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A BRIEF PRESENTATION OF THE BACKGROUND AND STRUCTURE OF MODIS IV

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1. Introduction

The aim of my contribution to this workshop is to present a brief outline of the background and structure of the macroeconomic model MODIS IV. I do not think that the details of the model are particularly relevant for the topics of this workshop so I shall be rather summary about the actual structure of the model. (Especially in view of programmatic idea expressed earlier during this meeting of starting from scratch I shall devote the major part of my contributions to the historical background of the model.)

This model has not been built to demonstrate techniques of optimal control. It is on the contrary a quite down-to-earth model with a very modest use of advanced techniques. The all important reason to introduce the model in this context of a workshop in optimal control topics is thus not its intrinsic properties but rather the fact that this model is by far the most important model ever constructed in Norway in terms of its use and utility in policy-making.

MODIS IV has come to play a central part in the day-to-day work of the Economic department of the Ministry of Finance which is responsible for the short-term economic policy decisions. This has been the result of a continuous effort over many years. In most countries there are by comparison much wider gaps between model builders and policy-makers although strenuous efforts are exerted in many places to achieve better use of existing economic tools and development of new ones. Our own experience seems strongly to indicate that the increasing and adaptive use by administrative bodies and civil servants of mathematical models and advanced techniques is - and must be - a fairly slow process where one has to stand firmly with both feet before one takes the next step. Flashy demonstrations of modern elaborate techniques are often built on a base of shifting sand with regard to data requirements and user needs. It will, however, be of the greatest interest to all parties connected with the use and further development of MODIS IV if modern mathematical techniques can be exploited to increase the efficiency and utility of this model.

2. The Norwegian approach to model building

The work on the construction and use of the MODIS models has been an ongoing project for more than fifteen years. In a long time before the first MODIS model, MODIS I, was created in 1960, stretching nearly all the way back to the period immediately after the Second World War, a comprehensive model for national economic planning was envisaged as a future development and the foundations for such a model was laid.

The model was built as a tool for economic planning to fill a specific need within a certain historical, political and administrative context. This environment is today basically the same as it was in 1960 with some new features added. The economic problems faced by Norway have drastically changed but the approach and methods of dealing with them within a comprehensive "national budgeting" framework is not fundamentally different.

The original conception and later development of the model is rather different from the mainstream of short-run models in the sixties and seventies. This has been noted by Waelbroeck in a survey of short-run model research outside the United States. "A completely different tradition in model building exists in Norway. Stemming from the model-building work of Frisch and Johansen, the Central Statistical Bureau has, under the direction of Aukrust, built a series of "Modis" and "Prim" models, to predict industrial output, prices, and income distributions by means of input-output analysis. These models, in which the major final demand aggregates are predicted exogenously, and in which coefficients are not estimated econometrically, are completely different from the other models surveyed; no comparable work exists elsewhere: in other countries input-output has found applications in long-term rather than in short-term planning." (Waelbroeck (1975)).

It is certainly misleading to speak of a "completely different tradition" as Waelbroeck does when referring to model building in Norway. There are marked differences in emphasis and environment rather than in basic methodology which makes the MODIS model stand apart from the bulk of models surveyed by Waelbroeck.

In the modern fashion of characterizing a model by concatenation of the names of its inspirators and originators MODIS IV might be tagged as a Frisch-Leontief-Stone-Keynes-Aukrust model. In the following I shall say a few words about the respective contributions of these prominent economists as part of a discussion of the background and structure of the model.

Ragnar Frisch's contributions to the theory of economic planning and econometric model building were pioneering and far-reaching. This is, of course, not the time and place to present a full appraisal of his contributions[1]. His contributions to the construction and use of the MODIS model has been manifest in several ways, foremost by his all-pervasive influence on economic theorizing in Norway, in general, and his central role as teacher of several generations of economists at the University of Oslo. Of more particular interest are his contributions to the philosophy and methodology of macroeconomic model building set forth in lectures and in a great number of memeographed memoranda from the Institute of Economics (of which comparatively few have been given a wider circulation). His efforts in this field were not limited to theoretical studies, he initiated a number of pioneering attempts to build models of the Norwegian economy at a time when the available data and computing equipment could not pay justice to his ambitious aims. Some of these early models of the 1950's, in particular one called the Oslo Median Model, are direct precursors of the first MODIS model.

To Frisch the basic and all important rationale of economic model building was the need for and use of models as tools for a comprehensive national and international economic planning. In a classification of stages in economic forecasting he distinguished between four stages called by him the on-looker approach, the ad hoc instrument approach, the feasible instrument approach and the optimalization approach (see Frisch (1961), pp. 1-6). These may be regarded as stages of attitudes toward optimal control rather than of methods.

The on-looker approach may cover a wide range of methods from mechanical trend extrapolation to refined econometric models. The common feature is that the on-looker analyst "simply tries to guess at what will happen without making any systematic attempt at finding out what somebody - the Government or a private organization or a coalition of private organizations - ought to do if they want to influence the course of affairs" (ibid. p. 2).

In the second stage, the ad hoc instrument approach, it has dawned on the analyst that there are in the economy certain instruments or decisional elements which may be changed at will to induce changes in the course of affairs. His understanding of the interrelations of the economy has not reached the stage, however, where it can be formulated as a complete model with a definite number of degrees of freedom. To follow the advice of the ad hoc instrument analyst one runs the risk of arriving at "... quite unexpected, even chaotic, results, producing extreme tensions and contradictions in the economic structure" (ibid. p. 3). The ad hoc instrument approach is thus an intermediary stage, "... a very first and tentative preparation for a further analysis that does lead to a precise dynamic model with a well defined number of degrees of freedom" (ibid. p. 3).

In the feasible instrument approach the analyst has reached a stage where he thinks in terms of a complete model where the degrees of freedom correspond to the number of instrument and uncontrollable variables. For each set of guesses at values for the uncontrollable variables there is a whole range of alternative fixations of the instruments which span the feasibility space. At this stage the analyst has to co-operate with the decision-makers. "Only through such a co-operation with demonstrations of alternatives will it be possible to map out to the authorities the feasible alternatives and to help them understand which one - or which ones - amongst the feasible alternatives are the most desirable from their own viewpoint. To develop a technique of discussing feasible policy alternatives in such a scientific way is one of the most burning needs in economic policy-making today" (ibid. p. 4).

But even the feasible instrument approach is not sufficient for a rational approach to economic policy. "When the effort to map out a spectrum of feasible alternatives has gone on for a while, the conclusion will inevitably force itself upon the public and the authorities that the number of feasible alternatives is so great that it is impossible to keep track of them simply by listing them and looking at them" (ibid. p. 5). The fourth and final stage is the optimalization approach which includes a preference function and a mathematical programming techniques for locating the most

1) See e.g. Johansen (1969) and Edvardsen (1970).

preferred solutions among the feasible policy alternatives.

Frisch never lost this perspective on the future of model building. In fact, when macro-economic model building had got well under way and been put to practical use in Norway as well as in other countries, Frisch devoted a great part of his energy and ingenuity to attack the crucial problems of the final stage in model building, as he saw them, namely, how to deduce and establish preference functions and how to solve the ensuing problems of mathematical programming.

On occasions Frisch could let out considerable scorn over model builders and users who - in his view - did not have a proper understanding and perspective of what they were doing. He had a never faltering and strong belief in the possibilities for improving the material conditions of mankind as well as promoting a true democracy by appropriate use of scientific economic programming at the national and international level.

The macro-economic model building work in Norway has never reached higher than a moderately reasonable satisfaction of the feasible instrument approach. A formal approach to preference functions in the context of overall macro-economic models has been tried in very few places around the world apart from merely academic exercises. The identification and estimation of observed preference functions of various interest groups - as attempted by Frisch - involve methodological questions of an exceedingly intricate nature. Rational discussion of postulated preference functions is a much harder task than discussion of policy alternatives. On the other hand in the absence of an explicit preference function one is left with precisely the problem expressed by Frisch in the quotation above, that a successful implementation of a feasible instrument model may be used to generate too many feasible alternatives to be sorted out and evaluated in a wholly intiutive manner in the minds of the planners. Paradoxically, the better the model is for generating feasible alternatives the more difficult it may seem to choose one among them. With regard to MODIS IV this problem has up to how been dealt with on the basis of a close collaboration between the planners and the model building unit. Great effort has been put into achieving a user-oriented model, especially with regard to the two-way communication betwwen the planners and the model. The basic idea has been that the shortcomings of the model with regard to the theoretical content as well as the lack of formal procedures for evaluation of alternative results and other weaknesses have to be compensated for in some way or other within the administrative environment of the model. The close collaboration around MODIS IV between economic theoreticians, statisticians, model builders and planners and the integration of the model into the planning administration is certainly in the spirit of Frisch although his formal devices in terms of preference functions and optimalization is lagging far behind.

The MODIS models are rooted in national accounting both historically and by the internal structure of the models. After the Second World War a comprehensive political effort was made to build up a planning apparatus in Norway to deal with reconstruction and other post-war economic problems. At the time planning models in the modern sense were only to be seen in the distant horizon by the most farsighted planners and theoreticians. The immediate task on the research front was to collect and organize statistical data to give a coherent overall picture. National accounting was in an embryonic stage growing out of the prewar discipline of measuring national income and early efforts to formulate comprehensive and consistent systems of concepts for national accounting.

The task of constructing national accounts for Norway was undertaken by the Central Bureau of Statistics. By the middle of the 1950's operational routines for the construction of yearly national accounts were well established. Main responsibility for this work was carried by Odd Aukrust. The early work is summed up in the introduction to Central Bureau of Statistics (1952) and in Aukrust (1955).

In his discussion of the theoretical foundation of the national accounts Aukrust underlines the analytic use of the data thus organized. Rather than relying on some conventional accounting principles Aukrust stresses that "the main function of national accounting is to produce a well-organized system of economic statistics to meet the needs of economic policy and economic theory" (Aukrust (1955), p. 103). This orientation of the national accounting work also makes clear its place within an overall effort towards developing analytic tools for economic analysis and policy formation.

According to Aukrust the accounting system he implemented was a fruitful synthesis of three major influences, which to a great extent can be identified with that of the persons Ragnar Frisch, Richard Stone and Wassily Leontief. Ragnar Frisch has since before 1940 been preoccupied with the idea of replacing the then common national income calculations with comprehensive national accounts based on an adequate and consistent system of concepts. The idea was worked out in some detail in the early 1940's, see e.g. Frisch (1942), and later systematized in an axiomatic form by Frisch and associates, see Aukrust, Bjerve and Frisch (1948). The contribution by Frisch and others was centered on the conceptual problems of national accounting covering the logical structure between the concepts and the use of terminology and mathematical notation. the conceptual structure was called by Frisch "the eco-cirk system", a term which became common in Norway ("økosirksystemet") but never won international recognition.

Hardly less important than Frisch was the influence of Richard Stone. Aukrust in particular stresses Stone's influence on the Norwegian national accounts and on his own views in many matters. Aukrust gives credit to Stone as the leading theoretician behind the efforts to achieve an international standardization of national accounting.

Stone's early work is more pragmatic and empirically oriented than that of Frisch. Aukrust acknowledges the direct influence of Stone on the practical implementation of a national accounting system in Norway basically within a theoretical framework provided by Frisch. Stone has also been instrumental in bringing about a revised version of United Nations Standard of National Accounts, see United Nations (1968). He acted as chairman of the sessions of the Expert Group convened to assist and advice in preparation of the new standard. The new standard pays much attention to the interface with input-output models and it has had great significance for the present version of the MODIS model.

The third influence named by Aukrust was that of Leontief. Although Leontief did not deal with the accounting problem per se, his work up to the early post-war period did significantly influence the Norwegian national accounting system in one important respect. The decision was taken at an early stage to include input-output tables as an integral part of the accounts. Aukrust says about this desicion: "When the possibilities of input-output analysis had been demonstrated by Leontief if was reasonable to assume that an interest in such analyses would arise in Norway too. The Norwegian national accounting system was accordingly designed to supply data for such a purpose and it was one of very few accounting systems with this feature" (ibid. p. 35). The subsequent use of input-output tables as soon as the computational facilities made them easy to handle, certainly proved the decision right. At the time, however, the use of input-output analysis was still at an illustrative stage. Leontief had worked for quite a long time with input-output tables of the American economy. His early publications (see Leontief (1936), (1941)) were focused more on the structural and descriptive aspect of such tables. The operational use to which the tables could be put and the formulation of the simple Leontief model seem to have been conceived during the war. Some articles written by Leontief during the war was later added to his 1941 book and published in 1951 as the Second Edition of "The Structure of the American Economy, 1919-1939".

Input-output tables at a fairly disaggregated level were included in the yearly national accounts from 1949. The Norwegian national accounts were brought up to a very high standard by international comparison by the early 1950's.

On the basis of the first input-output tables prepared by the Central Bureau of Statistics model building efforts were exerted by Frisch and associate at the Institute of Economics. In this period there was close contact between the Institute and the research group of the Bureau with links to the policy-makers and planners. Towards the end of the 1950's one of the very first electronic computers to become available in Norway, a British made DEUCE computer was installed in the Bureau. Shortly afterwards the first input-output model of the Bureau was worked out and with some ingenious programming effort it was made operational.

As indicated above the future use of models in policy-making had been envisaged at an early stage. The work on national accounts had included a conscious effort to lay the cornerstones for future model building. On the user side the model was expected to play a role primarily in the yearly national budgeting process. The model was awaited to take over a task formerly performed by

administrative and quite insufficient methods. The first MODIS model could thus be put right into a planning context.

An important feature of the Norwegian model building effort has been the close co-operation between model builders, planners, data suppliers, and the main academic institution for economic research. The Central Bureau of Statistics has served in a double role within this co-operation, as the main model building agency as well as the data supplier. The Ministry of Finance which carries main responsibility for macro-economic planning has shown a very open-minded and positive attitude towards adapting its routines according to the requirements of the model. There has been two-way channel of adaptation. The Ministry of Finance has had ample opportunity to influence the model development and the successive model versions have been evermore dedicated to the policy-making framework of the Ministry. The links between the Central Bureau, the Ministry of Finance and the Institute of Economics at the University of Oslo have been maintained through a Model Advisory Committee ("Modellutvalget") appointed by the Minister of Finance with representatives also from the Bank of Norway. This permanent committee which was established in the early 1960's has regularly reviewed the use of the model and given recommendations on further development and also on other model issues.

3. The Structure of MODIS IV

What I shall say about the structure of MODIS IV will be in the form of a brief commentary to the structural map in diagram 1. The map indicates certain interrelations between the parts of the model structure and how it is linked to the policy-making environment. The main points to be made about the model are the following:

a. The model has an internal representation of the national accounts in almost the same amount of detail as the accounts themselves. Accounting definitions, accounting rules and accounting consistency requirement are strictly adhered to in the model. This is indicated by the central block in the map. All variables refer to calendar years as the time unit.

b. The quantity model and the price model are the main parts of the model structure. These are both input-output models related to the original Leontief scheme. The quantity and the price parts are duals of each other, although not in a strict mathematical sense. The input-output framework underlying the quantity and price model differs from the traditional Leontief framework based on a square matrix of intersectorial transactions by being rectangular in commodities by activities. This modification of the traditional input-output framework is made possibly by the new UN Standard of National Accounts. Similar and approaches has also been adopted as the standard framework in some other countries, notably in Canada. It is believed by us that this framework implies better use of the underlying observational data as well as advantages with regard to the rest of the model. On the other hand the beautiful simplicity of the Leontief is no longer present.

c. The basic logic of the quantity model is that of Keynesian demand management. Final demand apart from private consumption is treated mostly as exogenous variables. Some sectors are given special treatment with exogenous production levels. It is assumed that labour is mobile and that there are no quantity restrictions on commodity imports.

d. The price model is based on the Aukrust hypothesis of a dichotomy of sheltered and exposed industries with some refinement compared to the original crude hypothesis.

e. There are submodels for imports, private consumption, direct taxes, indirect taxes and depreciation. These submodels are more or less integrated in the quantity and price parts. The private consumption submodel includes a macro consumption function explaining total consumption as a function of real disposable income in socio-economic groups and distributions relations using relative prices and total consumptions as explanatory variables. With regard to the tax models an attempt has been made to have the institutional rules as given by tax laws etc. represented in full detail, that is with micro tax rules represented within the macro model.

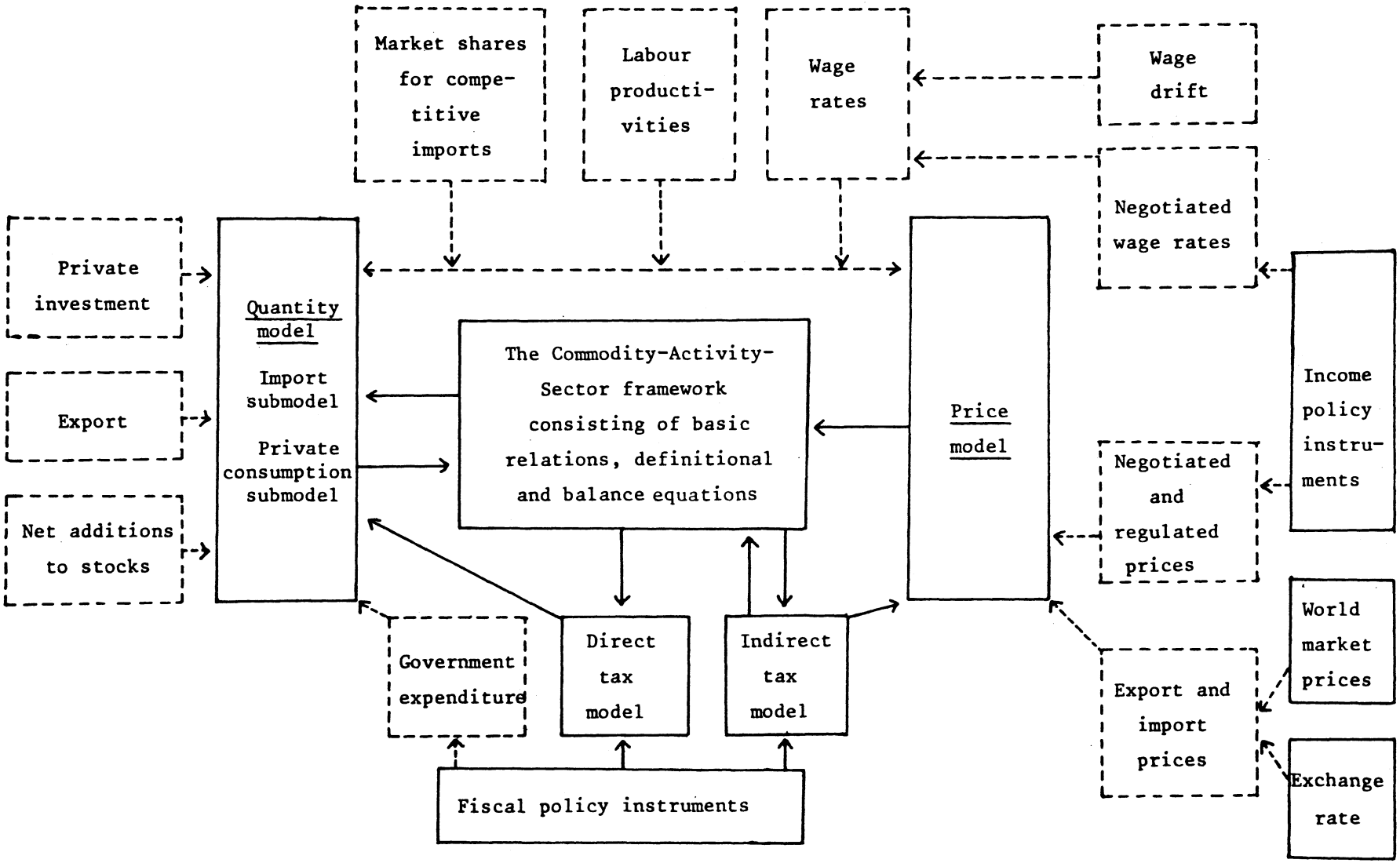

Diagram 1. Structural map of MODIS IV

f. The model is basically a static model. The only dynamic element of any importance is the presence of a lag effect in the macro-consumption function. The absence of more dynamic relations may be seen as a weakness, especially in short-term analyses. The importance of this may, to some extent, be subdued by a more sophisticated use of the model.

g. The exogenous variables of the model fall into different groups. One group we may call the truly exogenous variables as for instance the world market prices. Another group are the instruments or policy parametres. The remaining exogenous variables have an intermediate or more questionable character. There are many variables in this last group and for a proper use of the model it is necessary that the user has a thorough understanding of the model as well as of the interrelationships of the economy, especially of those insufficiently taken care of in the model. The model is thus not designed to serve as a black box.

h. The size of the model may be indicated by some key numbers. The number of commodities is nearly 200, the number of production activities is more than 250. Exports and imports are specified by commodities. Final demand categories are quite disaggregated with nearly 50 private consumptions categories, and 140 investment categories. All variables connected with government budgets are as a rule quite disaggregated. There are for instance specified around 80 types of indirect taxes and subsidies. For a complete solutions of the model it is necessary to insert values for about 2 000 input variables while the number of result variables coming out of the model is about 5 000. As the model can be and usually is solved for a number of years and alternatives simultaneously these may be hundreds of thousands individual values going into and out of the computer in a single solution of the model.

i. The quantity and price models viewed separately are almost linear equation systems and they are solved in a linear form with an iteration procedure to take care of non-linearities. The interrelations between the quantity part and the price part make it necessary first to solve the price model preliminarly, then the quantity and the price models are solved in succession and, finally, some subsidiary calculations and the complete set of accounts are worked out.

j. I began by speaking of the historical background of the model. The concrete manifestations of this model today as MODIS IV anno 1977 is very much a product of the history, that is of the experiences and lessons learned since 1960. The modifications and extensions which have been accumulated through the four successive MODIS versions and from year to year of each individual version have mostly been low-brow suggestions put forward for better use of the existing tool rather than revolutionary overthrow of the basic economic logic of the model. The model has picked up very little from the tremendours progress in econometric model building in the 1960's and 1970's. At the present we may be prepared as we were not ten years ago for further advances towards more useful model tools by applying modern techniques for instance from optimal control theory. Such techniques are required, I think, mainly for two purposes. First, to achieve better representations of the relations between the main targets and the policy parametres. This is difficult because of the sheer size of the model and the impossibility of an explicit algebraic solution. The other purpose is the representation of uncertainty. We have not managed to find very efficient ways of representing the impact of uncertainty in the assessment of exogenous variables. By using some fairly simple ideas from optimal control theory with good computational procedures a great deal might be achieved. I would like to end here by expressing the hope that seminal influences from engineering cybernetics may move the model higher up on the Frisch scale of stages of model development.

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