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MACROECONOMETRIC MODELLING IN AN OIL EXPORTING COUNTRY: THE CASE OF IRAN

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The critical review undertaken in this paper pinpoints some of the major deficiencies and the strength of the earlier macroeconometric models (MEMs) constructed for Iran as a major oil exporting country. In constructing a new MEM, the flaws of past MEMs should be rectified and their strengths need to be retained. Most of the equations in these models are directly and indirectly affected by oil and gas exports and/or value added in the oil sector. Two dualities are observed in most models, viz. the traditional duality of the agriculture sector and industrial modern sector, and the oil duality featured by an enclave modern oil sector with negligible links to the rest of the economy. Similar to the MEMs constructed for other developing countries, only a few models have been subject to various parametric and diagnostic tests prior to their release. Not all model-builders tested for a simultaneity problem in determining the estimation method. In future MEMs substantial attention should be placed on the equations for capital formation, price, wage, investment, exchange rate, unemployment, channels of distribution and demographic characteristics. It appears that the majority of the earlier models suffered from excessive "Keynesianism", which means the modellers gave insufficient attention to the role of the supply side in the long run.

JEL classifications: B23; C52; C51
Keywords: Macroeconometric modelling, Iranian economy, Oil exporting countries.

INTRODUCTION

The use of macroeconometric models (MEMs) for policy analysis and forecasting has a tumultuous history since World War II when Marschak organised a special team at the Cowles Commission by inviting luminaries such as Tjalling Koopmans, Kenneth Arrow, Trygve Haavelmo, T.W. Anderson, Lawrence R. Klein, G. Debreu, Leonid Hurwitz, Harry Markowitz, and Franco Modigliani (Diebold, 1998). For a detailed account of the role of the Cowles Commission in macro modelling visit http://cowles.econ.yale.edu .For a comprehensive literature review of MEMs see Bodkin, Klein and Marwah (1991) and Valadkhani (2004).

Macroeconometric modelling in developing countries has also a relatively long history. In fact, the persistent economic predicaments in many developing countries such as high rates of inflation and unemployment, a meagre growth in real GDP, a substantial rent-seeking behaviour, income inequality, macroeconomic imbalances in the form of foreign indebtedness, large trade and public sector deficits and stagflation led a significant number of developing countries to use MEMs. See, *inter alia*, Ichimura and Matsumoto (1994) and

Uebe (1995) for a long list of the estimated MEMs for a large number of countries. Uebe has also tabulated a useful summary and list of MEMs for 150 countries at http://www.unibw-hamburg.de/uebe/modelle/titelseite.html . One can select a particular country and view a list of the constructed MEMs for that country including the construction date, modellers' names, the type of model, the number of equations etc. For a number of models a neat list of estimated equations and the identities of the model together with the corresponding sources are also available in the pdf format in the Uebe website.

The main objective of this paper is to critically review the eight major macroeconometric models which have been previously constructed for the Iranian economy. This critical review highlights some of the major deficiencies and the strengths of these MEMs. These issues can also be useful for other major oil exporting countries with similar economic structure and reliance on petrodollars. Both the deficiencies and the strong points will be highlighted so that the future MEMs for similar economies can take them into account.

This paper is structured as follows: The next section reviews the simple two-gap model which was designed by Economic Commission for Asia and the Far East (ECAFE, 1968). Then I examine the United Nations Conference on Trade and Development (UNCTAD,1968) model which is a more elaborate two-gap model. The Vakil (1973) model, a clone of the Klein-Goldberger model is reviewed next followed by a discussion of the Shahshahani (1978) simultaneous equation model. I then describe the Heiat (1986) small demand-oriented model which emphasises the role of the oil sector in the Iranian economy. The next section evaluates the Management and Planning Organisation (MPO, 1990) model with a very disaggregated government block. An examination of the MEMs constructed by Noferesti and Arabmazar (1994) and Valadkhani (1997) is also presented. The penultimate section of the paper critically evaluates the common shortcomings and strong points of the above-mentioned seven MEMs followed by some concluding remarks.

THE ECAFE (1968) MODEL

The ECAFE (1968) model is a two-gap model which uses data from the period 1961-1967. It makes projections for the years 1971 and 1975 for the key macroeconomic indicators in order to determine the level of foreign aid under various feasible growth rates. Important features of the ECAFE model are highlighted in Table 1.[1] The structure of the model is simple and comprises behavioural equations only relating to consumption, production and imports. The model equations are estimated using the OLS method with a limited sample size. The projections of the model are based on an incremental capital-output ratio (ICOR) generated by the Harrod-Domar production function and the estimated marginal propensity to consume and import. The important policy implication of this model is that achievement of high economic growth is not possible unless there exists a "good performance of the export sector and success in further mobilisation of domestic savings" (ECAFE, 1968, p.99).

The UNCTAD (1968) Model

Like the ECAFE model, the main objective of the UNCTAD model was to provide a basis for foreign aid policy by using a two-gap model under various feasible growth rates. This model was used to forecast the regional and world demand for foreign capital for the years

[1] The first two-gap model was constructed by Chenery and Bruno (1962) to analyse development alternatives in Israel.

1970 and 1975. The salient characteristics of this model are also presented in Table 1. This model uses annual data from 1956 to 1963 at 1960 constant prices. The OLS method is used to estimate all the linear equations of the model. Out of 32 behavioural equations, 29 equations have one exogenous variable and the rest are explained only by two explanatory variables. This model consists of 40 endogenous variables of which 8 are identities.

The main exogenous variables of the model are value added in the oil and agriculture sectors, crude oil production and government consumption and investment expenditures. As with the ECAFE model, the Harrod-Domar production function is estimated to compute the ICOR. This model underscores the role of trade in the Iranian economy through the disaggregation of the export and import functions. Most of the equations of the model are directly and indirectly affected by value added in the oil sector. For instance, it is interesting to note that the following behavioural equations are explained by value added in the oil sector: the non-oil portion of GDP, indirect taxes, net factor income paid abroad, and production of crude oil. Regardless of the DW statistic, which in some cases indicates autocorrelation problem, no other diagnostic test has been reported.

THE VAKIL (1973) MODEL

Vakil (1973) was the first Iranian to design a MEM for Iran. He held several positions at the Iran's MPO and gathered the available data to build a MEM. His model is to some extent comparable to the Klein and Goldberger model in that it only captures the demand side of the economy.

As with the ECAFE and the UNCTAD models, the oil sector plays a determining role in the model. The government sector through the channelling of oil revenues to the rest of the economy, acts as the driving force in the model. Probably the purpose of this model was to assist the government in forecasting the key macroeconomic indicators. The notable features of this model are summarised in Table 2. The limited number of observations (1959-1971) precludes the use of the 2SLS method. Vakil has evaluated the estimated behavioural equations on the basis of only R^2 and t statistics. The monetary sector, prices, and labor market are not modelled in his study.

Two types of dualities were addressed by Vakil in the context of the Iranian economy which were also used by his successors. First, the duality between traditional and modern sectors of the economy was considered as proposed by Lewis (1954) and Ranis and Fei (1961). This duality was clarified by the specification of two behavioural equations, *viz.* rural and urban consumption functions. Second, the duality between the private sector and government sector which manifested itself through the crucial role assigned to the oil sector.

Table 1
SUMMARY OF THE MAIN CHARACTERISTICS OF THE ECAFE AND THE UNCTAD MODELS[2]

Description	ECAFE Model	UNCTAD Model
Type of data	Annual	Annual
Estimation method	OLS	OLS
Estimation period	1961-1967 (7 observations)	1956-1963 (8 observations)
Number of behavioural equations	3	32
Number of identities	2	8
Number of exogenous variables	4	10
Main endogenous variables	1) consumption; 2) imports.	1) GDP growth; 2) non-agricultural GDP; 3) consumption: private, government; 4) investment in new construction; 5) indirect taxes; 6) net factor income; 7) exports: services, other commodities; 8) imports: capital goods, construction material, raw materials, pharmaceutical goods, non-durable consumer goods, durable consumer goods, invisible imports.
Main exogenous variables	1) investment; 2) oil exports; 3) GDP	1) sectoral value added: petroleum, agriculture and the rest; 2) aggregate investment; 3) production of crude oil; 4) GDP at market and factor price; 5) total exports.
Dynamic features	1) cumulative investment lagged by one year; 2) use of time trends.	1) cumulative investment lagged by one year; 2) historical growth rates; 3) use of time trends.
Objectives of the model	determination of the saving and trade gaps for projection and aid policy.	determination of the saving and trade gaps for projection and aid policy.
Reported diagnostic tests	none.	DW.
Other noteworthy features	1) use of intercept dummy variables 2) behavioural equations run in real terms; 3) use of Harrod-Domar production function.	1) use of intercept dummy variables; 2) behavioural equations run in real terms; 3) limited significance of *t* statistics; 4) problem of autocorrelation for some of the estimated equations is left untreated; 5) use of Harrod-Domar production function.

Sources: ECAFE (1968) and UNCTAD (1968).

[2] The schematic format of Tables 1 to 7 has been adapted from the Nerlove (1966) tabular survey of MEMs for a number of countries.

Table 2
SUMMARY OF THE MAIN CHARACTERISTICS OF THE VAKIL AND SHAHSHAHANI MODELS

Description	Vakil Model	Shahshahani Model
Type of data	Annual	Annual
Estimation method	OLS	OLS and 2SLS (using the first three principal components).
Estimation period	1959-1971 (13 observations)	1956-1973 (15 observations).
Number of behavioural equations	14	19
Number of identities	6	9
Number of exogenous variables	7	9
Main endogenous variables	1) GDP and GNP; 2) consumption: private urban, private rural, government; 3) taxes: direct and indirect; 4) banking credits given to the private sector; 5) investment: private sector investment in machinery, private sector investment in construction, government investment; 6) exports: oil and non-oil; 7) imports: consumer, intermediate and capital; 9) net factor income from abroad.	1) GDP and GNP; 2) sectoral value added: agriculture, petroleum, the rest; 3) consumption: private urban, private rural, government; 4) government revenues: direct taxes, indirect taxes; 5) investment: private investment in construction, private investment in machinery, government investment; 6) imports: consumer, intermediate and capital; 7) non-oil exports; 8) money supply; 9) general price level (inflation); 10) net factor income from abroad.
Main exogenous variables	1) sectoral value added: agriculture, petroleum, and manufacturing; 2) rural population; 3) change in wholesale price index; 4) lagged money supply.	1) high-powered money; 2) index of active population in agriculture; 3) adjusted capital stock; 4) oil and gas exports; 5) population; 6) oil revenue received by the Plan Organisation; 7) total oil revenues; 8) terms of trade.
Dynamic features	1) use of adaptive expectations and partial adjustment models; 2) change in wholesale price as exogenous variable.	1) cumulative nature of capital stock; 2) demographic variables; 3) use of lagged dependent variables and ratchet effect.
Objectives of model	policy analysis and forecasting.	Forecasting.
Reported diagnostic tests	none.	DW.
Other noteworthy features	1) all variables are measured in current prices, thus before any forecasting they need to be adjusted; 2) there is no production function; 3) estimated equations could suffer from simultaneity bias; 4) problems of autocorrelation are left untreated.	1) use of intercept dummy variable; 2) all variables are measured at 1959 constant prices; 3) GDP is disaggregated into several sectors.

Sources: Vakil (1973), Razavi and Vakil (1984), Shahshahani (1978) and Shahshahani and Dowling (1976).

THE SHAHSHAHANI (1978) MODEL

Shahshahani (1978) in his PhD dissertation at the University of Colorado constructed a MEM for Iran as an oil-based economy. The main objective of his model was to provide *ex ante* forecasts for the major macroeconomic variables of the Iranian economy for the period 1974-1985. However, given dynamic multipliers (*i.e.* impact, interim and total multipliers), this model can also be used for policy analysis.

The salient features of this model are presented in Table 2. As seen from this Table, the sample period runs from 1956 to 1973 and the model consists of 19 behavioural equations and 9 accounting identities. Two estimation methods of OLS and 2SLS have been applied by Shahshahani. There are four important issues highlighted in the specification of the model: (i) the urban-rural dichotomy reflected in the consumption functions; (ii) the dominance of the oil sector and the resulting duality in the economy; (iii) the consideration of possible imperfections in capital and money markets; and (iv) the linkage of the monetary base with total oil revenues.

As with the earlier MEMs for Iran, the oil sector performs an important role in the Shahshahani model in both the explanation of structural equations and the projections of exogenous variables for *ex ante* forecasting. The overall forecasting performance of this model is relatively poor due to the Islamic revolution in 1979 and the outbreak of the Iraqi war. Shahshahani (1976) asserts that the Iranian economy is a consumption-oriented economy, especially in relation to the increasing urban share of total consumption. He concludes that economic development and sustainable growth rates can not be achieved unless export of manufactured goods is promoted and industrial protectionist policies are reversed.

THE HEIAT (1986) MODEL

Heiat (1986), in his PhD thesis at Portland State University, formulated a small MEM for Iran in which considerable emphasis was placed again on the oil sector. The major characteristics of the Heiat model are presented in Table 3. The equations of the model are estimated for the period 1959-1976 using OLS and 2SLS methods. In addition, Heiat assigned a crucial role to the agriculture sector, but he did not specify any behavioural equation for the monetary sector. The linkage between the oil sector and the rest of the economy was established via government capital and current expenditures. The two basic dualities proposed by Vakil (1973) were also addressed by Heiat: first, the traditional duality of the agriculture sector and industrial modern sector, and second, the oil duality featured by an enclave modern oil sector with negligible links to the rest of the economy.

In common with the earlier MEMs for Iran, no econometric diagnostic tests were reported in the Heiat model. This model can also be criticised on the basis of its ignorance of the monetary sector. By and large, Heiat's study deepened our knowledge of the structure and behaviour of Iran as an oil-based developing country. The Heiat model was not used for policy analysis and forecasting by the Iranian government, but it provided some valuable information for new generation of macroeconometric modellers.

Table 3
SUMMARY OF THE MAIN CHARACTERISTICS OF THE HEIAT MODEL

Description	Heiat Model
Type of data	Annual
Estimation method	OLS and 2SLS
Estimation period	1959-1976 (18 observations)
Number of behavioural equations	12
Number of identities	5
Number of exogenous variables	8
Main endogenous variables	1) sectoral value added: agriculture, petroleum, urban; 2) consumption: private rural, private urban, government; 3) net indirect taxes; 4) non-oil exports; 5) imports: consumer, capital-intermediate; 6) labour employed in the agriculture and urban sectors; 7) GDP.
Main exogenous variables	1) investment: agriculture, urban; 2) growth in labour employed in agriculture; 3) growth in area under cultivation; 4) population: rural, urban; 5) oil exports.
Dynamic features	1) use of adaptive expectations model and partial adjustment mechanism.
Objective of the model	policy analysis
Reported diagnostic tests	DW
Other noteworthy features	1) dynamic multipliers were used for policy analysis; 2) an important role was given to petroleum and agriculture sectors; 3) the monetary sector was not modelled.

Source: Heiat (1986).

Table 4
SUMMARY OF THE MAIN CHARACTERISTICS OF THE MPO MODEL

Description	MPO Model
Type of data	Annual
Estimation method	OLS
Estimation period	1959-1985 (27 observations)
Number of behavioural equations	85
Number of identities	65
Number of exogenous variables	38
Main endogenous variables	1) GDP and value added: agriculture, petroleum, consumer industries, intermediate and capital industries, heavy industries, light industries, mining, construction, water, electricity, gas, transport, other services; 2) consumption: private and government; 3) investment: private, government, and investment in eight sectors, *viz.* agriculture, petroleum and gas, consumer industries, intermediate and capital industries, construction, water and electricity, transport, other services; 4) non-oil exports: agriculture, mining, manufacturing; 5) consumer imports; 6) intermediate and capital imports: agriculture, mining and manufacturing, construction, services; 7) monetary base; 8) domestic borrowing; 9) budget deficit; 10) liquidity; 11) GDP deflator; 12) retail price index; 13) government current and capital expenditure price indices. For main endogenous variables of the government block see Table 5.
Main exogenous variables	1) oil production; 2) oil exports; 3) net government foreign assets; 4) investment in the oil and gas sector; 5) the war expenditures; 6) capital depreciation rate; 7) depreciation in light and heavy industries as a result of the war; 8) exchange rate; 9) net capital exports; 10) the ratio of agriculture price index to wholesale price index; 11) import price index; 12) trend variable; 13) the shares of non-oil exports in agriculture, mining, and manufacturing; 14) population; 15) government oil income; 16) the numbers of students before entering universities; 17) the number of student after entering the universities; 18) the number of the government employees; 19) capital expenditures: tourism, oil, commerce, post and telecommunications; 20) principal and interest paid on loans and profit obtained from government investment.
Dynamic features	1) extensive use of the Koyck distributed-lag models.
Objectives of the model	policy analysis and forecasting
Reported diagnostic tests	None
Other noteworthy features	1) substantial disaggregation of the government block; 2) disaggregation of sectoral production, investment and trade; 3) extensive use of dummy variables; 4) some variables measured at constant prices and some in current prices; 5) exports and imports are measured in both rials and dollars; 6) most behavioural equations are linear but some are non-linear; 7) the sectoral non-oil exports are set to be a constant share of the sectoral value added; 8) some price deflators are modelled; 9) the government block is closely linked with the monetary base; 10) employment is not modelled; 11) there is no theory-based production function.

Source: MPO (1990).

THE MANAGEMENT AND PLANNING ORGANISATION (MPO, 1990) MODEL

The MPO (1990) model was used to provide information for the formulation of the first five-year development plan after the 1979 revolution on a macro scale[3]. Using a three-gap approach, this model aims to address three equilibria, *viz.* the saving-investment, the balance of payments, and the government budget. The model consists of five main blocks, namely production, government, money, consumption and investment, and foreign trade.

This model is highly disaggregated. It consists of 150 endogenous variables of which 85 are behavioural equations and the remaining 65 are accounting identities. Apart from the lagged endogenous variables, there are 38 exogenous variables in the model. The important features of the MPO model are presented in Table 4. Most of the equations are estimated for the period 1959-1985 using the OLS method. Dummy variables have been used extensively to capture the impact of the Iraqi war, oil shocks, and the 1979 revolution. The dynamic performance of the full model was evaluated in terms of root mean square error (RMSE). However, no diagnostic tests were undertaken for the individual behavioural equations.

There is no theory-based production function in the model. Instead, the value added in each sector is regressed in terms of some of the following variables: the lagged sectoral value added in the sector itself, sectoral imports, sectoral investment, and value added in other sectors. There is a possibility of data mining in this model. However, in the consumption and investment block, private consumption is specified on the basis of a simple version of the permanent income hypothesis. Government consumption is simply specified in terms of government current expenditure. Investment is modelled in three stages. In the first stage, total investment is categorised into private and government sectors. Government investment is explained by the government capital expenditure. In the second stage, total investment is further divided into a number of sectors. Investment in each sector is explained by value added in that sector and lagged dependent variable. In the third stage, private investment is estimated as an identity by subtracting the government investment from total sectoral investment. It is interesting to note that in this model the sectoral non-oil exports are assumed to remain a constant share of the sectoral value added.

The monetary block comprises six equations including four price indices, *viz.*, the GDP price deflator, the retail price index, government consumption and investment price indices. It is assumed that net government foreign assets and the government debt determine the monetary base. Liquidity in circulation is specified by the monetary base. It should be noted that the change in government debt is determined by the government borrowing from the Central Bank. The government borrowing from Central Bank is explained by the annual government budget deficit. This link is important and will be considered by the present study in a slightly different manner. The GDP price deflator, which plays a critical role in other price deflators, is explained by liquidity and real GDP.

The government block forms a large part of the MPO model. There are 42 behavioural equations and 15 identities in this block. The government revenues and expenditures are disaggregated into several components and the budget deficit is then

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[3] There are three small supplementary models connected to this model. The first model is a system dynamic model which has been used to determine demand for agricultural products. The second model itself consists of two sub-models: the first sub-model is a linear expenditures system which estimates the demand for petroleum products while the second sub-model estimates the derived demand for inputs in the electricity sector. The third model is also a system dynamic model which determines the exchange rate, given the required macro variables by the main model.

linked with the monetary sector. Table 5 presents the main endogenous variables in the government block.

THE NOFERESTI AND ARABMAZAR (1994) MODEL

This model was constructed in association with the Department of Economic Affairs in the Ministry of Economic Affairs and Finance in Iran. The government has not directly used this model for policy formulation or forecasting, as the model was part of a research project. Noferesti and Arabmazar assert that in all the earlier MEMs aggregate supply is assumed to be perfectly elastic and equilibrium output is determined by aggregate demand. In other words, the earlier MEMs are based on Keynesian income-determination framework, which assume supply can adjust itself to match aggregate demand.

In the Noferesti and Arabmazar model the main determinant of equilibrium output is aggregate supply, and any gap between aggregate supply and demand affects the general price level. They estimate a Cobb-Douglas production function for four main sectors. The salient futures of the Noferesti and Arabmazar model are shown in Table 6. The parameters of the model are estimated by OLS and 2SLS methods using annual time series data for the period 1959-1990. This model consists of 27 behavioural equations and 29 accounting identities. The model is divided into seven blocks, *viz.* production, consumption, investment, government revenue, foreign trade, monetary sector and prices. As with the previous MEMs no econometric diagnostic tests are reported for the estimated equations. Two of the equations of their model seem to have an unstable and explosive dynamic behaviour, because the estimated AR(1) coefficients are greater than unity. Despite the crucial importance of the link between the monetary sector and the government sector in the context of the Iranian economy, this linkage has not been considered. It should be noted that the above-mentioned link has been taken into account by both the MPO (1990) and Valadkhani (1997) models.

Furthermore, the black market exchange rate is not endogenised in the Noferesti and Arabmazar model. In the context of the Iranian economy, there is an inter-relationship between the black market exchange rate and some macroeconomic variables in the monetary and real sectors (Bahmani-Oskooee, 1995). By assuming the black market exchange rate as an exogenous variable, the Noferesti and Arabmazar model is likely to suffer from mis-specification problem. Noferesti and Arabmazar suggest that their model can be used in policy analysis and forecasting, but they do not undertake any simulation experiment. Nor do they evaluate the dynamic performance of the full model on the basis of sensitivity analysis and dynamic response.

THE VALADKHANI (1997) MODEL

Table 7 foreshadows the major characteristics of the Valadkhani (1997) model in order to facilitate the cross-model comparison. As seen from this Table, there are altogether 38 behavioural equations and eleven accounting identities in the model. The production side of the model consists of 20 equations. Of these 20 equations, 10 equations are obtained from the "conversion matrix", which translates five aggregate final demand components to value added in ten major sectors. The second 10 equations are related to the modelled sectoral residuals, which are to be added to the previous ten equations to enhance the tracking performance of the production side of the model.

Table 5

CLASSIFICATION OF THE GOVERNMENT BLOCK EQUATIONS IN THE MPO MODEL

Revenues	Expenditures
(1) Oil and gas	(1) Capital:
(2) Taxes:	(1.1) Economic category:
	Agriculture
(2.1) Direct:	Water resources
Companies	Power
Salaries and wages	Manufacturing
Jobs	Mining
Real estates	Gas
Income	Transport
Wealth	
	(1.2) Social category:
(2.2) Indirect:	Education
Imports	Culture and art
Consumption and sales	Health
	Social security
(3) Other income:	Physical education
Monopolies and government ownership	City development
Services and sales of goods	Rural development
Insurance premiums	Housing
	Environment conservation
	Regional multi-purpose development operations
	(1.3) Public category:
	Statistics and public services
	Information and mass-media
	Government buildings
	(2) Current:
	Education
	Social security
	Health
	Universities and higher education institutions
	Aids and subsidies
	Income generating government institutes
	Other government institutes
	Other current expenditures

Source: MPO (1990).

Table 6
SUMMARY OF THE MAIN CHARACTERISTICS OF THE NOFERESTI AND ARABMAZAR MODEL

Description	Noferesti and Arabmazar Model
Type of data	Annual
Estimation method	OLS and 2SLS
Estimation period	1959-1990 (32 observations)
Number of behavioural equations	27
Number of identities	29
Number of exogenous variables	16 exogenous variables and 10 different intercept dummy variables
Main endogenous variables	1) GDP and GNP; 2) sectoral value added: agriculture, manufacturing and mining, petroleum, services; 3) consumption: private rural, private urban, government; 4) investment: agriculture, manufacturing and mining, petroleum, services, private sector, change in capital inventory; 5) government revenues: oil, direct taxes, indirect taxes; 6) non-oil exports; 7) imports: consumer, intermediate, capital, services; 8) term deposits; 9) real money supply; 10) real money demand; 11) real liquidity; 12) consumer price index; 13) implicit price deflator.
Main exogenous variables	1) budget deficit; 2) black market exchange rate; 3) net factor income from abroad; 4) employment: agriculture, manufacturing and mining, petroleum, and services; 5) oil exports; 6) "profit rates" paid on term deposits; 7) import price index; 8) subsidies.
Dynamic features	1) use of adaptive expectations model and partial adjustment mechanism; 2) some equations have explosive dynamic behaviour since the estimated coefficient for AR(1) exceeds unity.
Objective of the model	policy analysis
Reported diagnostic tests	DW
Other noteworthy features	1) main determinant of equilibrium output is aggregate supply; 2) any gap between aggregate supply and demand affects the general price level; 3) some equations suffer from autocorrelation; 4) DW statistic is reported mistakenly for h-Durbin statistic; 5) no policy simulation has been undertaken; 6) behavioural equations run with data in both constant and current prices; 7) extensive use of dummy variables.

Source: Noferesti and Arabmazar (1994).

Table 7
SUMMARY OF THE MAIN FEATURES OF THE VALADKHANI MODEL*

Description	Valadkhani model
Type of data	Annual
Estimation method	OLS and 2SLS
Estimation period	1964-1992 (29 observations)
Number of behavioural equations and identities	38 behavioural equations and 11 identities
Number of exogenous variables	15
Main endogenous variables	1) GDP; 2) sectoral value added: agriculture, petroleum, manufacturing, water-electricity-gas, construction, trade, transport, financial and real estate, public services, personal and domestic services; 3) consumption: private and government; 4) investment: private and government; 5) government revenues: oil, direct taxes, indirect taxes; 6) non-oil exports; 7) imports: consumer, intermediate, and capital; 8) money supply; 9) demand for money (a price-dependent equation); 10) consumer price index; 11) black market exchange rate; 12) total employment.
Main exogenous variables	1) oil and gas exports; 2) government current expenditure; 3) government capital expenditure; 4) total labour force; 5) debt of commercial banks to the Central Bank; 6) other sources of the government revenues; 7) other government expenditure; 8) import price index.
Dynamic features	1) use of adaptive expectations model and partial adjustment mechanisms; 2) two equations of the model have an error correction mechanism; 3) use of the first differenced variables in the estimation of some behavioural equations.
Objective of the model	policy evaluation
Reported diagnostic tests	1) DW; 2) Ramsey RESET; 3) Jarque-Bera; 4) Breusch-Godfrey Lagrange Multiplier; 5) ARCH; 6) Box-Pierce; 7) Ljung-Box; 8) Chow forecast; 9) testing for the stationarity of stochastic residuals of the estimated equations.
Other noteworthy features	1) use of input-output system in the production side; 2) examination of time series properties of the data; 3) use of the Hausman test for simultaneity problem; 4) modelling aggregate employment; 5) extensive use of intercept dummy variables to take account of a few outliers in each equation; 6) modelling the black market exchange rate as a new phenomenon in the Iranian economy; 7) considering the important link between the monetary sector and the government sector; 8) considering the important relationship between the petroleum sector and the government sector; 9) evaluating the dynamic performance of the full model by presenting several goodness-of-fit statistics; 10) evaluating the full model by sensitivity test; 11) investigating the dynamic response of the complete model; 12) undertaking five hypothetical simulations for policy analysis.

Source: Valadkhani (1997).

Also there are eighteen behavioural equations capturing aggregate demand components, the monetary sector and employment. Of these equations, two equations use an error correction mechanism. The MEM constructed by Valadkhani (1997) overcomes some of the major deficiencies of the previous MEMs for Iran. He constructed a MEM for the Iranian economy using annual time series data for the period 1964-1992. The major contributions and innovations of his study, which advances previously developed models for the Iranian economy, fall into four categories. First, this model represents the first attempt to incorporate the production structure of an input-output system into an econometric model for Iran. To achieve this, a conversion matrix, which translates the aggregate demand components into the sectoral value added, is incorporated. This procedure captures the production inter-dependencies among inter-related sectors, as suggested by many leading model-builders such as Klein (1983) and Bodkin (1976). Second, the estimated behavioural equations have been validated by a battery of parametric and diagnostic tests prior to the use of this model for any policy analysis. These diagnostic tests have been undertaken to check for various possible violations of the classical linear regression model. Third, Valadkhani (1997) determined time series properties of the data to avoid spurious regressions and/or inconsistent estimators. Almost all equations in the production side of his model use stationary data. On the demand side and for the monetary sector of the model, most of the equations have been balanced by equalising the order of integration of dependent and independent variables. Fourth, most of the preceding model-builders for Iran used the two-stage least squares (2SLS) method to estimate a simultaneous equation system indiscriminately, but in this study the Hausman (1976) test has been utilised to determine the estimation method. If the simultaneity problem exists, the 2SLS method is used, but if not, OLS estimators are used.

The Valadkhani (1997) model consists of 38 behavioural equations and 11 accounting identities. Most of the equations have been estimated on constant price (1982) data. The reliability of the complete model as a system has been tested using three evaluation criteria, *viz.* dynamic tracking performance, sensitivity and dynamic response. The dynamic tracking performance of the full model over the simulation period is both satisfactory and stable. Like previous models, intercept impulse dummy variables were used extensively to capture a few outliers in each equation that occurred as a result of the Iran-Iraq war, volatile oil exports, the Islamic revolution, and frequent data revisions by statistical centres.

A CRITICAL REVIEW OF EARLIER MEMS FOR IRAN

The preceding sections presented a synoptic review of the main features of the eight MEMs which have been previously constructed for Iran. There are some common shortcomings in these MEMs which should be obviated in the future studies and some strengths which need to be retained. Since no MEM can claim to be impeccable and flawless, there will always be room for improvement. Generally speaking, MEMs can be enhanced on the basis of four developments: "the improvement in computational capacity, improvement in the quality and availability of economic data, developments in econometric theory and the virtuous circle of improvements in macroeconomic theory and the evolution of macroeconometric models" (Bodkin, Klein and Marwah, 1991, p.527). Model-builders should take advantage of these developments to construct superior models.

From the previously constructed MEMs for Iran, some important lessons can also be learned. These lessons provide useful background information on the specification of the behavioural equations of the present study. These lessons are fourfold. First, there is a duality between the private and government sectors which manifests itself through the crucial role played by the oil sector in the model. Second, the government sector is closely linked to the monetary sector because of the lack of independence of the Central Bank of Iran from the government. This is an important link which should be taken into consideration in the construction of any MEM for Iran. Fourth, in all the earlier MEMs the oil sector has a crucial role in determining the behaviour of the key macroeconomic variables.

It should be noted that oil export earnings can play three vital roles in the context of the Iranian economy: "provision of foreign exchange, addition to national savings, and contribution to government revenues" (Karshenas and Pesaran, 1995, p.95). By providing investment funds, the oil and gas sector should pave the way to establish a platform for strengthening those sectors which can be substituted for the oil sector in the long run as a mainstay of the economy. For example, the share of value added by the petroleum sector averaged 40 per cent of GDP for the period 1959-1977 because of a massive increase in the receipt of petrodollars. About 95 per cent of total exports for the same period emanated from this sector. However, according to past experience, the oil sector financed inefficient and inward-looking manufacturing industries, protected by high tariff barriers. Therefore, instead of diversification and rapid growth of non-oil exports, the oil sector aggravated the economic reliance on imports. In this regard, Aghevli and Sassanpour (1982) found that the impact of the 1973 oil boom on output and economic growth was conspicuously large. However, the oil sector gave rise to a marked increase in imports and distorted relative prices at the expense of productive tradeable sectors. As a result, non-oil exports markedly decreased in the 1970s. This phenomenon can be referred to as a manifestation of "Dutch disease" in the context of the Iranian economy. See Corden and Neary (1982) and Corden (1984) for a review of literature on booming sector economics and the Dutch disease.

The major weaknesses of the earlier MEMs fall into six categories. First, with the exception of Valadkhani (1997), none of the earlier models considered production interdependencies among interrelated sectors by incorporating an input-output system. Klein (1983) provides detailed discussion of the integration of an input-output system to a MEM. Second, Intriligator, Bodkin and Hsiao (1996) recommended that various parametric and diagnostic tests should be undertaken prior to the release of MEMs. However, most of the previous modellers have not provided sufficient parametric and diagnostic tests prior to the release of their MEMs and as a result some of their estimated equations suffer from "econometric pathologies". Third, the time series properties of the data have not also been investigated by majority of the previous modellers. This criticism is particularly pertinent for the Noferesti and Arabmazar (1994) and MPO (1990) models, because at the time of the construction of these models, an extensive literature on unit root analysis was available. For example, as a result of this omission, two of the estimated equations of the Noferesti and Arabmazar model have an estimated coefficient of greater than unity for AR(1), which can make the dynamic behaviour of their model explosive.

Fourth, some model-builders did not test for a simultaneity problem. On the basis of the theoretical specification of the equations of the earlier MEMs some equations are simultaneous. Thus, the modellers employed the 2SLS method to obtain consistent estimators. However, the use of 2SLS instead of OLS, when there is no simultaneity problem, can result in inefficient estimators. Fifth, with the exception of the Heiat (1986) model and the Valadkhani (1997), none of the previous MEMs has modelled employment. The reason for this can be related to either the lack of data or the poor quality of data on employment. However, this is an important issue otherwise the impacts of counterfactual simulations and hypothetical shocks on total employment cannot be measured. Sixth, some of the theoretical underpinnings of the earlier MEMs were based on an arbitrary division of endogenous and exogenous variables. For example, most of the behavioural equations of the MPO (1990) model did not have a theoretical premise and largely were simple autoregressions.

CONCLUDING REMARKS

This paper presents a synopsis of the main characteristics of the eight MEMs which have been previously constructed for Iran. The shortcomings and strengths of each MEM are briefly discussed. Both the ECAFE and UNCTAD models used a two-gap approach to provide a basis for foreign aid policy and world capital needs. Using small sample sizes (7 and 8 annual observations), these two models estimated the ICOR and the marginal propensity to consume and to import in order to project capital need under various growth rates. The Vakil model and the Shahshahani model are demand-driven MEMS with some resemblances to the Klein and Goldberger model for the US.

The Heiat (1986) model is a small demand-driven MEM which assigns an important role for the oil sector without considering the monetary sector. With the exception of the Vakil and MPO models, none of these MEMs have been used by the Iranian government for policy analysis and forecasting. The MPO model (1990) can be classified as a large MEM, but the specification of some of its behavioural equations does not have a theoretical premise. This model extensively uses simple autoregression. Noferesti and Arabmazar (1994) constructed another MEM for Iran in which equilibrium output was determined by aggregate supply rather than aggregate demand. Valadkhani (1997) overcame some shortcomings associated with earlier models but this model has not been updated since 1997. In majority of these MEMs one can vividly observe the dominance of the oil sector and the resulting duality in the economy. Knowledge of the strengths and weaknesses associated with earlier models is useful in designing future MEMs of oil exporting countries.

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