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Review of Macroeconomic Modelling Needs of the Ministry of Planning of the Kingdom of Saudi Arabia*

by

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Contents

Preface

This report from a two months assignment for the United Nations in June-August 1993 to work in the Ministry of Planning of the Kingdom of Saudi Arabia reviews the macroeconomic modelling needs of the Ministry in connection with the five-year Development Plans (DP). The assignment has been part of a long-term technical cooperation provided to economic planning in the Kingdom within the framework of the United Nations Development Programme. The cooperation project is called *Development Planning Advisory Services, SAU/92/002, phase IV*, having as one of its objectives the strengthening of planning capabilities of the Ministry of Planning.

After consultation with the Ministry of Planning the task was defined as reviewing the existing macroeconomic model tools in the Ministry, proposing appropriate model tools to be developed according to the Ministry's need in connection with the 6DP and future Development Plans including the statistical requirements needed to support the Ministry's macroeconomic responsibilities, and improving the currently used macroeconomic tools.

The main report is kept short with additional material in appendices. The report has been written on the basis of somewhat incomplete knowledge about the national planning process of the Kingdom, and I apologize in advance for shortcomings. The models proposed in the report are represented in brief outline, not as drafted model structures. The outlines should be read as suggestions about directions in which to develop new tools rather than as definitive proposals.

The Ministry provided a pleasant and convenient working environment during my stay. I owe thanks for the information and valuable assistance given to me by many staff members and by the library of the Ministry. Special thanks are due to the Project Manager Assistant Deputy Minister A.I. Al-Hakamy for taking me on as a short-term contributor to the project and to Hashem A-Shami, Heinz Muerdter and Erwin Wartenberg for very useful discussions and advice.

1. Summary and recommendations

The macroeconomic planning needs of the Kingdom of Saudi Arabia (a topic on which much has been written) is discussed briefly in chapter 2, mainly to reflect my understanding of the current phase of development of the Kingdom and to give some views on the relationships between the oil sector and the non-oil economy.

The use of macroeconomic models for national economic planning is taken up in chapter 3, mainly with reference to appendix 1 summarizing ideas drawn from the general theory of macroeconomic planning and appendix 2 on types of models for macroeconomic analysis.

Chapter 4 summarizes reviews of the macroeconomic model tools in current use in appendix 3 and of the macroeconomic model developed for the Ministry of Planning in 1981 by Coopers & Lybrand in appendix 4. The current macroeconomic tools are found insufficient to cover the needs.

Chapter 5 elaborates on deficiencies with regard to macroeconomic modelling needs in the statistical system of the Kingdom, while appendix 5 discusses what is needed to te get national accounts able to support the needs of macroeeconomic modelling for the national economic planning of the Ministry.

Chapter 6 outlines a system of three models to cover the needs and responsibilities of the Minstry of Planning: (1) a small, stylized model to study the

long-term economic sustainability of the Saudi economy, (2) a supply-oriented model to assist in the preparation of the DP, and (3) a medium-term econometric model for economic policy analysis and the monitoring of the execution of the plan.

The recommendations of the report are as follows:

* *The macroeconomic tools in current use are useful, but inadequate in several respects with regard to the planning and policy-advising role of the Ministry.*

* *The statistical system of the Kingdom is underdeveloped and need major improvements. The national accounts, in particular, are insufficiently developed and of too poor quality to support the macroeconomic tasks of the national planning. Improvements may benefit from international expertise.*

* *Closer links should be developed between the Ministry and the Central Department of Statistics (CDS) to influence priorities, contribute to the development of improved national accounts statistics, reduce the need for ad hoc production of statistics within the Ministry, utilize the expertise of CDS for planning purposes, and ensure that the best and most updated statistical information is used in the planning work.*

* *New macroeconomic models ought to be developed to give long-term issues stronger bearing upon the DPs, to improve the macroeconomic coordination in the preparation of the DP, and to monitor the execution of the pland and adjust plan assumptions and policies through the plan period.*

2. Macroeconomic planning needs

Saudi Arabia is still, and for a long period to come, an overwhelmingly oil dominated economy in terms of the size of the oil sector relative to the size of the economy and in the role crude oil play as a source of foreign exchange and government revenue. The oil boom period lasting from the oil price increases of 1973-74, through the price hike of 1979-80, and until the collapse of the oil market in 1985-86 provided means for a massive development of the Kingdom's infrastructure, and the Kingdom has undergone in a short time span an economic transformation unlike any other country. This has been a costly process in absolute terms, but relative to the size of the oil wealth it has only absorbed a minor part.

The purposes of the economic transformation have been modernization, diversification of the production structure and long-term economic sustainability. In the course of two decades Saudi Arabia has been equipped with a modern infrastructure in transportation, energy and water supply, education, health services and other fields. The modernization in terms of physical infrastructure has come a long way towards completion and entered a phase of keeping up with increasing demand for extended infrastructure. The diversification program has been less clearly defined. Considerable diversification has taken place, but relatively little new production capacity that can be sustained without the support

of the oil sector either in terms of raw materials, subsidies or general demand mediated through the government budget, has been generated. The diversification may be viewed as part and parcel of the long-term economic sustainability.

The diversification policy has emphasized two major sectors: agriculture and manufacturing. The former faces a formidable constraint on its further expansion by the severe limitation of water resources, while the latter is constrained by manpower availability and technical capabilities. For two manufacturing subsectors, petrochemicals and oil refining, the Kingdom clearly has a comparative advantage. However, the poor forward and backward linkages of these sectors within the economy limits their impact with regard to diversification.

The remaining oil wealth of Saudi Arabia is huge, yet it remains an exhaustible resource of uncertain future value. The oil wealth will be drained over a long period of time according to current reserve estimates. With regard to the long-term economic sustainability of the current growth pattern of the economy what matters most is the future value of the annually depleted oil wealth relative to the size of the economy and the extent to which the depleted oil wealth is converted to permanently reproducible sources of income. The oil wealth can be transformed into reproducible assets via two channels: Oil revenues can be invested abroad and turned into an oil fund that can provide a permanent addition to the country's income generating capacity (but prone to the variations in international rates of return), or when invested domestically in real capital and human capital the oil revenues can be converted to reproducible sources of income in the long-run.

Since the oil revenues started to pour in, especially since the mid-1970s, Saudi Arabian has undergone an economic transformation stage of enormous proportions. This transformation should be followed by a transition towards a sustainable economic development. The transition stage, which may last for decades, should result in an economy able to operate and grow without major impetus provided by drawing down the remaining oil resources.

The oil boom years led to false expectations about future oil prices both in the Kingdom and in the world at large, a fact which doubtlessly contributed to the consumption and investment excesses in the later boom period. The oil-producing countries may have been the last to surrender the belief in the recovery and further increase in the oil prices, after the set-backs in the early 1980s, as witnessed i.a. by the Ministry of Planning's Long-term Energy Plan from 1984 ([2]) projecting oil prices remote from reality, e.g. an oil price in 1995 of more than $50 per barrel, combined with totally unrealistic growth rates in world energy demand.[1] The experiences of the oil market over the last twenty years has been an important learning process both for oil-producing countries and for the rest of the world. The increased awareness of energy and environmental issues in the world community has increased the understanding of these vital components of human societies and sobered the perspectives for oil-rich countries.

The oil price will continue to fluctuate and might very well cause windfall gains, particularly when supply disturbances occur, as happened in 1990, but the upper and lower limits of oil prices in the longer run now span a considerably nar-

[1] At the peak of the second oil price shock in 1980 almost all forecasters projected in this vein, e.g. the highly reputed DRI, International predicting in 1981 the oil price of 1995 to be $168 per barrel!

rower interval than conceived some years ago. The resource-rich oil-producing countries of the Arabian Gulf seem to put trust in the fact that the fast depletion of oil resources in many countries currently producing oil will increase their own control of the market, but may pay too little attention to the possibility that the oil price may nevertheless remain relatively low in the longer run due to a higher degree of energy conservation in many processes consuming energy, upcoming new energy sources and the possibility of severe taxation of petroleum products by importing countries.

It is often stated that the oil resources of the Kingdom will last for a century. However, considering the carbon/energy-tax proposals considered by the EC and USA with its implied reduction in the oil rent accruing to the producing countries and the limits this will set on price hiking by OPEC, the Kingdom may opt for a substantial production increase as the best response, or even necessity to maintain an acceptable level of oil revenues. The change in the R/P ratio implied may easily cut in half the lifespan of remaining oil resources! Hence, the importance of the accelerating the transition phase should be emphasized.

The historical experience of Saudi Arabia through the transformation phase shows an extremely strong link between oil revenues and the development of the non-oil economy, especially via government expenditures as the driving force of the massive expansion of economic growth and diversification. There is no good reason why variations in short-term oil revenues should continue to influence expansionary forces in the domestic economy. On the contrary in line with the reasoning above it can be argued that the time has come for a higher degree of separation between the oil sector and the revenues it provides for the government's disposal and the development and growth rate of the non-oil economy.

The oil sector demands relatively small inputs from the rest of the economy in terms of investment, intermediate consumption and labour power, hence the interaction between the oil sector and the rest of the economy is rather limited in terms of real flows. The oil sector should be run as a separate concern, little influenced by the development of the non-oil economy, and, vice versa, the non-oil economy, although heavily dependent upon the surplus of the oil sector, ought to develop rather uninfluenced by short-term variations in the profitability of the oil sector.

The aim of the oil production and price policies is to ensure the maximum long-term value of the total crude oil and natural gas assets. The domestic use of oil revenues should be stabilized at a level consistent with the long-term views of the value of oil as an international commodity. This level cannot be decided once and for all, hence the level of domestic use of oil revenues need to be reviewed from time to time, in particular in connection with each Development Plan. (Stabilization in the use of oil revenues need not preclude a flexibility in the use of government financial resources to conduct countercyclical policies when needed.)

The non-used oil revenues accumulate in income earning assets abroad to the extent that they are not given away as financial or military aid or as development assistance. As part of a long-term sustainability policy it should be considered to have a major part of the accumulated assets set aside and protected as an oil fund to be drawn upon to maintain a stable level of oil-generated revenues over a longer horizon. With the resource situation for Saudi Arabia with regard to oil this may not be regarded as a very urgent issue, but an oil fund need to be accumulated a long time before it is needed, and, hence

ought to be considered as part of the very long-term policy for the utilization of the Kingdom's oil wealth.

Considerations of the optimal policy of an oil-rich country with regard to the production of oil and the use of revenues has generated - with Saudi Arabia as the prime example - an endless flow of theoretical and empirical studies, most of which have probably turned out to be rather futile efforts. The problem will not be considered any further here, except with the remark that as an overall rule for the oil policy and the use of oil revenues the equalization of returns to capital should be aimed at. Under stylized conditions the returns to physical capital invested in the Kingdom, to human capital through investment in education and welfare, to foreign assets, and to natural resource assets (i.e. unexploited oil and gas) should be equalized to maximize total net benefits. This may not be possible due to constraints. With low future oil prices the returns to unexploited petroleum resources will be low, but reducing the natural resource capital by massive depletion may not be a viable policy for a large oil producer.

The main point to be made is that, although not totally satisfactory on theoretical grounds, the medium-term planning of the oil sector and the non-oil sector should be separate exercises. The main interaction between the two - the injection of oil revenues in the domestic economy - should be determined from long-term considerations and reviewed periodically.

3. Macroeconomic models for national planning

Macroeconomic model tools can be used for a number of different purposes in a national planning context. Any macroeconomic model is a tool to be integrated and used in a human work environment. To serve its purpose it must be understood and used by the planners and not left to model experts alone. The quality of the results of the use of models is constrained by the quality of the data providing the basis for model estimates as well as the ingenuity and relevance of the modelling work. If reliable data to a lerge degree are missing, there is no substitute.

Appendix 1 sets out some viewpoints drawn from the general theory of macroeconomic planning. It describes in general terms the advantages of formalization and the types of relationships to be included in a macroeconomic planning model. The exposition is elementary.

In the discussion of the choice of macroeconomic models opinions of the advantages and disadvantages of various types of macroeconomic models are often voiced. Appendix 2 gives some notes on the historical background of the main types of models and their stylized properties.

4. Macroeconomic model tools in current use

The macroeconomic model in current use has a number of shortcomings and deficiencies to serve as a planning model. Some of its features are at variance with reasonable theoretical assumptions, and it is doubtful whether it can accommodate the need for macroeconomic consistency, except in a rather limited technical sense, needed for planning purposes . For this reason it is referred to

in the following as a macroeconomic module, rather than model.[2] The module is embedded in an integrated data system (spreadsheet) to update, extend and adapt the (highly deficient) national accounts data for Ministry of Planning use and to produce a complete set of macroeconomic tables for plan preparation purposes. The data system is highly proficient and useful. The macroeconomic module is reproduced and commented upon in Appendix 3. Some contributions towards improving the module is included in Appendix 6.

The Ministry of Planning engaged the consultancy firm Coopers & Lybrand Associates Ltd. during the Second Development Plan to develop a macroeconomic model tools to be integrated in the planning process. The project resulted in an operational tool as documented in great detail in [1]. The model, which is deemed as adequate and well thought out, but overambitous relative to the Ministry's technical capability and the data availability at the time, was apparently never put to actual use by the Ministry. The macroeconomic model is Appendix 4 gives a brief review of the Coopers & Lybrand contribution with a view to whether it contains elements worth reviving in the further work of the Ministry.

5. Deficiencies in statistics

All efforts directed towards establishing macroeconomic model tools for Saudi Arabia for whatever purpose will be severely constrained by lack of data. The system of providing statistical information for macroeconomic planning needs is poor. It is poor when compared with the tremendous achievements of the Kingdom in public utilities and other public services required in a modern society. It is also poor in comparison with the informational infrastructure provided for the conduct of the oil policy. And, finally, it is poor in comparison with the statistical system in many developing countries with a low income level compared to Saudi Arabia, but with a far, far better statistical system.

The importance of the oil sector in Saudi Arabia needs no corroboration, and the requirements for reliable information for the conduct of the oil policy seems to have been met, in stark contrast with the limited information available about the economic development and economic structure of the country at large. It may even seem surprising that the 'statistical infrastructure' for government needs, such as the planning of the non-oil economy, has not benefitted sufficiently from the massive build-up of infrastructural investment in general which has taken place in the Kingdom. The statistical system is deficient in several respects.

The backbone of the economic statistics in modern statistical systems is the national accounts. Such accounts have been developed in the Kingdom, but are at an embryonic stage of development. The national accounts are a necessary requirement for macroeconomic models and national planning. The national accounts of Saudi Arabia seem to be out of step with the vast advance Saudi Arabia has made in many fields and highly deficient with regard to the ambitions expressed for the planning and diversifying the economy. The shortcomings have apparently been pointed out on several occasions within the Ministry of Planning. An insufficient statistical system to support macroeconomic modelling was

[2] From the information available the macroeconomic module does not seem to have been constructed to serve in this function, but has been amended from the macroeconomic part of the energy model developed for the Ministry of Planning some years ago.

observed 15 years ago, the advance since then seems to have been quite limited.

It is also odd - and a bad sign - that the national accounts are not published in the Statistical Yearbook, and treated apparently as confidential information. There should be no need for secrecy which serves no purpose. National accounts data ought to be the common reference framework for government administration as well as for non-government bodies taking an interest in the overall development of the country. The secrecy treatment certainly reduces the knowledge about the national accounts and prevents more widespread use.

National accounts is the superstructure of economic statistics and can only be erected on the basis of a comprehensive system of economic statistics. Important elements in such a system is still missing. Hence, the national accounts cannot be improved without stronger efforts to improve the statistical infrastructure, and the quality of the existing national accounts data is be dubious in many respects. The most blatant weaknesses of the national accounts from a model building point of view is the lack of input-output tables, the lack of constant price data for final demand aggregates, the lack of capital stock data, the absence of employment information, and the completely outdated base year for value added in constant prices. All these deficiencies can be related to the lack of primary economic statistics.

The national planning administration is the prime user of national accounting information and economic statistics. Close contact with the statistical agency ought to be a necessity for the national planning institution to ensure (1) that the best available statistical information is utilized and interpreted correctly, and (2) that new statistics is developed and existing statistics adapted to cover national planning needs. National accounts incl. input-output tables provide the conceptual and empirical framework for macroeconomic planning. The detailed specification and empirical underpinning of this framework ought to be of great interest to the Ministry of Planning and efforts should be exerted to cooperate with and influence the work of the Central Department of Statistics in this important area. The time schedule of plan preparation and the time lags in the production of statistics also implies that provisional and preliminary national accounts should be regularly produced. Close links between the Ministry of Planning and the Central Department of Statistics should be encouraged to make better use of Ministry resources, avoid duplication and statistical work done in the Ministry rather than at CDS. For all new statistics the Ministry of Planning ought to be on an advisory board to ensure that the specifications of improved statistics match planning needs. In some countries the central statistical bureaus support the national planning administration in important ways beyond the production of statistics, e.g. in the construction and use of models, econometric studies, etc.

An overall plan for the development of the statistical system of Saudi Arabia seems to be missing. The first step would be to draw up a plan with realistic resource requirements. International expertise may be needed for this, but should be easily available through the UN system (and IMF in special fields), the International Statistical Institute and national statistical bureaus.[3]

Improvements in statistics will require more statistical surveys of various kind

[3] At the present time much advisory resources are tied up in connection with establishing statistical services in the countries of the former Soviet Union, but even so this is hardly likely to be a bottleneck.

to be conducted. As surveys are resource demanding to conduct other sources of statistical information ought to be exploited as well. Administrative data collected or registered primarily for other purposes ought to be exploited. An infrastructure of statistical registration is called for. Tax assessments, social security contributions, concession and license systems can with suitable adaptation all be exploited for statistical purposes. The underdeveloped taxation system in the Kingdom means that important source of income and wealth statistics is missing.

The establishment of a better statistical system is a slow process (especially with regard to model building as time series of observations are often required), and too important to be postponed. The neglect of the statistical infrastructure in earlier years will bother model builders and others for years to come.

The Central Department of Statistics is subordinate to the Ministry of Finance, an arrangement also found in other countries, but the statistical agency is also found directly under the Prime Minister or under ministries of interior or administration. In the Kingdom the cross links between ministries, all serving the same royal authority, seem to be less developed than in most countries. The CDS ought to be of no less importance for the Ministry of Planning than the Ministry of Finance. Its status and responsibilities, budget sources, and its professional autonomy in statistical matters should be defined, if needed, by a royal decree. To the extent that the CDS serves as an ad hoc resource pool for the Ministry of Finance, there may be a conflict of interest to be sorted out.

Some further notes on statistics for improved national accounts are included in Appendix 5.

6. A system of models

For the macroeconomic part of the national planning a system of models is needed rather than a single comprehensive model. The model system should address the needs for macroeconomic perspective, coordination and analysis in the different stages of the national economic planning as conducted by the Kingdom. For the time being the five-year cycle of Development Plans is the given format of the planning process.

For national economic planning a longer time perspective is required for Saudi Arabia than for almost any other country. This is due to (1) the heavy reliance upon a long-lasting, but yet depletable natural resources for the financial viability of the economy for several decades to come, (2) the time span required to develop a basis for sustainable economic development, and (3) the expressed will to manage and guide the social and economic development of the Kingdom to ensure the welfare of the Saudi population. As a background for the DPs a model to draw up a longer perspective focused on the economic sustainability of the Saudi economy would be useful. One could play with the time frame for this perspective, perhaps even looking one hundred years ahead, hence the name *century model* could be suggested.

The purpose of such a model exercise is, however, not prediction, but to study the viability of the Saudi economy in a long-term perspective, the risk factors that can endanger a transition to a sustainable economic growth path, and the essential trade-offs the Saudi economy will be facing. Needless to say, there is no way to acquire the information needed to acertain the future of the Saudi

economy, the model can only work out the implications of the current beliefs and best guesses made today for the exogenus variables and parameters, but this may be interesting enough to be well worth an effort. The interest in the results of the model is primarily what it has to say about the next few decades, and 30-50 years might be a suitable horizon for the Century model. If the model is used in an optimizing mode, the time horizon must be long enough to avoid any end-of-period effect on the horizon of greatest interest. Some further thoughts on the Century model is set out in section 6.1.

The most important role of macroeconomic model tools in the plan preparation is to ensure macroeconomic consistency. The central element in the Development Plan from a macroeconomic point of view is the investment program, i.e. investment by production sector whether undertaken by the government or the private sector. To select an investment program to be implemented in the Plan a model is needed to corroborate the consistency between the investment program and the growth rate, sectoral production pattern, labour market assumptions etc. For this model the name *selection model* is suggested. The model should as a minimum requirement ensure the feasibility of the plan in terms of the overall balance of the Development Plan between aggregate supply and demand. The Selection model should also contribute to the choice between different investment programs. Major projects within sectors should be considered in the Selection model. The time-phasing of large-scale projects should be evaluated to avoid investment humps causing delays and excessive costs. The choice between different investment programs requires the availability and incorporation in the model of data to assess the returns to investments in different sectors, linkages between sectors, and other relevant information. Assessments of returns to investments within a macroeconomic framework may give other results than at the sector level and open for fruitful dialogue between national planners and sector planners. The Selection model should also contribute towards corroborating other balances of the economy in the plan period, such as the balance of payments, government finances, the labour market, the credit market, etc. The Selection model is further discussed in section 6.2.

It can be argued that planning ought to be a continuous process rather than taking place at discrete five-year intervals. Discussions over this have arisen in many countries with development planning, some have attempted to make the planning system more flexible by preparing development plans at more ad hoc intervals or allowing sectoral plans to be drawn up at different times, while others have for political and practical purposes maintained the discrete format of four, five, six or seven years plan period. It goes without saying that the actual economic development planning hardly ever goes according to the drawn-up plan, as major assumptions relied upon in the planning process have been severely contradicted by events. Saudi Arabia has experienced this to a high degree as oil prices increased beyond expectations in the Third DP, plummeted in the Fourth DP while the Iraqi war caused disturbance to the the Fifth DP.

Even in the absence of such dramatic events there is a strong need for monitoring the development throughout the plan period, updating the plan as new information arrives and plan assumptions have to be revised, and contribute to policy analysis. To monitor the implementation, update infor-mation and revise policy recommendations an *implementation model* is needed. In the Implementation model the emphasis will be on the follow-up of the plan proposals

and the use of instruments to implement the development drawn up in the selection model.

The formulation of the Implementation model should relate to the long-term planning methodology pursued by the Ministry of Planning (as approved by the Minister). It has been recognized by the Ministry, as part of the long-term planning strategy, to emphasize indicative planning towards the private sector. For the public sector the need for greater flexibility has been accommodated through the adoption of the program-based approach (though the public sector planning will remain a binding type with gradual phase-out in the longer run). The adopted long-term methodology also emphasizes the use of fiscal and monetary policies in the management of the economy and presumes their increased importance in the future. This also calls for the Implementation model. It allows reformulation of policies in the short-to-medium term. The Implementation model is outlined in section 6.3.

To construct the models outlined in sections 6.1-6.3 requires qualified manpower resources, statistical data (not readily available today) and computer software for estimation and operation. The latter requirement is fairly easy to cope with and is not further commented upon. Manpower resources are discussed in section 6.4 and statistical needs in section 6.5.

6.1 The Century model

National wealth consists of real capital, net foreign assets, human capital, and natural resources (although only real capital and net foreign assets enter when national wealth is conventionally measured). The purpose of the Century model is to elucidate the management of national wealth.

The motivation for the Century model is primarily Saudi Arabias strong dependence upon exhaustible petroleum resources, which means that the national income as measured in the national accounts is - in a more profound sense - not really income, but to a considerable extent liquidization of national wealth. The financial resources provided by current oil revenues also gives the Kingdom considerable freedom in the choice of options for developing the economy.

Although Saudi Arabia has many depletable natural resources only those on which the future of the country really depends need to be included in the Century model, i.e. oil, but also water. Water is in the long run, of course, the more important resource, and the drawing down of depletable water reservoirs at a high rate (and marketed at negligible prices compared to the real cost) calls for the inclusion of water supply in the long-run perspective.

It can be argued that in the study of the long-run management of national wealth the Kingdom's oil policy should be a central concern, and hence included in the model. By oil policy is here meant the Kingdom's production policy for given conditions of the world energy markets. The suggestion here is, however, that the oil policy is kept outside the model and taken as exogenous. Although it certainly can be argued for the opposite view, the rationale for this choice is partly simplification: inclusion of the complicated oil policy issues would dominate the model, turn it into an OPEC oil policy model and crowd out other issues. (The model may, however, shed light on the optimality of the oil policy which may be of importance in the thinking about long-run oil policy.)

The model will necessarily have to make a number of stylized assumptions

about the long-term development without strong empirical underpinning. Key parameters on the functioning of the Saudi economy decades ahead cannot be precisely estimated by any means, but the modelling should strive at empirical corroboration. The model should be kept small and transparent, its contribution is primarily to work out the long-term effects of policies which cannot really be evaluated properly in the short time perspective of the DPs.

The central part of the model is production and cost functions and accounting relations. As a minimum the model will distinguish the oil sector, the water sector, the education sector and the rest of the economy, but more details may be needed to provide an adequate descriptive picture of the features to be studied (e.g. by distinguishing the agricultural sector as the main user of water). For given world energy market scenarios and other external assumptions the model will illustrate the combined effects of the given oil policy, use of oil revenues for consumption and investment, returns on accumulated foreign assets, domestic investments in real and human capital, population growth, expansion in the non-oil economy and water use patterns to shed light on the long-term viability of the Saudi economy. The increase in productivity of the non-oil economy will come about as a result of investments in real and human capital.

To establish a simple deterministic model along these lines is not a big deal, but that would only be the starting point. When the model is reasonably corroborated with regard to specifications and estimation or calibration of parameters, it should be adapted for an optimizing mode, i.e. used to determine an optimal long-term policy of using oil revenues to balance consumption needs against the long-run need for investment to sustain a viable economy after the oil revenues decline. The reason for conducting optimization is not primarily to find out how well an optimal policy will do over a long horizon, but to derive optimal strategy rules, i.e. policy rules about what to do now on the basis of currently available information. Whether optimizations of this kind would have any bearing upon current policy, depends i.a. on the belief in the crucial parameters of the model. Apparently small parameter changes might very well result in considerable effects over a long period of time (and perhaps reduce the belief in model exercises of this kind if there seems to be little reason to choose one parameter value rather than another!). Increased awareness of the crucial parameters may give important insight.

The deterministic model, whether in optimizing mode or not, is not dealing explicitly with the uncertainty of important exogenous variables and parameters, e.g. international energy prices, the amount of unexploited oil resources, the rate of return on foreign assets etc. It may illustrate the uncertainty by running scenarios with different values for these variables and parameters. This is, however, an unsatisfactory way of dealing with uncertainty. The policy choices of the Kingdom towards achieving a sustainable economy is a stochastic decision problem. hence, the Century model should be cast in a stochastic form.This can be done at different level of ambition using stochastic simulation or stochastic optimal control techniques. From such models can be derived optimal strategy rules under uncertainty, which is what is needed to steer the economy towards an unknown future with regard to the value of oil, international interest rates, the amount of water, etc. and incomplete knowledge about many important parameters of domestic economic relationships.

Needless to say, although the first steps may be easy the higher levels of ambition for the Century model sketched above are difficult to master. Work on

the Century model may encourage more thinking in terms of managing the national wealth, i.e. more long-time considerations in the short and medium-term policy

6.2 The Selection model

The Selection model should be cast as an applied general equilibrium model, but adapted to the specifications and the special needs of the DP. The central relations in the model are production functions representing the available production capacity of individual sectors. The production capacity and actual production can be enhanced by new investments and increased productivity. New investments can be incorporated as additional capital in the production functions or treated as separate additions to production capacity with full specification of factor inputs, output capacity and capital gestation. Large-scale projects ought to be treated separately. The model should provide a more detailed treatment of investments effectuated directly or indirectly by the government than private sector investments.

An input-output matrix provides the link between the production sectors for assessment of forward and backward linkages and for the balance in supply and demand for the output of individual sectors.

The other demand components are treated as follows: Exports are exogenously determined, possibly supported by modelling of some export relations. Private consumption demand can be determined from an estimated macro consumption equation determining private consumption from an income concept closely related to the gross domestic product. The remaining elements in the overall supply and demand balance are government consumption and imports. With imports estimated on the basis of the observed propensities to import and price sensitivity, the model determines government consumption residually from the available capacity. Lower government consumption will leave idle capacity in the non-oil economy and a higher level will strain the resources, create inflationary pressure, crowd out investment and endanger the target path of non-oil GDP. Alternatively, government consumption is detemined exogenously and imports make the residual, showing a need to increase or decrease the import propensities.

The applied general equilibrium format also gives price relations between output prices and input costs using the user price as the cost of capital investments. For most sectors, i.e. all except crude oil and natural gas, water supply and agriculture constant returns to scale can be assumed. For these sectors the price relations will not include quantity variables. Special consideration must be paid to sectors with considerable price discrimination between users, such as oil, refined products, water et al. It may be found advantageous to represent the output of these sectors also in physical quantities. An assessment of the deadweight loss of subsidizing should be attempted.

By means of the Selection model alternative scenarios for the investment program can drawn up. Preliminary assessments of the balance of payments, the fiscal balance, labour market balance, inflation etc. implied by the invest-ment program should be given. On the basis of the scenarios, feedback from the sectoral planning units and other bodies as to the overall desirability and implementability a final selection can be made.

6.3 The Implementation model

The main purpose of the Implementation model is to monitor the plan implementation. The model should be cast in the format of a short-to-medium term econometric model rather than the applied general equilibrium format suggested for the selection stage. The model should be designed to utilize the preliminary indicators of the economic development available in the Kingdom to provide an updated picture - corresponding to the macroeeconomic framework adhered to in the DP - of the state of the economy. The Implementation model should also incorporate fiscal and monetary instruments allowing policy analysis in pursuance of plan targets.

The Selection model with the emphasis on production functions is tilted towards the supply side, while the Implementation model (which also can be used in the plan preparation stage) is leaning more towards demand in its general orientation. While the Selection model is formulated in terms of real flows and relative prices, the Implementation model will to larger degree incorporate financial flows. Preliminary information about investments undertaken may e.g. be assessed from credit market information rather than from the statistical reporting of enterprises.

The Implementation model should give more attention to private consumption demand and incorporate government instruments such as transfers and subsidies to households, to be able to assess the development of standard-of-living indicators. The effects on the government budget and fiscal balance of government expenditures for goods and services, transfers, subsidies and non-oil revenues should be calculated in a fair amount of detail.

The labour market development is an important part of the monitoring and should be modelled in more detail than in the Selection model where the emphasis primarily is on the use of labour as a production factor. The labour market representation in the Implementation model should allow the monitoring of the targets for the labour market policy, e.g. participation rates of the Saudi population.

To fulfill its purpose the Implementation model may have to be formulated as a model open for improvization and ad hoc adaptations. It is a practical question how comprehensive the implementation model should be, but as a general recommendation it should not be overloaded with details. It should also make full use of information from sectoral planning units.

6.4 Resource requirements

The resource requirements in terms of manpower for developing the proposed model tools are contingent on the level of expertise of the manposer recruited, the level of refinement and ambition in the modelling, the availability of statistics, and the logistic support (in terms of computer and software resources, office environment, translation services if needed, access to resource persons in the Ministry of Planning, CDS, Ministry of Finance and National Economy, SAMA et al.) are here roughly assessed as low estimates on the assumption that an efficient utilization of the resources has been facilitated.

The presumption is made that the model development is undertaken by a small team of short-term experts and that the development also includes the testing, documentation, presentation and evaluation of the models as well as the training of (semi-)permanent staff to operate, maintain, and update the model

tools. As part of the training some participation by (semi-)permanent staff ought to take place under the development of these models.

To work on all three models simultaneously would perhaps not be practical. It is suggested that the Century model and the Implementation model is given priority over the Selection model as the latter can hardly be completed in time for the preparation of the 6DP.

For each of the models - if they are found to be useful tools - the need will arise for revision and adjustment, perhaps reconstruction, as experience in using them is gained, better data sources become available and more insight is developed on how they best can be adapted for use for the Ministry's tasks.

To establish the Century model as sketched in section 6.1 as an optimizing model, but without the uncertainty aspects formalized would in my assessment require 3-4 man-months. The Implementation model is a larger project, requires the use of more diverse data sources, more insight in the economic structure of the Kingdom, more econometric techniques and better understanding of the planning process. For this model the resource requirement is assessed to be 7-9 man-months. Under less perfect conditions than assumed above time will be lost and the resource requirements will increase. for increased realism the resource requirements should perhaps be increased by 50 per cent.

A team of 3-5 persons may be required to undertake the task. They should be drawn from an environment of macroeconomic modelling and familar with the use of models for government planning.

The models are all assumed to accommodated on personal computers. on For acquiring the necessary software for the Ministry's use a limited expenditure will be needed, probably not more than of $10 000. The Ministry seems to be fairly well equipped with PC capacity, but some upgrading may be needed.

6.5 Statistical needs

The needs for improved statistics follow from the sketches of the models and the status of the statistical system as described above. The most urgent needs are extension and improvements in the national accounts to include input-output tables, capital stock data by sector, employment by sector, and expenditure and production accounts in constant prices (for a more recent year than 1970). Other data needs (e.g. fiscal data, financial and monetary flows, energy and water use, etc.) beyond what has been found published, will surely arise and have to be solved as the project progresses, but hopefully most of these needs can be fulfilled from existing sources.

References

[1] Coopers & Lybrand Associates Ltd.: *Macroeconomic Modelling Project*, Vol. I-IV. Ministry of Planning, 1981

[2] *Long-Term Energy Plan, Executive Summary.* Ministry of Planning, 1984

APPENDIX 1: Macroeconomic models vs. informal methods[1]

A 'macroeconomic model' in a national planning process can be conceived in a more abstract sense as the implicit set of assumptions about the functioning of the economy adhered to by the planning authority when evaluating policy decisions. Alternatively, a more common interpretation of a macroeconomic model is as a mathematically formulated set of equations expressing the relationships of the economy. Obviously, planning has no meaning unless there exists a model in the first sense, the planning authority must have a fairly clear picture of the functioning of the economic system to be able to fulfill its task. Such a picture, which may not be very tangible, can be denoted an implicit planning model. An explicit, mathematically formulated model on the other hand is neither necessary nor sufficient for adequate planning, it is more a question to what extent a mathematical model can be developed to serve as a practical tool to improve the planning procedures.

App.1.1 Advantages of formalization

A formal model does not by itself give a better representation of the economy than the implicit model. A mathematical model is certainly better for achieving certain tasks in the planning process, even when it offers a less sophisticated representation of the economic relationships than those held by an experienced planner. It is thus not an either-or situation, the macroeconomic evaluation can hardly be left to the model alone, but the advantages of the model can be used to corroborate the understanding of the economy and facilitate improved planning procedures.

The introduction of a mathematical model contributes towards a formalization of the planning process. The advantages of such formalization are several:

* *Formalization provides a means of securing logical consistency between assumptions made at various points. Consistency here means both definitional consistency and the theoretical impositions. Strict consistency is virtually impossible to achieve without formal tools.*

* *A model provides a framework for efficient and systematic use of available information, through estimation of structural relations and utilization of forecasts for various exogenous elements.*

* *Solving formal models by means of computers provides a means for simultaneous handling of vast amounts of information far beyond what is humanly possible without formal tools.*

* *To the extent that the planning process aims at optimization this can hardly be achieved with any degree of accuracy without formalization*

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[1] This exposé of concepts is drawn from the theory of macroeconomic planning, with particular reference to Leif Johansen: Lectures in macroeconomic planning, Vol I-II, North-Holland: Amsterdam, 1976-77.

* *Formalization by models may also help to clarify issues with regard to the division of tasks between experts and politicians.*

* *Finally, formalized methods can be taught and learnt more systematically than good intuition and judgment.*

Over the last couple of decades these (and perhaps other reasons) have led to the introduction of models in the planning process in very many countries. The role played by these models vary highly. Planners with experience from a "pre-model" period may remain skeptical about the benefits from formalization by models, and perhaps for good reason. The quality and suitability of the model is, of course, essential for its validity and reliability in a given planning context. All models have limitations with regard to what questions they can answer and the quality of the answers, because of insufficient insight and understanding of the economy on the part of the modellers, insufficient data for estimating relations adquately, or other constraints in the modelling process.

Sometimes major problems in the planning process is completely beyond a formal model, e.g. the need for better communication between the planning experts/planning authority and the political level and other authorities, say, with regard to getting access to updated information or knowledge about policies to be implemented. Such problems may, however, be reflected in the way of formalizing the planning procedure. It is of considerable importance for the practical use of the formalized tools that the results from using these tools can be communicated outside the limited circle of modelling experts. Hence, transparency is essential, and excessive formalization should be warned against. This is, of course not meant to imply that expert methods, e.g. advanced econometric techniques, are not to be used in the modelling exercise. On the contrary, a major benefit from the use of models is to benefit from such techniques, but the overall layout of the model must be transparent and comprehensible enough to serve as a basis for dialogue between modelling experts and policy-makers. The model must be suitable for en iterative use in a two-way exchange of information through which the planning objectives and constraints are gradually clarified.

Even if a formal model does not become the centerpiece of the planning process, it may have important uses on the sideline. First, it may be used to check the consistency of plan drafts incorporating the implicit model assumptions. Second, it may take the plan targets as given constraints and be used to study the feasibility space given these targets. Third, it may take the development path in the plan draft as given and explore possible alternatives in the neighbourhood of this reference path.

App.1.2 Types of relationships to be included in a planning model for five-year plans

There are certain types of relations one would expect to find in a planning model for five-year planning rather independent of the given circumstances and planning framework of the country concerned and even independent of the type of economic regime adhered to. Major types of relations are briefly discussed below as a background for reviewing the existing model of the Ministry of

Planning and suggestions for a more adequate planning model.

* *Definitional (balance/circulation) relationships are relationships which have to hold as a consequence of the definitions of the concepts involved. These comprise e.g. balance relationships in physical terms (such as supply and demand for oil), balance relationships in value terms (such as income generation relations), definitional relations (such as volumes times prices equal values), definitions of indexes, and financial circulation relations.*

* *Technical relationships of production comprising relations describing the production possibilities in the economy. These relations may cover the short-run relations between inputs and outputs of production processes and also relationships describing how investment in new capital equipment changes production capacities.*

* *Behavioural relations comprising producers' behaviour (with regard to short-run adaptations in factor demand and product supply), the behaviour of consumers/workers (with regard to consumption/saving decisions, demand for individual goods, and relations for labour supply), financial behaviour, and foreign trade relations.*

* *Institutional relations describing the organizational and institutional arrangements in the economy and the rules and regulations under which the various entities operate, such as relations describing the system of taxes and subsidies, the social security system, relations describing the connections between different levels of government, relations describing the rules under which the financial institutions operate, regulations referring to price formation, rules referring to the formation and operation of incentive funds etc., relations describing the working of rationing and licensing systems, and relations of market clearing. While technical and behavioural relationships will have to be estimated, institutional relationships can often be more exact represented.*

* *Demographic, biological and ecological relationships are less frequently included in economic models, but can be important determinants of planning representing population development, enviromental relationships, limitation of natural resources, et al.*

* *Forecasts of non-controlled exogenous variables are relationships only in the sense that a variable in the model is set equal to a forecasted value, but deserves to be mentioned along with other relations because there is often a choice whether to introduce an equation explaining a variable in terms of other variables or treating the variable as a non-controlled exogenous variable, hence the forecast replaces a relation.*

* *Preference relations take the form of preference functions to be maximized or minimized, or, alternatively, preference constraints to be adhered to.*

Explicit preference relations are relatively seldom included in formal models, although there is an obvious rationale for them. Sometimes preferences are expressed only as indicators derived from the solution of the model.

This is a fairly exhaustive list of types of relations to be found in planning models. In a more aggregate model the distinction between different types of relations may not be as clearcut as this list suggests.

It may not be obvious whether this list distinguishes the relationships to be found in a planning model as distinct from those of a forecasting model, as similar types of relations may be needed for the latter kind of model as well. A model designed for forecasting may, of course, turn out to be useful in a planning process. The differences between these two categories of models are partly qualitative and partly matters of emphasis and degree. First, preference relations in are only found in planning models. Second, a planning model must contain a set of instrument variables and relations relating other variable to the instruments. Government instruments may be found in forecasting models too, but the operational character is given more emphasis in planning models. Third, a forecasting model to be complete will have to contain behavioural relations for the central government, which is not meaningful in a planning model. Fourth, in a planning context it is of interest to explore and choose from a wide set of possibilities and relations that unduly reduces the possible outcomes should be avoided, while such considerations are of no concern in a forecasting context.

App1.3. Some macroeconomic planning concepts

Macroeconomic models are used for many purposes. To illuminate types of models some concepts coined many the years ago by the first Nobel Laureate in economics (1969), Ragnar Frisch (d. 1973) of the University of Oslo, can be utilized. Professor Frisch invented and pioneered the field of macroeconomic planning as an economic discipline in the early post-Second World War period and was an advisor in macroeconomic planning to the Egyptian government. To explain the role of a macroeconomic model for planning purposes Frisch drew a distinction between an on-looker approach and a decision approach in macroeconomic modelling. The on-looker approach models the economy from an observer's point of view, while the decision approach models the economy from a policymaker's point of view. The on-looker model forecasts the economic development independent of any planning activities, while the decision model demands policy decisions prior to forecasting the economy. Frisch scorned the policymaker who demanded of his advisors: "tell me how the economy will develop, and I shall tell you what we shall do". An on-looker model may be highly sophisticated, but still not an adequate tool for a planning and implementation process.

Frisch also introduced in the theory of economic planning the concepts of 'selection model' versus 'implementation' model; by the former concept he designated a model to illuminate the possible paths of an economy and by the latter a model to analyse how to implement a chosen path. These concepts are used in this report in a related meaning with reference to the model tools proposed in chapter 6.

APPENDIX 2: Types of models for macroeconomic analysis

Most of the macroeconomic models used historically in other countries in overall contexts comparable with that of development planning in Saudi Arabia fall into three generic categories: short-term econometric models, input-output models and applied general equilibrium models. Needless to say, models falling into each of these categories vary highly, and the categories are not quite separate either, but they spring out of different traditions.

App. 2.1 Types of models

Short-term econometric models - or macroeconometric models - is the mainstream of macroeconomic model building and can be traced back to early pre-war work by Jan Tinbergen of the Netherlands (who was awarded the first Nobel Prize in economics in 1969 for this work). After 1950 the field of macroeconometric modelling grew quickly, especially after 1960, when the era of the large macroeconomic model was initiated. Lawrence Klein of University of Pennsylvania (also a Nobel Prize Laureate) did early work both in model building and in developing appropriate econometric methods which influenced this tradition very much, and he has continued to exert a strong influence internationally, not least through the international LINK model, which links together macroeconometric models for a large number of countries (now transferred from the Wharton School, University of Pennsylvania to the Department of Economic and Social Development, United Nations). The original aim of the macroeconometric model was to study economic fluctuations. The statistical indicators available were combined in equations on the basis of theoretical assumptions about relationships and estimated by statistical and econometric methods which early were developed to a high degree of sophistication. Although often constrained by the lack of good data, these models proved to be a very versatile (but not always reliable) tools and has been adapted for very many uses, including government planning and policy analysis. The wide-spread availability af data bases, powerful computer systems and efficient econometric software have made such models much easier to construct and popularized the use of them.

Input-output models were originated by Wassily Leontief (for which he many years later was awarded the Nobel Prize) at Harvard University, shortly after he had arrived at USA in the early 1930s. Leontief's project aimed primarily at gathering the data necessary to construct an input-output table as a data basis for economic analysis taking intersectorial relations into account. The operational input-output model as it is wellknown from textbooks was developed by Leontief during the Second World War. After 1950 Leontief demonstrated the many uses the input-output model could be put to, using US data, and he has continued to dominate this model tradition by innovative use of the basic framework. This model technique spread at an early stage only to the few countries having developed input-output tables (United Kingdom, Norway, the Netherlands & al.). The tractability of the input-output model as an operational tools lead to development of input-output tables in very many countries and also at sub-country level. This development is still continuing, very many input-output models have been developed and a large share of them for government planning purposes.

Applied general equilibrium models are closely connected to the general

ideas embedded in general equilibrium theory as developed originally by Walras. This was also the source of inspiration for Leontied who simplified the general equilibrium scheme by constant input-output coefficients. The first model which can be called an applied general equilibrium model was developed in 1960 by a wellknown Norwegian economist (L. Johansen, d. 1982), drawing on earlier work by Ragnar Frisch (who shared the first Nobel Prize with Tinbergen). The ingenuity of Johansen was i.a. to construct the model in a way which made it solvable within the severe computing constraints of the 1950s. This first model called MSG (for Multi-Sectoral Growth) was put to practical use in Norway at an early stage. Applied general equilibrium modelling, inspired also by other sources than Johansen's original model has grown very quickly, in particular since the late 1970s and such models are now found in very many countries both within and outside government.

App. 2.2 Stylized properties

In a stylized description of these categories the short-term econometric model concentrates on catching the dynamics of economic fluctuations using whatever statistical indicators that are available. These models tend to be very aggregate in description of the economy, and the structure is taken as given. Traditionally these models are demand orientated and pay less attention to supply factors, structural change and technical progress. The focus is put on the stability indicators of the economy, above all inflation, unemployment, and the balance of payments. The short-term designation is appropriate for most of these models as they ignore the capacity-enhancing function of investment. The input-output models give structural descriptions in the form of the pattern of inter-sectorial connections. These models tend to be disaggregate, often using the maximum level of disaggregation available in the statistical data which may range from several hundred sectors in some countries and 5-10 at the other extreme. The input-output models tend to be relatively "open", i.e. with many exogenous variables instead of explanatory relations. While the textbook version of the model usually emphasizes only the quantity part of the model, the dual price model is also extensively used, usually in combination with the quantity model. Hence, income flows can be generated. The input-output model's focus on intersectorial flows make it a preferred choice in an economy constrained by bottleneck and rationing of scarce resources, but the detailed descriptive features of the model can be utilized also for completely different purposes such as specifying technological change by altering the input-output coefficients or introducing completely new processes. The input-output model has been found useful in applications for may different purposes, e.g. environmental analyses, disarmament, occupational hazards, demand for higher education et al., where the connections with the macroeconomy is very specific and must be formulated at a detailed sectorial level. The input-output model has been much used for government purposes and must be viewed as fairly transparent and flexible. As a model it is very far from a "black box" and demands much from the user to perform well. Most model implementations is closely to national accounts and input-output tables and the quality of the results relies much on the quality of the data base. The data base for constructing an input-output model is a complete set of data for a single year.

The applied general equilibrium model has a reputation of being based on "calibrated" data, i.e. priori assessments by the model builder of "reasonable" values for crucial coefficients and macro aggregates set such as to have a similarity with real observations in a benchmark year, but with no claim to proper estimation and verification. In defense of the calibrated model it is argued that such models demonstrate the effects of the economic mechanisms at play and may be used for policy analysis even on a shaky empirical foundation. Although the calibrating variety can still be found, especially when data are scarce, but applied equilibrium models have proceeded far beyond that stage in many countries, and there are many excellent applications (Dale Jorgenson at Harvard University has influenced this tradition and combined ambitious modelling and firm empirical foundation). This model type is found in various levels of aggregation, sometimes less than five sectors, while the more ambitious application may go into 25-40 sectors, but seldom beyond that. Applied general equilibrium models are very demanding on data and requires time series and/or appropriate cross-section data for estimating the many parameters substution properties found in these models. The applied general equilibrium models have found applications mainly in two directions: (1) in long-term projections of the economy, and (2) in solving for the alternative equilibrium solutions resulting from a shock of some kind (e.g. increased oil price for an oil-importing country, new capital tax rules, introduction of greenhouse taxes etc.). These models usually say little about the movement of the economy from one equilibrium solution to another.

App. 2.3 Conclusion

Above three model traditions and model categories have been briefly described. The stylized description emphasized mostly the traits characterizing the early versions of these models. In countries with scanty data and weak modelling tradition stylized models can still be found, but in more mature modelling environments the traditions are merged and there are overlapping features between the model types. The use of input-output tables is incorporated into macroeconometric models as well as in applied equilibrium models. Econometric relationships are utilized in input-output models as well as in applied general equilibrium models. The macroeconometric models are not only short-models. The three model traditions have different origin, but are depicting the same reality and draws to a large extent on the same descriptive framework of economic reality, namely the national accounts (although most models will also utilize other data sources for describing the economy or for estimation of relationships).

The choice of a model to be used in a certain environment and for a given purpose is a practical question, not only with regard to type of model. The specification of the model, the attempts done to "dig up" necessary data, the efforts put into the estimation, etc. will altogether determine the usefulness and the quality of the model results. The data availability will often constrain the possibilities of building a model aduquate for the purpose (it is not unusual in data poor environments to find models built virtually without real data, but made to look like a real models). If the model under consideration is to be used in a planning context, it must have specifications that corresponds to a sufficient degree with the planning framework and the institutional set-up. The transparency of the model is also important if the model results are to be communicated to and used by non-experts.

APPENDIX 3: Review of the macroeconomic module

The macroeconomic module in current use has a number of shortcomings and deficiencies as a planning model. It has apparently not been constructed to serve in this function. According to the documentation from the 5DP, the module has the following structure as a system of equations:

(1) OREV = a1 + b1 * OSUR
(2) PINV = a4 + b4 * NGDP + c4 * CRED
(3) NINV = GINV + PINV
(4) NGDP = a6 + b6 * NINV + c6 * NGDP(-1)
(5) OGDP = a7 + b7 * OSUR + c7 * OCOM
(6) IMDU = a8 + b8 * IMPO + c8 * Dummy
(7) TGDP = OGDP + NGDP + IMDU
(8) IMPO = a10 + b10 * TGDP
(9) PCON = a11 + b11 * TGDP + c11 * PCON(-1)
(10) INCR = TGDP + IMPO - [GCON + PCON + OINV + GINV + PINV + OEXP + NEXP]

The left-hand variables - endogenous in the model - are the following:

OREV = Oil revenues in the government budget
PINV = Investment in private sectors
NINV = Investment in non-oil sectors
NGDP = Non-oil gross domestic product
OGDP = Oil gross domestic product
IMDU = Import duties
TGDP = Gross Domestic Product
IMPO = Imports
PCON = Private Consumption expenditure
INCR = Increase in stocks

The exogenous variables appearing on the right hand side are the following:

OEXP = Oil exports
NEXP = Non-oil exports of goods and services
OINV = Investment in oil sectors
CRED = Investment credit awarded to private sectors
OSUR = Operating surplus of oil industry
OCOM = Compensation of Employees in oil industry
GCON = Government consumption expenditure
GINV = Investment in government sectors

The system is estimated and solved both with the given endogenous and exogenous variables both in current prices and in constant (1989) prices.[1] Although the system has been constructed and refined for use in plan

[1] The model as described includes also two autoregressive relationships determining GCON and GINV with OREV as explanatory variable, but these relations have not been implemented.

preparation, it is better understood as a forecasting model with somewhat mechanical features than as a planning model. The system clearly pays attention to the overall balance equation of the economy, cf. eq. (10), and includes some behavioural relations. It should be noticed e.g. that shifts neither in government consumption nor in private consumption will influence GDP, hence the model is not useful for studying economic policy. Neither are instruments well represented in this model. The labour market is not at all included in the model. The model generates price indexes for the endogenous variables as the ratios between the relations in current and constant prices, but the theoretical rationale for this approach to price formation is obscure to say the least.

The most important equation in the system is (4) which has the interpretation of a capital-output relation derived implicitly from a production function using a Koyck-lag transformation. The relation makes theoretical sense, and marks the model as supply-oriented and useful primarily for plan preparation which also seems to be the use of the model, rather than monitoring of the plan implementation. The relation seems difficult to estimate from historical data in a meaningful way. Taking the investment data of the boom period at face value probably exaggerates grossly the capital intensity of the economy. Direct assessments of the capital stock in total and by sector would be helpful.

The investment relation (2) is misspecified as the credit variable (CRED) seems to be the sum of new disbursements from specialized credit institutions and net claims on the private sector by commercial banks, i.e. the sum of a flow and a stock variable. Through (2) and (4) the credit variable becomes a crucial determinator of the total non-oil activity level of the economy. The import equation (8) explaining imports by total GDP alone, and the macro consumption function (9) as autoregressive with total GDP as the only income variable are both rather crude.

Added to this system are equations expressing the development of value added in 12 sectors as simple functions, primarily of the development of non-oil GDP, also as parallel relations in current and constant prices.[2]

(11) Log AGRI = Log a1 + b2 * Log TIME
(12) MINE = a2 + b2 * TIME + c2 * CONS
(13) Log PETR = Log a3 + b3 * Log TIME
(14) Log MANU = Log a4 + b4 * Log NGDP
(15) Log ELEC = Log a5 + b5 * Log TIME
(16) Log CONS = Log a6 + b6 * Log NINV
(17) Log TRAD = Log a7 + b7 * Log NGDP
(18) Log TRAN = Log a8 + b8 * Log NGDP
(19) Log REAL = Log a9 + b9 * Log NGDP(-2) + c9 * Dummy
(20) Log FINA = Log a10 + b10 * Log NGDP
(21) Log COMM = Log a11 + b11*Log NGDP + c11*Log TIME
(22) Log IBSC = Log a12 + b12 * Log FINA

[2] There are some slight differences betwen the relations in constant and current prices for AGRI and REAL. The system given in (11)-(22) are the current price relations.

AGRI	=	Agriculture, forestry and fishing
MINE	=	Other mining and quarrying
PETR	=	Petrochemicals
MANU	=	Other manufacturing
ELEC	=	Electricity, gas & water
CONS	=	Construction
TRAD	=	Wholesale & retail trade, restaurants and hotels
REAL	=	Ownership of dwellings
FINA	=	Finance, insurance, real estate and business services (excl. Ownership of dwellings)
COMM	=	Community, social & personal services
IBSC	=	Imputed bank charges

There is here a lack of integration between the determination of sector value added and the macro aggregates. The individual sectors will not add up to non-oil GDP. The sectoral activity levels are in high demand for sectoral planning, but this relationships are unsatisfactory for this purpose. Without input-output data and factor inputs there is no easy way out to get the at sectoral levels.

There is merit to the macroeconomic module in its systematic formulation and the consistency adhered to, but rather doubtful whether it can serve well as a model for a planning process to be organized around.

APPENDIX 4: Review of the Coopers & Lybrand model

Coopers & Lybrand (C&L) was invited by the Ministry of Planning in 1976 to collect data needed for a comprehensive set of models to be used by the Ministry of Planning and construct the models on the basis of the data gathered. The project seems to have lasted for 4-5 years, the final reports are dated June 1981, see [1]. The data gathering effort took the form of three major surveys: an establishment survey, a household survey, and a government expenditure survey. On the basis of these surveys and other available statistics C&L constructed a Social Accounting Matrix (SAM) with an embedded input-output table of nine production sectors. The SAM, which is an elaboration of the national accounts with more institutional and other details, served as the conceptual framework and main database for the modelling effort. C&L also advised on the need for developing the national accounts to become better suited for model building, advice which went largely unheeded.

This appendix reviews only the model proposed by C&L. In addition to the model and the data gathering effort C&L also contributed towards developing a computer based planning system built around the model.

The C&L model belongs to the class of Applied General Equilibrium (AGE) models and follows the standard format of these models at that time with particular reference to a wellknown model for South Korea by Irma Adelman and Sherman Robinson. The model is very disaggregate with 36 production sectors, 14 household types (by occupation of head household), five labour skill categories, 31 consumption wants etc. The production sectors included several with very low or non-existent Saudi production at the time, but believed of potential interest for the diversification policy. The high number of skill categories and household types was founded in an intension of evaluation the socio-economic development in terms of income distribution.

For each production sector intermediate inputs are determined by constant input-output coefficients. The factor inputs of capital and labour (by skill type) combine an a CES production function. Constant-returns-to-scale was not assumed. The capital stock data acquired through the establishment survey were recognized as inadequate as they measured book values rather than replacement values. The relationships determining new investments in a sector, when it was not simply given exogenously, comprised determination of the desired capital stock increase distributed as investment over two years. Invested capital seems to have been treated in principle as irreversible, but with some relaxation allowing "migration" of capital between sectors on the basis of comparisons of rates of return. Labour demand is, as mentioned, divided into five skill groups, but with some possibilities of "migration" from one skill group to another.

In the determination of private consumption by household group Friedman's permanent hypothesis was attempted modelled, but using unsatisfactory data (i.e. no time series) that hardly could do justice to the theory. (Applying this hypothesis for determining consumption in a society in a flux of transformation as the Kingdom were at the time may not have been the best choice.) For the breakdown of consumption of each household group in consumption categories the Linear Expenditure System (LES) is used with an adaptation that allow different marginal budget shares for higher incomes than for lower incomes. The model even includes the income distribution, represented by the parameters of the logormal distribution, within each household groups. The

capital income of households was calculated from "ownership profiles" of each household group.

The sectors were divided into tradables and non-tradables. The price of tradables were set equal to the world market price adjusted for tariffs and a price addition depending upon port capacity requirements.[1] The price determination of non-tradables followed a rather complicated formula, which in most cases seems to boil down to a Leontief-type price relation with a variable mark-up (depending upon capacity utilization) on labour costs.

The labour market part of the model used labour supply schedules both for Saudi labour supply and for expatriates to determine employment levels ad wages when combined with the demand schedules derived from the production functions.

AGE models are normally solved only for relative prices, using one prise as *numeraire*, the C&L added a simple money equation to the model to arrive at absolute prices.

The C&L achievement is admirable in view of the start from almost scratch. The model seems to have been well thought out and had several forward-looking features. The effort failed, however, as the model structure and planning system erected apparently never was put to actual use. The reasons for this may have been several. The data collection efforts included in the C&L project, may not have been followed up by the Central Department of Statistics. The model and the planning system was designed for a mainframe computer and have been (too) resource demanding for the Ministry of Planning to keep operational. The model formulation was certainly also overambitious in its detailed specifications, level of disaggregation and attempts of including dynamic features, such as lagged relationships, expectations and improvized iterative solutions.

Looking back it seems that the Ministry would have been better served with a much simpler model, within the reach of the Ministry's capacity to handle technically and with regard to updating. The model may not have been transparent enough either to gain the trust of the planners. Most regrettable 12 years later is that the lack of statistical data observed by C&L, filling the need for data through special surveys, is still by and large the same. One of the few, perhaps the only, major improvements is the Consumer Expenditure Survey of 1985/86.

[1] The model was constructed at a time when the port capacity was a very severe bottleneck for the capacity to import.

APPENDIX 5: Statistics for improved national accounts

National accounts constitute the empirical foundation for national economic planning in very many countries. National accounts data in constant prices provide not only the GDP numbers defining the economic growth, but the broad picture of the overall economic structure and its development. If the Kingdom had remained the oil economy it was twenty years ago, there would have been less need for good national accounts. As the transformation of the economy has progressed Saudi Arabia should have the same need for reliable national accounts as most other countries, in particular for national economic planning.

Pursuance of a policy of diversification make input-output tables a must for planning and modelling purposes. Input-output tables can be compiled separate from the national accounts, as they were in a number of countries in earlier years. The UN Standard of National Accounts (SNA) did not include input-output tables as an integrated part prior to 1968, but these were included as an integral part in the SNA of 1968. Hence, the only satisfactory way today would be to develop the national accounts to comprise input-output tables.

National accounts and input-output tables can never be completely tied to primary statistics, but have to be supplemented by discretionary judgements based on more or less scanty empirical evidence. If the main infrastructure of economic statistics is missing, however, the final result can never be satisfactory.

The backbone of national accounts *cum* input-output tables is good production statistics. The lack of production indices on a current basis in the Kingdom is a serious flaw in the current statistical system. Production indices ought to be available on a monthly basis. The manufacturing establishment census for 1992 which is under way, will be an important step in strengthening the foundation for national accounts and will i.a. provide a much needed source for capital stock data (without which it is not possible to establish production functions for macroeconomic modelling purposes). The census will have to be supported by adequate annual reporting from establishments. The number of manufacturing sectors in the national accounts should be increased. The system for gathering production statistics for other sectors should be reviewed. Special efforts must be undertaken to secure production data for services which is an expanding sector with bad statistical coverage. The trade sector is of special importance, special investigations of trade margins of the commodity flows of the national accounts should be undertaken. Administrative sources for production data such as agricultural data from the Ministry of Agriculture should be scrutinized. Ideally, the CDS should have the upper hand in assessing the production of every sector, but it makes sense to utilize the administrative sources available.

The population census of 1992 is another cornerstone for better national accounts. The population numbers do not directly enter into the national accounts, but the population census collected also housing data, for which there is no other source, and important employment information, educational data et al. The population census can provide a sampling frame for many different surveys of great importance for improved national accounts and increase their statistical basis of survey data. (The Ministry of Planning has apparently not received any results from the Census yet, which is another indication of insufficiently close links between the Ministry and the CDS.)

With regard to wage, employment and labour force data the situation is not good. Both with regard to the emphasis on labour market policies in the 5DP (and presumably in the 6DP) and for general knowledge about what is going on in the country, improved data for employment and the labour force are urgently needed. Employment data can be gathered together with production data, but special investigations may be required for sectors poorly covered in production statistics. Administrative data sources, such as social security systems covering major groups of employees should be utilized. For labour force data population statistics combined with Labour Force Surveys may be required. Wage data are important for the estimating the compensation of employees by sector, for the understanding of inflationary mechanisms as well as for income distribution studies.

Capital stock data will allow depreciation to be calculated (totally absent in the existing national accounts) and operating surplus net of depreciation.

Reliable measurement of production output and factor inputs open for productivity studies which are highly needed for assessing the returns to the large investments the Kingdom has undertaken.

Price statistics seem to be poorly developed apart from the cost-of-living and retail import indexes. Import and export price indices for major groups of commodities are missing in spite of the highly developed and detailed foreign trade statistics. This foreign trade statistics seem to be underutilized by not extracting price information. For studies of competitiveness of domestic industry reliable price data are vital.

Household surveys should be undertaken not too infrequently, say every five years, to gather information about household consumption pattern and other living conditions. Annual surveys of households are now common in many countries.

The important role of the government budget in the Kingdom's economy makes it of utmost importance to get a reliable national accounts classification of budget expenditures. The situation does not seem to be satisfactory as it is. For classification in this area as in other areas internationally adopted classifications should be adhered to. The classification of financial items such as subsidies and transfers seem to be particularly weak, perhaps as a consequence of lack of well defined institutional rules for the determination of these items.

Income data for households and enterprises are harder to get by in the Kingdom because of the rudimentary system of taxation. Unless income assessment systems for tax purposes are introduced there is a need for income surveys. The importance of tax assessment for better statistics is a reason for introducing this sooner rather than later. There can hardly be any doubt that taxation of businesses and individuals will have to be introduced at some point in time.

Also in other statistical areas improvements may be needed to establish national accounts according to the UN SNA recommendations.

For planning purposes regional information is also highly required. It is too much to ask for regional national accounts, but central indicators in the national accounts should be attempted regionalized.

The building of an infrastructure of economic statistics for better national accounts should also pay attention to the need for preliminary national accounting

data. In some countries preliminary national accounts are revised twice before the final data are produced. Although it may seem confusing with many revisions the need for preliminary national accounts as soon as possible after the end of the year is a serious need for the economic policy and planning purposes, and the absence of preliminary data means that users such as the Ministry of Planning will have to spend resources on less satisfactory ways of updating the national accounts for own purposes.

APPENDIX 6: Improving the macroeconomic module

This appendix aims at estimating macroeconomic relations for Saudi Arabia that can be fitted together to a model to be used by the Ministry of Planning in preparation of the Sixth Development Plan. The work is undertaken with reference to the existing macroeconomic module in the Ministry of Planning and the results may be utilized wholly or in parts by amendments in the current macroeconomic module.

The main purpose of the model set out below is, as for the Selection model outlined in the main text of this report, to provide a consistent macroeconomic picture around the sectoral plans, but on a lower level of ambition with regard to theoretical coherence. Severe limitations in available and reliable statistical information also constrains the model to be more aggregated than desirable.

The model is outlined in an informal way below, and the results of attempts at estimating most of the relationships is reported in separate sections. Needless to say, the estimation work is incomplete. Estimation of macroeconomic relationsships can easily become a neverending process, especially when the relationsships are to be used in a simultaneous model, but should always continue until the whole model has been tested out. There has been no time for simulataneous estimation, refinement of the detailed specification and fine-tuning. The estimation period is throughout 1969-89, except when lagged variables cut off early years or when indicated otherwise.[1] The estimation method is Ordinary Least Squares unless otherwise indicated. The database used in the construction of the model is the national accounts of the CDS, as amended and recalculated with 1989 as constant price year by the Ministry of Planning in preparation of the 6DP.

The macroeconomic picture is given in terms of national accounts aggregates in constant 1989-prices. Important pieces of the overall picture is assumed exogenously given. Some of the exogenous variables may have to be reconsidered in view of the model solution. The model should allow easy calculation of revised solutions as a result of revised exogenous assumptions or reconsideration of some of the relations of the model.

The presentation of the model which follows is given in a recursive form, i.e. step-by-step. The model specification is more simultaneous than the recursive description indicates, the degree of simultaneity depends upon the final specification of the individual equations.

The oil sector is taken as exogenous, i.e. value added in the oil sector, roughly proportional to production, is taken as given, as well as the oil price, exports, investment and employment in the oil sector. The link between the oil sector and the non-oil economy is primarily through the use of oil revenues. The oil sector as a producing entity has relatively little interaction with the rest of the economy in terms of investment, intermediate consumption and employment.

For the non-oil economy the starting point is a capital-output relation, in fact a relation between investment in fixed capital formation and production capacity in value added terms. In the plan period the actual production is

[1] In the existing macroeconomic module the estimation period is 1969-90, except when lagged variables eliminate the early years. The 1990 national accounts have not yet been published.

assumed equal to production capacity. Underutilization of production capacity at the outset have to be taken into consideration in the capital-output relation. The capital-output relation is at the centre of the model, and has turned out to be almost impossible to determine in a relaistic way from historical data. The relation has to be reviewed in iview of the results it generates.

The amount of investment required for growth in value added depends upon the sectoral composition of GDP and the availability of other production factors. A more satisfying approach would be to hav eproduction functions for individual sectors.. The capital-output relation determining the capital formation needed to support the a growth path of value added can be considered as derived from a production function (on the assumption that labour is not scarce at the going wage). The composition of capital formation in broad categories of capital equipment is determined by fixed coefficients which is also somewhat unsatisfactory.

Some sectors have the production levels drawn up separately. These are petrochemicals, electricity, gas & water and agriculture. These sectors are considered as determined from the supply side. Agriculture seems to be a mixture of tradittional small-holding agriculture and large-scale capital-intensive units which dominate the overall development of the sector. The value added in the government production sectors is also exogenous. In the absence of capital data this amounts to the (constant price) value of labour power used in the government sectors. The capital-output relation should logically be applied only to the remaining endogenous sectors, but as investment by sector is not available in the national accounts , the capital-output relation covers all non-oil sectors.

Starting with the capital-output relation (or, if it is disconnected, with the amount of investment) the macroeconomic picture is pieced together. Private consumption is determined by an aggregate consumption relation determining consumption from some aggregate chosen to represent the disposable income of household.

Non-oil exports is exogenous (as well as the addition to stocks). In the overall macroeconomic balance the remaining components are government consumption and imports. If government consumption is taken as given, imports become residual and may be determined at a higher or lower level than what results from using the econometric import relation, determining imports from final demand components. Alternatively, imports can be taken from the econometric relation and government consumption becomes the residual, i.e. the government consumption allowable within the macroeconomic balance which follows from the capital-output relationship and growth in the exogenous sectors.

The sectoral composition of value added is determined from the the final demand aggregates and the GDP path (different explanatory variables for different sectors). When value added by sector has been derived, the investment needs for each sector ought to be assessed by sector specialists to corroborate and revise the capital-output , assumptions made in the model.

After establishing the macroeconomic balance and the sectoral composition the balance of the labour market should be considered (not included below). Benchmark data for employment levels by sector, as given e.g. in the 5DP document, can perhaps be used to calculate employment coefficients. By means of the the employment coefficients and assumed productivity rates by

sector, employment by sector and in total can be calculated. The employment results, broken down in Saudis and non-Saudis, should be evaluated with regard to feasibility and desirability within the overall plan framework and the plan projections revised if needed.

From the sectoral projections the amount of wages can be calculated using the wage shares (i.e. wage per unit of value added) from the national accounts together with productivity assumptions and a wage index. To get the factor income, i.e. also the operating surplus, either the price index of value added or the assumed development of operating surplus per unit value added is required in addition to projections or calculations of net subsdies by sector.

Prices must be projected for calculations of current values. Price indexes for imports and exports are taken as given from the world market. This is sufficient to establish the balance of payments together with exogenous items. Other price projections may be held to a minimum consisting of, say, a price index of private consumption, total domestic absorption and GDP. The price index of private consumption can be constructed e.g. as a cost relation in wage costs and import price in addition to changes in private consumption subsidies. The price data available seem to be of rather poor quality.

Gross capital formation must be split in government investment and private investment. Government investment and government consumption in current values enter the fiscal account to provide a preliminary assessment of the fiscal balance.

This completes the informal presentation of the model. It should be understood that this is a rather primitive model necessitated by the lack of vital information, such as capital stock data, and incomplete and unreliable national accounts.

In the sections below each type of relation is discussed and estimated. A concluding section pieces the model together. Lists of specifications and variables in the model are given at the end. The econometric equations are presented with alternative specifications and estimations. Needless to say, the presentation is incomplete, in view of the short-term assignment.

App.6.1 Capital-output relation

This relation connects production capacity measured as value added (Y) and gross investment (J) on the basis of the existing production capacity (Y_{-1}). In the plan projections value added for individual sectors and totally will naturally be equal to full (normal) capacity utilization. At the outset, i.e. in the base year for the plan projections, lower than full capacity utilization must be taken into consideration. The capital-output relation can be formulated as

$$Y = a' + b'*J + c'*Y_{-1} \qquad (1.1)$$

This is in generic form the same as the relation in the existing

macroeconomic module.[2] The relation can be interpreted as a transformation of a relation connecting production and capital stock (K), with K determined from previous capital stock by new investments and depreciation.

$$Y = a'' + b'*K \tag{1.2}$$

$$K = (1-\delta)*K_{-1} + J = \sum_{i=0}(1-\delta)*J_{-i} \tag{1.3}$$

Combining (1.2) and (1.3) by Koyck-lag transformation we get (1.1) with $a'=a''*\delta$ and $c'=(1-\delta)$. The capital-output relation (1.2) can be seen as a derived from a constant returns to scale production function in capital and labour, assuming non-scarcity of labour. With a Cobb-Douglas production function, i.e.

$$Y = A*L^{\alpha}*K^{(1-\alpha)} \tag{1.4}$$

the optimum amount of labour for given price p and wage w is

$$L = \alpha*p*Y/w \tag{1.5}$$

which inserted in (1.4) gives

$$Y = A^{1/(1-\alpha)}*(\alpha*p/w)^{\alpha/(1-\alpha)}*K \tag{1.6}$$

hence a linear relation between Y and K.

The investment-output relation as given by (1.1) can be solved with regard to J to give

$$J = a + b*(Y - (1-\delta)*Y_{-1}) = a + b*(Y - Y_{-1}) + b*\delta*Y_{-1} \tag{1.7}$$

with the marginal capital-output ratio $b=1/b'$ and $a=a'/b'$. This is the form of the capital-output relation to be included in the model. The Y and J ought to have been value added and capital formation of endogenous sectors, but investment is not broken down to individual sectors in the national accounts, hence is has to be applied to the total non-oil sector.

It has turned out very difficult to estimate this equation from existing time series. This is due to the lack of capital stock data, perhaps dubious quality of investment and value added time series, and, not least, to the actual development pattern pursued in Saudi Arabia in the great oil boom and transformation period of massive investment build-up, particularly in infrastructure. The investment in this period reflects not only additions to productive capital, but probably also a lot of wasted unproductive capital expenditures, increased real expenditures due to bottlenecks, needless overcapacity etc. Attempts of utilizing the historical time series at face value result in gross overestimation of capital-output ratios. A straighforward estimation of (1.1) gives (comp. footnote 2)

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[2] In the existing module it is formulated as a relation between non-oil GDP (NGDP) and non-oil investment (NINV), i.e. as NGDP = 10806.2 + 0.168025*NINV + 0.896579*$NGDP_{-1}$.

$$Y_x = 11609 + 0.201*J_x + 0.868*Y_{x-1} \qquad (1.8)$$
$$(3.84) \quad (5.50) \quad (35.3) \qquad DW=2.63, \text{ Adj. } R^2=.993$$

(Y_x and J_x are non-oil GDP and non-oil capital formation, respectively.) This relations is for the reasons mentioned above unusable as it stands.

App.6.2 Private consumption

In the existing module the macro consumption function is specified as an autoregressive relation between private consumption and GDP and estimated as follows:

$$CP = -25040 + 0.170*Y + 0.830*CP_{-1} \qquad (2.1)$$
$$(-1.88) \quad (2.90) \quad (12.9) \qquad DW=2.69, \text{ Adj. } R^2=.952$$

Although this Koyck-lag transformation has a rationale as a stylized macro consumption function with income in earlier periods influencing current consumption. I do not regard it as a particularly good specification fitting the Saudi Arabian households. As can be seen private consumption reacts very little to short-term income changes, as the autoregressive term is completely dominant.[3] Y does not represent national disposable income very well either as oil price fluctuations implies that the oil sector value added constituting a large share of GDP measures production rather than income and the difference can be quite significant. Furthermore, oil revenues do not accrue to households to any significant extent except as trickled down via the government budget. The relation can be improved by using non-oil GDP (Y_x) instead of Y.

$$CP = -26136 + 0.530*Y_x + 0.444*CP_{-1} \qquad (2.2)$$
$$(-2.83) \quad (4.50) \quad (3.71) \qquad DW=2.18, \text{ Adj. } R^2=.968$$

A more straightforward approach would be to estimate total private consumption as a function of real disposable income. How can real disposable income be defined from the data available? The simplest approach is to use GDP or some subaggregate, as in the existing consumption function, but without the autoregressive term. This could be improved upon by using gross real income (GRI), which is defined as GDP in current prices deflated by the price index for domestic absorption, as the GRI catches the real income effect of changes in the terms-of-trade, which GDP does not. Non-oil GDP is presumably closer to the income of households than total GDP and can also be converted into a gross real income concept, but neither of these aggregates get close to the real disposable income of households. A book definition of this concept would be the factor income accruing to household plus net transfers and net interests minus wage remittances. The access to soft government loans for households should perhaps

[3] In the existing macroeconomic module the macro consumption is actually as autoregressive in Private consumption (CP), but with total GDP (TGDP) lagged twice as the current income argument, i.e. PCON = -29525.6 + 0.253409*$TDGP_{-2}$ + 0.679248*$PCON_{-1}$.

be included as a transfer too. Net transfers and net interests to households seem to be out of reach without considerable data mining.

Of the factor income compensation of employees is given in the National Accounts as well as the operating surplus by sector. How much of the operating surplus in each sector is accruing to households is beyond reach. It might be considered to include operating surplus from sectors with many self-employed, households, say agriculture or trade, but this might bring us into deep water. The annual remittances by expatriates are, however, given in the Balance of Payments and included in the National Accounts. Hence, the easiest seem to stick to compensation of employees (i.e. wages and salaries, incl. non-cash components) as the main explanatory variable with or without correction for remittances, or a gross domestic product related variable.

$$CP = \underset{(.030)}{92.6} + \underset{(35.5)}{1.16*W/p_{CP}} \qquad (2.3)$$

DW=.513, Adj. R^2=.984

The constant term is clearly insignificant, the DW-coefficient shows serial correlation in the residuals. Correcting for autocorrelation gives the following result:

$$CP = \underset{(.378)}{-2310} + \underset{(19.3)}{1.18*W/p_{CP}} \quad \underset{(5.04)}{\rho=0.743} \qquad (2.3')$$

DW=1.51,Adj.R^2=.993

The deduction of remittances make little difference. We get

$$CP = \underset{(.347)}{1044} + \underset{(35.7)}{1.\ 21*(W-Z_R)/p_{CP}} \qquad (2.4)$$

DW=.574, Adj. R^2=.985

and when corrected for autocorrelation

$$CP = \underset{(.099)}{-564} + \underset{(20.0)}{1.22*(W-Z_R)/p_{CP}} \quad \underset{(4.51)}{\rho=0.701} \qquad (2.4')$$

DW=1.58, Adj. R^2=.992

We can also look at some related specifications. If non-oil GDP is used to represent income we get a weaker fit

$$CP = \underset{(5.79)}{-46235} + \underset{(18.6)}{0.920*Y_x} \qquad (2.5)$$

DW=.770,Adj.R^2=.945

which improves if non-oil GDP is averaged over the last two years.

$$CP = \underset{(-6.49)}{-45333} + \underset{(21.6)}{0.933*(Y_x+Y_{x-1})/2} \qquad (2.6)$$

DW=1.08, Adj. R^2=.960

The number of possible alternative specifications is great, but we finish the search with the following specification having as income argument non-oil gross real income (GRI_x) defined as GDP in current prices deflated by the price index for private consumption.

$$\begin{array}{lll} CP = -5638 + & 0.737*GRI_x & (2.7) \\ \quad (-2.03) & (40.7) & DW=.626,\ Adj.\ R^2=.988 \end{array}$$

App.6.3 Sectoral production

In this section we shall look at how sector levels of value added can be determined from the macro aggregates. In the introductory part of the model presentation we assumed that some sectors had exogenously determined production. These include - in our notation - OIL, AGR, PCH and EGW.

We first look at the determination of value added for the private services sector (Y_{PSV}). This sector contributes broadly to all the other sectors and is not closely tied to any specific component of final demand. Hence, we explain the development of this sector by the development of non-oil GDP.

$$\begin{array}{lll} Y_{PSV} = -5877 + & 0.411*Y_{\Sigma x} & (3.1) \\ \quad (-3.82) & (43.2) & DW=.352,\ Adj.\ R^2=.989 \end{array}$$

This relation has considerable autocorrelated residuals and when corrected for this we get

$$\begin{array}{llll} Y_{PSV} = -5390 + & 0.408*Y_x & \rho=.799 & (3.1') \\ \quad (-1.81) & (22.7) & (0.120) & \\ & & DW=.988,\ Adj.\ R^2=.996 & \end{array}$$

We shall next consider the construction sector. It seems natural to relate the development of this sector to the total building and construction investment. This gives the following relation:

$$\begin{array}{lll} Y_{CON} = 3765 + & 0.503*JC & (3.2) \\ \quad (1.95) & (18.4) & DW=.499,\ Adj.\ R^2=.944 \end{array}$$

This relation does not give a very good fit and one reason for that is that the Saudi construction industry has increased its capacity relatively to demand considerably over the estimation period. The industry now seems to have a capacity reasonably well suited to the needs for building and construction investment. We estimate the (3.2) with a time varying coefficient for the total building and construction investment.

$$\begin{array}{llll} Y_{CON} = 5227 + & (0.344 + & 0.013*t)*JC & (3.2') \\ \quad (4.36) & (10.7) & (5.78) & \\ & & DW=1.45,\ Adj.\ R^2=.979 & \end{array}$$

t is a time term (= Year - 1970).

Another alternative which gives a reasonably good fit, but is somewhat less satisfactory on theoretical grounds is to use total non-oil investment as explanatory variable.

$$Y_{CON} = \underset{(4.99)}{5985} + \underset{(28.2)}{0.391 * J_x} \qquad (3.3)$$

DW=.782, Adj. R^2=.975

A major output of the Other mining sector is building materials. This sector is small and may be joined with the construction sector in a consolidated construction sector. Applying the specification (3.2') to the consolidated sector gives

$$Y_{CON}+Y_{OMI} = \underset{(4.84)}{6062} + \underset{(10.1)}{(0.338} + \underset{(6.10)}{0.01438 * t) * JC} \qquad (3.4)$$

DW=1.38, Adj. R^2=.979

After this consolidation the only remaining sector is Other manufacturing. We approach the determination of this sector by using non-oil GDP as explanatory variable.

$$Y_{OMA} = \underset{(-2.95)}{-2086} + \underset{(15.0)}{0.0658 * Y_x} \qquad (3.5)$$

DW=.435, Adj. R^2=.918

This did not give particularly good results. The Other manufacturing sector is rather mixed with regard to deliveries. Most of the production is probably for private consumption, some for government consumption, investment and for non-oil exports. using private consumption as explanatory variable gives the following result:

$$Y_{OMA} = \underset{(3.23)}{1295} + \underset{(19.1)}{0.0707 * CP} \qquad (3.6)$$

DW=1.281, Adj. R^2=.948

Finally, we apply the same trend specification as for the construction industry retaining private consumption as the explanatory variable.

$$Y_{OMA} = \underset{(4.01)}{1848} + \underset{(3.91)}{(0.0472} + \underset{(2.03)}{0.00138 * t) * CP} \qquad (3.7)$$

DW=1.404, Adj. R^2=.955

App. 6.4 Imports

The determination of imports is hampered by the lack of reliable price data to use relative prices as an axplanatory variable. Hence, the amount of imports has to be explained purely in quantity terms. The simplest way seems to use total consumption and total investments as explanatory variables. Total consumption is for this purpose defined as private consumption plus non-labour government consumption.

$$M = \underset{(4.51)}{-25449} + \underset{(8.91)}{0.468*(CP+CG-Y_{GOV})} + \underset{(10.9)}{1.06*J} \qquad (4.1)$$

DW=1.42, Adj. R^2=.980

App. 6.5 Capital composition

$$JC = \underset{(2.70)}{4330} + \underset{(41.6)}{0.690*J} \qquad (5.1)$$

DW=0.470, Adj. R^2=.989

Correction for autocorrelation gives

$$JC = \underset{(1.83)}{4799} + \underset{(26.1)}{0.680*J} \quad \underset{(5.48)}{\rho=0.745} \qquad (5.1')$$

DW=1.53, Adj. R^2=.995

App.6.6 Price relations

Price relations seems hard to estimate from the avilable national accounts price data which may have become severely distorted in the recalculation and rebalancing of the national accounts to new years of constant prices.[4] In the first attempt the price index of private consumption is determined from the cost side by the average wage per unit of GDP and import prices.

$$p_{CP} = \underset{(2.97)}{0.182} + \underset{(5.11)}{0.607*W/Y} + \underset{(1.34)}{0.256*p_M} \qquad (6.1)$$

DW=0.440, Adj. R^2=.922

Dropping the constant term to check the homogeneity gives

[4] The only constant price data published by the Central Department of Statistics has 1970 as base year. Recalculations have been undertaken by the Ministry of Planning.

$$p_{CP} = \underset{(3.54)}{0.434*W/Y} + \underset{(5.07)}{0.700*p_M} \qquad (6.2)$$

DW=0.246, Adj. R^2=.910

gives rather inflationary results. Using instead the wage per unit of value added in the non-oil sector and correcting for autocorrelation gives

$$p_{CP} = \underset{(4.32)}{0.550*W_x/Y_x} + \underset{(5.63)}{0.528*p_M} \quad \rho=\underset{(14.2)}{0.918} \qquad (6.3)$$

DW=0.837, Adj. R^2=.978

whcih is closer to homogeneity and this relation can be scaled to give coefficients adding to one. For the price index of non-oil GDP a regression of the price index with respect to wage and gross operating surplus per unit of value added gives

$$p_{Yx} = \underset{(6.92)}{0.352*W_x/Y_x} + \underset{(12.0)}{0.659*R_x/W_x} \qquad (6.4)$$

DW=0.801, Adj. R^2=.998

This adds up reasonably well as it should, leaving a (too small?) margin of one percent for net subsidies. Using only the wage per unit gives

$$p_{Yx} = \underset{(2.80)}{0.039} + \underset{(50.7)}{.989*W_x/Y_x} \qquad (6.5)$$

DW=0.267, Adj. R^2=.992

which when corrected for autocorrelation gives

$$p_{Yx} = \underset{(0.778)}{0.024} + \underset{(25.4)}{0.998*W_x/Y_x} \quad \rho=\underset{(8.76)}{0.857} \qquad (6.5')$$

DW=1.27, Adj. R^2=.998

and when also dropping the constant term

$$p_{Yx} = \underset{(36.2)}{1.019*W_x/Y_x} \quad \rho=\underset{(11.3)}{0.888} \qquad (6.5'')$$

DW=1.31, Adj. R^2=.999

Finally, we add a simple autoregressive forecasting equation for W_x/Y_x.

$$W_x/Y_x = \underset{(3.27)}{0.060} + \underset{(36.8)}{0.972*(W_x/Y_x)_{-1}} \qquad (6.6)$$

DW=0.297, Adj. R^2=.986

This relation has considerable autocorrelation and correction (by the Cochrane-Orcutt method) gives

$$W_x/Y_x = \underset{(0.140)}{0.175} + \underset{(0.780)}{0.852*(W_x/Y_x)_{-1}} \quad \rho=\underset{(0.706)}{0.834} \qquad (6.6')$$

DW=1.54, Adj. R^2=.996

App.6.7 Putting the pieces together

What follows below is no more than a first attempt of putting selected relations estimated above together to make a determinate model. The equations selected are as follows:

$$J_x = a1 + b1 * Y_x + c1 * Y_{x-1} \quad (7.1)$$

(7.1) is the capital-output relation with coefficients easily derived by solving (1.8) for J_x to give

a1 = 11609/0.201
b1 = 1.0/0.201
c1 = -0.868/0.201

(As mentioned above, these estimates are wholly untenable.)

$$JC = a2 + b2 * J \quad (7.2)$$

(7.2) gives the capital composition (or what is needed for the other equations). The estimates are taken from (5.1)

a2 = 4330
b2 = 0.690

(Better to use the corrected values in (5.1')?)

$$CP = a3 + b3 * p_{Yx} * Y_x / p_{CP} \quad (7.3)$$

(7.3) is the macro consumption function as estimated in (2.7).

a3 = -5638
b3 = 0.737

(Other alternatives might as well be chosen)

$$Y_{OMA} = a4 + b4 * CP + c4 * t * CP \quad (7.4)$$

(7.4) is the equation for value added in Other manufacturing as estimated in (3.7).

a4 = 1848
b4 = 0.0472
c4 = 0.00138

(A linear trend is a vulnerable way of adjusting for structural change!)

$$Y_{CMI} = a5 + b5 * JC + c5 * t * JC \quad (7.5)$$

(7.5) is the equation determining value added in Construction (incl. Other mining) as estimated in (3.4)

a5 = 6062
b5 = 0.330
c5 = 0.01438

(Same remark as for (7.4)!)

$$Y_{PSV} = a6 + b6 * Y_x \quad (7.6)$$

(7.6) is the equation determining value added in the aggregate of private service sectors (net of Imputed bank charges) using (3.1').

a6 = -5390
b6 = 0.408

(It would have been more consistent with the logic of the model to determine the value added in all endogenous sectors from final demand component. Determining subsectors of non-oil GDP by the total may increase the danger of instability in the model.)

$$M = a7 + b7 * (CP + CG - Y_{GOV}) + c8 * J \qquad (7.7)$$

(7.7) is the import relation as estimated in (4.1)

a7 = -25449
b7 = 0.468
c7 = 1.06

$$p_{CP} = a8 * w_{Yx} + b8 * p_M \qquad (7.8)$$

(7.8) is the selected equation for the private consumption price index as determined from (6.3) by scaling the coefficients.

a8 = 0.550/(0.550+0.528)
b8 = 0.528/(0.550+0.528)

$$P_{Yx} = b9 * w_{Yx} \qquad (7.9)$$

(7.9) is the equation for the non-oil GDP deflator from wage costs per unit as estimated in (6.5").

b9 = 1.019

$$w_{Yx} = a11 + b11 * w_{Yx-1} \qquad (7.10)$$

(7.10) is the forecasting equation for wage costs per unit in the non-oil sector as estimated in (6.6') using the estimates corrected for autocorrelation (in spite of the dubiousity of these estimates for an autoregressive equation).

a10 = 0.175
b10 = 0.852

$$J = JOIL + J_x \qquad (7.11)$$

$$Y_x = Y_{AGR} + Y_{PCH} + Y_{EGW} + Y_{GOV} + Y_{OMA} + Y_{CMI} + Y_{PSV} \qquad (7.12)$$

$$Y = Y_X + Y_{OIL} + Y_D \qquad (7.13)$$

$$CG = Y + M - CP - J - X_{OIL} - X_x - JS \qquad (7.14)$$

(7.11)-(7.14) are all identities.

Annex: Variable notation

Production sectors and aggregates

OIL = Oil (incl. Petroleum refining)
AGR = Agriculture, forestry and mining
OMI = Other mining and quarrying
PCH = Petrochemicals
OMA = Other manufacturing
EGW = Electricity, gas & water
CON = Construction
PSV = Private services (=TRA+TRC+FIR+COM+IBS)
TRA = Wholesale & retail trade, restaurants and hotels
TRC = Transport, storage and communication
FIR = Finance, insurance, real estate and business services (=DWE+OFI)
DWE = Ownership of dwellings
OFI = Other finance etc.
COM = Community, social & personal services
IBS = Imputed bank charges
GSV = Government services
x = All sectors, excl. OIL

Variables:

Y = Gross Domestic Product
Y_i = Value added in sector/aggregate i, M89SR
Y_D = Import duties, M89SR
J = Total investment in fixed capital formation
J_i = Gross investment in sector/aggregate. i, M89SR
JC = Total investment in buildings and constructions
JC_i = Gross inv. in buildings and constructions in sector/aggr. i, M89SR
JS = Net addition to stocks, M89SR
CP = Private consumption, M89SR
M = Imports, M89SR
X = Exports, M89SR
X_i = Exports sector/aggregate 1, M89SR
W = Compensation to employees, MSR
Wi = Compensation to employees in sector/aggr. i, MSR
Z_R = Wage remittances abroad, MSR
GRI_x = Gross real income for the non-oil sector ($=p_{Yx}*Y_x/p_{CP}$), MSR
p_{CP} = Price index for private consumption (1989=1.00)
p_{Yx} = Price index for non-oil GDP (1989=1.00)
p_M = Pric index for imports (1989=1.00)
w_Y = Wage costs per unit of value added (1989=1.00) (= scaling of W/Y)
w_{Yi} = Wage cost / value added in sector/aggregate i (1989=1.00)