IMPACT PROJECT

A Commonwealth Government inter-agency project in co-operation with the University of Melbourne, to facilitate the analysis of the impact of economic demographic and social changes on the structure of the Australian economy

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THE MAJOR STREAMS OF ECONOMY-WIDE MODELLING : IS RAPPROCHEMENT POSSIBLE?

by

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ABSTRACT

of

THE MAJOR STREAMS OF ECONOMY-WIDE MODELING : IS RAPPROCHEMENT POSSIBLE?

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This paper was written as a personal response to the issues raised at the NBER-NSF Conference on Macro-econometric Modeling, October 1978. The paper does not deal with purely time-series approaches to modeling, but classifies the remaining economy-wide models into three classes : the Keynes-Klein (KK) class, the Phillips-Bergstrom (PB) class and the Walras-Johansen (WJ) class. These correspond respectively to models built in the Wharton tradition, the newer continuous time disequilibrium models developed at LSE, and the applied general equilibrium school. Against the background of the last five years experience in the Australian Government's inter-agency IMPACT Project, it is conjectured that :

(i) The integration of small disequilibrium macro models in the PB class with large applied general equilibrium models in the WJ class is feasible.

(ii) The integration of models in the KK class with models in the WJ class does not seem feasible.

(iii) The three major approaches within the WJ class - - development planning, neoclassical general equilibrium models solved in the levels, and Johansen models - - seem likely to be dominated by Johansen models due to their superior flexibility, susceptibility to solution by general purpose (rather than tailor made) methods, relatively low cost of computing, and relative transparency of the economic mechanisms which drive them.

Contents

THE MAJOR STREAMS OF ECONOMY-WIDE MODELING : IS RAPPROCHEMENT POSSIBLE?[1]

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1. INTRODUCTION

In a recent survey of economy-wide model building, Challen and Hagger introduced the following nomenclature to describe the three major classes of ongoing work[3] in Australia :

(i) Keynes-Klein (KK) models ;
(ii) Phillips-Bergstrom (PB) models ;
(iii) Walras-Johansen (WJ) models .

Whilst acknowledging some room for disagreement on the choice of labels, Challen and Hagger motivate their taxonomy as follows :

> "The second name in each label is the name of the econometrician who produced the model which we regard as the prototype -- the father of the family, so to speak. The first name belongs to the theoretical economist who provided the vision -- whose special way of looking at the working of the macroeconomy was

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1. Paper written in response to the discussion of issues in modeling at the NBER-NSF Conference on Macroeconometric Models, Ann Arbor, Michigan, October 26-27th, 1978.

2. I wish especially to thank Peter B. Dixon for feedback on on the first draft. Others who kindly commented on drafts include Don Challen, Ken Clements, Russel Cooper, Bill Evans, Alf Hagger, Peter Jonson, Jan Kmenta, Warwick McKibbin, Keith McLaren, Ian McDonald, Bill Norton, John Taylor and Rob Trevor. To all of these, my sincere thanks. The errors are my own.

3. D. W. Challen and A. J. Hagger, "Economy-wide Modelling with Special Reference to Australia," Economic Society of Australia and New Zealand, Eighth Conference of Economists, La Trobe University, Melbourne, Australia, August 1979; paper available from Department of Economics, University of Tasmania, Hobart, Tasmania, Australia.

taken over by the second-named and used as the framework for his prototype model."[4]

For the moment I will assume that each of these terms is sufficiently suggestive to allow postponement of their definitions. What I wish to attempt in this paper is to provide a perspective on the scope for reconciling the three approaches. In the case of the PB and WJ models, I will draw heavily on my experience over the last half decade with the Australian government's inter-agency IMPACT Project.[5] The project does not provide direct experience of the KK models; I will however attempt to integrate my remarks with the insights on KK models provided by the other participants in the NSF-NBER Conference reported in this volume and, in the Australian context, by Challen and Hagger.[6]

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4. Ibid., p. 4.

5. IMPACT is an inter-agency Project of the Australian federal government in co-operation with the University of Melbourne. Its purpose is to facilitate the analysis of the impact of economic, demographic, and social changes on the structure of the Australian economy. For a brief description of the institutional history and the flavor of the Project, see Alan A. Powell and Brian R. Parmenter, "The IMPACT Project as a Tool for Policy Analysis : Brief Overview," Australian Quarterly, Vol. 51, No. 1 (March 1979), pp. 62-74. For a comprehensive non-technical description of the Project, see Alan A. Powell, The IMPACT Project : An Overview, March 1977, First Progress Report of the IMPACT Project, Volume One (Canberra : Australian Government Publishing Service, 1977); for technical details of the largest of the Project's models, ORANI, see P. B. Dixon, B. R. Parmenter, G. J. Ryland and John Sutton, ORANI, An Applied General Equilibrium Model of the Australian Economy : Current Specification and Illustrations of Use for Policy Analysis, First Progress Report of the IMPACT Project, Volume Two (Canberra : Australian Government Publishing Service, 1977). Since July 1975 the Project has produced about one hundred working papers, most of which are available on request. For a catalog, write to : Mr. Mike Kenderes, IMPACT Information Officer, Industries Assistance Commission, Benjamin Offices, Chan Street, Belconnen. A.C.T., 2617. AUSTRALIA.

6. Op. cit..

The plan of the paper is as follows. In Section 2, I define the three classes of models discussed in the paper. My discussion is confined to 'econometric' as distinct from 'time series' models. Section 3 contains my perspective on why we bother to model at all, and highlights some of the risks of overenthusiastic salesmanship and wishful thinking. In Section 4 I try to show how various design features and practices in model building reflect the purposes for which the models were built, and the constraints under which the modelers perceive themselves to be working. In the fifth section I describe briefly some developments in the IMPACT Project which seem to indicate that a measure of reconciliation between the different approaches is possible. The sixth and final section contains my concluding remarks.

2. DEFINITIONS

In the case of the first two categories, the definitions adopted here are in the spirit of Challen and Hagger.[7] The boundary lines between the three groups are somewhat blurred and some (but not many) models would fall partly into more than one of them.

2.1 KK Models

These models may be identified by their emphasis on behavioral relations determining the big components of the national accounts : consumption, investment, government spending, imports and exports. The flavor of the models is decidedly demand dominated and disequilibrium (especially business cycle) oriented. KK models are invariably formulated in discrete time - - lag mechanisms, often of the geometric and/or polynomial families, are directly posited and freely used in an attempt to come to grips with expectations and other frictions in the system. Finally, relative prices of all sorts play a minor role by comparison with 'activity variables.' These five characteristics - - emphasis

on (a) large aggregates which are largely

(b) demand determined,

on (c) disequilibrium (especially business cycle) dynamics formulated in

(d) discrete time,

and on (e) activity variables to the exclusion of relative prices[8] - -

are the major distinguishing marks of the KK models.

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7. Op. cit..

8. A reader has pointed out that the KK models blossomed during a period of relatively stable relative prices. The minor role accorded the latter may therefore have reflected the times rather than the proclivities of the KK model builders.

The prototype KK model recognized by Challen and Hagger is Klein's 1950 model.[9] From this 16 equation beginning developed the 200 - 400 equation models in the KK class which today exist for many OECD countries. In this development large aggregates were successively broken down into smaller and smaller components, e.g., consumption was split first into durables and non-durables, then the former into automobile purchases and other durables, and so on. As characteristic (a) became attenuated under finer and finer disaggregation, likewise (b) became less prominent as supply side constraints were added to the models. In some (but by no means all) of the KK models equilibrium began to assume a role as consistency constraints were imposed on steady state properties, thus tending to soften characteristic (c). Ando puts the point nicely in his discussion of the design of the MPS (MIT - Pennsylvania - Social Science Research Council) model :

> "the model should exhibit the neoclassical features at the steady state, but be Keynesian in its adjustment process."[10]

Given the considerable falling away from (a), (b) and (c) as marks of the latter day KK models, will these characteristics nevertheless still serve to identify them? I believe the answer is 'yes.' Surviving

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9. L. R. Klein, Economic Fluctuations in the United States 1921-1941 (New York : Wiley, 1950).

10. Albert Ando, "On a Theoretical and Empirical Basis of Macroeconometric Models," Paper presented to the NBER-NSF Conference on Macroeconometric Models, Ann Arbor, Michigan, October 26-27, 1978, this volume.

design features of the KK models (like vestigal gills) point to their origins. No student of the MPS model is likely to be in doubt which came first -- its short term dynamics or its steady state properties. Nor would a student of any of the many models in the Wharton tradition be likely to believe that these models had been built on a 'bottoms up' rather than a 'tops down' approach to aggregation.

2.2 PB Models

Challen and Hagger have used formulation in continuous time as a major distinguishing characteristic of the newer macro models developed by Bergstrom and Wymer,[11] Jonson and others.[12] By comparison with the KK class, the steady state properties of a PB model are much more visible, and critical, elements of its structure. Behavioral relations are mainly of two types : functions describing the target (or long run) values of the endogenous variables, and adjustment rules describing the time paths by which the endogenous variables approach these targets. The adjustment rules are specified as differential (rather than difference) equations; conceptually an endogenous variable is capable of instantaneous response to an exogenous stimulus, even in the

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11. A. R. Bergstrom and C. R. Wymer, "A Model of Disequilibrium Neoclassical Growth and its Application to the United Kingdom," in A. R. Bergstrom (ed.), Statistical Inference in Continuous Time Econometric Models (Amsterdam : North-Holland, 1976).

12. P. D. Jonson, "Money and Economic Activity in the Open Economy : The United Kingdom, 1880-1970," Journal of Political Economy, Vol. 84, No. 5 (October 1976), pp. 979-1012; P. D. Jonson, E. R. Moses and C. R. Wymer, "The RBA 76 Model of the Australian Economy," in Conference in Applied Economic Research, December 1977, Reserve Bank of Australia, Sydney, pp. 9-36.

sense that its target value could be reached instantly if the value of the estimated adjustment coefficient is high enough. This provision for rapid approach to equilibrium reflects the strong interests of the model builders in monetary and financial markets[13] -- it is not (they argue) unreasonable to suppose that in some international financial markets arbitragers are able to close price gaps by telephonic/telegraphic transactions within a matter of hours. Whilst the development of the PB models in the seventies coincided with the resurgence of monetarism, it is not clear that the marriage of monetarism and continuous time modeling was historically inexorable.

The PB modelers have introduced new techniques of econometric inference designed to cope with the continuous time nature of their systems,[14] and have exploited the flexibility of temporal aggregation allowed by such a formulation. Notwithstanding the non-linearity (in the parameters) of the PB models, Wymer's massive contribution to econometric software[15] has made it possible to estimate substantial sub-sectors, or even entire models, by FIML.[16] This is, of course, only possible because the models are (by today's standards) small -- typically less than 30 equations.

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13. In Wymer's 1971 model [see C.R. Wymer, "A Continuous Disequilibrium Model of the United Kingdom Financial Markets," pp. 301-334 in Alan A. Powell and Ross A. Williams (eds), Econometric Studies of Macro and Monetary Relations (Amsterdam : North-Holland, 1973)] all but nine of 37 variables in the system are holdings of assets or the yields on these assets. In Jonson's (op. cit.) minimal macro model of the Australian economy, about half of the two dozen endogenous variables in the system are financial or monetary variables.

14. See the papers in A. R. Bergstrom (ed.) cited above.

15. C. R. Wymer, "Computer Programs," International Monetary Fund, Washington, D.C., 1977 (mimeo).

16. For an example of a discrete time general equilibrium model estimated as a complete model by FIML using Wymer's software, see Kenneth W. Clements, The Trade Balance in Monetary General Equilibrium (New York : Garland Publishing Company, forthcoming) and "A General Equilibrium Econometric Model of the Open Economy," International Economic Review (forthcoming).

What, then, are the principal marks of the PB models? Apart from a monetarist flavor (which may not in the longer run turn out to be an indispensable characteristic), they are

(A) formulation in continuous time

with

(B) a target or equilibrium value of each endogenous variable determined according to a function respecting notions of neoclassical equilibrium

and

(C) differential equations (usually of first order, though occasionally of second) specifying adjustment paths.

2.3 WJ Models

Challen and Hagger's taxonomy was designed to cope with the contemporary thrust of Australian applied work. This led to a less than exhaustive classification of applied general equilibrium models. Here the WJ label is extended to encompass all such models. The more neoclassical of these models are characterized by non-linear production and consumption relations which recognize various kinds of substitutability pertaining among factors in production, and among commodities in consumption. In the words of Dervis ,

> [These models] "postulate neoclassical production functions and price-responsive demand functions, linked around an input-output matrix in a Walrasian general equilibrium model that endogenously determines quantities and prices."[17]

The solutions for the endogenously determined quantities and prices are continuous and differentiable functions of the exogenous variables. As used in this paper, the term Johansen model refers to the subset of neoclassical WJ models which, in the words of Taylor, are solved

> " ... by logarithmically differentiating the equations characterising a Walrasian competitive equilibrium with respect to time in order to get a simultaneous set of equations which are linear in all growth rates. A set of growth rates is specified exogenously and a matrix inversion then suffices to calculate the other growth rates in the system."[18]

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17. Kemal Dervis, "Planning Capital-Labour Substitution and Intertemporal Equilibrium with a Non-Linear Multisector Growth Model," European Economic Review, Vol. 6 (1975), pp. 77-96.

18. See Lance Taylor, "Theoretical Foundations and Technical Implications," Chapter III in C. R. Blitzer, P. B. Clark and L. Taylor (eds), Economy-Wide Models and Development Planning (New York : Oxford University Press for the World Bank, 1975), p. 100. The seminal study by Johansen is Leif Johansen, A Multisectoral Study of Economic Growth (Amsterdam : North-Holland, 1960).

Examples of neoclassical members of the WJ class are Adelman and Robinson's model of Korea,[19] and the Australian policy model ORANI[20] Of these, the latter is a Johansen model, while the former is solved in the levels. Later in this paper it will be claimed that suitable extensions of the Johansen solution method are likely to dominate, and in time replace, other approaches to the solution of these models.

The less neoclassical models of the WJ class have often been referred to as 'mathematical programming' and/or 'development planning' models. Like other members of the WJ class, these models recognise explicit inter-industry relations, and factor constraints. Unlike the neoclassical members of the class, many of the production and consumption relations, and/or constraint sets, are linear. Kuhn-Tucker conditions need to be invoked in specifying the Walrasian general equilibrium solution of such models. The solution itself involves corners, and is not everywhere a differentiable function of the exogenous variables. Such models have usually been solved either as full non-linear programming problems, or by successive approximations based on linear programs. Non neoclassical WJ models have been built for many countries, including India,[21] Israel,[22] Mexico,[23]

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19. Irma Adelman and Sherman Robinson, Income Distribution Policy in Developing Countries : A Case Study of Korea (Stanford : Stanford University Press, 1977).

20. Dixon et al., op. cit.

21. J. Sandee, A Long-Term Planning Model for India (New York : Asia Publishing House, and Calcutta : Statistical Publishing Company, 1960).

22. Michael Bruno, "A Programming Model for Israel", Chapter 12 in Irma Adelman and Eric Thorbecke (eds), The Theory and Design of Economic Development (Baltimore : Johns Hopkins, 1966), pp.327-352.

23. Alan S. Manne, "Key Sectors of the Mexican Economy 1960-70". Chapter 16 in Alan S. Manne and H.M. Markowitz (eds) Studies in Process Analysis (New York : John Wiley and Sons, 1963), pp.379-400.

Australia,[24,25] and the Ivory Coast.[26]

It will be argued later in this paper that the non-neoclassical members of the WJ class do not possess any worthwhile advantages over the neoclassical members, and that the latter will in time replace them. In the remainder of this section, therefore, attention is concentrated on the neoclassical members, which are compared briefly to the KK and PB classes.

Noeclassical WJ models and PB models are, on one scale, much closer to each other than is either to the KK class. Both WJ and PB models have been described at times as 'neoclassical growth models.' In terms of numbers of equations, latter day KK models and WJ models are 'big' relative to the current set of PB models. The KK and WJ models also share an emphasis on the real economy in contradistinction to the monetary emphasis of the existing PB models. Also like KK models, WJ models are usually formulated in discrete time. Unlike either the KK or the PB models, the methodology of the WJ class is strictly comparative static (although the comparative static element of course does have an important subsidiary role in all PB, and in some KK, models). The emphasis on relative prices of commodities and of factors is nowhere stronger than among neoclassical members of the WJ class.

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24. H. David Evans, A General Equilibrium Analysis of Protection : The Effects of Protection in Australia (Amsterdam : North-Holland, 1972), pp. xv + 216.

25. P.B. Dixon and D.P. Vincent,"The SNAPSHOT Model : Underlying Theory and an Application to the Study of the Implications of Technical Change in Australia to 1990", IMPACT Preliminary Working Paper No. SP-14, Industries Assistance Commission, Melbourne, October 1979.

26. Louis M. Goreux, Interdependence in Planning : Multilevel Programming Studies of the Ivory Coast (Baltimore : Johns Hopkins for the World Bank, 1977).

3. METHODOLOGY AND MORALS

Before canvassing the scope for reconciliation between the different approaches to economy-wide modeling, a prior issue needs at least brief attention. I believe considerable disenchantment is evident in the U.S., Australia, and elsewhere, with the performance over the 1970's of models (and modelers).[27] It is perhaps timely to reflect on why we bother to build models at all.

First, I take it as self evident that a model is primarily a device to organize one's thinking. Second, the potential and actual performance of any model is only defined relative to the purpose for which it is constructed. I shall take up this theme in the context of forecasting versus policy analysis in the next section. Given a clearly defined purpose for which a model might be constructed, there exist at least the following advantages in proceeding actually to construct it :

(a) A formal model forces its builder to identify in a systematic, precise and explicit way the range of concepts necessary to address the issue in question.

(b) Equally important, a formal model identifies the factual evidence (i.e., data base) needed to support analysis, and often leads to recognition of important gaps and inconsistencies in the available information.

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27. Thus Ando (op. cit.) feels compelled to defend the KK class of models against the charge of 'spectacular recent failures,' while from within its central bank two of Australia's best known model builders take a somewhat agnostic stance concerning the likely future influence and utility of further modeling effort. See W.E. Norton and P.D. Jonson, "Macroeconomic Modelling : the RBA Experience," paper read to the Eighth Conference of Economists of the Economic Society of Australia and New Zealand, La Trobe University, August 1979 (available from Research Department, Reserve Bank of Australia, Sydney, N.S.W., 2000, Australia).

(c) Models improve communication. Although some effort is usually required to understand the language in which any particular model is constructed, of necessity any adequately documented model gives a clear statement of every assumption.

(d) Models form the basis for formally articulated (as distinct from intuitive) knowledge, which can be taught and learnt.

(e) Models provide a framework for learning from experience.

(f) Many issues of interest are not amenable to analysis in terms of a small number of relationships. Formal modeling may be the only practical way of handling the information load.

(g) Finally, the enormous intellectual effort which has gone into the theory of measurement over the last three decades would be largely lost outside the framework of formal models.

It is not usually on these issues that disagreement surfaces. Whilst attractive, the features listed above would not persuade governments or foundations to support model building in a big way -- a fact of which every model builder is aware. In attempting to 'sell' models to the clients we have sometimes been trapped by our own wishful thinking. Economics is a well developed non-experimental science, i.e., a science which, in spite of its strong analytical traditions, is almost never able to settle differences of opinion about empirical magnitudes by recourse to experimentation. Not only are our data generated by uncontrolled 'experiments' :

they are generated in limited amounts. Typically nature pr
the applied economist an indifferently designed experiment wh
even have the courtesy to replicate.[28]

It follows that we are confronted by an irreduci
ignorance. If

$$\hat{E}(y|\underset{=}{x}) = \hat{\underset{=}{\beta}}^T \underset{=}{x} \tag{1}$$

is an optimal conditional forecast (according to some agree
y given $\underset{=}{x}$, and y follows the model

$$y = \underset{=}{\beta}^T \underset{=}{x} + \varepsilon , \tag{2}$$

with ε classically well behaved, then attempting to redu
error by modeling ε (or even $(\hat{\underset{=}{\beta}} - \underset{=}{\beta})$) is silly. Yet
the 'fine tuning' of quarterly models (so that they track
within sample) is undoubtedly an attempt to do just this.
to a never ending quest for a σ^2 that is smaller than a
reading of the evidence would suggest. If the σ^2 sug
evidence is 'too large' for the client with the cheque bo
matter of morals, not of methodology to tell him so. Si
Keynesian theorist and a monetarist hold severely confli
which are, nevertheless, observationally equivalent with
available historical evidence, no pretence should be mad

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28. This distinction between design of experiment and m
is important. Except in extreme pathological cas
compensate for poor design by multiplication of rep

sell either product that its superiority has been scientifica
(i.e., objectively) demonstrated. Although it may be diff
discuss with a clientele steeped in a naive belief in the ob
of scientific method, it is nevertheless encumbent upon us t
explain to our customers the role of a priori knowledge in c

Lipsey also sees self-inflicted wounds in the c
profession. He puts it this way :

"Some of the difficulties are of our own making.
common practice for an investigator to try man
specifications and to fit them to alternative
then to choose to publish the specification ar
produce the highest t statistics, and then
to use the t statistics as if they were val
particular ad hoc theory. This is very comm
but if you describe it, as I have done to bic
medical researchers, they will usually refus
that a profession so highly regarded as econ
expect to proceed in so unscientific a fashi
of this common procedure, we should not be
the literature contains at least one ad hoc
competing high level theories, each one of
fair fit to existing data. Of course, t
pudding comes when the models are extrapol
and here they fail in droves." 30

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29. This view has been put forcefully by Christopher
of Leamer's Specification Searches in the Journal
Vol. 17, No. 2 (June 1979), pp. 566-568.

30. Richard G. Lipsey, World Inflation, Charles Josep
Lecture, La Trobe University, Melbourne, Australi
in Economic Record, Vol. 55, No. 151 (December 19

We do not yet have widely accepted procedures for calculating e
loss of degrees of freedom during specification searches based
given stock of data.[31] In cases that we all know of, effecti
of freedom must have become zero well before the selection of
'preferred' ad hoc version of the high level theory. In thes
the specification search is probably best regarded as nothing
an extremely inefficient way of fitting a high order polynomi

31. It is to be hoped that in time Leamer's work will systematic, and honest, approach to specification Edward E. Leamer, Specification Searches : Ad Hoc Non-experimental Data (New York : Wiley, 1978).

4. THE RELATIONSHIP BETWEEN PURPOSE AND DESIGN OF MODELS

A 'good' model is one which achieves the purpose for which it was designed. A tailor's dummy is a good model of the human body from the viewpoint of displaying a suit; as a vehicle to teach anatomy to medical students it leaves something to be desired. Economic models are built for a wide variety of reasons, including pedagogy and pure intellectual curiosity. But the two purposes most often attracting support from the government, from business, and from foundations are forecasting and policy analysis.

4.1 WJ Models and Forecasting

IMPACT's ORANI model[32] belongs to the WJ class. It has never been used to make 'forecasts' in the sense of providing unconditional projections or best guesses about the likely levels of its endogenous variables at some sequence of future dates. The WJ models lack the temporal disaggregation of the KK and PB models, so that statements surrounding simulation results naturally seem somewhat vague from the macroeconomic perspective. In typical 'short run' ORANI solutions -- solutions in which net addition to capacity actually in use is allowed -- we have offered opinion that the simulated outcome could be expected to occur 'one or two years' after the initial sustained changes in the chosen exogenous variables. (To provide some factual evidence for this surmise is a major methodological problem, which is dealt with below

32. The version of ORANI that I will refer to most often is ORANI 77 documented in Dixon et al., op. cit.. Occasionally I will also refer to ORANI 78, documented in Peter B. Dixon, Brian R. Parmenter, John Sutton and David P. Vincent, ORANI, A Multi-Sectoral Model of the Australian Economy (Amsterdam : North-Holland, forthcoming).

the discussion of the interface between a PB model and ORANI.) We have not to date used the ORANI model to project levels of the endogenous variables, but only those components of changes in levels due to the postulated changes in the selected exogenous variables.

The discussion becomes clearer if we think of the final form of a Johansen model in simulation mode :

$$y = Az \quad , \tag{3}$$

where y is a vector of growth rates of endogenous variables, z is a vector of growth rates of exogenous variables, and A is a rectangular matrix whose coefficients are built up as (non-linear) functions of the parameters appearing in the model's structural form (i.e., in its production functions, demand relations, primary factor constraints, etc.). Equation (3) says that if the economy is initially in a state consistent with the structural model and data base that gave rise to A, and is then subjected to the shock z in its exogenous variables, the proportional difference between the initial levels of the endogenous variables and their levels <u>after a period long enough for 'full' adjustment to occur</u> is y. In this sentence the phrase 'full' adjustment is defined relative to

(a) the model structure , and

(b) the notional adjustment lags underlying the values of the parameters used to construct A .

I shall take in turn an example of each of these in the ORANI context, commencing with (a). The structural form of this model includes demand functions for nine categories of labor, but does not include their supply functions.[33] Consequently, simulations with ORANI proceed in one of

33. Labor supply functions are handled in a separate model called BACHUROO. It is planned at a later date to interface the latter model with ORANI. See Alan A. Powell, <u>The IMPACT Project : An Overview</u>, First Progress Report of the IMPACT Project, Vol. 1 (Canberra : Australian Government Publishing Service, 1977), Ch. 3, Section 3.

two basic ways : real wages are set exogenously on the assumption of excess labor supply (the actual situation in Australia since 1975), or else the chan ment are set exogenously and the real wage changes which wo required changes in labor demand are projected. In an (therefore, 'full adjustment' does not mean a period long e simultaneous interaction of labor supply and demand forces unconditional clearing of the labor market. I now turn orated within A are a large number of behavioral parame capital-labor and labor-labor substitution elasticities, e elasticities, and demand-side substitution elasticities be and domestically produced commodities at the input-output aggregation. These parameters have been estimated by a techniques, from a variety of different sources.[34] Assoc estimate is a time frame and an explicit or implicit lag particular response involved. Among the successfully e lags are often short (less than a year), and rarely excee is one consideration that led us to propose that 'full' a short run simulations would correspond to a period of 'on I want now to leave, for the time-being, the difficult qu the point of the above discussion being that the actual c

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34. Given the state of collections of official statistic (including Australia), for large WJ models like ORAN will not exist an integrated data base giving quarte time series for any but a small subset of the variab are necessarily inventive and opportunistic in their data to support parameter estimation. In the case the largest and most important deficiency lay in the statistics needed to support reliable estimates of d tion elasticities between imported and domestic prod industry level of disaggregation. This deficiency special purpose data mobilization exercise - - J. S Milkovits, "The Construction of Price and Quantity I Trade Flows," IMPACT Preliminary Working Paper No. I Assistance Commission, Melbourne, October 1977. Th

the comparative static approach must be applied in WJ models rules out statements with the 'precision' common in the idea of forecasting as often purveyed by the builders of KK models.[35]

Accepting the inherent limitations with respect to the timing of events of the WJ class, what other considerations are relevant to their ability to produce forecasts? I will attempt to answer this question again by reference to the Johansen sub-class.

Consider a particular scalar equation belonging to (3) :

$$y_i = \sum_{j=1}^{N} a_{ij} z_j \quad . \tag{4}$$

Footnote continued from p. 19 .....

data base paid off handsomely in the precision of the estimates subsequently obtained (Chris M. Alaouze, J. S. Marsden and John Zeitsch, "Estimates of the Elasticity of Substitution Between Imported and Domestically Produced Goods at the Four-Digit ASIC Level," IMPACT Working Paper No. O -11, Industries Assistance Commission, Melbourne, July 1977; and Chris M. Alaouze, "Estimates of the Elasticity of Substitution Between Imported and Domestically Produced Goods Classified at the Input-Output Level of Aggregation," IMPACT Working Paper No. O -13, Industries Assistance Commission, Melbourne, October 1977). The only parallel I am aware of is the data mobilized by the CIA's trade flow project (see Stephen H. Goodman, "Overview of the CIA Trade Flow Model Project," Office of Economic Research, Central Intelligence Agency, Washington, D.C., April 1974; Paper presented to the Winter Meeting of the Econometric Society, December 1973) of which at least some has been published (J.S. McMenamin and J.P. Pinard, "Specification and Estimation of Dynamic Demand Systems Incorporating Polynomial Price Response Functions : An Application to US Clothing Imports," Journal of Econometrics, Vol. 7, No. 2 (April 1978), pp. 147-162.

35. I have already indicated above in Section 3 that insofar as claims to accuracy of timing are based on within-sample tracking performance, I believe that the appearance of precision may be an illusion. And as E. Phillip Howrey and others pointed out in discussion at the NSF-NBER Conference, our present economic theory has little to say about short run dynamics. A framework for developing a dynamics based on prior theory, but which has not yet filtered down to practical procedures in model building, is given by Keith McLaren, "The Optimality of Rational Distributed Lags," International Economic Review, Vol. 20, No. 1 (February 1979), pp. 183-192.

In ORANI 77, the number of exogenous variables N is typically 900. The number of endogenous variables runs into some millions, the vast majority of which are there for reasons of accounting necessity only. However the model contains several thousand endogenous variables of policy interest, including activity levels and rates of return in 109 industries, employment demand by industry and occupation, domestic prices, imports and exports, all on a disaggregated basis. In spite of this vast size (an issue addressed below), the use of the model to make point forecasts clearly presents difficulties. The first is that although the 900 exogenous variables cover many of the determinants of the domestic economy -- the list typically would include items such as foreign prices and domestic tariff levels, and perhaps the aggregate level of real absorption[36] -- there are many other variables of potential importance which are left out of account. In ORANI 77, for instance, industry specific technological change is not recognized.[37] To forecast on the basis of (4) one would need

(i) to extend the set of exogenous variables to include every exogenous influence relevent to y_i ;

(ii) to prepare forecasts on a very large (>> 900) number of exogenous variables.

If the forecast is required in terms of levels, then the initial level of the i^{th} endogenous variable must also be known. In all this is a formidable information load which it will rarely be feasible to meet in applied forecasting.

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36. Absorption is defined as gross domestic product minus the balance of trade, and therefore equals consumption plus investment plus government spending.

37. ORANI 78 (Dixon, Parmenter, Sutton and Vincent, op. cit.) includes provision for an extremely flexible treatment of technological change. The cost is a major explosion in the size of the model.

4.2 Flexibility and Policy Analysis

I now wish to turn to the strengths of th
and especially of the Johansen approach as further de
ORANI model, in the area of policy analysis. In t
lity is a key requirement. In our experience the a
different partitions of the variables into endogenous
is a major source of flexibility in Johansen models.[38]

In estimation, the partition of variables
and exogenous sets reflects a maintained hypothesis a
economy worked during the sample period. Given his
economy actually operated, there is no further degree
the investigator as to how he should classify the var
simulation with a Johansen model like ORANI, however,
apply. The applied econometrician attempting to su
estimates to the ORANI parameter file, of course, wil
some view about endogeneity/exogeneity with respect t

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38. There is no reason in principle preventing the s
being exploited in the use of KK or PB models in
The targets : instruments allocation problem in
economic policy (Jan Tinbergen, On the Theory of
(Amsterdam : North-Holland, 1952)) is, after all
of this flexibility. Practical difficulties in
simulations which reallocate variables between t
exogenous list include (i) the widespread pract
the coefficients of the system by OLS or other es
known invariance properties under the transforma
repartitioning; (ii) non-linearities.

variables and sample with which he worked.[39] A variety of different reduced forms, however, can be derived for simulation purposes from any given consistent set of estimates of structural form parameters. It is, of course, required that every new partitioning into endogenous and exogenous variables be a maintained hypothesis under which the simulation is mounted. These ideas can be clarified with the use of some simple notation.

In the formulation of the ORANI model of which (3) is a reduced form, an earlier stage involves the structural form of the model (after expression in logarithmic differentials) :

$$(5) \qquad Cx = [\Gamma \; B] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = 0 \quad ,$$

in which C is a rectangular matrix with row order and rank equal to the number M of endogenous variables in the system (in ORANI, very large) and with column order equal to the total number of variables $(M + N)$. In the

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39. The rational expectations debate has led applied workers to the view that 'policy variables' may sometimes be endogenous and sometimes exogenous. If prior evidence is available to identify in which period a particular variable is endogenous and in which exogenous, no particular problem arises. If there is uncertainty about the status of a policy variable at different points in the sample, then our inferential (viz., likelihood) framework breaks down. Hillier and Giles have recently addressed this problem and suggested methods for its solution - - see Grant H. Hillier and David E. A. Giles, "Estimation in Equilibrium Models Involving Discretionary Instrument Choice : An Application to the Australian Monetary Sector," Paper presented to Section 24 of the 49th Congress of the Australian and New Zealand Association for the Advancement of Science, Auckland, New Zealand, January 1979 (available from Department of Econometrics and Operations Research, Monash University, Clayton, Victoria, 3168, Australia).

middle term of (5), one feasible partitioning of C is shown. Many such partitionings are possible, the essential requirement being that Γ is square of rank and order M. For a given partitioning of x into endogenous variables x_1 and exogenous variables x_2, a reduced form is obtained as

$$x_1 = -\Gamma^{-1} B x_2 \quad . \tag{6}$$

This is equation (3). Provided care has been taken to use consistent methods in the estimation of C, then the consistency of any particular reduced form elasticity matrix,

$$A = -\Gamma^{-1} B \quad , \tag{7}$$

is assured. Because the estimated structural form should transform to a consistent estimate of an arbitrary reduced form which is user determined (and therefore highly variable), emphasis has been placed on consistency in the estimation of the elements of the ORANI parameter file (which undergo transformations to become C).[40]

Two examples of pairs of variables which have been routinely switched between the endogenous and exogenous lists in ORANI simulations are (i) real absorption and the balance of trade, and (ii) the real wage vector and the vector of occupational employment demands.[41] This flexibility is a design feature of the ORANI model clearly reflecting the policy analytic

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40. For a fuller account of the procedures involved in moving from the structural form of ORANI to any chosen reduced form, see section 17 of Dixon, Parmenter, Ryland and Sutton, op. cit., pp. 175-192.

41. See, e.g., Peter B. Dixon, Alan A. Powell and Brian R. Parmenter, Structural Adaptation in an Ailing Macroeconomy (Melbourne : Melbourne University Press, 1979).

purpose for which it was built. KK models are not usually designed to accommodate the analysis of hypothetical questions involving switches of endogenous and exogenous variables. The widespread use of single equations techniques for the estimation of KK models clearly works against the possibility of mounter counter-factual simulations of the type described above. Even if it could be established that the single equations estimators are 'optimal' in the context of the tracking properties of KK models, such a property would not survive a reallocation of variables into the endogenous and exogenous sets. Partly due to their smaller size, and due partly no doubt to the different methodological orientation of their builders, the PB models have often been estimated by full-information techniques.[42] For this reason the possibility of switches between the endogenous and exogenous list is real for simulations with PB models.[43] Also for this reason the prospects of interfacing a Johansen model with a PB model are much better than those for interfacing a Johansen model with a KK model.

4.3 Size and Complexity

In the Conference discussion of Gregory Chow's paper, Zvi Griliches remarked that 'much of the objection to large models is motivated by a lack of understanding of the internal mechanisms of large models.'[44] As Griliches saw it, size was not the issue, but appropriateness of the model design in relation to its purpose. Many concepts of size were discussed by Conference participants, but the distinction drawn by Zellner

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42. Jonson, et al., op. cit..

43. This possibility so far remains unexploited, to the best of my knowledge.

44. Circulated report of discussion on Chow's paper.