced to publish shortly after the reference period. The product which is delivered to users does however not completely consist of observed facts but is the outcome of model calculations with some theoretical model about the business cycle in the background.

Another important aspect of coherence is numerical consistency. Reconciliation plays an important role to make basic data consistent. Because of errors and omissions in the underlying data (deviations of the 'observational variables' from the 'true variables') the basic data has to be adjusted to meet a priori given criteria.

3. Input-output statistics – the empirical foundations of input-output analysis

Wassily Leontief defined input-output analysis «as a general methodological approach designed to reduce the steadily widening gap between *factual observations* (emphasis added) and deductive theoretical reasoning» (Leontief, 1989, p. 3). «Input-output exemplifies Leontief's intuitive sense for simple, powerful theory, and respect for real-world fact» (Carter and Petri, 1989, p. 8) or as Maurizio Grassini has put it «Leontief's contributions to input-output analysis are characterized by a rooted empirical approach» (Grassini, 2011, p. 5).

From these few quotations one can conclude that in the tradition of input-output analysis more emphasis was put on the empirical basis than in other fields of empirical economics. Leontief himself had a strong preference for using engineering data.

Starting from the underlying methodological considerations and not from the de facto situation some authors argue that «input-output analysis is based exclusively on magnitudes that are *directly observable* (emphasis added) and that can be measured using the ordinary instruments for measurement in economics» (Kurz and Salvadori, 2006, p. 373).

Such a view neglects the fact that most input-output analysis is based on input-output tables fully integrated in economic statistics and in particular in national accounts. In the long sequence of steps which lead from the basic observation of some aspects of economic reality via economic statistics to the input-output table (Blackburn, 1996; Richter, 2002) information taken – using the terminology used by Richard Stone in his 1984 Nobel Memorial Lecture (Stone, 1986) – from the box labelled 'facts' is combined with data taken from the box labelled 'model results'. Input-output statistics share a number of the general characteristics of economic data mentioned above.

In this sequence of steps to an input-output table, supply and use tables can be seen as an important intermediate stage. They serve as a coordinating framework for economic statistics, both conceptually for ensuring the consistency of the definitions and classifications used and as an accounting framework for ensuring the numerical consistency of data drawn from different sources (SNA 1993[5], 15.3).

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[5] European Commission, IMF, OECD, United Nations, World Bank (1993) referred to as SNA (1993) adding the chapter number.

The SNA states that supply and use tables are *data-oriented in nature* (emphasis added) whereas the (so-called) symmetric tables are always constructed from having made certain analytical assumptions (SNA 1993, 15.7). Most users familiar with the SNA will therefore suppose that supply and use tables consist of 'facts' only or on data which at least 'in principle' could be directly observed.

They are aware that these 'statistical' supply and use tables provide the foundation from which the analytical input-output tables are constructed (SNA 1993, 15.7). They recognize that all the entries they find in the analytical (symmetric) input-output table are model results based on specific hypotheses.

They are less aware that in order to arrive at 'statistical' supply and use tables a number of modelling steps are unavoidable which alter the cognitive character of the results. Three steps deserve special attention.

3.1 Data on the establishment level

From a theoretical viewpoint the units to be aggregated to industries should be homogenous with respect to the underlying production technology used. As a way of operatonalising this criterion the SNA states that in order «to study production and production functions in detail, it is necessary to refer to more homogeneous units. This unit is the establishment» (SNA 1993, 2.44).

In order to arrive at more homogeneous unit, enterprises which consist of more than one establishment have to be partitioned into separate establishments (SNA 1993, 15.13). Measuring the output by products for each of the establishments usually causes no major difficulties. Problems arise on the input side. All inputs of such units are at least 'in principle' observable on the level of the enterprise. Some, but not all inputs may also be observable on the level of the establishment.

If the production programs of the different establishments belonging to one enterprise are quite distinct, the allocation of the 'embodied material' (Arrow and Hoffenberg, 1959) or 'direct material' (Sevaldson, 1970) can be based on technical knowhow. In most cases, however, the allocation of all non-specific inputs and overheads to establishments has to be based on some assumptions.

If the allocation is based on the consideration that the non-specific inputs are proportional to indicators like the total output of the establishments or the number of employees, this hypothesis corresponds to the industry technology assumption. If the allocation of non-specific inputs like costs for handling and transportation is done proportional to some specific output indicator (tons produced, for example) or the share of a specific product in the output-mix, this hypothesis is equivalent to the commodity technology hypothesis. Modelling procedures of this kind have to be and are used by many different people who have to fill in questionnaires.

For an ‘outsider’, and to some extent even for the Statistical Office, it is impossible to assess which hypotheses have already gone into the data generating process which resulted in the basic statistical data. The share of multi-establishment enterprises in the total population of units may give some broad indication of the order of magnitude of the problem.

3.2 Steps from use tables at purchasers’ prices to use tables at basic prices.

The basic identity on which input-output analysis rests is that total supply of a given product equals total demand for this product. This identity only holds if the valuation of supply is equal to the valuation of demand.

Supply by products is observable at producers’ prices and basic prices. Use data as reported in the use table are observable at purchasers’ prices. Both data may have strong ties to basic statistics, although a series of imputations, reconciliations and other national accounts requirements in fact usually entail considerable and varied compilation work on basic data to complete and balance the supply and use tables (SNA 1993, 15.122).

In order to balance supply and demand it is necessary to have at least a vector of distributional margins in a breakdown *by products*. What is observable is a vector of margins *by industries*. What has to be estimated is a complete matrix (in the real world a number of different matrices) which provides a cross classification of distributive margins by producing industries and by products. Under very favourable circumstances a subset of elements in this matrix might be observable, but most of the elements will not be observable. What is observable is the turnover by industries and by products. Such a matrix can be seen in analogy to a make/supply matrix and can be used as a starting point to calculate distributive margins such as trade margins by products (Rainer, 1983). The calculations have to rely either on the assumption of product technology (the same margin by product independent of the industry), industry technology assumptions (the same margin for all products distributed by an industry) or a combination of these assumptions. In any case the step of arriving at these vectors of distributive margins goes far beyond the domain of descriptive statistics.

The use table at purchasers’ prices can be seen as the sum of the following matrices:

- Matrix of domestic production at basic prices,
- Matrix of imports,
- Matrix of trade margins,
- Matrix of transport margins,
- Matrix of taxes on products,
- Matrix of subsidies on products.

The process of arriving at a use matrix at basic prices usually starts from a use matrix at purchasers’ prices. In order to transform the use table to basic prices, each element of the table must be decomposed. This can be seen as estimating similarly sized tables of the format products by uses, each of which contains all the items for one of the components. Intermediate and final uses calculated at basic prices are one step further removed from basic statistics and actual observations (Eurostat, 2008, 11.2.1).

As has been shown in an empirical analysis (Richter, 2012) this step leads to a very nonhomogeneous data set as far as the direct link to observations is concerned. Some elements are still close to the original data, some elements are quite far away. As a consequence the uncertainty and the 'model content' differ from element to element. As was shown for the situation in Austria 2007, the overall distance on the average is only 11%, but there is a considerable variation around the mean between 0% and considerably more than 50%. In general terms the distance for tangible products is higher than the one for services, which are not subject to trade and transport margins. The coefficients of variation for the final demand part are much higher than the ones for the intermediate part.

In a use table at basic prices the products for trade services and transport services have a very special cognitive character. The entries are the result of aggregation over (in principle) directly observable services such as repair services on the one hand and margins, which are not directly observable, on the other hand. The products for trade services and transport services serve as repositories for margins. In the tables at basic prices (as they are published by Statistical Offices) the 'margin part' is not longer identifiable.

3.3 Derivation of technology matrices

Supply and use tables at basic prices represent an intermediate stage between the basic statistics and the unknown, hidden pure industry – or product – specific input structures.

Before technology assumptions are applied it is strongly recommended that supplementary statistical information is utilized as much as possible, for example specific information on inputs required to produce certain kinds of output, in order to separate out inputs relating to a secondary product (SNA, 15.140). As shown in Rainer and Richter (1992) various ways of rearranging data may also help to improve the quality of the technology matrix. The empirical results indicate that much can be done to proceed from the supply-use system to a more analytically oriented system without running into very arbitrary decision.

Almost all users of analytical input-output tables are aware that the conversion to either industry by industry or product by product tables (the subject of Chapter 11 'Transformation of supply and use tables to symmetric input-output tables' of the Eurostat Handbook; Eurostat, 2008) has to be based on technology assumptions. These assumptions are extensively discussed and there is a rich body of literature dealing with the pros and cons of the various alternatives.

Few users however are aware that such assumptions are applied to data which result from a long chain of transformation processes. In many of these steps model assumptions have already gone into the data generating process. It is modelling on the basis of models, again based on modelling processes. For the outsider but also for the insider in a Statistical Office it is not easy to describe the link to the direct observation any longer.

4. Consequences for empirical economics

In many textbooks economic data and in particular the results of national accounts are characterized as corresponding to bookkeeping figures and as directly derived from observable variables by aggregation. As it was shown in the previous paragraphs this standard interpretation of data provided by Statistical Offices is not correct. A considerable part of these datasets is produced on the basis of assumed functional relationships, either on the basis of models of Type 2 or Type 3. «These functional relationships have the methodological character of model-hypotheses» (Holub and Tappeiner, 1997, p. 505). Using such results will necessarily lead to «modeling on the basis of the results of model» (Richter, 1994, p. 104).

The use of models of Type 2 and 3 «must not be confounded with the fact that each economic variable inevitably has a theoretical background. Observation is always observation in the light of theories. In the general sense ex post data are theory laden» (Holub and Tappeiner, 1997, p. 506). «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 and Richter, 1989, p. 235). Data producers often do not make the theoretical background of their data explicit, which might, to a certain extent, be taken as an excuse for the improper use of the results.

The order of magnitude of the problem of the high modelling content of economic data is difficult to access, also because in many data items not just one model-hypothesis is embodied. In most cases a number of such hypotheses have gone in the long chain of data transformations which lead to the final result. Another difficulty arises from the fact, that in particular on the macro level observational data cannot be isolated. It is «irreversibly intermingled with data generated with the help of functional relations between variables» (Holub and Tappeiner, 1997, p. 508).

The consequences of the characteristics of economic data for empirical economics are manifold. Only a few of them can be mentioned in the following paragraphs.

4.1 Lack of coherence of information

As mentioned above coherence is a necessary condition for information from different statistical sources to be combined in a meaningful way. The main criteria usually mentioned are that the data are based on the same statistical units, the same reference period, the same coverage, the same breakdown and the same basic concepts. One could add that the variables used jointly should belong to the same category of information.

Production functions are prominent examples for an obvious lack of correspondence in this respect. The variables on labour input and the variables describing capital input have quite different characteristics. Employment data usually are based on direct observations, the data are highly volatile. All variables on capital inputs belong to the category of model results either of Type 2 or Type 3. A considerable asymmetry in modelling capital stock and use of capital is also worthwhile mentioning. Entries to the capital stock always reflect the specific situation of a reference period, exits from the capital stock usually are entirely based on model assumptions and do not reflect the specific situation of the reference year.

Many models, such as for example the family of Computable General Equilibrium (CGE) Models, do not put many resources into arriving at a sound and consistent data base as the starting point of the modelling exercise. They start from (more or less coherent) data from national accounts and combine this data set with all kinds of parameters selected from literature. These parameters are based on (usually unknown) different reference periods, different scopes of observations, sometimes even data for different countries. This obviously incoherent data set is then 'calibrated' to a data set that fulfils the equilibrium conditions and can be taken as the starting point for simulations.

From a methodological viewpoint this 'calibration' is quite different from the process of 'reconciliation' in national accounts. The original data set is 'adjusted' because the values of the starting period belong to different reference periods, different scopes and the like. «CGE modelers are used to build their model from manipulated data which contains statistical data to match the CGE requirements. In other words, a CGE modeler asks for a data set with data (and parameters) which fit the model, not vice versa» (Grassini, 2007, p. 338). Such a modelling approach might be considered as a theoretical model with numerical examples to demonstrate the complex properties of the model. The link to the world of observations remains more or less undefined.

4.2 Lack of homogeneity of data

Many types of analyses start from the assumption of perfect homogeneity of the underlying data. A prominent example is input-output analysis.

The obvious heterogeneity of an input-output table is not only caused by differences in the accuracy in the measurement of the various elements (the topic of the famous book of Morgenstern, 1950). It is, to a large extent, caused by the very different degree to which modelling procedures went into the estimation process of the various parts of the table. The link to observable reality can (only to a certain extent) be described for a supply use framework at basic prices, as illustrated above. In the Leontief Inverse each element – to an unknown degree – is dependent on elements with a very different 'model content'.

The assumptions which have gone into the models used to generate elements of the table might be the same which are the tasks of the analysis of these tables. Users may also run into serious inconsistencies. As it has been shown by Kop Jansen and Ten Raa (1990) only the commodity technology assumption is consistent with the standard application of the input-output model. In the various steps before deriving analytical input-output tables, several times models based on the assumption of industry technology or some mixed assumption might have already been used.

4.3 Respecification of models

A specific implication which might result from 'modelling on the basis of the results of model' is that the model is unintentionally respecified.

Economic literature is concentrating on the effects of all kinds of errors and shortcomings of data from the perspective of errors in observations. Using the distinction made by Haavelmo, emphasis is put on the relationship between 'true variables' and 'observational variables'. Less attention is paid to the relationship between the 'theoretical variable' and the 'true variable'. The 'theoretical variable' is used throughout the entire argumentation neglecting that the statistical data used (the 'true variable') de facto measure something different from what was intended to be measured. Viewed from the perspective of the information content of the variables – the equation is respecified. In the simplest case the chosen variable is replaced by the variable which the statistician substituted for the target variable in the data generating process.

4.4 Modifying the data generating model

Few economists respond to the fact that their data are so heavily based on hypotheses with which they do not agree. One example for a different reaction is the procedure chosen for the Bilateral Trade Model (BTM) linking the various Inforum models[6]. The trade shares computed in the BTM are primarily dependent on prices and capital stocks on a disaggregated level. The capital stock data are intentionally not taken from the official sources in the various countries, because they are «largely based on different criteria and may not always be comparable. Consequently we chose to compute capital stock directly from statistics taken from a "comparable" perpetual inventory model where comparability is mainly based on the use of a common depreciation rate» (Bardazzi and Grassini, 2003, p. 42).

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[6] For a detailed description of the BTM approach see inter alia Nyhus (1991), Ma (1996) and Nyhus, Ma, Wang (1998).

The authors are aware that the use of the original data would mean a respecification of the model, by mainly substituting the differences in capital stocks by the differences in assumptions made by national accountants in the different countries. Instead they chose the (very unrealistic) assumption that depreciation rates are the same across countries. The unobservable variable 'capital stock' according the theoretical concept is replaced by a very specific proxy. The link to observable reality is only given by the past series of capital formation. The model is also respecified, but in a different way.

In some cases it is evident that some unexpected relationships reflect little more than the hypotheses that have gone into the data generating process: «Industry capital stocks – at least, as measured by the Instituto Nazionale di Statistica (ISTAT) – have maintained an almost constant ratio to output over the last two decades while output per employee has increased steadily» (Almon and Grassini, 2004, p. 339). Because of these properties of the data the authors conclude that some sort of technical change has to be introduced. They acknowledge that «there is no shortage on possible ways to do so. The problem is that there are very slim statistical grounds for preferring one form of technical change to another, but the different forms may have very different implications for the effects of a policy of stimulating investment» (Almon and Grassini, 2004, p. 339).

4.5 The danger of tautology – the example of labour productivity

The estimation of labour productivity – either directly or indirectly – plays a very important role in many economic models. In all these exercises some measure of constant price output (either total output or value added) is related to labour input (measured in number of jobs, full-time- equivalents or hours) only or in combination with other variables, mainly with the intention of covering the contribution of capital to the growth of output.

The insurmountable difficulties encountered when arriving at measures for capital input well rooted in observable phenomena in a non-ambiguous way were already discussed before. The compilation of constant price output indicators is also not as straightforward as assumed by most users of the data.

For many industries there is a considerable lack of price information which would allow adequate estimates in constant prices. Given this situation Statistical Offices have to rely on models of Type 2 or of Type 3 for market oriented industries and on models of Type 3 for non-market oriented industries.

As might be seen from an OECD documentation (OECD, 1996) more than 14 different approaches (models) for deriving value added at constant prices in service industries are used in the twenty industrialized countries covered by this documentation. Although the report primarily deals with value added at constant prices many of the problems described in this survey also occur in the calculation of total output at constant prices.

Because service industries are often very labour intensive, output in constant prices in period t is often seen as output in the base year multiplied by the change in labour input from the base year to period t, adjusted by the *assumed* change in labour productivity from the base year to period t. If no adjustment for labour productivity is made the change is assumed to be equal to one.

It is not very promising to base the analysis of productivity or the estimation of production functions on such output measures based on models of Type 2. The analysis will not reveal any insight into the substitution process between primary factors of production, if the underlying data were generated under the assumption that such substitution does not exist and it is sufficient to take the change in labour input into account.

In the case of non-market production it is always a model of Type 3 that has to be used. The output of non-market goods and services is neither observable at current prices nor can the aggregate be decomposed into a price term and a volume term on the basis of price observations.

For some kinds of non-market services the estimation of constant price measures can be based on detailed physical output indicators. The compilation of services such as collective services has always to rely on the input convention as the proxy for output. Since labour plays a key role as an input in government services, the SNA discusses the use of a volume measure for labour alone combined with an explicit assumption about changes in labour productivity. «The attention of users should always be drawn to any built-in-assumption about the rate of growth of labour productivity which should be stated explicitly, even when it is zero» (SNA 1993, 16.141).

When the analysis of labour productivity is carried out for an industry, the constant price output measure of which is completely based on labour input and some assumed labour productivity, the exercise will reproduce nothing else than the assumptions which have gone into the data generating process. The completely tautological character of such labour productivity measurement is evident.

The correct interpretation of results is more difficult at the aggregate level. As already mentioned, building blocks of different cognitive character are lumped together. At least in the European standard aggregations mentioned before (according NACE Rev. 2), market output and non-market output are not shown separately. Economists using such data partly based on reliable price observations, model results of Type 2 (for the market output part) and model results of Type 3 (for the non-market part of output), may perhaps find some influence of capital, although the parameters will always be considerably biased. It is not, however, the standard bias of errors in observations, but a built-in-property of the data generating process.

The shares of the different components – different also with respect to their cognitive character – in real product are changing over time. The shares change because economic development is not proportional in real terms. One of the consequences is that what is measured is – among others factors – the result of the changing composition – a kind of product-mix effects.

5. What can be done to improve the 'uneasy' relationship?

5.1 Reorientation in the economic profession

Economists tend to state that they have to work with the data they can (easily) find. They neglect that «the truth value of work based on inadequate data is not improved in some magic way by the fact that better data is not available» (Mayer, 1993, p. 74).

«To hold that economic theory should be practically useful and yet to deny that there is any place for empirical testing in economics is, surely, inconsistent» (Blaug, 1994, p. 118). In more general terms one can argue that any economic exercise with some empirical background, aiming at giving policy recommendations, needs to pay attention to the empirical foundation. Taking up the 'kitchen metaphor' by Zvi Griliches again, economists should not only be familiar with the recipes they should also know the nature of the ingredients they are using and should not mix up veal with poultry meat.

At the moment the qualification to make this distinction is not always given. This lack of awareness is closely related to the standard curricula for economists. Economic statistics and even national accounts do not play a big role, if they play any.

Referees of economic journals also do not pay much attention to the underlying data. They accept information on data sources like OECD or Eurostat without any additional specification. The disrespect of core statistical concepts is also reflected in the nearly frivolous use of the terminology. In the field of input-output analysis most of the empirical work makes use of official input-output tables according the SNA standards. Nevertheless even in journals like Economic Systems Research, specialized in input-output analysis, use is made of the term 'sectors' instead of 'industries' or 'products'. In a number of contributions in this well-known journal it remains unclear whether the material presented is in the industry or the product dimension.

Data work is often considered time consuming 'dirty work' which is not rewarded, although methodologists like Mayer note that «the time that authors spend on polishing the strongest link to shining perfection could often be better spent on one of the weaker links» (Mayer, 1993, p. 58). In most cases the empirical basis is the weakest link in the exercise.

Although this statement holds for a good part of mainstream economics there are also many remarkable exceptions. One of them is the work on dynamic interindustry models done in the consortium of Inforum models. «Builders of Inforum models take data and behavioral equations seriously» (Grassini, 2001b, p. 29).

This strong attitude to the empirical basis can be proved by numerous examples. A few of them were already mentioned before, here are some additional ones:

i. Input-output data

The derivation of analytical input-output tables (product by product) by made to measure algorithms guaranteeing a solution based on the product technology hypothesis but with no negatives has a very long tradition (e.g. Almon, 1970; Almon, 2000).

Much attention is paid to the properties of the input-output data (e.g. Meade, 2001; Meade, 2011). Specific updating methods were developed for the rejuvenation of the input-output table making full use of the different characteristics of the data at hand (e.g. Almon, Buckler, Horwitz, Reimbold, 1974).

ii. Full use of the system of national accounts

Instead of relying on «as we know from literature» economic reality is primarily perceived through the eyes of the statistical system of the country. Most country models are fully imbedded in national accounts: not only the production sphere is modelled according to the system of national accounts; many models also make use of the sector accounts dealing with the generation and distribution of income. These parts of the models are usually referred to as the 'accountants' (e.g. Almon, 1997; Grassini, 2008). Some models also make use of extended accounting frameworks such as NAMEA (Plich, 2011). Inforum modellers also reacted to what was called the 'chain index drawback' (Grassini, 2008) and the implications of 'backcasting' time series (Richter, 2010).

iii. Valuation matrices

In Inforum modelling the treatment of trade and transportation margins and of indirect taxes is not simply neglected as in most textbooks but considered «a perennial problem in applied input-output analysis» (Almon, 2008, p. 79). Chapter 16 of the 'Craft' (Almon, 2008) is devoted to trade and transportation margins and indirect taxes.

It is acknowledged that valuation matrices are not only necessary to arrive at use tables at basic prices, they are of analytical interest themselves and play a decisive role in the adequate modelling of price formation (e.g. Bardazzi, Grassini, Longobardi, 1991; Grassini, 2001b; Boratynski, 2006).

iv. Calculation of capital stock

As already mentioned before a lot of hard work has gone into alternative ways to estimate capital stocks for particular modelling purposes (e.g. Almon, 1966; Almon, Buckler, Horwitz, Reimbold, 1974; Grassini, 2008).

In the case of capital stock it should be obvious to every user that statistical data are not only the basis for economics but also the outcome of economics, of combining facts and hypotheses. Statistical data are man-made, although «one tends to suppose that national accounts just naturally appear every month like the new moon. In fact, they are perhaps the single greatest success of economic science» (Almon, 1998, p. 83).

v. Nonhomogeneity of time series

As mentioned above, in many cases the last elements in a time series are based on some model calculations of Type 2 whereas the other elements are based on observations. The approach proposed in treating the 'ragged end' of a series in an Inforum model pays attention to the different cognitive character of the various parts of the time series (Almon, Sampattavanija, 2008).

5.2 Improving the communication and understanding between data producers and users

One of the main reasons for the problematic relationship between producers and users of data is the lack of communication. Both groups seem to speak their own language and those who are willing to communicate have to cross 'context borders'.

Most of the standard textbooks implicitly propagate the illusion that the underlying data is perfectly homogeneous and spread the view that to deal with 'data problems' must be considered as a waste of time. This view is quite widespread among researchers in the academic world because they suppose that what is not present in textbooks is not worth dealing with.

For decades economists interested in the background of their data had no or little access to the information or knowledge about how the data were generated. Statistical Offices always published the main underlying concepts such as statistical units, scope and classifications. On the other hand the processes (the 'models') were usually treated as 'top secret'.

This not very user-friendly information policy has changed considerably during recent years. Many Statistical Offices publish detailed metadata on a regular basis. In the European Union, the European Code of Practice (Eurostat, 2011) contains the obligation for Statistical Offices to provide all relevant information to users. Principle 15 states: «European Statistics are presented in a clear and understandable form, released in a suitable and convenient manner, available and accessible on an impartial basis with supporting metadata and guidance».

In Statistical Offices there is also a growing awareness of the need to actively improve transparency, and to provide for a better and more transparent communication towards the users of statistical data. In this respect the Eurostat *Manual of Supply, Use and Input-Output Tables* (Eurostat, 2008) must be considered as a milestone. It is easily accessible and no economist working in the field of input-output analysis can argue that the compilation process should be considered as a black box.

5.3 More influence on the analytical orientation of the statistical system in general and in particular on national accounts

Given the budget constraints and the need to limit the response burden, statistical systems are multi-purpose systems which try to meet different needs. Because of the lack of communication economists have lost much of their influence on the design of the statistical system in general and on national accounts in particular.

National accounts always had to serve very different purposes. But in the early days the influence by model builders was strong. Eminent economists such as Gottfried von Haberler, Ragnar Frisch and Jan Tinbergen pioneered in econometric model building covering the whole national economy and therefore were asking for national accounts data as the main source of information. «The introduction of the systematic application of macroeconomic theory to national accounts permitted the integrated statistical treatment of the main economic processes; moreover the acceptance of double-entry accounting provided the means for implementing this integration» (Kennessy, 1993, p. 37).

Heavily influenced by the works of Keynes, national accounts established itself as the framework for macroeconomic reasoning, as the standard language of macroeconomics. National accounts became the empirical basis for macroeconomic analysis in general and macroeconomic model building in particular. The first fully worked out and detailed national accounting system published in 1947 as an annex in a UN-report (Bos 2003) was drafted by Richard Stone, an eminent economist very interested in economic modelling. The 1968 edition of the SNA (United Nations, 1968), fully integrating supply and use tables into the system, reflects the interest of economists in structural analysis. Since the 1968 SNA input-output analysis is fully embedded in the system, thus making Leontief's intellectual approach an important and integral element of national accounts (Kennessy, 1993).

Unnoticed by most economists this general orientation of the system has considerably changed in recent decades, in particular in the EU. The European version of the SNA (the ESA) is characterized by a clear hierarchy of objectives that have to be met. The needs of economic analysis are recognized but do not show up among the priorities. Because of the eminent operational relevance of the results of national accounts for financial obligations, subsidies and providing the data for the Maastricht-criteria, national accounting is not longer seen as part of economic science, «the implementation of legal norms may become a target predominating over scientific interpretation, canonistic understanding is promoted, thinking in alternatives is discouraged, casuistic tendencies may creep in as to solve borderline cases» (Franz, 1997, p. 56).

This considerable re-orientation can be identified in many details which seem to be of pure methodological/conceptual nature. The provision to update weights annually and to move to chain-linked indices for example is adequate for economists interested in short term changes only and very favourable for the control of the compliance with Maastricht criteria. It is certainly not in the interest of model builders for which additivity of series over a longer period is vital.

The general re-orientation of the statistical systems towards the needs of administration is to some extent caused by the absence of economists in the many fora in which the design of statistical systems is discussed and decided. If empirical economists want that their requirements play a more important role in the hierarchy of objectives they will have to articulate their needs much more actively than in the recent past.

6. Concluding remarks

A continuous and intensive dialogue between producers and users of economic data could contribute to improve the present problematic relationship. Such a dialogue is certainly beneficial for both sides.

For the Statistical Office it would be very stimulating and rewarding to know that the users are true connoisseurs who are in a position to appreciate all the efforts and modelling work that has gone in the data generating process.

The economics profession would get an important insight into the extent and the way to which their findings have a sound empirical basis. The statement by two pioneers of input-output analysis that «a science that purports to deal with the real world but that ignores its empirical and observational side is likely to appear a rather empty and unproductive discipline» (Evans and Hoffenberg, 1955, p. 56) is still valid. Economists should follow the instruction Sherlock Holmes gave to his friend and companion Dr. Watson: «It is a capital mistake to theorise before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts» (Doyle, 1994, p. 7).

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REGRESS TO REVEAL

Clopper Almon[1]

Suppose you have just done a regression and you know that the conditions for the t-values shown on your printout to be validly interpreted at Student t-statistics are *not* satisfied. In this case, what can you learn from these t-values?

I have posed this question to dozens of graduate students who had just completed the econometric training at various respectable universities. Many had some difficulty understanding so stupid a question, but once they understood it, they all replied emphatically, 'Nothing'. They thereby confessed that their instruction had been so one-sided that they were missing more than half of the descriptive information about their sample which the regression gave them. If you would have agreed with them, then you may be interested in the alternative, richer way of looking at regression presented here. This paper will show how those t-values could be converted to statistics which would present nearly the same information in an intuitively easily grasped measure, valid as a description of the sample despite the fact that the t-values could not be validly used for testing. Similar, descriptive replacements will also be offered for the standard errors of regression coefficients and F-statistics.

The emphasis on testing has led to the availability of a large battery of test statistics, most of them valid only under very special conditions. By contrast, descriptive statistics – statistics that speak to us with easily understood pictorial meaning – are an underdeveloped area. These statistics make no claim to inform us about a world beyond the sample, but they do reveal relations which exist in the sample. The notion, however, that 'science' consists only of formulating hypotheses and testing them on data not consulted in their formulation has been thoroughly exploded by historians of science (Kuhn, 1962). It is just as 'scientific' to explore data and look for relationships as it is to test hypotheses. Indeed, revolutionary science seems to have followed the exploratory path. In fact, it is exactly in this way that researchers generally use regression but do so with feelings

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[1] Department of Economics and Inforum, University of Maryland, College Park, MD 20742. I am indebted to Maurizio Grassini and Ralph Monaco both for discussions which led me to put this material in writing and for comments on earlier drafts. The comments of Kang Chen have added significantly to the substance.

Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online),

of guilt. It is the purpose of this paper both to set aside the guilt and to offer several measures designed, not to test, but to reveal in a an intuitively comprehensible way what is happening in the data. I am sure that there are numerous further such measures, and I hope this paper stimulates further developments along this line.

Before turning to this alternative view of regression, however, it is worth reviewing the conventional view just to remind ourselves of how far it is from what we really do. In order not to bore you with a list of assumptions which you know perfectly well, let me put the review in the form of a fable. In spinning it, I had in mind more work with time-series data than with cross-section data, but it is not without relevance there also.

1. The Datamaker Fable

We econometricians face a body of data. Where did it come from? It was made, according to our fable, by the Great Datamaker. Though we never see Datamaker, we know a lot about how he works. We know that, to make the data we are looking at, he took a matrix, **X**, and a vector, **β**, and then generated many, many vectors, **y**, by picking vectors of random numbers, **e**, and calculating

$$y = X\beta + e. \tag{1}$$

He then bundled each **y** with **X** into a packet, (**X**, **y**), and threw it out into the universe. One of these packets struck the Earth, burst open, and created the economy which we are studying. We have had the great good fortune to find the primordial (**X**, **y**). There is no doubt about that. Our problem is to find out what **β** is. We know exactly what **X** is and we are perfectly sure that there was some real, true **β**. Though there is absolutely no chance that we will ever catch a second one of these packets, the infinitely many others are all caught elsewhere in the universe. Everyone who catches one must compute

$$b = (X'X)^{-1} X'y \tag{2}$$

and send the result to the Cosmic Information Center (CIC). The folks there – ordinary mortals like ourselves with no direct knowledge of Datamaker's **β** – will take the average of all the **b** and that average will be **β**. Unfortunately, confidentiality requirements preclude them from any communication back to us. So we will never know **β**, only our one and only **b**. Nevertheless, it is gratifying to know that we are part of their effort which will reveal to them the true **β**. We express our pleasure in that fact by saying that our **b** is unbiased.

Although Datamaker generally plays by the rules, he is known to sometimes play a little trick on us and include in **X** one or more variables which in fact were not used in making up **y** – or which had a 0 coefficient in **β**. One of our particular tasks is to detect such jokes on the part of Datamaker.

Within this general fable, many details may be added. We may perhaps assume that the elements of **e** are all independent and identically distributed. That assumption allows us to compute easily the variances and covariances of all the elements of **b**. If all data catchers send along these estimates to the CIC, the average taken there will again be the true variances and covariances of **b**. We may believe further that the elements of **e** are drawn from a normal distribution. That belief allows us to deduce that the **b**'s arriving at the CIC have a multinomial normal distribution and that the ratio of an element of our **b** to our estimate of its standard error will be distributed as a Student t variable. That conclusion is very nice because it can be used to detect jokers which Datamaker may have thrown into the **X** packet. In some cases, we may believe that the elements of **e** are not independent and that we know something about the structure of the relations among them. If that knowledge is correct, it can be used to cut down on the variance of the **b**'s flying into the CIC. Though it is quite respectable to suppose that we know something about how **e** was generated, it would endanger our reputation as scientists to imagine that we know anything about **β**, for that would imply some economic understanding on our part.

Recently, some have supposed that Datamaker has a new trick. He makes up the elements of **y** one at a time, starting from the top, and one of the elements in each row of the **X** matrix is just the element of **y** from the row above. Those who take this notion seriously say that they, and presumably only they, are doing 'time series analysis'. (Anyone working with time series data without this assumption is left homeless). These self-styled time-series analysts devote great energy and ingenuity to determining whether or not the coefficient in **β** on this variable is equal to 1.0. We will not pursue this school further save to note that its results seem to depend very heavily on knowing exactly how Datamaker works.

2. Seeds of Doubt

I have the greatest possible admiration of the ingenuity and beauty of the mathematical derivations based on the Datamaker fable. The derivations of the distributions of the regression coefficients, of t- and F-statistics are marvelous. Von Neumann's derivation of the distribution of his δ (on which the Durbin-Watson statistic is based) is, for me, miraculous. I am awed by the thoroughness of theoretical econometricians in working out the consequences of various assumptions. For years, the sheer beauty of the derivations blinded me to the basic fact that the Datamaker fable has little connection with what I am doing as an applied econometrician working with time series data. That is not to say that there may not be cases where the Datamaker fable may be entirely appropriate, as in the analysis of repeatable, controlled experiments, where one knows exactly what has changed from one experiment to another.

But that is not what I am doing as a builder of econometric models. I have one set of data on the American economy in the 1990's and there is no chance that I will ever get a second set with only certain known policy changes. Furthermore, the process generating the data is vastly more complex than any equation I can write down, though I may have some insight into it, and I may try to capture that insight in the equation. I do not, however, believe for one second that I know the full $\mathbf{X}$ matrix nor, indeed, that there is any true $\boldsymbol{\beta}$. As a builder of economic models, I am just looking for rough but workable approximations of a vastly complicated reality. I model consumption of ice cream with income and relative prices. But you buy ice cream; you know that how much you consume depends on how hot the weather is, on whether or not you or your children have milk allergies or philosophical positions about animal-derived food, on what kind of diet you may be on, and on how loudly the children are howling in the back seat. Price? Income? Hardly. The one thing I am relatively sure of is that there is no true equation of the form I am fitting. All claims about the $\mathbf{b}$ that I calculate being 'unbiased' or 'consistent' 'estimates' of your true parameters seem pretty meaningless. Most econometric theory seems, in the end, to be about how to make unbiased, consistent, efficient estimates of non-existent parameters.

I am surely not alone in doubting the appropriateness of the fable to what we are doing. Poirier (1988, p. 132) notes «Such parameters need not 'exist' in the external world, but only in the minds of researchers». He finds them regarded as anything from metaphysical mental constructs to 'waste products' of prediction. Leamer (1983), Sims (1996) and others have expressed various doubts on this point. McCloskey and Ziliak (1996), in their criticism of the profession for all too often forgetting the difference between «statistical significance» and «economic significance», rightly observe «Essentially no one believes a finding of statistical significance or insignificance». Keuzenkamp and Magnus (1995) have offered a handsome reward to anyone who can produce one point on which the opinion of the profession has been changed by a significance test. If significance tests have, rightly, lost all persuasive power, perhaps we should look for other, less presumptuous ways of presenting the information about the sample that the test statistics do, actually, contain.

These arguments certainly do not mean that I have no use for regression. Quite the contrary. I find it an indispensable tool in economic modeling, which, despite the criticism of recent years, remains the only way that I know to test my understanding of the economy and to put together pieces of understanding into a coherent whole. In modeling, I am looking for a workable summary of extraordinarily complicated economic behavior. I find it helpful to admit that complexity, not to gloss over it by the Datamaker assumption. I do not regard, however, the regression coefficients as estimates of anything. They are just a sort of summary statistic of the data. My concern is not to reject regression but to make it speak in terms that are easily understood without invoking Datamaker.

I will use the word 'metaphysical' to describe a statement which relies on the Datamaker fable for its meaning. In doing so, I intend no offense to the science of metaphysics, nor indeed, to say that the statement is vague or unreal. In reading Aristotle's *Metaphysics*, however, it struck me that his Unmoved Mover and Datamaker might be of similar substance. I only wish to say that these statements rely for their validity on the existence of a reality beyond anything we can observe – that they go 'beyond nature'. They may assume, for example, the existence of a true $\boldsymbol{\beta}$, a transcendent reality beyond our powers of observation. I will use the word 'factual' to describe a statement that does not invoke the unobservable; its meaning is intuitively clear without the fable. If I say that I have regressed y on X with ordinary least squares and the result was b, that is a 'factual' statement. If I say that b is an unbiased estimate of $\boldsymbol{\beta}$, that is a 'metaphysical' one. If I say that the standard deviation of the residuals is 16, that is a factual statement. If I add that the 16 is an unbiased estimate of the standard deviation of the normal distribution from which the elements of **e** were drawn, that is a metaphysical statement.

'That was easy', you may say, 'but what about the standard errors of the regression coefficients, the t-statistics and the F-statistics. Aren't they all inextricably bound up with the fable?' Indeed, the names we give these measures are justified only by the fable. Without the fable, these particular measures are virtually incomprehensible; they make no intuitive, pictorial sense. In this sense, I will call them also 'metaphysical' statistics. In other words, if a particular measure can be used to make a meaningful factual statement, I call it a 'factual statistic'; if is well adapted only for making metaphysical statements, I will call it a 'metaphysical statistic'.

How to replace the metaphysical statistics to which we are all accustomed with factual statistics which convey essentially the same information but in an form meaningful without Datamaker is the subject of the rest of this note.

3. Factual Loss Limits and Metaphysical Standard Errors

Let us begin with 'standard error of the regression coefficient'. There must be conceivably more than one of something for the concept of standard error to make sense. The very idea that the regression coefficients have standard errors depends upon there being, at least potentially, many b vectors. When we are working with economic time series and trying to estimate equations for, say, the U.S. economy in the 1970 – 1998 period, only the Datamaker assumption that many (**X**,**y**) packets are cast off into the universe can supply the multiplicity of **b**'s, for we shall certainly not see these years re-run with just the 'errors' changed. We are essentially working with the whole population; and, without, Datamaker, there is no meaningful standard deviation of the regression coefficients. If you ask me, 'What was the average value of the Treasury bill rate in the 1980's?' you expect an answer like, '8.8 percent'. If I add, 'and the standard deviation of that mean is .44 on the assumption that our 1980's were a random sample from all possible 1980's', you are likely to mutter, 'No, no, I just wanted to know about the 1980's as they really were', and think me some kind of lunatic. The mean that I gave you, however, was just the regression coefficient of the Treasury bill rate on a series of 1's, and I thought – in my lunatic way – that you would want to know its standard deviation. Standard errors of regression coefficients on economic time series data are all more or less in the same class with my lunatic answer about the standard deviation of the mean. The regression coefficients themselves, however, are useful descriptive statistics.

With random samples of cross-section data, matters are a bit more favorable to the usual interpretation, for we can conceivably draw multiple random samples and compute **b** and the 95-percent confidence interval for each and reasonably expect that about 95 percent of these intervals will include the **b** that would be found by running exactly the same regression on the whole population. Even in this case, however, the confidence intervals tell us nothing about what to expect if another variable is added to the regression. Only the belief that we know the full **X** matrix used by Datamaker enables us to make any statement that transcends the particular choice of variables we have made. And should we find that one of the variables is 'insignificant' and rerun the regression without it, the standard errors the program gives may be utterly misleading, for we may have made a type II error in throwing out the variable.

We may, however, in any case ask What is the factual content of the number that is usually reported as the standard error of a regression coefficient? That statistic is really just giving us information about how rapidly the sum of squared residuals (SSR) rises as that regression coefficient is moved away from its least-squares value and the other regressions coefficients change to compensate, as best they can, for that movement. To be more precise, let us divide the **X** matrix vertically into two parts, $\mathbf{X}_1$ and $\mathbf{X}_2$, where $\mathbf{X}_2$ contains only a single variable and $\mathbf{X}_1$ contains all the others. Similarly, we divide up the **b** vector between $\mathbf{b}_1$ and $\mathbf{b}_2$ and then define the vector **r** of residuals by

$$r = y - (X_1 b_1 + X_2 b_2). \tag{3}$$

Now let us take hold directly of $\mathbf{b}_2$ and move it about, but always changing $\mathbf{b}_1$ so as to minimize the sum of squared residuals. Thus the SSR becomes a function of the $\mathbf{b}_2$ we choose, which we may call SSR(b_2). We can easily write it down:

$$SSR(b_2) = \left(y - X_1\left(X_1'X_1\right)^{-1} X_1'\left(y - X_2 b_2\right)\right)'\left(y - X_1\left(X_1'X_1\right)^{-1} X_1'\left(y - X_2 b_2\right)\right) \tag{4}$$

Expanding and simplifying gives:

$$SSR\left(b_2\right)=\left(y'y-y'X_1\left(X_1'X_1\right)^{-1}X_1'y\right)2\left(X_2'X_1\left(X_1'X_1\right)^{-1}X_1'y-X_2'y\right)b_2+ \\ \left(X_2'X_2-X_2'X_1\left(X_1'X_1\right)^{-1}X_1'X_2\right)b_2^2. \tag{5}$$

To see what familiar friends those long matrix products really are, let us write out the normal equations for the regression of y on X and the simultaneous inversion of X'X to create its inverse, S. They are just

$$\begin{pmatrix} X_1'X_1 & X_1'X_2 \\ X_2'X_1 & X_2'X_2 \end{pmatrix}\begin{pmatrix} b_1 & S_{11} & S_{12} \\ b_2 & S_{21} & S_{22} \end{pmatrix}=\begin{pmatrix} X_1'y & I_{11} & 0 \\ X_2'y & 0 & 1 \end{pmatrix}$$

If we now proceed with the Gauss-Jordan elimination process to the point just before the final pivot operation to determine **b**$_2$, we have

$$\begin{pmatrix} I & (X_1'X_1)^{-1}X_1'X_2 \\ O & X_2'X_2-X_2'X_1(X_1'X_1)^{-1}X_1'X_2 \end{pmatrix}\left(\begin{pmatrix} b_1 & S_{11} & S_{12} \\ b_2 & S_{21} & S_{22} \end{pmatrix}\right)= \\ \begin{pmatrix} (X_1'X_1)^{-1}X_1'y & (X_1'X_1)^{-1} & 0 \\ X_2'y-X_2'X_1(X_1''X_1)^{-1}X_1'y & -(X_2'X_1)(X_1''X_1) & 1 \end{pmatrix} \tag{7}$$

Let us denote the matrix on the left here by **A** so that **a**$_{22}$ is the element in the lower right corner. By looking back at equation (5), we see that this element is precisely the coefficient on b_2^2 in (5). Moreover, the coefficient of b_2 in equation (5) is just -2 times the expression in the lower left corner of the matrix on the right of equation (7). Furthermore, the last step of the Gauss-Jordan process will divide this element by a_{22} to produce b_2^*, the least-squares value of b_2. The first term on the right of (5) is just SSR1, the SSR resulting from the regression of y on just X_1. Thus, equation (5) can be written as

$$SSR\left(b_2\right)=SSR_1-2a_{22}b_2^*b_2+a_{22}b_1^2. \tag{8}$$

Now the final pivot operation for solving equation (6), the step following that shown in equation (7), will involve dividing the 1 in the lower right corner of the matrix on the right in (7) by a_{22} to get s_{22}, the diagonal element of the **(X'X)**$^{-1}$ matrix corresponding to the coefficient we are moving. Thus, equation (8) can be written as

$$SSR\left(b_2\right) = SSR_1 - 2b_2^* b_2 / s_{22} + b_1^2 / s_{22}. \tag{9}$$

Setting $b_2 = b_2^*$, we find for the SSR for the full least squares regression, which we may call SSR*,

$$SSR^* = SSR_1 - b_2^{*2} \tag{10}$$

If we now introduce δ as the deviation of b_2 from its least-squares value and substitute $b_2 = b_2^* + \delta$ into (9), it becomes, after simplification,

$$SSR\left(\delta\right) = SSR^* + \delta^2 / s_{22}. \tag{11}$$

Suppose now that we ask, How far from its least-squares value can we move b2 before the SSR for the whole equation would increase by more than λ percent? The answer, quickly deduced from equation (11), is

$$\delta = \sqrt{.01\lambda SSR^* s_{22}}. \tag{12}$$

If for example, we picked λ = 5, then we would have for what we might call the 'five-percent loss limit' on b_2:

$$\delta = \sqrt{.05\lambda SSR^* s_{22}}. \tag{13}$$

Now if a regression has 20 degrees of freedom, what is the 'standard error' of b_2 by the usual calculations? Exactly the δ given by equation (13). For 20 degrees of freedom, the metaphysical 'standard error' of the regression coefficient as printed out by the computer is, factually speaking, its five-percent loss limit. If there were 100 degrees of freedom, the metaphysical 'standard error' would be the factual 1 percent loss limit, and so on.

For the calculated number to really be a standard error, a whole host of assumptions must be valid. Firstly and most unlikely, there must be a true equation of exactly the form we are estimating. Secondly, we must be sure that we know *a priori* what X is. If we have done any previous regression and discarded some variables on the ground that their t-statistics were insignificant, then through this pre-test we have admitted that we do not know what the true X is; and our present estimates of **β** are biased (because we may have made a Type II error and thrown out a variable which belongs in the equation), and the standard errors are more or less meaningless. (This point is eloquently made by Fomby *et al.* [1984, p. 130]). Thirdly, **X** must be non-stochastic. Fourthly, the errors must be un-correlated with one another. Fifthly, they must all have the same variance. Sixthly, if the standard error is to be used to calculate a valid t-statistic, the errors must also be normal. By contrast, the factual loss-limit statement is always valid. If you change a regression coefficient by its five-percent loss limit and recompute the others by least squares, the SSR will for sure and certain go up by five percent. That is just a fact. (Some of these conditions can be relaxed a bit for large samples, but that fact hardly helps the worker who has twenty years of historical data with which to fit his equation. He can't go back further because the structure of the economy, the **β**, would have almost certainly changed and he can't go into the future, because those data don't yet exist.)

The second of these conditions almost eliminates the valid use of classical statistical methods in economics. These methods are aimed at estimating parameters or testing hypotheses when the correct specification of the equation is known. But the notion that economic theory will tell us what variables to put into an equation and the form of the equation is almost always simply laughable. If we are to find equations with acceptable fits, we have to rely on our own explorations of the data or on the empirical work of others. That reliance totally invalidates the classical statistical tests and sampling properties. Loss limits, being purely factual statements, remain perfectly valid no matter how much we have explored the data. They are, of course, descriptive only of the sample and do not make any claim on a wider applicability.

What happens to loss limits and standard errors as the sample size increases? Suppose for example that we were able to double the sample and that it just so happened that the additional observations turned out to look, one for one, exactly like the first set. The loss limits will be unaffected by such a doubling of the sample. The standard errors will all shrink by a factor of $1/\sqrt{2}$. Large sample studies nearly always have tiny standard errors and huge t-statistics. Isn't that nice? Their loss limits, however, are not necessarily very different from those of regressions on a much smaller sample. Isn't that a drawback for the use of loss limits? Is there any way in which a factual statement can express the superiority of the large sample? In my view, the factual statement is simply the sample size and its structure. I am very leery of tiny standard errors in large-sample studies, because the large sample is just as sensitive as the small to errors in specifying the X matrix. The fact that some regression coefficient is ten times its standard error is supposed to make me very confident of its sign. But the truth is that I don't really know what the X matrix should include. After I have done my best, you may come along and suggest a new variable. When I throw it into the regression, lo, the sign changes on the variable whose t-statistic was 10. My confidence in my metaphysical knowledge shattered, I decide to stick to factual statements next time.

Since the loss limit statement is so much more factual than the standard error statement, one might well ask that a regression program display loss limits. The G regression program available on the Internet at inforumweb.umd.edu does so. If you give the command 'll 5', then after the next regression you will see the 5 percent loss limits for each coefficient.

4. Factual Mexvals and Metaphysical t-Statistics

Most regression programs report the t-statistics for each regression coefficients. Their main use is in deciding whether or not the variable is one of the jokers that Datamaker slipped into the packet. Their validity is subject to all the conditions we have just enumerated for the standard errors. If we have the slightest doubt about their validity we can ask the factual statement, How much does the SSR increase if we drop this variable? The answer is immediately clear from equation (10). It goes up by b_2^{*2}/s_{22}. A convenient way to express the answer is to ask by what percent the standard error of estimate goes up when the variable is eliminated and all others adjust to compensate as best they can for the elimination. We may call this measure the marginal explanatory value, or mexval, of the variable. If we denote it in general by m and by m_2 for the particular case we have been developing, then

$$m_2 = 100\left(\frac{\sqrt{SSR^* + b_2^{*2}/s_{22}}}{SSR^*} - 1\right) \tag{14}$$

The t-statistic is

$$t_2 = \frac{b_2^*}{\sqrt{s_{22} \cdot SSR^*/\left(T-n\right)}} \tag{15}$$

so if your software fails to compute the mexvals, you can do so yourself by the equation

$$m = 100\left(\sqrt{1 + \frac{t^2}{T-n}} - 1\right) \tag{16}$$

where T is the number of observations and n is the number of parameters estimated. (You might also consider switching to the G software or demanding that the makers of your software put in mexvals).

Just as the relation between the loss limits and the standard errors depended on the degrees of freedom in the equation, so does the relation between mexvals and t values. Which one is telling you what you want to know? Consider an equation with a variable that has a t-statistic of 3. If that equation has 10 degrees of freedom, eliminating the variable will wreak havoc with the fit: mexval = 40. If the equation has 1000 degrees of freedom, though the variable is somewhat more 'significant' by the t-test, eliminating it will have little effect on the fit: mexval = .45. As a non-believer in Datamaker, I find the mexvals to be telling me exactly what I want to know in the two cases but the t-statistics to be tricky to compare.

5. Factual Derivatives and Metaphysical Covariances

What sort of factual statements correspond to the covariances of regression coefficients? If we return to equation (3) and ask how $\mathbf{b}_1$ changes to compensate for changes in $\mathbf{b}_2$, we find

$$b_1 = \left(X_1'X_1\right)^{-1} X_1'\left(y - X_2b_2\right) = \left(X_1'X_1\right)^{-1} X_1'y - \left(X_1'X_1\right)^{-1} X_1'X_2b_2 \qquad (17)$$

The matrix (actually, it is a vector) which is multiplied by b_2 in the last term of the right side of this equation is the derivative of b_1 with respect to b_2. Now note in equation (7) that if we carry the Gauss-Jordan pivoting process to its conclusion we will have

$$S_{12} = -s_{22}\left(X_1'X_1\right)^{-1} X_1'X_2. \qquad (18)$$

Note the similarity to the coefficient of b_2 on the extreme right of (17). Recalling that the variance-covariance matrix by the usual formula is s^2S, we see that if we divide each of its columns by the diagonal element in that column, we obtain a matrix whose jth column shows the derivatives of all the regression coefficients as b_j is independently varied and all the others are varied to maintain as good a fit as possible with the given b_j. This matrix of derivatives is the factual way of interpreting the information contained in the metaphysical variance-covariance matrix. In factual terms, the variance-covariance matrix is showing us how sensitive the other regression coefficients are to the value chosen for any one. One could, of course, also multiply each column of this derivative matrix by, say, the five-percent loss limit for the corresponding variable to see how far each of the other regression coefficients would move if a given one were moved out to its five-percent loss limit.

5.1 Factual Normalized Residuals and Metaphysical F Statistics

If a regression is computed by successive Gaussian pivots, it is little extra work to carry one more row which will give in the diagonal element the SSR after each pivot. If these numbers are saved, they can be used for printing at the end of the regression the F statistics for testing, under the usual Datamaker assumptions, the significance of the last variable, the last two, the last three, and so on through the whole equation. (If your software gives only one F, the one for the whole equation, change to G or demand an improvement). These F's are, of course, designed for making metaphysical statements about significance. The same information can be conveyed factually by simply showing the SSR for each stage, or by expressing each of them as a ratio to the SSR when all variables have been included. In the G program, these ratios are called "Normalized residuals" because they have been normalized by the last one. They are routinely shown by G and are helpful for judging the usefulness of a group of variables, especially if the group is placed at the end of the list of regressors. These ratios are, of course, simply factual statements without metaphysical overtones.

6. Other Factual Statistics

A number of other standard statistics are factual in nature. For example, the ρ or autocorrelation coefficient of the residuals has a simple intuitive meaning as the regression coefficient of the residual on its lagged value, the tendency of the equation to go on making the same mistake. Putting the same information in the form of a Durbin-Watson statistic takes away the intuitive interpretation and raises the suspicion that one has in mind making some metaphysical statement about how Datamaker drew the **e** vector. The mean absolute percentage error is a factual statistic, as are the elasticities of the various variables evaluated at the means of the observed values. The leverage vector, used in detecting outlying observations, is simply the derivative of the predicted value of each observation with respect to its observed value. It is also factual. Beta coefficients, which express the regression coefficients in units of standard deviations of the dependent and independent variables, are likewise factual.

7. Data Mining, Factual Statistics, Judging Regressions and Prior Information

Exploring the data with regression analysis certainly invalidates the metaphysical test statistics. It is therefore often held to be reprehensible and is referred to in pejorative tones as 'data mining' or 'data snooping'. Let me say plainly that I think that it is the responsibility of the researcher to explore the data thoroughly. Isn't that what makes one an expert on a subject? Isn't that precisely what the researcher is getting paid for? Have you ever, on looking at someone else's regression, asked, 'Did you try so and so?' If so, you explicitly recommended data exploration. Indeed, if we are not allowed to learn about the real world by looking at data, how then are we supposed to learn about it? From other researchers who have also not looked at their data?

So if the researcher has done a thorough job, the data is completely mined and the conventional test statistics utterly misleading. The factual statistics, however, remain perfectly valid for the sample.

Does this attitude open the spillways to all manner of junk regressions? Not at all. The next step after estimating an equation is to use it in a model. To do so implies that we expect that the relations found by the equation will continue to hold in the future or at least would have held in the past even if some of the independent variables had been different. That expectation gives us a number of ways to judge an equation. In Almon (1994), there is a checklist of such criteria which have nothing to do with test statistics. They include accounting for important influences, parsimony, appropriate dimensions, reasonable attention to cointegration, adequate allowance for lags, plausible parameter values, stability of coefficients when the sample period is changed, satisfactory fit, and several others not easily explained out of context. The leverage variable should be examined to detect outlying observations and those observations considered carefully. Indeed, the notion that all an equation needs is a high R^2 and significant t-statistics will certainly admit more junk equations than do these criteria.

Since plausibility of regression coefficients is a primary concern for me, one might suppose that I would use (or at least advocate that others use) Bayesian regression. But the Bayesian position, just as much as the classical position, involves assuming that there are true parameters. One who holds that there are no true parameters needs a procedure closer to the emphasis on regression coefficients as summaries of data. If we want the parameters of an equation to satisfy approximately some linear constraint – the simplest being that the parameter should have a certain value – but the regression refuses to give 'nice' values, we can just make up artificial data which would be fit perfectly by any equation whose parameters satisfy the constraint. We then combine this artificial data with the natural data in proportions to give a balance between our desires that the equation fit both the natural and the artificial data. A good regression package can make it extremely easy to use these 'soft' or 'stochastic' constraints without any appreciable increase in the time required for the regression computations. As with Bayesian regression, use of this procedure obligates us, of course, to report the use of the artificial as well as the natural data. The use of the artificial data affects the loss limits, mexvals, and normalized residuals, for in their calculation the artificial data is just as much data as is the natural data.

8. Conclusion

It has proven possible to give factual alternatives to all the common metaphysical statistics. In reporting results from regression analysis, you do not have to make metaphysical statements that you don't believe. You can convey the same information to your readers with purely factual statistics. These statistics can easily be incorporated into regression programs, as they already are in the G program. By a de-emphasis of testing and an increased emphasis on economic measurement and interpretation, I hope that they will contribute to putting both the *econ* and the *metrics* back into econometrics.

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IL PROF. GRASSINI E L'IRPET

Stefano Casini Benvenuti[1]

1. Gli anni della contestazione: un incontro fugace ma significativo

Conosco Maurizio Grassini da quando, giovane studente, cominciai a seguire presso l'università di Pisa, il suo corso di Econometria in attesa che nel piano di studi ne accettassero l'inserimento al posto di Diritto commerciale. Non l'accettarono e quindi fui costretto ad abbandonare prematuramente il corso, non prima, però, di avere seguito con interesse alcune lezioni. Erano gli inizi degli anni Settanta, gli anni dei movimenti di lotta studenteschi, degli esami di gruppo, in cui gli studenti contestavano i metodi autoritari dei "baroni", i percorsi di studio obbligati (in cui ci sono insegnamenti propedeutici ad altri) e mi sorprese il coraggio mostrato dal professor Grassini nell'affrontare alcuni studenti che contestavano l'insegnamento in quanto, non avendo alcun rudimento di matematica, non riuscivano a capire ciò che Grassini insegnava. Gli studenti furono sconsigliati – diciamo molto energicamente e senza troppa paura – di seguire il corso se prima non imparavano la matematica indispensabile per capirne i contenuti: il consiglio fu accettato.

Parto da questo episodio perché mi pare sintetizzi efficacemente almeno due caratteristiche di Maurizio Grassini: il senso del rigore e il coraggio di contrapporsi al pensiero dominante.

2. L'IRPET del "documento" di Becattini

A metà degli anni Settanta quando l'IRPET era ancora adolescente – era nato nel 1968 – uscì il primo rilevante studio sulla Toscana curato dall'allora direttore (e fondatore) Giacomo Becattini dal titolo *Lo sviluppo economico della Toscana: con particolare riguardo all'industrializzazione leggera* (1975).

Io non ero ancora entrato all'IRPET, fui assunto alla fine degli anni Settanta dal successivo direttore – Giuliano Bianchi – e rimasi meravigliato dall'atteggiamento di venerazione verso quel lavoro, chiamato dai ricercatori di allora semplicemente "Il documento". L'avevo letto per prepararmi al concorso che poi vinsi, ma debbo sinceramente ammettere

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Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online),

che non avevo capito, allora, l'importanza di quella analisi, per cui quel modo, quasi religioso, di trattarlo mi risultava in parte incomprensibile.

Assieme a molti altri – sia nell'accademia, che nel mondo politico – l'importanza di quella analisi la capii però più tardi e credo abbia segnato gran parte del mio percorso di studi.

Non credo che Maurizio Grassini condividesse troppo le analisi contenute nel "documento", ma sono abbastanza sicuro che quello che non approvava era quel clima di venerazione che, in contrapposizione al pensiero dominante di allora – quello basato sulla grande impresa e sulle economie di scala – stava formando un nuovo pensiero dominante, valido 'a prescindere'.

Ciò che – credo – non condividesse era la chiusura rispetto alle critiche che alcuni ponevano a quell'analisi, alcune certamente ideologiche, assieme però ad altre che invece tentavano di entrare nel meccanismi di funzionamento di quel modello, cercando di richiamarne le debolezze (non facevo parte dell'IRPET in quegli anni e, quindi, ciò che dico è una mia libera interpretazione, ma sono certo che Grassini stesse in questo secondo gruppo).

Devo tuttavia riconoscere che la chiusura dei sostenitori del modello di Becattini era, almeno in parte, giustificata dalla necessità di proteggere un soggetto nascente – il distretto industriale –, che contrastava con le teorie di allora e che trovava in larga parte del mondo politico della Toscana di quegli anni una avversione ideologica poiché, di fatto, metteva in discussione alcune categorie classiche dell'ortodossia di sinistra: spariva – o si affievoliva molto – il contrasto capitale-lavoro, ben più evidente nel mondo della grande impresa, e si negava persino l'esistenza di una classe operaia.

Oggi è noto a molti come da quel lavoro sia nata una parte importante della letteratura del paese e sono nati anche i successivi approfondimenti dell'IRPET. Innanzitutto quelli che, nella consapevolezza della difficoltà di misurare le economie esterne all'impresa ma interne al distretto, puntavano ad individuare almeno i luoghi al cui interno tali economie sembravano avere operato più efficacemente. Da quella riflessione nascevano, infatti, i sistemi locali del lavoro che l'ISTAT continua ancora oggi a delimitare a partire proprio dai lavori iniziali dell'IRPET (1986, 1989).

3. L'IRPET e la tavola delle relazioni interindustriali

Ma dal timore che nel corso degli anni alcune debolezze dei distretti industriali potessero affiorare, nacque anche un altro filone di studi cui Maurizio Grassini ha dato – non solo per l'IRPET – un grande contributo.

L'ipotesi di partenza era che la quasi esclusiva specializzazione nelle produzioni di beni di consumo durevole, tipica dei distretti toscani, se da un lato consentiva alle imprese della regione una notevole capacità di esportare all'estero, dall'altro sottoponeva l'economia regionale ad una altrettanto forte debolezza sul fronte delle importazioni, non solo di materie prime, ma anche di macchinari.

Vi era quindi la necessità di comprendere più a fondo come era fatta l'economia regionale, quali le tecniche produttive adottate dalle imprese, quali le relazioni che si instauravano all'interno della regione e quali invece ne fuoriuscivano. In altre parole il timore era che, a fronte di una notevole capacità di esportare beni di consumo finale (moda, lapideo, oreficeria), la capacità di attivazione 'a monte' fosse modesta in quanto non si producevano in Toscana alcuni dei beni – soprattutto quelli di investimento – di cui i settori esportatori avevano bisogno.

Nei distretti vi era infatti una forte integrazione orizzontale e verticale, ma questa si limitava strettamente alle fasi più prossime della lavorazione e/o alla varietà dei prodotti, ma non risaliva anche ai macchinari per i quali si dipendeva quasi totalmente dall'esterno.

Vi era in quegli anni all'IRPET una notevole attenzione verso i lavori di Hirshmann (1958) i quali sottolineavano l'importanza, nelle prime fasi dello sviluppo, della presenza di settori 'chiave', settori cioè che avessero una forte capacità di attivazione a monte e a valle: la loro presenza avrebbe, infatti, attivato maggiori economie esterne al sistema, favorendo l'insediamento di quelle attività che, appunto, stavano a monte e a valle del settore.

Il concetto di effetti a monte e a valle (*forward* e *backward linkages*) era stato approfondito da alcuni contributi di Rasmussen basati sulle tavole intersettoriali dell'economia. Forse quella teoria non si adattava *sic et simpliciter* ad una economia che aveva già superato la fase del decollo come era quella toscana, ma poneva un interessante interrogativo, ovvero se un sistema economico sviluppato – e che avesse una certa dimensione – dovesse anche avere una maggiore completezza e varietà di produzioni riducendo in tal modo la dipendenza dall'esterno. Oppure in termini di programmazione – termine allora ancora in voga – si trattava di capire su quali settori orientare la politica industriale in modo da sfruttare al massimo i potenziali *linkages* a monte e a valle, favorendo l'insediamento e la nascita di nuove imprese.

Posta in questi termini la questione appare forse un po' troppo banalizzata ed effettivamente poco adatta ad affrontare la situazione di una regione che il suo decollo lo aveva avuto da tempo; in fondo ed in modo un po' scolastico la questione potrebbe porsi nei seguenti termini: è meglio essere molto specializzati, esportare molto, ma con un basso moltiplicatore, oppure essere meno specializzati in singole produzioni esportare di meno, ma avere un moltiplicatore più elevato. Detto in altri termini si tratta di chiedersi se sia meglio un modello export-led o un modello basato sull'import substitution.

Non credo vi sia una risposta univoca a tale dilemma: le combinazioni sono molte a parità di esito finale e dipendono da tanti fattori, non ultimo la dimensione del sistema osservato, ma credo che la questione sia tutt'altro che banale e per alcuni versi anche molto attuale.

L'idea di allora che in Toscana non si producessero macchinari e si fosse costretti ad importarli (per cui quanti più beni della moda di producevano ed esportavano tanto più macchinari si dovevano importare), non mi pareva l'argomento più importante per manifestare preoccupazioni sull'eccessivo orientamento della Toscana verso le produzioni della moda. Mi pare che più forte fosse l'obiezione sul fatto che la competitività sul fronte delle produzioni tradizionali fosse largamente di costo per cui, con il passare del tempo, questa la si poteva perdere a vantaggio dei paesi più arretrati e che invece una maggiore presenza nelle produzioni della meccanica ci salvaguardasse maggiormente da tale rischio.

Giusto o sbagliato che fosse quell'interesse resta il fatto che l'IRPET decise di costruire una tavola dalle interdipendenze settoriali della Toscana con metodo semi-survey. Si riteneva probabile che la Tavola sarebbe stata molto sparsa, con una forte concentrazione in alcuni settori ed in particolare in alcune caselle, quelle dei cosiddetti 'reimpieghi', che indicavano la presenza di forti flussi di scambio all'interno dello stesso settore produttivo tipiche delle economie più distrettuali. La costruzione della Tavola ebbe il suo termine nel 1978 e come spesso accade confermò solo parzialmente le attese, ma consentì di avere un'inquadratura ben più completa dell'economia regionale.

4. Il sistema di modelli dell'IRPET

Ma il merito dell'allora direttore il direttore dell'IRPET Giuliano Bianchi fu di non accontentarsi di avere costruito una tavola dell'economia toscana, ma di costruire attorno ad essa un gruppo di lavoro che portasse alla costruzione di un modello dell'economia toscana da utilizzare a fini di programmazione. Maurizio Grassini fu sin dall'inizio parte integrante di questo gruppo. È infatti bene ricordare che tra la fine degli anni Settanta e la prima parte degli anni Ottanta vi fu un revival delle tavole intersettoriali a livello regionale, anche per l'enfasi che in quella stagione veniva attribuita alla programmazione regionale. Molte ne furono costruite, ma di fatto solo l'IRPET ha continuato a lavorare sulle tavole I/O e questo è dovuto proprio al fatto che non ci si limitò alla costruzione iniziale ma si provò a sviluppare attorno ad essa un sistema di modelli tuttora funzionante.

Il progetto che fu avviato era quello di costituire un modello input-output tradizionale che poggiasse sulla tavola costruita e che avesse alcune caratteristiche di fondo, in particolare che lo si potesse "chiudere" dal lato degli scambi con il resto del paese e dal lato dei consumi dei residenti e che fosse inserito all'interno di un modello mondiale, in modo che anche le esportazioni non fossero una variabile trattata autonomamente, ma derivasse da un modello che tenesse in conto le variabili internazionali in modo più completo e coerente con l'impostazione di un modello I/O.

Per soddisfare queste esigenze il progetto si inserì all'interno di una collaborazione con lo IIASA di cui Grassini fu il principale artefice, lavorando per alcuni mesi nel bellissimo istituto austriaco localizzato a Laxemburg, nei pressi di Vienna. Anch'io assieme ad altri ricercatori dell'IRPET e alcuni studiosi che collaborarono al progetto (ricordo in particolare Alessandro Petretto e Dino Martellato) passai alcuni mesi allo IIASA con l'obiettivo di costruire il sistema di modelli dell'IRPET a cui demmo il nome di SMART (Sistema di Modelli per l'Analisi della Regione Toscana).

Maurizio Grassini seguì l'intero progetto, ne curò in modo particolare alcuni dei moduli, soprattutto quello del consumo, ma soprattutto fu l'artefice del tentativo di connettere questo modello con l'INFORUM, ovvero l'Interindustry Forecasting Project at the University of Maryland coordinato dal professor Clopper Almon.

Nei mesi di lavoro allo IIASA il modello dell'IRPET prese corpo con le seguenti caratteristiche:

- era un modello biregionale Toscana-Resto d'Italia;
- prevedeva una parziale endogenizzazione del consumo;
- era corredato di moduli collaterali in grado di fornire stime sulle principali componenti della domanda finale.

Il modello, frutto della collaborazione con lo IIASA e basato sulla disponibilità per lo stesso anno, oltre che della tavola intersettoriale dell'economia Toscana, anche di una tavola dell'economia italiana, assunse la seguente forma strutturale:

$$\begin{aligned}
x+m_r+m_w &= Ax+c+g+i+dsc+e_r+e_w \\
m_w &= M(Ax+c+g+i) \\
m_r &= B(I-M)(Ax+c+g+i) \\
e_r &= Q(I-M)(Ax+c+g+i) \\
c &= Hx+k
\end{aligned}$$

In cui:

x : vettore della produzione
m_r : vettore delle importazioni dall'altra regione (r=1,2)
m_w : vettore delle importazioni dall'estero
c : vettore dei consumi interni delle famiglie
k : vettore dei consumi esogeni (dei turisti e di coloro che non ricevono redditi dal processo produttivo)
g : vettore della spesa pubblica per consumi collettivi
i : vettore degli investimenti
dsc: vettore della variazione delle scorte
e_r : vettore delle esportazioni nell'altra regione
e_w : vettore delle esportazioni all'estero
A : matrice dei coefficienti tecnici
H : matrice del consumo
M : Matrice (diagonale) dei coefficienti di importazione estere

B : Matrice (diagonale) dei coefficienti di importazione dall'altra regione
Q : Matrice dei coefficienti di importazione dall'altra regione (matrice B ruotata in modo che B+Q dia la matrice dei coefficienti di allocazione della domanda nelle due regioni)

La forma ridotta risultante è quindi la seguente

$$x =[I-(I-B+Q)(I-M)(A+H)]^{-1} [(I-B+Q)(I-M) (k+g+i)+dsc+ e_r+e_w]$$

Il modello aveva quindi una forma classica in cui a partire dalle variabili esogene (consumi, investimenti ed esportazioni), forniva stime sulla produzione sulla base dei coefficienti tecnici e di scambio stimati all'anno base.

Naturalmente vi furono continui arricchimenti del modello attraverso l'aggiunta di moduli in grado sia di stimare le variabili esogene, che passare dalla produzione alle variabili ad essa connesse, in particolare l'occupazione. Vi furono anche tentativi di dinamizzare alcuni dei coefficienti del modello, successivamente abbandonati.

Questa struttura del modello è rimasta sostanzialmente inalterata sino ad oggi con alcune rilevanti novità che riguardano:

- l'estensione del modello alle 20 regioni italiane;
- il costante aggiornamento delle tavole intersettoriali con metodo indiretto ogni volta che ISTAT aggiorna i dati di contabilità regionale attraverso la metodologia di bilanciamento Stone-Champernowne;
- la costruzione di una NaMea per la Toscana;
- l'inserimento delle tavole intersettoriali all'interno di una SAM per le regioni italiane.

Ma al di là di queste estensioni mi piace soffermarmi su alcuni aspetti della discussione che si avviò con il professor Grassini nell'ambito della costruzione del modello, in particolare sul modulo del consumo e sulla procedura utilizzata per la sua endogenizzazione: in poche parole sulla matrice H che noi costruimmo seguendo un approccio alla Miyazawa.

Il modello utilizzato era il seguente:

$$\mathbf{c}=\mathbf{b}\bullet\pi\bullet Y_d$$
$$Y_d= (1-\tau)\bullet Y + P$$
$$Y=\mathbf{v'}\bullet\mathbf{x}$$

Da cui risultava che

$$\mathbf{c}=\mathbf{b}\bullet\pi\bullet(1-\tau)\bullet\mathbf{v'}\bullet\mathbf{x} + \mathbf{b}\bullet P$$

ovvero

$$\mathbf{c}=\mathbf{H}\bullet\mathbf{x} + \mathbf{k}$$

in cui

$$\mathbf{H}= \mathbf{b}\bullet\pi\bullet(1-\tau)\bullet\mathbf{v'}$$
$$\mathbf{k}= \mathbf{b}\bullet P$$

Y_d = valore aggiunto totale
Y_d = reddito disponibile
$\mathbf{b}$ = vettore a somma 1 della struttura del consumo
π = propensione media la consumo
τ = aliquota media di imposizione diretta
$\mathbf{v'}$ = vettore (riga) dei coefficienti di valore aggiunto
P = Pensioni

5. *Empirici ma con attenzione*

La matrice H era quindi di fatto una 'strana' matrice ottenuta da prodotto tra due vettori: quello della composizione della spesa e quella dei coefficienti di valore aggiunto. In altre parole un euro di produzione finale di ogni branca si trasformava in valore aggiunto sulla base del coefficiente di valore aggiunto di ciascuna branca (il vettore **v'**), veniva depurato delle imposte dirette e dei contributi sociali (l'aliquota t) divenendo reddito disponibile e poi tramite la propensione al consumo p consumo totale, suddiviso poi nella domanda rivolta alle singole branche attraverso una struttura dei consumi uguale per tutti (il vettore **b**).

Ricordo che noi, che avevamo lavorato con intensità alla costruzione del modello, eravamo molto soddisfatti dell'esito raggiunto, se non altro per il fatto che in tal modo i moltiplicatori che ottenevamo potevano essere i tradizionali moltiplicatori leonteviani (ponendo H=0) o quelli keynesiani.

Maurizio Grassini ci fu sempre vicino in questo lavoro, ma in questo caso contestò sin dall'inizio questo approccio, pur comprendendo l'esigenza di semplificazione che ci animava.

In realtà all'inizio noi non capimmo le motivazioni della sua contestazione che – dovendo qui sintetizzarla – stavano tutte nel significato da dare a quel vettore **v'** che trasformava la produzione in valore aggiunto, ovvero una grandezza reale in un'altra che, invece, è una grandezza nominale.

Usare quei coefficienti significava, di fatto, accettare il concetto di valore aggiunto a prezzi costanti, una grandezza che in realtà viene regolarmente utilizzata, ma che non esiste nel mondo reale; usarlo può condurci talvolta a veri e propri paradossi.

In sintesi la questione può porsi anche in termini molto semplici: il valore aggiunto può essere visto anche come la remunerazione dei fattori che hanno partecipato al processo produttivo e, quindi, risente dell'andamento reale della produzione, ma anche di quello dei prezzi dei beni prodotti e degli *inputs* produttivi. Se trascuriamo la dinamica dei prezzi è come se ipotizzassimo che questi hanno la stessa dinamica in ogni settore e quindi negassimo che invece alcuni fattori ricevono una maggiore remunerazione proprio perché i prezzi hanno dinamiche diverse. Detto in altri termini è come se deflazionassimo in modo diverso le remunerazioni dei fattori solo perché maturate in settori diversi: un salario nominale di 1000 euro di un lavoratore dell'industria tessile varrebbe meno (o di più) di un analogo salario nominale di un lavoratore dell'industria meccanica.

L'obiezione di Grassini non era dunque solo statistica ma aveva evidenti conseguenze economiche e non era determinata dal fatto di non accettare la semplificazione che avevamo adottato nel tentativo di endogenizzare il consumo. Gli altri aspetti della semplificazione erano infatti accettati: il fatto che vi fosse una unica propensione al consumo oppure una unica aliquota fiscale non furono oggetto di contestazione, dal momento che non sarebbe stato impossibile prevedere, con successivi approfondimenti, propensioni diverse e imposizioni diverse.

La lezione non era quella del professore accademico attento alle finezze teoriche ma aveva contenuti pratici evidenti di lettura ed interpretazione della realtà.

Del resto Grassini si è sempre schierato contro le analisi solo accademiche ricordando come l'obiettivo dell'economista è capire i comportamenti e non inventarseli con ipotesi astruse.

A questo proposito vale la pena di ricordare il suo atteggiamento nei confronti di uno degli argomenti usati da molti studiosi dei modelli input-output che era quello dell'invertibilità della matrice (I-A); nelle analisi del modello di Leontief il riferimento ai teoremi di Perron Frobenius era quasi obbligatorio, nel tentativo di indicare quanto una matrice delle tecniche di produzione potesse essere invertita.

Maurizio Grassini ha sempre ritenuto del tutto assurdo questo aspetto dell'analisi input-output per il semplice fatto che se l'inversa viene calcolata a partire da una tavola costruita su dati reali, quei teoremi sono pura astrazione: la matrice si deve per forza di cose invertirsi. Del resto l'attenzione alla correttezza dei dati da utilizzare è da sempre uno degli insegnamenti principali di Grassini.

6. Le connessioni con l'INFORUM

In realtà sebbene la struttura del modello dell'IRPET prevedesse sin dall'inizio la connessione con l'INFORUM, questa è avvenuta negli anni in modo limitato, almeno sino ad alcuni anni fa quando il progetto di inserire all'interno dell'INFORUM il modello per la Toscana ha ripreso vigore.

I rapporti con il modello INFORUM non sono in realtà mancati, ma questi si sono limitati a fornire all'IRPET, nelle nostre analisi previsive, lo scenario di riferimento per l'Italia.

In altre parole il modello sopra descritto e operante per le 20 regioni italiane è stato regolarmente utilizzato per una serie di applicazioni; tra queste molte analisi strutturali sulle caratteristiche dell'economia delle diverse regioni italiane; per analisi di impatto relative ad interventi, in genere, di spesa pubblica; per analisi previsive.

Quest'ultimo tipo di applicazioni partiva da una stima delle componenti della domanda finale, le collocava all'interno del modello ed otteneva produzione e valore aggiunto per branca e ricostruiva il conto delle risorse ed impieghi. L'ipotesi della costanza dei coefficienti, poco accettabile in un'analisi previsiva, veniva implicitamente rimossa vincolando le stime finali agli scenari esogeni sull'economia nazionale predisposti dai vari istituti nazionali ed internazionali (CER, Prometeia, IMF…).

L'utilità aggiuntiva che ci giungeva dal modello INFORUM era legata al fatto che gli scenari esogeni relativi all'Italia avevano lo stesso dettaglio settoriale che serviva al modello dell'IRPET.

Ciò ha consentito di migliorare le nostre previsioni, ma il rapporto con l'INFORUM era ancora molto parziale. Oggi l'IRPET è inserito a pieno titolo nel gruppo di lavoro dell'INFORUM. La nota presentata in questo volume da Leonardo Ghezzi descrive i contenuti di tale inserimento.

Quindi a distanza di anni si è compiuto quel processo di integrazione intravisto inizialmente da Giuliano Bianchi alla fine degli anni Settanta e che visto in Maurizio Grassini il principale protagonista.

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DANTE: VERSO UN NUOVO MODELLO MULTIREGIONALE – MULTISETTORIALE DELL'ECONOMIA ITALIANA

Leonardo Ghezzi[1]

1. Introduzione

Un modello, per definizione, è una rappresentazione di un fenomeno reale che si pone lo scopo di spiegarlo, innanzitutto, per poi eventualmente provare a prevederlo o a controllarlo. Questo è vero per tutte le scienze e vale quindi anche per l'economia. La costruzione di un modello è quindi un tentativo di riduzione della complessità e come tale dipende dagli occhi, dal tatto, dai pensieri e dai valori dello scienziato che si impegna in questo tentativo. In questo senso, la costruzione di un modello è qualcosa di simile all'artigianato, con il ricercatore che cerca di limare le complessità del mondo reale nella stessa misura di come il mastro artigiano lavora il pezzo grezzo per arrivare ad una forma più chiara e comunicativa, in una tensione continua tra realismo e comprensione.

La necessità, intesa talvolta come l'imperativo, di confrontarsi con la realtà ha mosso sostanzialmente tutta l'attività dell'IRPET negli ultimi trent'anni, con particolare riguardo soprattutto per quella parte di lavoro orientata alla costruzione degli strumenti operativi con i quali l'Istituto cerca di rispondere alle domande che arrivano dal policy maker[2]. Vale la pena ricordare al riguardo cosa si scriveva in un famoso volume di econometria[3]

> Models are constantly at the frontier of "unreality" and model users have to be ever vigilant that the conclusions drawn from the model will indeed apply to the real world.

Considerando che di fatto la costruzione di un modello economico coinvolge la sensibilità degli economisti interessati, non è facile dire in che misura si debba cercare l'equilibrio tra complessità (e quindi realismo) e

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[1] IRPET – Istituto Regionale di Programmazione Economica della Toscana.

[2] Si veda in questo volume l'intervento di Casini Benvenuti.

[3] Michael D. Intriligator (1978), *Econometric Models, Techniques, and Applications*.

Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online),

semplificazione (e quindi il tentativo di comprensione). In questo senso, nel momento in cui l'IRPET si è posto l'obiettivo di dare impulso alla costruzione di una nuova e più completa 'cassetta degli attrezzi', ci è venuta in soccorso l'esperienza maturata da alcuni ricercatori che in passato hanno introdotto la modellistica economica in Istituto che è ben sintetizzata nella domanda che si pone, uno di questi[4], quando si chiede

> […] se è possibile immaginare un modello derivato da quadri contabili capace di offrire spunti intellettualmente più [rispetto alla modellistica presente nei manuali di macroeconomia, n.d.r.] interessanti per l'analisi economica.

Questo passaggio ci indica due elementi chiave che rappresentano una guida nel tentativo di costruzione di un nuovo modello multiregionale dell'economia italiana. Il primo di questi è il ruolo chiave delle identità contabili di 'apertura' e più in generale della centralità dello schema contabile adottato alla base del modello che si vuole costruire. Con questo elemento chiaro in mente diviene fondamentale tutto il lavoro necessario a costruire una fotografia della realtà che, nel rispetto delle regole contabili, quantifichi le relazioni tra i soggetti economicamente rilevanti. Il secondo elemento che traspare, non solo dall'affermazione riportata, ma da tutto l'articolo di Grassini, è che il risultato che può essere prodotto dal modello deve necessariamente essere interessante, intendendo con questo ultimo termine probabilmente il significato di utile, cioè con un impatto potenziale nella formulazione delle politiche.

Ci sono diverse classi di modelli econometrici ma quelli che ci sembrano maggiormente in grado di rispondere alla domanda suggerita in precedenza sono quelli basati sulle tavole Input-Output con il contenuto contabile che esse esprimono. D'altra parte è vero che «nella letteratura economica i modelli input-output si incontrano nei più svariati contesti teorici […] non è difficile imbattersi nella rete dei flussi intersettoriali che caratterizzano lo schema analitico quantitativo messo a punto da W. Leontief» (Grassini, 1991). Nello specifico, i modelli basati sulle tavole input-output si ritrovano sia nella spiegazione delle relazioni economiche internazionali, usando approcci sistemici come nel caso dell'esperienza INFORUM[5], sia nell'analisi dell'evoluzione strutturale di una singola economia nazionale, come nel caso di INTIMO[6] o del modello LIFT[7], sia nell'analisi dell'evoluzione multiregionale di una economia, come quel-

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[4] M. Grassini (1991), Problemi econometrici della modellistica multisettoriale. In M. Faliva (ed.), *Il ruolo dell'econometria nell'ambito delle scienze economiche*, e ripubblicato in questo volume.

[5] Si veda al riguardo C. Almon (1991) D. Nyhus (1991).

[6] Si veda M. Grassini (1983a).

[7] Si veda D.S. Meade (2001).

la italiana, caratterizzata da un forte grado di disomogeneità nel tessuto produttivo delle diverse regioni[8].

L'IRPET non solo ha cercato di coltivare nel corso di questo tempo quell'esperienza iniziata oltre trent'anni fa, ma negli ultimi anni si è data l'obiettivo di fare un importante investimento per sviluppare quella strumentazione legata alle tavole multisettoriali con l'obiettivo di dotarsi di un nuovo modello multi regionale dell'economia italiana. In questo breve contributo si cercherà di riassumere i principali passaggi che stanno caratterizzando questa nuova fase, indicando gli elementi già sviluppati e quelli in corso di lavorazione.

2. *Una rapida descrizione del progetto DANTE*

L'obiettivo di sviluppare un nuovo modello econometrico di tipo multisettoriale è nato in IRPET nei mesi successivi all'esplosione di quella che molti economisti considerano la più grave recessione negli ultimi cinquant'anni. A fronte di una caduta de PIL così profonda e duratura e così diffusa tra le economie occidentali, il dubbio che si stesse vivendo una fase di potenziali cambiamenti strutturali ha spinto l'Istituto a chiedersi quali potessero essere le traiettorie seguite dall'economia regionale nei successivi anni per cercare di comprendere se già oggi erano presenti delle criticità, magari non immediatamente evidenti, in grado di rendere la situazione regionale, e più in generale nazionale, socialmente e economicamente difficile da sostenere[9]. Il nuovo modello economico dell'IRPET, il cui sviluppo operativo è iniziato negli ultimi due anni, nasce con un duplice obiettivo quindi: quello di essere uno strumento utile per l'analisi e previsione delle dinamiche di lungo periodo del sistema produttivo e, allo stesso tempo, quello di essere un valido sostegno per la valutazione dell'impatto che le politiche (nazionali e regionali) hanno nel determinare il sentiero di sviluppo regionale.

Per rispondere a questa esigenza l'Istituto si è appoggiato all'esperienza maturata da Maurizio Grassini[10] nella pluri-decennale collaborazione con i diversi partner internazionali del gruppo di ricerca INFORUM che ha sede presso la University of Maryland. Questo ha dato vita ad una condivisione di strumenti e di approcci che oltre ad essere estremamente proficua è risultata anche estremamente naturale vista la comune impostazione metodologica dei due Istituti.

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[8] Quest'ultimo è il caso dei modelli multiregionali sviluppati da IRPET. Si veda al proposito S. Casini Benvenuti, R. Paniccià (2003).

[9] Si tratta di un tema di riflessione che accompagna l'Istituto ormai da alcuni anni come testimoniato dalla pubblicazione di alcuni saggi tra cui A. Petretto (2005), *Toscana 2020. Una regione verso il futuro* e S. Casini Benvenuti (2012), *Il futuro della Toscana tra inerzia e cambiamento.*

[10] Si veda Grassini (2001).

Il progetto del nuovo modello, che prenderà il nome di DANTE[11], può essere sinteticamente riassunto richiamando le seguenti caratteristiche.

Innanzitutto, DANTE è un modello che non solo può essere definito come sub-nazionale ma che, probabilmente in modo più corretto, potremmo definire spaziale. Questo non tanto perché suddivide il territorio nazionale in tre regioni – Toscana, Centro-Nord, Sud (per le quali si è creato un set di equazioni comportamentali che differisce nei tre casi non solo in riferimento alla stima dei parametri ma anche per la specificazione delle relazioni stesse) – ma anche e soprattutto perché si tratta di tre aree che sono tra loro interdipendenti e i cui legami sono descritti attraverso una matrice di scambi bilaterali che permette di tenere in considerazione il ruolo del commercio interregionale nel determinare la dinamica economica di ogni territorio[12].

DANTE, come suggerito in precedenza, è un modello costruito a partire dalle tavole input-output e quindi include un dettaglio settoriale che permette al modello di considerare cambiamenti strutturali nel tessuto produttivo delle diverse regioni[13]. Proprio per rispondere alla caratteristica precedente le tavole sono specifiche per ognuna delle venti regioni italiane e sono poi aggregate nelle tre ripartizioni viste sopra.

Inoltre, DANTE assume la forma di un modello strutturale, cioè pone in relazione causale le componenti del modello che compongono così non un semplice insieme di elementi tra loro correlati, come invece avviene per i modelli a-teorici, ma bensì uno schema di lettura coerente logicamente. Seguendo la ripartizione richiamata da Maurizio Grassini, e ricavata dall'originale lavoro di Koopmans, Rubin e Leipnik (1950), si tratta di aver aggiunto, all'interno dei uno schema contabile rappresentato attraverso le tavole input-output, un insieme di equazioni comportamentali che fossero in grado di spiegare le scelte degli attori. Queste relazioni causali, di cui il ricercatore deve conoscere a priori segno e ordine di grandezza dei parametri (come ama ricordare Grassini ai suoi studenti), sono state oggetto di analisi econometriche che hanno consentito di quantificare l'intensità di tali legami. Di fatto, DANTE, può essere considerato un modello econometrico multisettoriale nella tradizione dei modelli sviluppati e simulati presso INFORUM.

La necessità di tenere in considerazioni anche variabili di politica tributaria che assumono andamenti non lineari rispetto alle principali variabili di contabilità nazionale ha imposto poi la necessità di pensare ad un modello che come obiettivo si ponesse quello di integrare il livello strettamente macro, o più correttamente 'meso', con quello micro descritto in

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[11] Dynamic Analysis for National and Tuscan Economy.

[12] Nella definizione e quantificazione delle relazioni economiche interregionali la matrice degli scambi bilaterali è ottenuta attraverso un approccio gravitazionale modificato in modo da tenere in considerazione la distanza non in termini strettamente geografici ma in termini di accessibilità. Si veda L. Cherubini, R. Paniccià (2013).

[13] Queste sono ottenute per ogni regione attraverso la stima di matrici Supply and Use che vengono bilanciate seguendo la procedura introdotta da Stone, Champernowne, Meade.

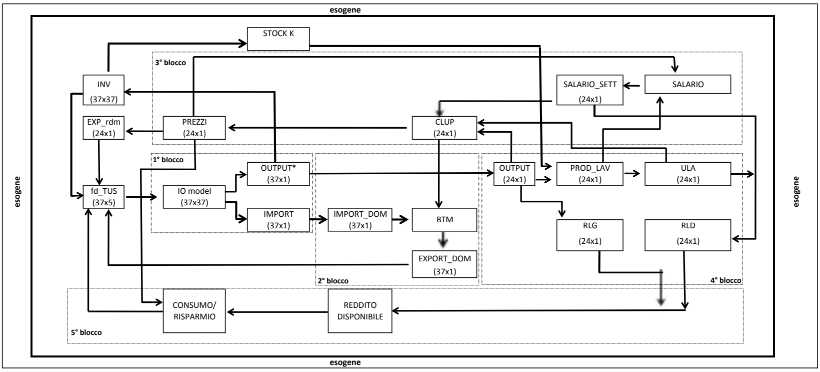
modo puntuale attraverso i modelli di micro simulazione a disposizione dell'Istituto. In questo senso, pur non avendo ancora progettato un legame stabile, DANTE si propone di interagire sia con il modello statico che micro simula il comportamento delle famiglie, per calcolare l'Irpef ad esempio, sia con quello che invece si occupa di micro simulare il pagamento Irap a carico delle imprese. In questo senso, DANTE si propone di diventare un modello micro-macro che cerca di sfruttare la potenzialità di una lettura aggregata nello spiegare in modo completo il circuito di formazione, distribuzione, utilizzo del reddito e allo stesso tempo che cerca di utilizzare i microdati disponibili sia in merito a certi comportamenti delle famiglie che ad alcuni aspetti delle imprese.

3. Il diagramma di flusso del modello

Lo schema generale del modello può essere sintetizzato attraverso la figura 1 che indica per una delle tre regioni inserite nel sistema interregionale il sistema di relazioni tra i vari blocchi.

Il primo blocco riguarda la più tradizionale componente input-output e consente di ottenere il livello di produzione settoriale data una certa domanda finale. Si tratta della componente che già è presente in IRPET e che è stata sviluppata nel corso degli anni. Ovviamente, accanto al livello di produzione si perviene al calcolo delle importazioni complessive.

Il secondo blocco del modello consente di stimare il commercio interregionale attraverso una matrice degli scambi bilaterali che distribuisce la domanda di importazioni di ogni regione alle altre distinguendo innanzitutto la parte che trae origine dall'estero e poi, utilizzando il residuo di questa, ricavando attraverso le matrici il valore del commercio interregionale[14].



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[14] Queste due parti del modello sono risolte in modo iterativo utilizzando la procedura Gauss-Seidel.

Sulla base di questi due passaggi DANTE non sarebbe niente di diverso da un semplice modello di impatto input-output multi regionale, tra l'altro già disponibile in Istituto. È in questo punto che interviene concretamente il nuovo progetto che IRPET sta perseguendo, nell'introdurre un sistema di relazioni che completino il quadro input-output, che per quanto ricco, non riesce a descrivere tutti i momenti rilevanti nel funzionamento di un'economia. Ed è in questo momento che ci si addentra per un percorso rischioso. Come suggerisce Grassini (1991) «I modelli multisettoriali o input-output sono per loro natura teoricamente eclettici e sono palesemente caratterizzati dalle identità contabili di apertura [...]. Quando da questo quadro si passa alla costruzione del modello econometrico emerge con chiarezza la condanna all'eclettismo teorico che caratterizza i modelli IO», ed è così che anche in DANTE dal rigore contabile delle tavole, nel momento in cui si tenta di passare ad un modello che intenda essere rappresentativo della realtà regionale italiana, si è costretti a cadere nell'eclettismo introducendo alcune funzioni che incrinano l'ortodossia.

Innanzitutto, nel terzo blocco, la funzione della produttività del lavoro viene specificata seguendo un approccio à la Kaldor-Verdoorn[15]; si tratta di un elemento centrale nel modello che assume rilevanza sia perché consente di determinare la domanda del fattore lavoro sia perché entra indirettamente come variabile esplicativa[16] nel determinare il valore delle esportazioni estere e quello delle esportazioni interregionali, determinando i coefficienti contenuti nelle matrici di scambio bilaterali tra regioni. La produttività del lavoro rientra infatti nella determinazione dei prezzi che, ancora una volta tradendo l'ortodossia, non segue il tradizionale schema nominale basato sulle tavole input-output ma poggia più chiaramente sull'idea di mark-up.

Nel quinto blocco, il reddito da lavoro e il risultato lordo di gestione, fluiscono alle famiglie secondo quanto previsto dagli schemi contabili dei conti dei settori istituzionali e, assieme anche ad altre poste (i redditi da capitale, le pensioni ad esempio) concorrono a determinare il livello di reddito disponibile delle famiglie. Il progetto DANTE prevede in questo punto di utilizzare queste informazioni, assieme allo stock di ricchezza finanziaria, per stimare l'equazione aggregata del consumo, con un approccio basato sulla teoria del ciclo di vita. Sempre nel quinto blocco relativo alle famiglie, dal consumo totale di queste ultime si passa, attraverso un approccio conosciuto come PADS (Almon, 1979), ad una stima del consumo per tipologia di bene. Infine, seguendo un più tradizionale approccio, abbiamo introdotto un modello accelerativo per spiegare il comportamento degli investimenti del sistema. Quelli contenuti nella figura 1, e descritti sinteticamente nel-

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[15] Rispetto ad un tradizionale approccio alla Verdoorn in questo caso è stato dato un ruolo fondamentale all'intensità di capitale produttivo per lavoratore come determinante della produttività del lavoro.

[16] Attraverso il calcolo del costo del lavoro per unità di prodotto.

le righe precedenti, sono solo alcuni dei punti in cui si abbandona il rassicurante schema contabile per introdurre i comportamenti dei soggetti e la loro risposta al mutare delle condizioni che li circondano, ma sono probabilmente sufficienti a confermare come anche nel caso di DANTE valga il richiamo di Maurizio Grassini: «egli [l'economista, n.d.r.] non potrà fare altro che convivere con la condanna all'eclettismo teorico».

4. Lo stato dell'arte nella costruzione di DANTE

Allo stato attuale, DANTE nella versione multisettoriale multi regionale qui descritta non è ancora stato pienamente sviluppato. Esiste una struttura macro che è già operativa e che ricalca di fatto tutti i passaggi previsti nel diagramma precedente. Per quanto riguarda la versione multisettoriale, l'IRPET sta ancora lavorando al progetto con alcune parti che possono essere considerate completate e altre ancora no. L'aspetto rilevante da cui partire per descrivere i passi fatti è sicuramente relativo allo schema contabile e ai dati inseriti in questo per dare concretezza e aderenza alla nostra realtà regionale, con particolare riguardo per la stima delle tavole input-output multi regionali sui cui l'IRPET si sta impegnando da anni.

Le tavole Input-Output multi regionali per il modello DANTE

A conferma del ruolo centrale delle cosiddette identità di apertura, DANTE trae fondamento da uno schema contabile adottato in tutte le economie europee. L'impostazione metodologica dell'IRPET segue quella nazionale adottata da ISTAT che a sua volta è basata sul SEC95[17]. La contabilità nazionale secondo quest'ultimo registra i flussi dell'attività economica utilizzando un insieme di conti rappresentati come tabelle a doppia entrata che sono: il conto della produzione; il conto delle risorse e degli impieghi; il conto della generazione del reddito; il conto dell'attribuzione del reddito; il conto dell'utilizzo del reddito; il conto patrimoniale.

Le matrici di contabilità ricalcano questi conti aggregati introducendo un dettaglio settoriale che nel caso dell'IRPET include 37 settori[18] e 54 tipologie di prodotto. Queste matrici possono essere di diversi tipi a seconda delle informazioni contenute ed in particolare tra le matrici prodotte dall'IRPET possiamo distinguere le seguenti: le matrici input-output e le matrici Supply & Use.

Le prime assumono come da tradizione la tipica struttura rettangolare dello schema input-output e nel caso dell'IRPET sono costituite da cinque grandi sottomatrici: esportazioni, domanda finale interna, scambi intermedi,

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[17] Sistema Europeo dei Conti.

[18] Le tavole dell'IRPET si basano su una articolazione in 37 branche che corrispondono ad aggregazioni delle divisioni Ateco 2007.

remunerazione dei fattori produttivi e importazioni. Le matrici degli scambi intermedi sono simmetriche e appartengono alla famiglia delle matrici *Industry by Industry* nel senso che le righe e le colonne rappresentano le branche produttrici. Queste sono ottenute da matrici più ampie, le cosiddette Supply & Use (o Make & Use), che forniscono informazioni più dettagliate sia sulle branche produttrici che sui beni e servizi da queste prodotti. Il nostro interesse in definitiva è concentrato più sulle simmetriche, perché è su queste che vengono costruiti i modelli input output multi regionali, ma sono le Supply and Use a contenere pienamente la struttura contabile prevista dal SEC95.

La costruzione dei dati che riempiono questi schemi è effettuata da IRPET utilizzando informazioni di diversa origine (in alcuni casi di fonte ufficiale, in altri derivanti da indagini dirette, in altri ancora frutto di stime effettuate in Istituto) e sottoponendo i dati così raccolti, le cosiddette *stime iniziali*, ad un processo di bilanciamento che renda i dati quantitativi coerenti con i vincoli contabili, sia nazionali che regionali. Il metodo fu proposto per primi da Stone, Champernowne and Meade (1942) e fu poi ulteriormente approfondito da Theil (1968), che ne mostrò l'analogia con il metodo dei minimi quadrati generalizzati, e da Byron (1978) che sviluppò adeguati algoritmi per risolvere il problema di minimizzazione. L'aspetto cruciale di questo metodo di costruzione delle tavole è la definizione delle matrici di affidabilità attraverso le quali procedere alla correzione delle singole stime iniziali.

La costruzione simultanea dei tutte le SUT regionali e la conseguente estrazione, con l'ipotesi adottata di *industry technology*, delle relative matrici simmetriche IO permette di stimare anche le matrici commerciali tra le regioni. Si tratta di matrici quadrate che per ogni prodotto (54 prodotti nel caso delle SUT) o per ogni branca (37 branche nel caso delle matrici IO) collegano regioni di produzione e regioni di domanda e mostrano nelle celle interne i flussi (in valore) di beni e servizi dalle regioni di origine a quelle di destinazione. Le matrici input-output così ottenute sono sommabili e così dalle venti regioni si possono ottenere varie aggregazioni di queste e in definitiva, si può ricavare la tavola italiana coerente con quella pubblicata da ISTAT.

Il blocco del consumo nel modello DANTE

A conferma dell'eclettismo nel quale si è spinti al momento in cui si decide di passare dalla teoria alla pratica dei modelli input-output, all'interno di una struttura contabile che assume i contenuti richiamati in precedenza sono state aggiunte varie equazioni comportamentali che trovano basi in vari approcci teorici. Come suggerito in precedenza, su questo punto il modello è ancora incompleto e il lavoro prosegue per terminare il sistema di relazioni illustrato sinteticamente nella figura 1. Tra i blocchi sui quali si è concentrato lo sforzo il primo ad essere stato affrontato riguarda le scelte di consumo effettuate dalle famiglie[19].

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[19] Si veda L. Ghezzi (2013).

La strategia adottata segue l'esperienza maturata negli ultimi trent'anni all'interno del progetto INFORUM che ha coinvolto molti ricercatori nell'implementazione e sviluppo di un approccio che per primo è stato introdotto da Almon (1979). La tradizione nella stima di questo sistema di domanda, denominato PADS[20], applicato al caso italiano è stata portata avanti prima da Maurizio Grassini (1983b) e poi da Rossella Bardazzi (Bardazzi 2000; Bardazzi, Barnabani 2001) come descritto in questo volume.

Nel caso di DANTE sono stati previsti due blocchi. Il primo è sviluppato a livello macro, basato sull'ipotesi del ciclo di vita, e consente di definire la traiettoria del consumo aggregato delle famiglie residenti. Visto però che la dinamica delle singole componenti del paniere di spesa ha un effetto rilevante nel determinare effetti sia in termini di produzione che in termini di occupazione si è inserito anche un secondo blocco che ricalca il sistema di domanda utilizzato all'interno dell'INFORUM, il PADS appunto, che invece consente di stimare le elasticità al reddito e ai prezzi di ognuno dei singoli beni.

5. *I prossimi passi nella costruzione di DANTE*

Al momento DANTE è in grado di essere simulato solo nella sua versione aggregata, che si compone di 210 equazioni di cui 74 in grado di descrivere specifici comportamenti degli agenti mentre le altre 136 sono identità contabili che ricalcano i passaggi descritti nella figura 1, ma in forma aggregata. Lo sviluppo multisettoriale sta avvenendo in parallelo all'implementazione del modello macro con l'idea di integrare lo schema contabile contenuto nelle tavole IO e le equazioni comportamentali settoriali in una logica bottom-up, nella quale, come suggerito da Grassini (1989) «le grandezze aggregate sono ottenute dalla somma delle grandezze settoriali». In questo senso le equazioni disaggregate andranno progressivamente, per blocchi, a sostituire le relazioni macro. È questo l'unico modo, a nostro avviso, di sfruttare la modellistica IO per analizzare possibili evoluzioni strutturali delle economie regionali italiane.

È chiaro che nel tentativo di incrociare la dimensione settoriale con quella regionale si incorre nel serio rischio che le affascinanti teorie contenute nella manualistica non si adattino perfettamente alla necessità di capire, descrivere, sintetizzare ciò che effettivamente osserviamo nella realtà. Siamo consapevoli di questo e siamo disposti a correre il rischio di commettere errori in questo tentavo di comprensione dei fenomeni nello spirito descritto da Maurizio Grassini (2001):

> Finally, it should be clear that builders of Inforum models take data and behavioural equations seriously. In contrast to models with

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[20] Perhaps Adequate Demand System.

> casually chosen parameters that have been "calibrated" to only one year of data […] the Inforum models can be tested over several years of past data and used to forecast specific future data. These forecasts may, of course, prove wrong. But they offer the possibility of learning from mistakes, something you cannot do with models that cannot make mistakes.

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MODELLING HOUSEHOLD CONSUMPTION: A LONG-TERM FORECASTING APPROACH

Rossella Bardazzi[1]

Author's note

My first encounter with multisectoral modelling was for a study of indirect taxation inspired by Maurizio Grassini and under his supervision. Only some years later did I come to appreciate how unique and original the perspective of this scientific approach to the study of indirect taxation effects on industrial price formation was. As a second topic of applied research within the Italian multisectoral model built and maintained thanks to the constant commitment of Maurizio Grassini, I was able to implement a revised version of the demand system originally developed by Clopper Almon in 1979 and later extended in 1996. Both researches deeply shaped my professional experience and recur from time to time in my studies, albeit in other research environments. Here I intend to assess the main features of the INFORUM approach to personal consumption expenditure modelling as a complex but very flexible system for investigating and forecasting household consumption in a disaggregated framework.

1. Introduction

In most industrialized economic systems personal consumption expenditures account for over two- thirds of gross domestic product. It is not surprising therefore that household consumption behaviour has been thoroughly studied in economics with the development of theoretical and empirical models applied to different data sources. Several characteristics could be used to build a taxonomy of demand models but here we are mainly interested in limiting the scope of our analysis to the study of consumption within a long-term macroeconometric model. In this specific setting, modelling personal consumption expenditures means explaining the largest final demand component in a long-run perspective where all possible explanatory variables may change substantially. Moreover, consumption patterns affect output both at the aggregate and at the sectoral level and relative prices will change as a result, with subsequent consequences on consumer demand. This simple statement explains why we believe it's ap-

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Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online), © 2013 Firenze University Press

propriate to evaluate the usefulness of a demand system in relation to its context and scientific purpose.

Some early examples of this approach are represented by the Interindustry Forecasting Project (INFORUM) modelling family (Almon, 1991) where personal consumption equations were implemented thanks to the pioneering contribution of Almon (1979) and updated both in theoretical and empirical terms since then to prove the flexibility of this analytical approach. Grassini (1982) gives a first application of the original 1979 demand system to the INTIMO (Interindustry Italian Model) econometric model.

2. *The foundations of the approach*

> We must first note that it is neither necessary nor sufficient for a functional form to be econometrically useful for market demand studies that it be derivable from the utility maximization of a single consumer (Almon, 1979, p. 85).

Consumer theory entails some broad constraints (such as additivity, price homogeneity and Slutsky symmetry) but only under additional assumptions regarding consumer preferences and the distribution of income does the microeconomic theory make constraints on the aggregate demand system.

Therefore, even if we assume that each household has a utility function that it maximizes, it does not follow that representative classes with well-defined utility functions exist, unless all households in a class have identical preferences.

Thus, in macroeconomic models, the use of a selected utility maximizing representative households to generate demand patterns is no more and no less theoretically sound than the use of any other demand function that fits the data reasonably well. In general, the aggregation issue is very well known in the literature and the limits of aggregate consumption studies are well summarized by Deaton (1992):

> Representative agents have two great failings; they know too much, and they live too long. An aggregate of individuals with finite lives, and with limited and heterogeneous information is not likely to behave like the single individual of the textbook (p. ix). […]
>
> One of the virtues of a representative agent is that the process of aggregation destroys all individual personality. The representative agent is neither young or old, is neither male nor female, and has a uniform and more or less constant number of perpetually youthful children […] Age and family composition matter, as do a host of other possible variables such as race, education, place of residence, and occupation. Indeed, diversity is so obviously important that it is hard to justify

> models that do not allow for the presence of unobservable individual fixed effects, effects that are certainly correlated with the income and consumption variables that concern us, and whose introduction generates sometimes intractable problems of statistical inference (p. 137).

The demand system originally designed by Almon, and then developed and applied in several directions and in a number of studies, has successfully captured the heterogeneity of households as well as the disaggregation of consumption functions and their simultaneous connections.

In his 1982 contribution republished in this book, Grassini states very clearly that the demand system built within the Italian model «is specifically designed to be a component of a large macroeconomic model; it should therefore be evaluated largely in terms of the required overall performance of this model». The 1979 system of personal consumption equations is formally presented in the paper referred to and applied to the Italian economy for the period 1970-1981. Grassini reminds a set of required properties – originally envisaged by Almon – this system should satisfy to produce meaningful results in relatively long-term studies. In particular, the demand function should have an analytical form able to deal with significant growth in real income, with demographic and other trends, and with changes in relative prices. It should allow for both complementarity and substitution between different goods. Prices should affect the marginal propensity to consume with respect to income and the extent of that influence should be an empirical question and not determined by the form of the function. Following the same reasoning, income will certainly make the demand for a given good vary according to its specific propensity to consume, but increasing income should not make any demand negative.

The original demand system was generalized by Almon (1996)[2] and named as PADS, a *Perhaps Adequate Demand System*. PADS equations have a form with a multiplicative relation between the income term and the price term:

$$x_i(t) = \left(\alpha_i + \beta_i \frac{y(t)}{P(t)} + \sum_{k}^{K_i} \theta_{ik} T_{ik} \right) \prod_{n=1}^{N} p_n^{\delta_{in}} \qquad (1)$$

where $x_i(t)$ is per capita consumption of product *i* in period *t*; a, b, d, and q are parameters; *y(t)* is a measure of nominal per capita income or expenditures, *P* is the overall consumer price index; and *T* are additional variables important to the product *i*; finally, p_n is the price of product *n* and is

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[2] The 1996 paper was re-published in Almon C., *The Craft of Economic Modelling*, Volume 3, available on the website <inforumweb.umd.edu.>

equal to one in an arbitrary base year. The price term of this equation is complicated by a grouping technique which is explained later on. In the estimated form of the model, the income term may include a cyclical variable as the first difference of real per capita income and T_k may include either a single linear time trend (as in the original 1979 paper) or additional variables other than price, income, demographics, and the passage of time which might be important in explaining expenditure behaviour. Interest rates, for example, may affect demand for durable goods as well as stocks of durable consumption goods, transfer payments, construction spending, and housing stock. Dummy variables also may be constructed to incorporate information not captured in prices or in other variables. This functional form is therefore very flexible and can be expanded to customize it to each expenditure category. However, one must bear in mind that in forecasting, each independent variable must either be produced in the macroeconometric model or must be exogenously predicted, the use of special-purpose explanatory variables must therefore be parsimonious.

As this system is applied to a highly disaggregate set of expenditures (80 categories for the US economy as in Dowd *et al.*, 1998; 40 categories for the Italian consumption system as in Grassini, 1982 and Bardazzi and Barnabani, 2001), a grouping procedure of consumption items is envisaged to economize on estimated parameters, and the symmetry of price effects is imposed (Almon, 1996). The definition of groups is based on the expected complementarity/substitutability of the various commodities to be determined at the responsibility of the model builder.[3] In this technique, a commodity may be a strong complement /substitute for other items in its own group while interacting less strongly with the prices of goods in other groups. Similarly, the functional form allows for subgroups within which we assume even greater sensitivity of the demand for one product to the price of others in the same subgroup.

This demand system can either be estimated as a ‘stand alone’ model of demand functions or included within a multisectoral macroeconometric model as originally meant for the PADS system. In the second, more interesting case, price and income variables become endogenous and results of estimates may significantly differ from those obtained when estimating the system without any feedback from the rest of the economy. When the demand system is included in the multisectoral model as explained by Grassini (2001), personal consumption categories must be linked to industrial production sectors so as to ‘translate’ expenditure for consumption purposes into the purchase of bundles of goods and services produced by

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[3] In Grassini (1982) nine groups of expenditures are defined (Food, Alcohol & Tobacco, Clothing, Housing, Durables, Health, Transportation, Education & Recreation, Other goods & services) while a different group definition is adopted in Bardazzi and Barnabani (2001).

industries. In general, a product-purpose matrix, also called consumption transition matrix, allows each expenditure heading to be simultaneously classified by output sector (product) and consumption purpose. In other words, this matrix makes it possible, for every good or service acquired by households, to determine the sector that produced it. This is the same approach used for modelling investment decisions in the multisectoral model. These bridge matrices between different classifications and agents (consumers and producers; investing sectors and industries producing investment goods) have always been used within the Italian INTIMO model and, in general, in the INFORUM multisectoral approach.[4].

3. The second generation of the INFORUM household consumption modelling approach

> To penetrate below the skin-thin surface of conventional consumption functions, it will be necessary to develop a systematic study of the structural characteristics and the functioning of the households, an area in which description and analysis of social, anthropological and demographic factors must obviously occupy the center of the stage (Leontief, 1971, p. 4).

Over the last decades, as microdata has become increasingly available and computing capacity and microeconometric techniques have developed further, the time-series approach to studying consumption has been extended by applied research on household budget data aimed at exploring issues in the direction suggested also by Leontief words. The first improvement within INFORUM modelling was to connect the demand system described above with a cross-section analysis based on household budget surveys data. There are several reasons which explain why an integrated cross-section/time-series model has been built. The objective of the cross-section analysis is to measure the effects of both income and demographic effects on household consumption. Influences such as the age structure of household members, the geographical region of residence, education and occupation, the size of family and working habits play a key role in determining consumption behaviour. The heterogeneity of these characteristics is effectively studied with household microdata, however the novelty of this approach, first proposed by Devine (1983), is to study these effects to acquire information to improve the time-series model. Indeed, demographic variables contribute to the determination of personal consumption expenditures and changes occurring over time must be accounted for, however these changes are many and slow and it is therefore impossible to identify

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[4] More recently, Mongelli *et al.* (2010) employ a bridge matrix to extend an input–output model with a specific household consumption model.

their complex interactions using time-series data only. Diversely, differences across the cross-section sample of households may be profitably exploited to identify these effects. However, cross-section data are not overly useful when one wants to estimate the price effects that will be used to shape long run consumption forecasts. Time-series data, on the other hand, can be used to measure price elasticities as shown in the PADS equations. Since neither data source alone would suffice, both should be used, with each contributing their special attributes to the formulation of the final system of equations. Other reasons for keeping the demand system based on the time-series data involve the data characteristics and their role within the macroeconometric model. In this modelling approach the underlying accounting system dictates an accounting consistency – derived from the national accounts framework – which must be satisfied.[5]. Therefore the total private consumption expenditure which is included in National Accounts and represents a component of GDP, is the aggregate which matches the sum of expenditure categories data used within the demand system.

Moreover, it should be clarified that the time-series PCE data are not obtained by summing the microdata of household surveys. Indeed, these data sources differ for several reasons. First of all, they are based on different methods of calculation. That is, the household data are collected through a direct survey while the National Accounts include household expenditures whose value must be estimated indirectly using different sources (several sample surveys, administrative sources and indirect methods). In addition, the two data sets differ as regards the unit of reference, definitions and classification criteria.[6]. Finally, microdata cannot be used to form a household panel as due to the design of the underlying 'rotating' sample survey: the ideal case of long time-series data that track individual households over time cannot be pursued.

In order to exploit the heterogeneity of household data to better capture the influences of income distribution and demographic variables in the demand system, the original approach was implemented in two stages and an integrated cross-section/time-series demand system was built.

The cross-section consumption function designed by Devine (1983) and developed in many INFORUM models[7] is designed to be flexible enough to be used as the consumption function for a long list of goods, as expected within a multisectoral modelling framework. The function should be able

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[5] As regards this requirement and the accounting identities within the model, see Grassini M. *Problemi econometrici della modellistica multisettoriale* and *The core of the Multisectoral INFORUM model* republished in this volume.

[6] For a general discussion on this topic and specific references to the British and US data see Attanasio (1999). A detailed description of the main differences of these data sources for the Italian case is given in Bardazzi (2000).

[7] For instance Dowd *et al.* (1998) apply this model to the US economy, while for the Italian case see Bardazzi and Barnabani (2001).

to represent the demand for luxury items, necessities or even inferior goods and should incorporate demographic effects in a straightforward manner.

The general form of this function can be represented as a simple equation which relates household consumption expenditures to income, demographic and age group variables, such as:

$$c_{ih} = f\left(x_h, d_h\right) N_h \left(n_{h1}, \ldots\ldots, n_{hg}\right) \tag{2}$$

where c_{ih} is consumption of good i by household h, x_h is per capita-income within household h, d_h is a set of demographic characteristics of household h, N_h is the size of household h which is a function of the number of members in separate age categories n_g.

The relationship between consumption and income is described by a linear spline, a piecewise-linear Engel curve. Per capita household income is divided into several income brackets; within each bracket, it is assumed that consumption responds linearly to income. However, households may change their consumption propensity over different brackets. Additionally, this relationship is estimated for each expenditure category. The slopes of these Engel curves represent the 'specific' propensity to consume both with reference to specific goods and to each income level. The main advantage of this curve is its flexibility: one functional form adapts to different shapes thus representing different income-consumption relationships as fitting alternative functional forms to different commodities. The demographic characteristics enter this function as zero-one dummy variables to indicate inclusion within various categories, thus assuming that all demographic groups have the same specific propensities to consume out of income and therefore the effect of these variables is to change the intercept of the Engel curve.

The specification of the effect of per capita income and demographic characteristics in equation (2) leads to the per capita consumption of each commodity within the family. To obtain the household consumption of each good, a measure of the family size must be introduced. This is the role of the last term on the right of the equation. Function N_h is a measure of the size of the household which weights members of different ages differently. It is a weighted household size which varies by commodity where weights depend upon the relative importance of each age group in determining consumption expenditures for commodity i. This weighting scheme waives the assumption that all individuals contribute equally to the size of the household, regardless of their age. The estimated cross-section function can be represented as follows:

$$c_{ih} = \left(a_i + \sum_{k=1}^{K} b_{ik} Y_k + \sum_{l=1}^{L} d_{il} D_l \right) \left(\sum_{g=1}^{G} w_{ig} n_g \right) \tag{3}$$

where c_{ih} is household consumption expenditure for good *i*, Y_k is per-capita income divided into *k* brackets; D_l are dummy variables used to show membership of the l^{th} demographic group; n_g is the number of household members in age category *g*. The estimated parameters *b* represent the specific propensity to consume and *w* are the adult equivalency weights for measuring the weighted family size.

As the cross-section analysis is intended to contribute to the time-series demand system, a linkage between the two stages has been designed. The main task of the cross-section analysis is to quantify the effects on household consumption of demographic variables, age structure and income distribution. To transfer this information into the time-series analysis, two variables are created. Firstly, by using the estimated adult equivalency weights w_{ig} of equation (3), a time-series of weighted populations for each commodity is created thus converting the age distribution into a scalar measure of population which is commodity-specific. The weighted size of population for good *i* in year *t*, WP_{it}, is calculated by the following formula:

$$WP_{it} = \sum_{g=1}^{G} w_{ig} N_{gt}$$

where w_{ig} is the adult equivalency weight for good *i* in age group *g* estimated from equation (3) and N_{gt} is the population in age group *g* in year *t*.

Using the estimated parameters *b* and *d* of the same equation – which respectively represent the marginal propensities to consume specific to each good in each income bracket and the effects of demographic variables – a 'prediction' of total expenditure for each commodity, defined as C^*, is computed by using the historical average amount of income in each bracket as variable *Y*, and the population proportions in each demographic category as *D* variables.[8]. This 'prediction' captures the effects of demographics and income and is used in the time-series equation (1) as an explanatory variable in place of disposable income, while the commodity-specific weighted population is used in the same equation to compute the dependent variable, consumption per capita, which is obtained by applying a different population for each commodity.

Through this linkage, microdata information capturing the effects on consumption of the population age structure, of non-age demographic characteristics and income distribution is indirectly used in time-series analysis where the price effects on consumption can be studied. As previously mentioned, in a forecasting perspective the use of this technique

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[8] For more details on the formulas and description of these two variables see Bardazzi and Barnabani (2001). In the following section a further development of the C^* variable is explained along with the related formula.

requires a forecast of income distribution through a specific module (as in Janoska, 1996) and a forecast of the population composition and age structure.

4. Further developments on specific issues

This integrated cross-section/time-series demand model has been further developed in several directions. The first issue we consider is a technical matter as it relates to the occurrence of zero expenditures in the survey data. Many households report zero purchases on several commodities which may or may not indicate zero consumption of these goods. The problem of zero expenditures is well known in the related literature[9] although it is often neglected because this issue is less evident when demand systems are estimated with a limited disaggregation of expenditure categories. However, even if commodity aggregation may hide the problem, the information content is biased by the presence of zeros which we need to interpret so as to apply the appropriate econometric technique for dealing with them. The key issue is that the theoretical concept of *consumption* which we are trying to explain differs from its observed counterpart *expenditure*. Households are observed for short periods only, therefore a zero expenditure reported in the budget survey does not mean zero consumption. Three main reasons for observing zero expenditures may be identified: (1) infrequency of purchase, (2) economic decision, and (3) conscientious abstention[10]. One of the main reasons for zero expenditure is infrequency of purchase. This is the case of durable goods: consumption of the good takes place every day while expenditure occurs only once every few years. In this case expenditure is a poor indicator of underlying consumption which may be positive. When this occurs, if we use zero as the dependent variable, the real consumption will be misrepresented. A zero expenditure could be due to an economic decision based upon variables such as income and price. This might be the case of luxuries as first analyzed by Tobin (1958). Zero expenditures may also arise from a variation of preferences across the sample: some households may simply not consume some goods at any price or income level. This is the case of conscientious abstention where the decision is based on culture, personal preference, religion or other factors. Typical examples include cigarettes, alcohol and meat.

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[9] See the pioneering work of Tobin (1958), and the words of Deaton (1986) who argues that «the problem of dealing appropriately with zero expenditures is currently one of the most pressing in applied demand analysis» (p. 1809).

[10] An additional explanation of zero expenditures is misreporting which is always a concern of survey data. For a detailed analysis of these different cases and related econometric models, see Bardazzi and Barnabani (1998).

In the cross-section analysis described above the issue of zeros needs to be accurately addressed because of the detailed expenditures classification and appropriate econometric models must therefore be used. For the Italian multisectoral model, alternative methods have been applied depending on the main reason of zero expenditures (Bardazzi and Barnabani, 2001): the main conclusion of the study is that a non-linear probability model could be used to tackle the existence of zero expenditures. This is a three-step approach where in the first step the probability of buying is estimated, then a non-linear regression model is applied to the observations where expenditure is positive and, finally, expected consumption for all households is estimated. In other words, it is a form of regression-based imputation which enables the replacement of zeros with the modelled values based on a multivariate model.

A second field of development for demand analysis aimed at long-run forecasting concerns demographic changes. Changes in the magnitude and structure of population have enormous consequences on the economic chances of individuals and the well-being of entire economies. They affect production and consumption, allocation and distribution both directly and indirectly through a variety of channels. Ageing will result in a different composition of the labour force, an altered sectoral structure of final demand and higher pressure on pension systems. Both the labour force and final consumption have a significant influence on the sectoral structure of the economy. A higher share of pensioners induces a trend towards more and smaller households, increases leisure time during life and the demand for health care services. The increasing consumption demand for services (health, leisure time activities) and housing, and the decreasing demand for durable goods (cars and electronics) brings about a change in the composition of consumption goods, which has a direct impact on sectoral final demand. This may affect production sectors differently, creating winners and losers. This in turn will change output composition and employment patterns.

Shifting consumption preferences are a crucial issue for ageing societies and may be investigated by integrating the cross-section/time-series system with cohort analysis and a demographic model. The cross-sectional investigation answers the question of how a household makes decisions on the purchase of various goods and services at a certain point in time. As explained in the previous paragraph, the effect of the household age structure on consumption is accounted for by means of an adult equivalency weighting scheme in the cross-section function. The estimated weights are then used to compute weighted population time-series which embody the age effect on household expenditures and are used to estimate and forecast the personal consumption expenditure demand system. However, adult equivalency weights do not represent a 'pure' age effect because they include both the characteristic life-cycle profile of consumption and a cohort effect which leads to differences in the positions of age profiles for different cohorts. Indeed, household expenditure decision may change if two families with exactly the same income and demographic characteristics live at different times; the two families' consumption patterns may differ because of generational specific preferences. One year of cross-sectional data is not sufficient for comparing households' spending at different times and, as we explained, it is not possible to follow an individual household for more than one year because of the rotating survey sample. However, with repeated cross-sections, we are able to construct cohort data to follow cohorts of households over many years.[11]. This analysis tells us how the consumption behaviour of households today differs from households of the same age and demographic characteristics during other time periods. In the case of Italian households, the main findings show that cohort effects have a distinctive pattern for some items such as selected food categories, tobacco, alcohol, financial services, and technical instruments. In these cases, we may observe a remarkable change of habit as a result of health awareness, technological progress and other causes: it's hard to believe in a backward evolution for future generations. These effects must therefore be taken into account in a forecasting perspective.

Cohort effects are included when modelling the link between the cross-section and the time-series step of the demand system: if repeated cross-section data are available, the 'prediction' of total expenditure for each commodity explained above – used to incorporate income distribution effects and non-age demographic influences in the time-series function where price effects are included – can be modified to benefit from this enlarged dataset and distinguish cohort effects on consumption. A C^* variable can therefore be defined as follows:

$$C_{it}^{*} = b_{i0} + \sum_{k=1}^{K} \frac{b_{ik} y_{kt}}{P_t} + \sum_{l=1}^{L} d_{il} D_{lt} + \sum_{m=1}^{M} c_{im} C_{mt}$$

where the first summation represents the piece-wise Engel curve, the second is the sum of non-age demographic effects, and the final term is the sum of cohort effects on consumption where *m* is the number of cohorts. The semi-aggregated structure of cohort data thus provides a link between micro-economic household level data and the macroeconomic national accounts.

Both C^* and weighted populations *WP* are calculated for each expenditure category and used in the time-series demand system where price dy-

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[11] Repeated cross-sections form a pseudo-panel where a cohort is built according to the age of the reference person in each household (household head). For each survey, expenditures by age of household head are averaged and then the sample from the same cohort one year older is tracked in the next year. For example, one can look at the average consumption of 30-year-olds in the 1990 survey, of 31-year-olds in the 1991 survey and so on. An empirical application to the Italian case may be found in Bardazzi (2001).

namics is introduced. With this development, the original PADS equation is modified as follows:

$$\frac{q_{it}}{WP_{it}} = \left(\alpha_i + \beta_i C_{it}^{*} + \sum_{k}^{K_i} \theta_{ik} T_{ik} \right) \prod_{n=1}^{N} p_n^{\delta_{in}}$$

The dependent variable, per-capita expenditure, is the ratio between total consumption and the specific weighted population, and C^* is used as an explanatory variable instead of disposable income to summarize all those effects related to income distribution and demographics as detailed above.

In this extended framework, to fully exploit the potential of this approach in household consumption simulation and forecasting, a demographic projection model may be added and linked to the main macroeconometric model. Through this model a forecast of population by age groups is obtained and several hypotheses of future demographic development effects on consumption may be tested. This approach has been adopted by the US INFORUM model LIFT and by the Italian INTIMO model (Dowd *et al.*, 1998 and Bardazzi, 2001)[12].

5. Concluding remarks

Building a macroeconometric model is an endless task. As described perfectly, once again in the words of Leontief (1971):

> True advance can be achieved only through an iterative process in which improved theoretical formulation raises new empirical questions and the answers to these questions, in their turn, lead to new theoretical insights. The "givens" of today become the "unknowns" that will have to be explained tomorrow. This, incidentally, makes untenable the admittedly convenient methodological position according to which a theorist does not need to verify directly the factual assumptions on which he chooses to base his deductive arguments, provided his empirical conclusions seem to be correct (p.5).

All econometric models are clearly therefore merely an approximation to vastly more sophisticated real world data-generating processes. As pointed out by Almon in his contribution included in this volume, we are

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[12] For these models, a cohort component method was adopted to obtain a population at time t+1 from a base year population as well as some additional hypotheses about mortality rates, net immigration by age and fertility rates.

just looking «for rough but workable approximations» of a complicated reality we may only have some insight into. An important role in the iterative process of improving a model is played by theoretical insights which indicate the direction and the magnitude of relationships between economic variables. Another fundamental and often neglected role is played by data: their informative content, quality, and consistency. The stock of information must be constantly updated: our capabilities will progressively expand only with new inflows of additional data having different qualities and characteristics.

The development of a personal consumption equation system within an INFORUM macroeconometric model is a good example of the iterative process explained by Leontief. The flexibility of the functional form has made room for changes to respond to new questions. Moreover, as new information progressively flowed in – such as household budget data, repeated cross-sections and longer time-series of additional macrovariables – it was explored and incorporated into the demand system in an effective manner. The accounting structure of the macroeconometric model is not just a constraint but a useful framework for checking the consistency of these different sources and finding the best way of utilising them.

Further developments may be anticipated as new policy issues arise.

Environmental issues are becoming very popular in the public debate and policies are designed to influence household's and firm's behaviour towards more energy-saving and less pollutant consumption. The effectiveness of these policies mainly based on price signals depends on price elasticities: a disaggregate consumption expenditure system may give useful insights to the likely effects of these policies where several energy type categories are identified. Shifting consumption preferences resulting from public policies or structural changes such as the ageing population affect economic growth and sectoral production composition as well as tax bases; conversely, the relative size of different bases (e.g. direct vs. indirect taxes) changes and, as a result, the revenue-generating capacity of the tax system – at given tax rates – is altered. These effects may be investigated in a long-run macroeconomic model where the demand system interacts with the rest of the economy and taxes are modelled as explained in Bardazzi, Grassini, Longobardi (1989).

Other advances of this integrated demand system may be imagined as well as of the macroeconometric model it belongs to. We are studying an economic system which is not only very complex but is also rapidly changing and which has been hit by a series of shocks. The behavioural relationships we can identify must be continuously monitored to check for potential discontinuities, the model should be a flexible tool characterized by a consistent framework of statistical information and by an internal logic which allows the model builder to describe a «story behind the figures» (Siviero and Terlizzese, 2007) explaining the links between economic variables and acting as a useful guide for policy-making.

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INVERSIONI CICLICHE E PREVISIONI MACROECONOMICHE: RACCONTO DI DUE RECESSIONI

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1. Introduzione

L'economia italiana ha affrontato, nel giro di pochissimi anni, due recessioni di violenza e durata complessiva inusitate. La prima (*la Grande Recessione* del 2008-2009), provocata da una crisi finanziaria originatasi negli Stati Uniti, ha assunto ben presto natura globale, inducendo una forte contrazione della produzione in tutte le principali economie e un collasso degli scambi mondiali. La seconda (*la crisi dei debiti sovrani*), sviluppatasi all'interno dell'area dell'euro, ha colpito in maniera selettiva i paesi nei quali si erano gradualmente accumulati nel periodo intercorso dall'introduzione della moneta unica ampi disequilibri di natura macroeconomica, in particolare (ma non solo) per quanto riguarda i conti pubblici. Tra le due recessioni si è verificata nel nostro paese una ripresa di intensità modesta e di breve durata; alla vigilia della seconda recessione, il livello dell'attività economica in Italia non si era ancora riportato nei pressi del precedente picco ciclico.

Nel periodo antecedente il 2008, l'economia mondiale era stata caratterizzata da oscillazioni della domanda e della produzione di entità modesta, tutte prontamente riassorbite; quegli anni si erano pertanto meritati l'appellativo di "Grande Moderazione". Dal 2008, la volatilità delle variabili finanziarie e macroeconomiche è divenuta repentinamente elevata, con sbalzi improvvisi e violenti dei prezzi delle attività, della domanda e del PIL.

In tali condizioni, la capacità di prevedere gli andamenti delle principali variabili economiche si è visibilmente deteriorata, tra il 2008 e il 2012 e per tutti gli analisti, nel confronto con il periodo precedente. L'attività previsiva è stata resa ancora più complessa dal manifestarsi di fenomeni inusitati non solo per via della loro dimensione ma anche della loro stessa natura. In particolare, la crisi finanziaria globale aveva colpito uno snodo – quello delle interrelazioni tra variabili macroeconomiche e variabili finanziarie – generalmente trascurato nei modelli previsivi in uso fino ad allora; essa aveva inoltre vissuto una lunga fase di incubazione in ambito prevalentemente finanziario, lontano dal campo di osservazione degli analisti macroeconomici. Anche la crisi dei debiti sovrani ha rappresen-

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[1] Banca d'Italia.

Rossella Bardazzi (edited by), *Economic multisectoral modelling between past and future: a tribute to Maurizio Grassini and a selection of his writings*, ISBN 978-88-6655-408-0 (print), ISBN 978-88-6655-409-7 (online),

tato una novità qualitativamente senza precedenti: prima del suo manifestarsi (quindi, solo pochissimi anni fa), si ipotizzava che tutti i titoli di Stato potessero essere trattati come un'attività finanziaria priva di rischio; nel nuovo mondo, tale ipotesi è chiaramente inadeguata.

Sia la crisi finanziaria globale sia quella dei debiti sovrani rappresentano quindi eventi rari, se non unici. Scarseggiano pertanto per definizione osservazioni del passato utilmente sfruttabili per cogliere le regolarità statistiche che alimentano i modelli di previsione macroeconomici.

In questo lavoro, dopo un rapido esame dell'evoluzione dell'economia italiana tra il 2007 e il 2012 (par. 2), viene presentata una valutazione della performance previsiva della Banca d'Italia e degli altri principali analisti pubblici e privati nel periodo antecedente la crisi e nell'ultimo quinquennio (par. 3). Il campo di indagine e gli strumenti impiegati sono simili a quelli in Visco (2009), i cui risultati vengono qui aggiornati tenendo conto anche delle previsioni formulate per il periodo più recente (2010-2012). Viene poi condotto (par. 3.1) un confronto della performance previsiva in occasione dei tre più recenti anni di flessione del PIL (2008, 2009, 2012), per verificare se gli analisti abbiano saputo far tesoro dell'esperienza passata, compiendo errori via via più contenuti e limitando quindi i danni. Nel paragrafo 4 viene presentata una scomposizione degli errori di previsione commessi dalla Banca d'Italia, sia nell'arco dell'intero periodo esaminato (1999-2012), sia per il periodo pre-crisi (1999-2007), sia infine per i recenti anni di elevata turbolenza (2008-2012). L'analisi si pone l'obiettivo di individuare e stimare separatamente la parte dell'errore di previsione attribuibile ai seguenti fattori: errata formulazione delle ipotesi relative alle variabili esogene; stima imprecisa delle condizioni iniziali; interventi *ad hoc* di natura *judgmental*, per tenere conto di informazioni che non possono essere colte direttamente col modello econometrico trimestrale, che costituisce il principale strumento per la realizzazione di previsioni macroeconomiche in Banca d'Italia (tali interventi hanno spesso riflesso informazioni derivate da modelli satellite). Il paragrafo 5, infine, prende spunto dalla seguente considerazione (cfr. Visco 2009): uno dei principali insegnamenti da trarre dall'esperienza recente, nella quale si sono ripetutamente materializzati rischi estremi, è che «una previsione va comunicata e recepita nella sua interezza: non solo, quindi, il suo valore numerico centrale, ma anche le valutazioni sui rischi prevalenti, sulla loro dimensione e probabilità di realizzarsi». Rispondendo a tale sollecitazione, negli ultimi anni in Banca d'Italia è stata rivolta una crescente attenzione alla necessità di stimare l'intera distribuzione delle previsioni macroeconomiche e affinare i mezzi impiegati per comunicare con efficacia direzione e intensità dei rischi; il paragrafo illustra strumenti e modalità comunicative messi a punto per tali finalità.

I risultati riportati in questo lavoro confermano che rispetto al periodo precedente, negli anni compresi tra il 2008 e il 2012 si è osservato un aumento cospicuo degli errori di previsione. Nel 2009 e nel 2012, tuttavia, gli errori sono stati relativamente contenuti nel confronto col 2008. Quanto alla scomposizione dei fattori sottostanti agli errori, le stime imprecise delle condizioni iniziali hanno fornito un contributo rilevante all'errore di previsione per l'anno corrente, minore per quello successivo; tali conclusioni sono valide sia per il periodo pre-crisi sia per quello di crisi. Gli errori compiuti nella formulazione delle ipotesi esogene sono stati rilevanti sia per l'anno in corso sia, soprattutto, per quello successivo; il loro impatto è stato particolarmente pronunciato nel periodo di crisi. Infine, le valutazioni *judgmental* hanno permesso, nell'ultimo quinquennio, di contenere in misura non trascurabile l'entità dell'errore di previsione. Particolarmente utili sono state le indicazioni ricavate da strumenti messi a punto per stimare l'impatto macroeconomico di fenomeni di razionamento del credito.

2. La Grande Recessione e la crisi del debito sovrano, con un rapido intermezzo di ripresa stentata: breve cronistoria dell'economia italiana tra il 2008 e il 2012

Dal 2008 a oggi l'economia italiana ha conosciuto in veloce successione due recessioni profonde, di gravità senza precedenti, inframezzate da una ripresa stentata e rivelatasi rapidamente illusoria.

Il primo dei due episodi recessivi, cui si fa ora solitamente riferimento col termine di "Grande Recessione", venne scatenato dalla crisi finanziaria internazionale culminata con la bancarotta della banca d'affari Lehman Brothers nel settembre 2008. I primi segnali di tensione nei mercati finanziari erano emersi nella primavera del 2007 nel segmento dei titoli collegati a mutui ipotecari particolarmente rischiosi (i cosiddetti mutui *subprime*) negli Stati Uniti; nell'agosto di quell'anno le tensioni esplosero con violenza, provocando all'inizio del mese una situazione di stallo nei mercati interbancari. A partire da quel momento la crisi peggiorò con una decisa accelerazione, trasmettendosi a tutti i mercati finanziari. Divenne straordinariamente virulenta negli ultimi mesi del 2008. I premi al rischio sui tassi interbancari, già aumentati nel 2007 e nella prima parte del 2008 in misura sino ad allora inusitata, salirono ulteriormente, raggiungendo livelli molto elevati; l'attività su quei mercati si ridusse e si frazionò, con la formazione di *cluster* di operatori. Cominciarono anche a manifestarsi, a fronte delle difficoltà si approvvigionamento per le banche, segnali di peggioramento nelle condizioni di offerta del credito. Nel frattempo, il contagio aveva iniziato a trasmettersi all'economia reale: a partire dal secondo trimestre del 2008 la domanda e la produzione cominciarono a flettere in tutte le maggiori economie avanzate (in Italia i primi segnali di decelerazione erano stati avvertiti già l'anno precedente) e a rallentare in quelle emergenti. Ne conseguì, a cavallo tra i mesi finali del 2008 e quelli iniziali del 2009, un vero e proprio tracollo, senza precedenti, degli scambi internazionali, che si contrassero di circa un sesto nel giro di soli due trimestri (il quarto del 2008 e il primo del 2009). La caduta del PIL divenne repentinamente tumultuosa in numerose economie, tra le quali la nostra; si arrestò solo intorno alla metà del 2009, grazie anche a interventi di politica economica – fiscale e monetaria – straordinari per entità, ampiezza e natura (vennero tra l'altro adottate in diverse economie avanzate, tra le quali l'area dell'euro, misure 'non convenzionali' di politica monetaria, miranti in primo luogo a sventare un arresto del flusso di finanziamenti verso l'economia), nonché per il grado di coordinamento internazionale col quale alcuni di quegli interventi vennero decisi. In particolare, nell'ottobre del 2008 le banche centrali delle principali economie mondiali decisero un taglio coordinato dei tassi di *policy*, continuando poi a ridurre il costo del denaro sino alla metà del 2009 (nell'area dell'euro, il tasso sulle operazioni di rifinanziamento della BCE toccò l'1,0 per cento, valore minimo, sino a quella data, dall'introduzione dell'euro).

In diversi paesi l'impiego della leva della politica fiscale in funzione anticiclica accentuò situazioni di squilibrio pre-esistenti. L'Italia, pur con un ampliamento contenuto del disavanzo pubblico, rimaneva particolarmente vulnerabile a ragione dell'elevato debito accumulato nei decenni precedenti.

La ripresa che si avviò a partire dalla metà del 2009, fu nel nostro paese debole; si rivelò ben presto di breve durata. Mentre in quella fase l'economia tedesca sfruttò appieno il nuovo vigore degli scambi mondiali, conseguendo una rapida crescita delle esportazioni verso i mercati più dinamici, la crescita del PIL dell'Italia fu modesta. Di conseguenza, mentre in Germania agli inizi del 2011 il prodotto era tornato a superare il livello massimo raggiunto prima dello scoppio della crisi globale, in Italia, il recupero si arrestò a circa un terzo della contrazione osservata nel corso della Grande Recessione.

La ripresa dell'economia italiana subì una brusca battuta d'arresto nella seconda parte del 2011, quando l'Italia venne investita (come era già avvenuto in altri paesi europei) da forti timori degli investitori internazionali riguardo alla capacità del paese di ripagare il proprio debito pubblico, nel contesto di acute preoccupazioni sull'adeguatezza dell'architettura istituzionale europea a far fronte a quella crisi di fiducia (cfr. Rossi 2012 e Visco 2013).

Gli investitori internazionali avevano cominciato a rivolgere un'attenzione particolare al rischio sovrano nell'area dell'euro a partire dalla primavera del 2010, quando la Grecia aveva dovuto far ricorso all'aiuto dell'Unione europea e del Fondo monetario internazionale; nei dodici mesi successivi lo stesso passo era stato compiuto anche dall'Irlanda (dove il disavanzo pubblico era fortemente aumentato anche per via degli aiuti concessi agli istituti di credito in difficoltà) e dal Portogallo. In questa prima fase l'Italia non aveva subito il contagio dei paesi in crisi; lo spread dei titoli a 10 anni italiani rispetto ai corrispettivi titoli tedeschi era rimasto relativamente stabile, in prossimità dei livelli che, secondo le successive stime effettuate da Di Cesare, Grande, Manna e Taboga (2012), possono essere giudicati in linea con le determinanti fondamentali.

Nell'estate del 2011 venne annunciato un piano di assistenza alla Grecia che prevedeva il coinvolgimento degli investitori privati. Da quel momento gli spread rispetto alla Germania di tutte le economie periferiche aumentarono vertiginosamente; le tensioni interessarono da subito anche l'Italia, il cui spread raggiunse un picco intorno ai 550 punti base nel novembre di quell'anno. Le tensioni si attenuarono a cavallo tra la fine del 2011 e l'inizio del 2012, grazie a tre ordini di interventi: i progressi conseguiti nell'affinamento dell'architettura istituzionale europea; le misure di finanziamento a lungo termine decise dalla BCE; gli interventi realizzati in alcuni paesi, tra i quali l'Italia, per riportare la dinamica dei conti pubblici su una traiettoria sostenibile e per rimuovere impedimenti strutturali alla crescita economica. In particolare, il governo italiano varò, in brevissimo tempo, misure di correzione del disavanzo pubblico che ammontavano a oltre 5 punti percentuali del prodotto, con l'obiettivo tra l'altro di anticipare di un anno, al 2013, il pareggio di bilancio concordato in sede europea.

Gli spread tornarono ad allargarsi tra la primavera e l'estate del 2012, soprattutto in relazione a preoccupazioni sulla solvibilità del sistema bancario spagnolo. Gli andamenti del credito e dei tassi di interesse nei diversi paesi dell'area dell'euro cominciarono a divergere in maniera sempre più marcata; si diffusero fra gli investitori timori non giustificati sulla effettiva capacità di tenuta dell'Unione Monetaria. In risposta a tale evoluzione, il Consiglio direttivo della BCE annunciò, nell'agosto del 2012, nuove misure di intervento sul mercato secondario dei titoli di Stato. Da allora, e fino alla metà del 2013, le tensioni si sono tendenzialmente attenuate, sia pur con repentini, forti aggravamenti. La situazione sui mercati finanziari rimane tuttora fragile.

Nel contesto di un innalzamento del costo del finanziamento, di una riduzione della disponibilità di credito e di un peggioramento delle prospettive di domanda, nel corso del 2011 le imprese italiane ridimensionarono rapidamente i propri piani di investimento; il PIL cominciò a flettere nel secondo semestre del 2011. Gli interventi di riduzione del disavanzo delle amministrazioni pubbliche decisi a partire dalla fine di quell'anno, pur necessari a sventare sviluppi finanziari potenzialmente drammatici, hanno inciso sulla capacità di spesa delle famiglie. Nel 2012, i consumi si sono ridotti in misura marcata, di pari passo con la caduta del reddito disponibile. In tutti i trimestri del 2011 e del 2012 la domanda nazionale nel suo complesso ha costantemente fornito un contributo ampiamente negativo alla dinamica del prodotto; solo la domanda estera netta ha sostenuto l'attività economica. Il PIL si è ridotto in media dello 0,7 per cento in ciascuno dei quattro trimestri dell'anno scorso; ha continuato a flettere anche all'inizio del 2013, scendendo su un livello inferiore di quasi il 9 per cento a quello raggiunto prima dell'avvio della recessione del 2008-2009. Si tratta di una contrazione che non ha precedenti per intensità né per durata.

Le due recessioni dell'economia italiana sopra descritte, se da un lato sono state entrambe scatenate, in origine, da shock di natura finanziaria, dall'altro differiscono tuttavia notevolmente quanto ai fattori di crisi e ai meccanismi di propagazione di questi ultimi alla macroeconomia.

Secondo i risultati delle analisi controfattuali condotte da Caivano, Rodano e Siviero (2010), la prima crisi assunse principalmente, per l'economia italiana, la caratteristica di 'crisi importata': la sua trasmissione alla domanda e al PIL dell'Italia avvenne principalmente per il tramite del deterioramento del quadro internazionale e in particolare del tracollo degli scambi. Questo fattore impartì da solo uno stimolo negativo più che sufficiente a rendere conto della caduta complessiva del prodotto nel biennio 2008-2009. Impulsi anch'essi recessivi ma relativamente contenuti vennero dal deterioramento delle condizioni di finanziamento delle società non finanziarie e dal peggioramento delle aspettative di famiglie e imprese. Nella direzione opposta agirono, in misura grosso modo equivalente, azioni espansive di politica monetaria e fiscale (sia pur nel contesto di un ampliamento contenuto del disavanzo).

Busetti e Cova (2013) presentano una stima dell'impatto dei principali fattori che hanno contribuito alla dinamica del PIL dell'Italia nel biennio 2011-2012. Secondo le loro stime, il peggioramento delle condizioni complessive di finanziamento (aumento dei tassi di interesse praticati alla clientela bancaria e contrazione dell'offerta di credito) è stato il principale elemento che ha determinato il rallentamento dell'attività economica nel 2011 e la sua caduta nel 2012. Un impatto negativo di entità grosso modo simile è attribuibile alle misure restrittive di bilancio varate per arginare l'aggravarsi della crisi del debito sovrano in Italia. Peraltro, le manovre di consolidamento dei conti pubblici, al di là di quegli effetti diretti negativi, hanno verosimilmente contribuito a impedire che gli spread raggiungessero livelli elevatissimi e insostenibili, con un conseguente collasso dell'offerta di credito e con sviluppi ben più drammatici di quelli effettivamente osservati. Ciò contrasta nettamente con quanto avvenuto, secondo le valutazioni di Caivano, Rodano e Siviero (2010), nel 2008-2009, quando l'azione pubblica mitigò gli effetti recessivi di altri fattori, sia pure in misura relativamente contenuta nel confronto con altri paesi. Alla recessione recente avrebbero fornito un contributo non trascurabile il rallentamento degli scambi internazionali e il deterioramento del clima di fiducia di famiglie e imprese.

Le stime di Caivano, Rodano e Siviero (2010) e Busetti e Cova (2013) mostrano quindi significative differenze nella natura e nella rilevanza relativa dei principali shock all'origine delle due recenti recessioni dell'economia italiana. Va tuttavia sottolineato che, per facilitare l'esposizione della 'storia alla radice delle due recessioni', in entrambi i lavori i diversi fattori di crisi vengono considerati come a sé stanti, mentre essi sono invece almeno in parte interconnessi (per esempio, il deterioramento del clima di fiducia e l'aumento dell'incertezza non si sarebbero verificati in assenza degli altri fattori di crisi).

3. Gli errori di previsione dal 1999 al 2007 e nel periodo della doppia crisi (2008-2012)

In questo paragrafo viene valutata l'accuratezza delle previsioni economiche per il PIL e l'inflazione dell'Italia realizzate dai principali analisti, tra i quali la Banca d'Italia[2], considerando separatamente il periodo compreso tra l'avvio della moneta unica e il 2007 e quello successivo (2008-2012). La valutazione della performance previsiva si fonda, per la maggior parte del paragrafo, sull'errore medio assoluto (*Mean absolute error,* MAE), dato dalla media del valore assoluto degli scostamenti tra dato previsto e dato effettivo.

Gli errori di previsione per PIL e inflazione nel periodo pre-crisi, dal varo della moneta unica sino al 2007, sono rappresentati dagli istogrammi colorati nelle Figure 1 e 2, rispettivamente. Nel complesso, le performance di tutti i previsori sono simili; per le previsioni riferite all'anno in corso, l'errore è relativamente contenuto, intorno a 2-3 decimi di punto percentuale per il PIL e a 1-2 per l'inflazione. L'errore sale considerevolmente per le previsioni relative all'anno successivo – in quanto la difficoltà di stimare gli andamenti futuri delle variabili macroeconomiche aumenta naturalmente con l'estendersi dell'orizzonte temporale –, portandosi nell'intorno del punto percentuale per il PIL e tra 0,3 e 0,6 punti, a seconda degli analisti, per l'inflazione al consumo.

Le stime formulate dalla Banca d'Italia nel periodo pre-crisi sono state in genere più precise rispetto a quelle degli altri previsori, in particolare per il prodotto. Le proiezioni degli organismi internazionali (che tipicamente predispongono valutazioni previsive per un numero molto ampio di economie) tendono a essere meno accurate delle altre, pur con alcune eccezioni (per esempio, l'errore di previsione per l'inflazione un anno in avanti è minimo per l'OCSE).

Con la crisi finanziaria globale si è verificato un peggioramento marcato e generalizzato della performance previsiva. La dimensione media degli errori registrati tra il 2008 e il 2012 è aumentata per tutti gli analisti, in misura particolarmente pronunciata per gli orizzonti temporali più lunghi. Per il prodotto, la precisione delle proiezioni per l'anno corrente si è deteriorata per solo qualche decimo di punto percentuale; per l'anno successivo l'errore è invece più che raddoppiato, portandosi intorno ai 2,5 punti percentuali in quasi tutti i casi, con l'eccezione di CSC. Esaminando i risultati riferiti ai singoli anni, la maggiore precisione delle proiezioni di Confindustria nell'ultimo quinquennio appare attribuibile soprattutto alla

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[2] In particolare, la nostra indagine prende in esame, oltre alle proiezioni elaborate in Banca d'Italia, anche quelle effettuate dai principali analisti privati italiani – Prometeia e Centro Studi Confindustria (CSC) –, dalle maggiori organizzazioni internazionali – FMI, OCSE e Commissione Europea (CE) –, nonché quelle di Consensus Economics (pubblicazione che riporta, a cadenza mensile, le previsioni effettuate da una quindicina di analisti privati nazionali e internazionali). Vengono prese in esame, per ciascun analista e per ogni anno, due proiezioni, finalizzate rispettivamente tra aprile e giugno e tra ottobre e dicembre. Le *previsioni per l'anno corrente* sono quelle formulate nella primavera e nell'autunno dell'anno t e riferite all'andamento di PIL e inflazione nello stesso anno t; le *previsioni per l'anno successivo* sono quelle realizzate in t per il periodo $t+1$.

Fig. 1 – Pil: errore medio assoluto nei periodi 1999-2007 e 2008-2012 (punti percentuali; gli istogrammi colorati si riferiscono all'errore nel periodo 1999-2007, quelli trasparenti all'errore nel periodo delle due crisi, 2008-2012)

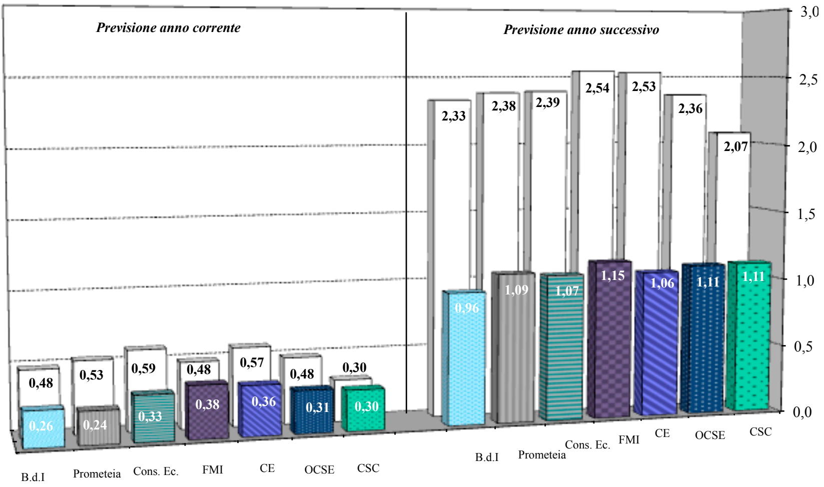
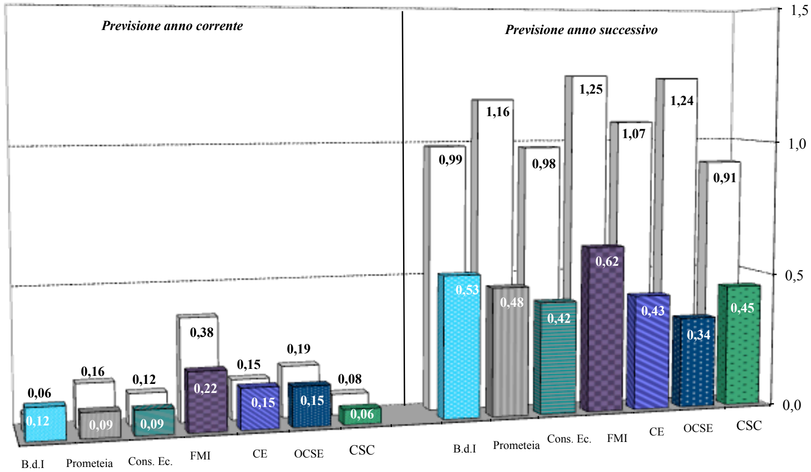


Fig. 2 – Indice prezzi al consumo: errore medio assoluto nel periodo 1999-2007 e 2008-2012 (punti percentuali; gli istogrammi colorati si riferiscono all'errore nel periodo 1999-2007, quelli trasparenti all'errore nel periodo delle due crisi, 2008-2012)



breve ripresa del 2010-2011, quando CSC seppe cogliere prima di tutti gli altri i segnali di svolta ciclica intorno alla metà del 2009. Per l'inflazione, il peggioramento della performance previsiva è stato trascurabile per l'anno in corso, sensibile ma relativamente contenuto, nel confronto con quanto registrato per il PIL, anche per quello successivo. Nel seguito del lavoro, l'analisi si concentra sugli errori di previsione del prodotto, variabile per la quale l'accuratezza delle stime si è deteriorata in maniera più netta.

La Tavola 1 riporta la scomposizione dell'errore di previsione quadratico medio del PIL (U di Theil) nelle componenti sistematiche ("Bias" e "Regression") e casuali ("Disturbance"), per tutti gli analisti e per i due sottoperiodi qui considerati. Tra il 1999 e il 2007, per l'anno corrente la porzione riconducibile al puro effetto di shock casuali è sempre molto elevata, intorno al 90 per cento o superiore. Per l'anno successivo tale quota si abbassa, in misura particolarmente pronunciata per OCSE e CSC (dove cade al 20 per cento), contenuta per Banca d'Italia e Prometeia (dove rimane intorno al 60). Nel periodo di crisi la rilevanza di distorsioni sistematiche è generalmente aumentata; essa rimane comunque non prevalente.

Il forte peggioramento dell'accuratezza previsiva nell'ultimo quinquennio suggerisce il verificarsi, intorno al 2008, di un momento di discontinuità statistica, legata presumibilmente a due ordini di fattori. Da un lato, meccanismi in genere trascurati nei modelli econometrici sino ad allora prevalentemente impiegati a fini previsivi hanno assunto rilevanza rapidamente crescente: in particolare, si è osservata, con l'esplosione della crisi finanziaria globale, una sempre più stretta interdipendenza tra variabili reali e finanziarie, da cui sono conseguiti effetti di amplificazione degli shock. Dall'altro, la relativa tranquillità che aveva caratterizzato gli anni della Grande Moderazione è evaporata in brevissimo tempo, cedendo il posto a una volatilità inusitata; vi si è accompagnato un repentino

Tav. 1 – Scomposizione dell'errore quadratico medio di previsione ("U di Theil")

	BdI	Prometeia	Consensus	IMF	CE	OCSE	CSC
Periodo pre-crisi, 1999-2007							
Anno corrente							
Porzione dell'errore quadratico medio dovuta a:							
Bias	0,03	0,00	0,00	0,11	0,16	0,03	0,01
Regression	0,00	0,00	0,03	0,00	0,00	0,08	0,14
Disturbance	0,97	1,00	0,96	0,88	0,84	0,90	0,84
Anno successivo							
Porzione dell'errore quadratico medio dovuta a:							
Bias	0,24	0,15	0,13	0,42	0,33	0,28	0,04
Regression	0,16	0,29	0,48	0,14	0,15	0,20	0,74
Disturbance	0,60	0,56	0,39	0,44	0,52	0,52	0,22
Periodo di crisi, 2008-2012							
Anno corrente							
Porzione dell'errore quadratico medio dovuta a:							
Bias	0,28	0,33	0,37	0,29	0,37	0,25	0,34
Regression	0,01	0,01	0,01	0,00	0,01	0,06	0,00
Disturbance	0,71	0,66	0,62	0,71	0,62	0,68	0,66
Anno successivo							
Porzione dell'errore quadratico medio dovuta a:							
Bias	0,39	0,44	0,48	0,44	0,50	0,54	0,52
Regression	0,02	0,01	0,00	0,01	0,00	0,00	0,01
Disturbance	0,59	0,55	0,52	0,54	0,50	0,45	0,47

e persistente innalzamento dell'avversione al rischio e all'incertezza da parte degli agenti economici. In presenza di sollecitazioni tanto inusuali, non è sorprendente che l'esperienza del passato cessi di essere una guida affidabile per il futuro. Come suggerito da Siviero e Terlizzese (2007), si potrebbe sostenere che i modelli funzionano quando non servono (quando l'economia naviga in acque tranquille e note), smettono di funzionare quando invece servirebbero (in contesti turbolenti e ignoti).

Se un deterioramento della performance previsiva è, nella situazione sopra descritta, pressoché inevitabile, è tuttavia possibile che, dopo una prima fase di comprensibile disorientamento, gli analisti abbiano imparato a orientarsi nel *brave new world* post-2008. Il prossimo paragrafo affronta tale questione.

3.1 Un confronto tra gli errori di previsione durante la Grande Recessione e nel corso della crisi del debito sovrano

A partire dalla crisi finanziaria globale il prodotto dell'Italia ha conosciuto, in rapida successione, cadute senza precedenti nel confronto storico: nel 2008 la contrazione del prodotto si è avvicinata all'1,5 per cento; nel 2009 ha superato il 5; dopo la breve, modesta ripresa del 2010-2011, nell'anno appena trascorso si è avuta una nuova, forte caduta, pari al 2,4 per cento.

La Figura 3 mostra l'evoluzione nel tempo dell'errore per il PIL commesso dalla Banca d'Italia per ciascuno di quei tre anni (i risultati per gli altri istituti di previsione sono qualitativamente simili). Dalla figura emergono indicazioni che sembrano suggerire una non trascurabile capacità degli analisti di fare tesoro dell'esperienza del 2008 e di adattarsi rapidamente al nuovo, più turbolento contesto economico, con una conseguente riduzione degli errori di previsione nel 2009 e nel 2012 rispetto a quelli relativi al 2008. Ciò è ancora più degno di nota se si tiene conto che la contrazione del prodotto osservata nel 2008 fu di entità relativamente modesta nel confronto con la caduta registrata negli altri due anni[3].

La figura mostra inoltre che, per data dimensione iniziale dell'errore di previsione, nel 2009 e nel 2012 le stime sono state adeguate molto più rapidamente, avvicinandosi in tempi relativamente brevi ai valori veri osservati *ex post*; l'errore per il 2008, per contro, era stato molto più persistente, rimanendo elevato anche verso la fine di quell'anno.

Tale miglioramento della performance è almeno in parte attribuibile a interventi di adeguamento della strumentazione previsiva impiegata in Banca d'Italia, avviati all'indomani dell'*affaire* Lehman e realizzati poi in tem-

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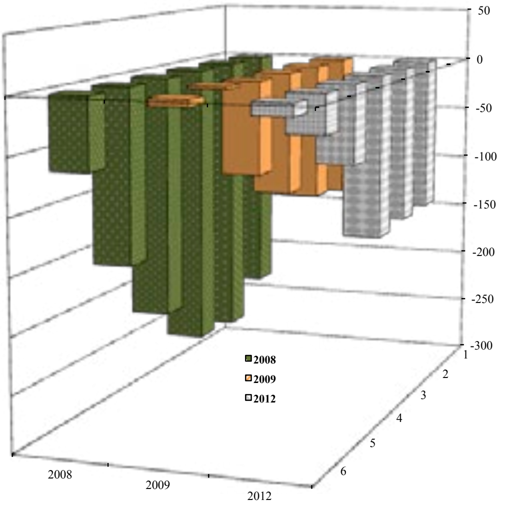
[3] Ponderando gli errori di previsione con pesi che tengono conto della maggiore difficoltà di prevedere dinamiche particolarmente violente del PIL, il miglioramento della performance tra il 2008 da un lato e il 2009 e 2012 dall'altro emerge in maniera ancor più netta.

Fig. 3 – Successione degli errori di previsione per il PIL nel 2008, 2009 e 2012 (punti base)



pi brevissimi. In particolare, quando divenne chiaro che non sarebbe stato possibile produrre stime affidabili senza tenere conto degli effetti su investimenti e PIL di restrizioni all'offerta di credito indotte dalla crisi finanziaria globale (cosiddetto *credit crunch*; per la rilevanza di tale canale nella Grande Recessione, cfr. Par. 2), venne sviluppato in breve tempo un modello satellite mirante a consentire la stima degli effetti prodotti da tale meccanismo. Venne allora sviluppato un approccio simile a quello messo a punto in Banca d'Italia (1986) per valutare l'impatto di vincoli amministrativi all'espansione dei prestiti – approccio a sua volta ispirato a Fair e Jaffee (1972). Tale modello satellite (per una descrizione più completa cfr. Rodano 2009; Caivano, Rodano e Siviero 2010; e Panetta e Signoretti 2010), sfruttando opportunamente le informazioni desumibili dalle indagini condotte presso le principali istituzioni bancarie (*Bank Lending Survey*, BLS), consentì di contenere in misura sensibile l'errore di previsione nei periodi successivi; una stima del suo contributo alla performance previsiva in Banca d'Italia nel corso delle due recessioni dell'ultimo quinquennio è fornita nel paragrafo successivo.

4. Fonte degli errori di previsione

In questo paragrafo viene mostrata una scomposizione degli errori di previsione compiuti dalla Banca d'Italia tra il 1999 e il 2012, con l'obiettivo di valutare separatamente l'influenza esercitata da diversi fattori (ipotesi esogene, condizioni iniziali, *judgment*). Tale scomposizione può aiutare, anche, a individuare in quali direzioni possa essere più opportuno investire per affinare in futuro l'affidabilità dei nostri strumenti di previsione: se, per esempio, sia consigliabile migliorare in primo luogo la performance dei modelli di *backcasting* e *nowcasting* (nel caso di elevata componente dell'errore dovuta a errata valutazione delle condizioni iniziali), ovvero sia più urgente dotarsi di strumenti in grado di fornire migliori proiezioni del quadro esogeno[4].

Nel resto di questo paragrafo valutiamo in primo luogo il contributo dei seguenti fattori all'errore di previsione complessivo:

- non corretta formulazione delle ipotesi relative alle variabili esogene (a sua volta, tale componente può essere attribuita all'impatto di diversi gruppi di variabili);
- valutazione imprecisa delle condizioni iniziali sulle quali si fonda la previsione.

Questa parte dell'analisi fa parzialmente leva sui risultati riportati, fino al 2011, in Bartocci, Cerioni e Rodano (2012). In questo lavoro forniamo inoltre una stima del contributo del *judgment* del previsore: con tale termine intendiamo indicare aggiustamenti al termine di intercetta delle equazioni stocastiche di un modello econometrico previsivo (*add-factors*) basati su informazioni extra-modello, informazioni spesso a loro volta desunte da modelli satellite (quale quello descritto in precedenza, utilizzato per la valutazione degli effetti restrittivi del *credit crunch*). Per quantificare l'effetto di questa componente, è stata realizzata una simulazione in assenza di *judgment*, nella quale la correzione al termine di intercetta è stata posta, per tutte le equazioni, pari alla media dell'errore di simulazione statica negli ultimi 8 trimestri (tale scelta riflette il fatto che, tipicamente, la stima delle equazioni stocastiche del modello econometrico trimestrale della Banca d'Italia tralascia, per motivi illustrati in Siviero e Terlizzese 2007, gli ultimi due anni di dati; con medie di 4 o 12 trimestri si raggiungono conclusioni qualitativamente simili). L'effetto del *judgment* è stato stimato confrontando gli errori effettivamente compiuti con quelli che si sarebbero avuti nelle simulazioni in assenza di aggiustamenti basati su informazioni extra-modello.

I risultati principali della scomposizione dell'errore di previsione, per l'intero periodo 1999-2012 e per i due sottoperiodi, sono riportati nella Figura 4.

L'errore per l'anno in corso riflette soprattutto, sia nel periodo pre-crisi sia in quello di crisi, l'impatto di una valutazione imprecisa delle condizioni iniziali. Tale componente spiega poco meno dei due terzi dell'errore medio

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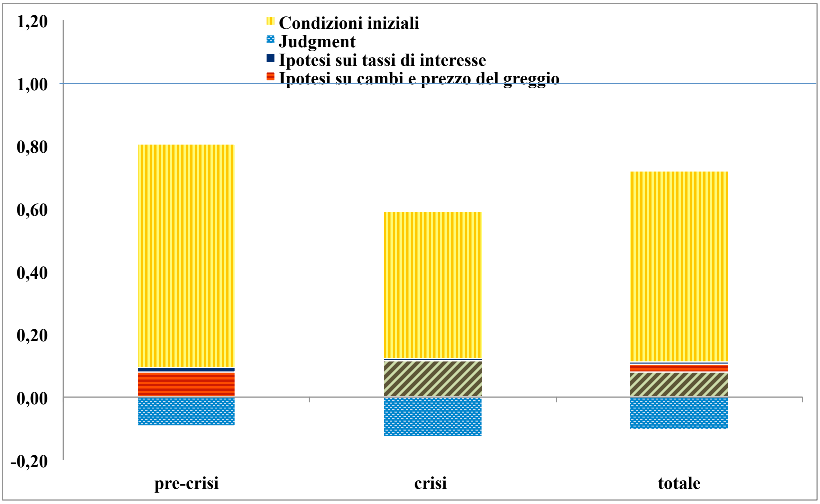
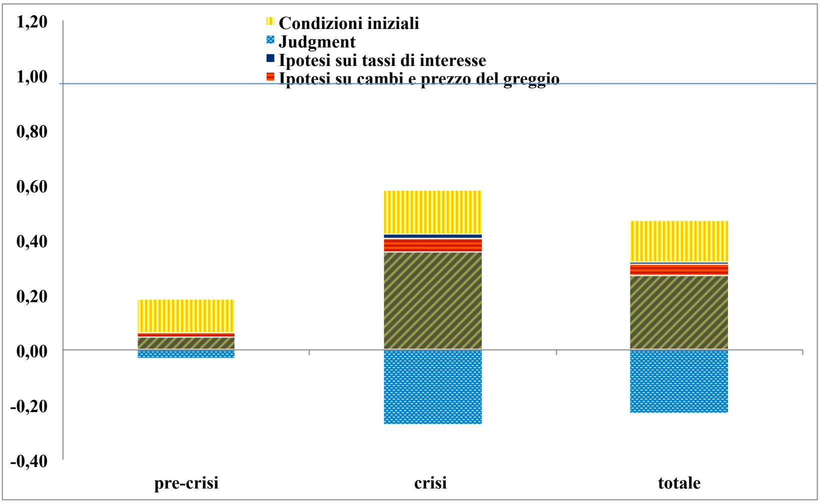
[4] A questo proposito va sottolineato che i margini di manovra per modificare le modalità di formulazione delle ipotesi relative alle variabili esogene sono ridotti, in quanto la Banca d'Italia è tenuta a seguire i criteri concordati a livello di Eurosistema e seguiti in occasione degli esercizi previsivi coordinati per l'area dell'euro.

Fig. 4 – Contributo di ipotesi esogene, condizioni iniziali e *judgment* all'errore di previsione del PIL

(a) previsioni per l'anno corrente



(b) previsioni per l'anno successivo



nel periodo 1999-2007, un po' meno (circa la metà) nella fase più recente. Il contributo delle variabili esogene è, per l'anno in corso, relativamente modesto, intorno al 10 per cento della discrepanza media tra previsioni e valori effettivi. In entrambi i sottoperiodi il *judgment* ha contribuito a contenere l'entità degli errori, sia pure in misura modesta.

I risultati per le previsioni relative alla dinamica del prodotto un anno in avanti sono sensibilmente diversi. L'impatto dell'errata stima delle condizioni iniziali si riduce in misura marcata (come è naturale attendersi), rendendo conto, al più, di un decimo dell'errore complessivo. Riguardo all'imprecisione nella formulazione delle ipotesi esogene, tale componente fornisce un contributo all'errore medio del periodo pre-crisi relativamente modesto; il contributo diviene invece rilevante nel periodo di crisi, arrivando a spiegare circa il 40 per cento della discrepanza tra valori stimati ed effettivi; l'errata proiezione della dinamica della domanda mondiale assume un rilievo particolarmente pronunciato.

Quanto all'apporto del *judgment*, esso è pressoché trascurabile nel periodo pre-crisi: negli anni compresi tra il 1999 e il 2007, l'inclusione di informazioni extra-modello non aveva contribuito a migliorare in misura apprezzabile la precisione delle proiezioni. Al contrario, la rilevanza di tale fattore aumenta notevolmente nella fase di crisi, quando esso abbatte di quasi un terzo, in media, l'errore di previsione. Il *judgment*, quindi, ha aiutato a contenere l'errore di previsione proprio negli episodi nei quali quest'ultimo ha mostrato una tendenza ad ampliarsi. Un esame dei dati riferiti alle singole previsioni mostra che il suo contributo è massimo in corrispondenza dei punti di svolta ciclica.

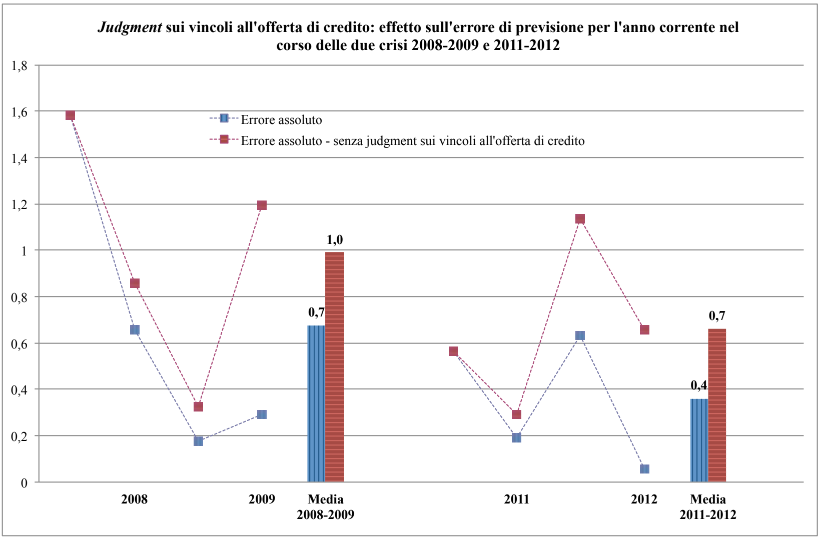
Tra i diversi aggiustamenti basati su informazioni extra-modello, nel periodo 2008-2012 sono stati particolarmente rilevanti quelli miranti a tenere conto delle restrizioni all'offerta di prestiti bancari (cfr. par. 3). La Figura 5 mostra che, senza tali aggiustamenti, l'errore di previsione del PIL nelle due recessioni del 2008-2009 e del 2011-2012 sarebbe stato più elevato, in media, di 3 decimi di punto percentuale, sia per la previsione riferita all'anno in corso sia per quella relativa all'anno successivo.

Questi risultati suggeriscono che, soprattutto in presenza di discontinuità statistiche – quando è quindi più probabile che il modello precedentemente utilizzato ometta meccanismi potenzialmente rilevanti – il ricorso a strumenti satellite può fornire un apporto decisivo per migliorare la precisione delle stime.

5. Prevedere il valore centrale o l'intera distribuzione?

L'attenzione dei fruitori delle previsioni macroeconomiche tende solitamente a focalizzarsi sulla sintesi numerica puntuale dello scenario la cui realizzazione è ritenuta più probabile. In realtà, i rapporti di presentazione dei quadri previsivi sono generalmente ricchi e articolati, comprendendo sempre, o quasi sempre, non solo lo scenario cosiddetto centrale ma anche, in forme diverse, una valutazione dei rischi che circondano quello scenario. Tuttavia, non v'è dubbio che spesso tali informazioni di corredo vengano pressoché ignorate (e anzi completamente ignorate, nel caso dei riferimenti alle previsioni macroeconomiche tipicamente riportati dai mezzi di comunicazione). Esse però non sono un 'di più', una sorta di or-

Fig. 5 – *Judgment* sui vincoli all'offerta di credito: effetto sull'errore di previsione per l'anno corrente nel corso delle due crisi 2008-2009 e 2011-2012



pello trascurabile: una corretta valutazione dei rischi è al contrario componente imprescindibile dei quadri previsivi.

A titolo di esempio, proprio nel periodo che aveva preceduto la forte e generalizzata contrazione dell'attività economica nel biennio 2008-2009, diversi analisti avevano più volte suonato campanelli di allarme sul pericolo che potessero materializzarsi forti rischi di caduta della domanda e della produzione, legati all'accumularsi di crescenti squilibri nei prezzi delle attività finanziarie e reali e nei saldi con l'estero di alcuni paesi. Se da un lato nessuno aveva previsto né l'esatto momento di avvio della crisi né il fatto che essa si sarebbe affacciata, in primo luogo, nello specifico segmento dei mutui *subprime*, gli scenari di rischio allora elaborati ipotizzavano frequentemente che eventuali scosse avrebbero avuto come epicentro iniziale proprio l'economia statunitense, come in effetti poi si verificò. Anche in Banca d'Italia, negli anni precedenti il 2008, i rapporti previsivi interni includevano in maniera pressoché sistematica uno scenario di repentina caduta dell'attività economica negli Stati Uniti, derivante da una improvvisa e convulsa correzione degli squilibri di quell'economia.

È utile interrogarsi sui motivi che hanno portato a tale sottovalutazione di quei segnali di allarme: perché essi non vennero colti? A chi va attribuita la responsabilità della loro mancata ricezione? A una disattenzione da parte degli utenti finali? O invece – o quantomeno anche – a scarsa efficacia comunicativa da parte di coloro che producono le previsioni, i quali non hanno saputo trasmettere con sufficiente forza e capacità persuasiva il senso di urgenza e la necessità di prepararsi a far fronte a rischi di entità straordinaria?

Le responsabilità sono presumibilmente condivise. Da un lato, l'attrazione esercitata dal singolo numero che rappresenta la previsione centrale è pressoché irresistibile; è difficile sottrarvisi. Ma, d'altro lato, le analisi dei rischi peccano forse per difetto di visibilità e per insufficienza comunicativa, pecche a loro volta probabilmente derivanti anche da inadeguatezza degli strumenti solitamente impiegati per realizzare analisi integrate della distribuzione complessiva dei rischi e per comunicarne i risultati in maniera immediatamente comprensibile e quindi efficace.

A seguito di tali riflessioni, anche in Banca d'Italia sono state avviate negli ultimi anni diverse iniziative per approfondire l'analisi dei rischi che circondano i quadri previsivi e per trasmetterne più incisivamente le conclusioni all'utenza interna ed esterna.

In primo luogo, a partire dal numero del Bollettino economico del luglio 2009, le stime centrali per il PIL e l'inflazione vengono pubblicate con un nuovo corredo grafico, che riporta anche l'intera distribuzione delle previsioni, consentendo quindi al lettore di cogliere con immediatezza l'entità dell'incertezza che caratterizza i quadri previsivi. In particolare, la distribuzione viene da allora illustrata per mezzo di *fan chart* (termine introdotto dalla Bank of England, che per prima ha impiegato quella forma grafica per mostrare l'incertezza che circonda le proprie previsioni di inflazione): fasce con sfumature di colore che, allontanandosi dal centro della distribuzione, divengono via via più pallide, segnalando visivamente una graduale diminuzione della probabilità. Le *fan chart* incluse nelle pubblicazioni della Banca d'Italia[5] si basano, a differenza di quelle prodotte dalla Bank of England e da altre istituzioni, su un approccio non parametrico, messo a punto da Miani e Siviero (2010). Tale approccio richiede ipotesi meno stringenti rispetto a quelle sottostanti alla metodologia più comunemente impiegata; esso consente inoltre di calcolare agevolmente altre statistiche potenzialmente interessanti, quali per esempio la probabilità che si verifichino 1, 2, ..., N trimestri consecutivi di variazione negativa del PIL o dei prezzi, nonché la distribuzione congiunta di più variabili. La rappresentazione dei rischi mediante *fan chart* non sostituisce quella, più tradizionale, che fa leva sul disegno di scenari di rischio alternativi, ma vi si affianca: quando si ritiene possibile individuare con sufficiente precisione gli elementi di rischio più rilevanti, la predisposizione di (un

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[5] Oltre che per il capitolo sulle previsioni pubblicato nel Bollettino economico di gennaio e luglio di ogni anno dal 2009, le *fan chart* sono state impiegate anche in Miani, Nicoletti, Notarpietro e Pisani (2012) al fine di rappresentare la distribuzione delle proiezioni a medio termine per il capitale delle banche; queste, a differenza delle *fan chart* incluse nel Bollettino economico, sono asimmetriche, riflettendo quindi, oltre all'entità dell'incertezza attorno alla previsione centrale, anche la direzione prevalente dei rischi.

numero necessariamente molto contenuto di) scenari diversi da quello di base rimane il modo più efficace per trasmettere al lettore le opinioni del previsore circa l'entità e la direzione degli elementi di maggiore incertezza. Addirittura, nel Bollettino economico del gennaio 2012, quando la dimensione dello spread tra i titoli di Stato italiani e quelli tedeschi era con tutta evidenza la variabile dalla quale più strettamente dipendevano le prospettive di crescita dell'economia italiana, venne presa la decisione straordinaria, sin qui rimasta unica, di pubblicare non un solo quadro previsivo ma due scenari distinti, differenziati in base alla dimensione di quel differenziale di rendimento. In casi come questo, nei quali si ritiene di trovarsi di fronte a distribuzioni potenzialmente bimodali, la rappresentazione mediante *fan chart* è meno significativa e utile.

Oltre alle *fan chart*, già da tempo utilizzate e visibili all'esterno, sono in via di realizzazione in Banca d'Italia progetti di ricerca che ruotano intorno alla produzione e alla validazione di *density forecast*. Per esempio, Alessandri e Mumtaz (2013) presentano diversi modelli per la previsione dell'intera distribuzione di probabilità del tasso di crescita del prodotto e impiegano test statistici per valutare la performance relativa dei diversi modelli – compito notevolmente meno agevole rispetto alla valutazione comparativa di stime puntuali. Vi sono inoltre ricerche in corso sui metodi statistici per aggregare in modo efficiente le distribuzioni ottenute con modelli diversi, così da poter produrre *forecast combination* non solo di previsioni puntuali ma di intere *density forecast*.

6. Per concludere: che insegnamenti trarre? In quali direzioni investire?

Chiosando Churchill, il quale sosteneva che: "È difficile fare previsioni, soprattutto quando riguardano il futuro", si potrebbe aggiungere: "Ciò è tanto più vero quanto meno il futuro assomiglia al passato". L'economia del giorno d'oggi non è sicuramente più la stessa di quella di solo pochi anni fa. Negli ultimi decenni, i cambiamenti tecnologici hanno inciso profondamente sulle modalità di produzione e di distribuzione; l'affacciarsi di nuovi attori sulla scena degli scambi mondiali ha eroso posizioni consolidate; la competizione internazionale, di prezzo e non di prezzo, si è fatta più serrata; più recentemente, le due crisi del 2008-2009 e 2011-2012 hanno portato scompiglio in un mondo che nei due decenni precedenti era parso incanalarsi lungo un sentiero di sviluppo relativamente stabile, con deviazioni di breve durata e trascurabile intensità; dal 2008 a oggi, l'economia mondiale ha invece sperimentato una volatilità senza precedenti; un forte, persistente aumento dell'avversione al rischio; interazioni più intense, rapide e drammatiche tra economia finanziaria ed economia reale.

In tali condizioni, non è sorprendente che la precisione delle previsioni dell'economia italiana esaminate in questo lavoro abbia mostrato nel periodo più recente un considerevole deterioramento. I nostri risultati suggeriscono tuttavia che i previsori, pur non disponendo ancora di un modello integrato adeguato al mondo nuovo, abbiano appreso velocemente alcune caratteristiche particolarmente rilevanti di quest'ultimo, adattando gli strumenti precedentemente in uso o sviluppandone di nuovi (a volte con soluzioni dichiaratamente provvisorie, come nel caso del meccanismo messo a punto in Banca d'Italia per prevedere entità ed effetti del *credit crunch*). Dopo l'inevitabile disorientamento iniziale, gli errori di previsione sono stati relativamente contenuti, pur rimanendo più elevati di quelli registrati nel periodo pre-crisi 1999-2007.

Migliorare la comprensione di alcuni dei meccanismi fondamentali sottoposti a sollecitazioni straordinarie dagli eventi degli ultimi anni costituisce uno dei sentieri lungo i quali procedere per migliorare la performance delle previsioni economiche; tra quei meccanismi sono particolarmente rilevanti: il funzionamento dei mercati interbancari; il loro effetto sull'attività di credito da parte delle banche; più in generale, l'impatto delle condizioni finanziarie sulla macroeconomia e, di converso, l'influenza esercitata da quest'ultima sui mercati finanziari. Un altro insegnamento che è opportuno trarre dagli eventi recenti è che una valutazione articolata dei principali rischi della previsione e una loro corretta comunicazione ai fruitori finali costituiscono elementi chiave per massimizzare l'efficacia e l'utilità dell'attività previsiva.

Più in generale, l'esperienza degli ultimi anni insegna che, in un mondo in continua e spesso brusca evoluzione, i cui meccanismi possono essere afferrati al più in maniera incompleta e sempre provvisoria, gli analisti macroeconomici devono esercitare un continuo vaglio critico degli strumenti di cui dispongono ed essere pronti ad adeguarli in tempi brevi e senza preconcetti. Come sottolineato in Visco (1987), i modelli econometrici strutturali sono particolarmente adatti a tale impiego, versatile e creativo, in quanto essi «aggregano e organizzano un gran numero di informazioni diverse, costituiscono uno strumento flessibile di valutazione quantitativa e in questo senso sono aperti a un uso intelligente e non meccanico». Essi possono pertanto continuare a fornire, anche nel nuovo mondo, un valido supporto all'analisi economica e una utile 'guida all'azione' di *policy.*

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