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Pre-revolutionary Iranian economic policy making

An optimal control based assessment

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An optimal control macroeconomic model of the Iranian economy is developed in order to evaluate the government's economic policies over the 1972–77 period. The main results of the study indicate that, after 1973, Iranian planners should have focused on shorter-run stabilization issues and contributed more actively to the budgetary decision-making process. This conclusion is true with regard not only to the longer-run supply effects of the government's programmes, but also to the shorter-run stabilization difficulties posed by the rapidly accelerating level of expenditures.

Keywords: Iran; Optimal control; Middle East economies

In order to examine the consequences of the increased oil revenues, a number of forecasting models were developed in Iran after 1973. The econometric models developed at the Iranian Plan and Budget Organization were designed with the premise that:[1]

. . . oil revenues may well be a mixed blessing, depending on the size of the annual liquidity injections relative to the availability of complementary factors of production. Indeed, these revenues are on the one hand like the blood of the economy carrying badly needed investment resources to particular areas for purposes of expanding productive capacity and on the other they are capable of producing an excessive liquidity situation, if capital resources become suddenly out of line with other complementary factors of production (such as skilled labor, technology, organizational skills, natural resources or general infrastructure services). This duality renders the planning task all the more difficult under conditions of financial surplus, since it requires a shift of emphasis in the planning circles, from an allocation of resources according to the now abundant factor to an allocation of resources according to the real scarce factor.

Using these models for forecasting over a 20-year period, several important difficulties associated with the country's development were identified.[2]

(i) The prospect of a recession during the period 1980–87.
(ii) The existence of impending difficulties in adjusting from oil induced growth to consumption induced growth.
(iii) High inflation anticipated during the decade 1972–82, as well as a highly uneven impact on various social and economic groups.
(iv) The need to identify areas of comparative advantage in the industrial and mining sectors.
(v) The prospect of a serious balance of payments disequilibrium beginning around 1987.
(vi) The prospect of an unusual widening of urban–rural income disparities with little hope of a self-adjusting mechanism.

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[1]Vakil [10], pp 715–716.

[2]Planometrics Bureau [7], p 89.

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(vii) Identification of the correct role of the public sector in a mixed enterprise economy undergoing rapid change.

Interestingly enough, when this particular forecast was tested for the sensitivity of these results to increases in government revenues, it was found that a 4.4% increase in revenues spread over 20 years (1972–92) did not have a significant impact in terms of the endogenous variables. Also apparent was that an increase in oil revenues without any correcting policy considerations contributed to urban-rural income disparities. Out of this analysis several scenarios were drawn.

The basic policy problems brought to light by the initial forecasts were therefore that: (i) a do-nothing approach to urban–rural disparities would not bring out a self-adjusting mechanism (and therefore something needed to be done); (ii) the level of disparities implied by the do-nothing approach was such that the social fabric would be able to withstand it only under a very tight control situation; (iii) the disparities would encourage rural–urban migration at a rate which might be untenable given the existing amount of urban infrastructure; (iv) for a more balanced society more acceptable targets had to be set even if the effect of such targets were reduced growth and increased inflation.[3]

Thus on the argument that oil was a depletable resource and that its wealth must be conserved in financial terms to serve future generations, a spending policy was derived. A number of simulations of the economy were made to determine if it was possible to:

(i) avoid the forecasted recessions of 1359–66;
(ii) extend the protective financial umbrella of oil based resource out in time;
(iii) smooth out Iran's growth path over the next 20 years;
(iv) avoid excessive inflationary pressures in the initial years;
(v) avoid exceeding the absorptive capacity of investment;
(vi) solve the anticipated balance of payments crisis of 1366-71;
(vii) leave future generations beyond 1371 with a certain size of capital stock.

In general these were found to be compatible goals and a number of policy recommendations[4] were made on the basis of the Plan and Budget Organization's econometric model and forecasts.

[3]Planometrics Bureau [7], pp 58–59.

[4]Planometrics Bureau [7], pp 69–93.

The use of econometric models for quantitative analysis of macroeconomic policy was thus a major development in Iranian planning. Using these econometric models it was possible for planners to make projections of key economic variables. Given a set of proposed future values for the policy variables or instruments at the government's disposal, planners were then able to examine the nature of these projections in order to evaluate policy proposals. While a productive start in the right direction, this approach to policy analysis was deficient for two reasons.

First, the dynamic response of the economic variables to a particular course assigned to the policy was complicated and unpredictable. The selection of policy by a trial and error process was therefore extremely inefficient. What was needed was the specification of a loss function of the key economic variables and the minimization of its value with respect to the policy instruments included in the model. The specification of an objective or loss function and the derivation of a policy solution by optimization would have given the planners a much clearer picture of the extent to which the country's economic performance could have been improved upon. There was no assurance that the trial and error methods actually used came anywhere close to forecasting the economy's optimal growth path.

The second and perhaps more important deficiency stemmed from the uncertainty inherent in the projections; ie given the proposed time paths for the policy variables, it is impossible to rely on an econometric model to make perfect predictions of the values important economic variables should assume. Uncertainty not only makes it difficult to evaluate a given policy path, but it makes the evaluation of such a path unrealistic and irrelevant.[5]

The former difficulty can be resolved by stochastic simulations which incorporate random elements in the econometric model in making projections; the means and variances of the future paths can then be calculated. Because of uncertainty in the economy, it would have been unrealistic to expect the government to adhere to a fixed plan irrespective of future developments; ie future decisions were made on the basis of future observations of the economy. Hence, it was unrealistic and irrelevant for the Plan and Budget Organization to evaluate the consequences of a preassigned sequence of policy actions. A more realistic policy would have taken the form of a reaction function, or a feedback control equation permitting the values of the policy variables to be determined according to future economic observations.

[5]Chow [2], p 341.

In sum the policy analysis at this time not only lacked optimization but it was also not conducted in a setting capable of yielding feedback as to the impact of policy actions. It is puzzling why several of the more sophisticated and insightful mathematical models available at the time were not used. In particular since the Plan and Budget Organization's econometric models were linear with an additive random disturbance, it would have been best to minimize the expected value of a quadratic loss function for T periods according to the methods developed some time earlier by Herbert Simon [8] and Henri Theil;[6] that of optimal control.

Method of optimal control

An optimal control consists of:

(i) a set of differential or difference equations that represent a system that is to be controlled;
(ii) a set of constraints on the variables of the system;
(iii) a set of boundary conditions on the variables: and
(iv) cost functional or performance index which is to be minimized.

The essential idea of optimal control is precisely to derive the optimal policy in order to steer the economy to a specified set of targets. A necessary step in this regard is to specify an objective function or a welfare loss function by which the outcome associated with the optimal policy or its alternatives can be evaluated. Given this welfare loss function and a dynamic model, a policy sequence can be found minimizing the expectation of the welfare loss for a given time horizon.

For example, the solution to the optimal control problem with unknown parameters using a quadratic loss function can be written as:

$$y(t) = A(t)y(t+1) + C(t) \times (t) + b(t) + u(t) \quad (1)$$

$y(t)$ is a vector of endogenous variables at time t; $x(t)$ is a vector of policy variables at time t; $b(t)$ is a vector combining the effects of all exogenous variables not subject to control, the matrices $A(t)$, $C(t)$ and $b(t)$ consist of unknown parameters whose probability distribution is assumed to be given, and $u(t)$ is a vector of random disturbances having mean 0, covariance matrix V, and being serially uncorrelated. Endogenous variables and policy variables with higher order lags can be eliminated by defining new endogenous variables so as to retain the form (1) of a system of first-order linear stochastic difference equations in which only the current control variables $x(t)$ appear. We can include the policy variables in the vector $y(t)$ so that $x(t)$ need not be an argument of the loss function.[7]

The loss function mentioned above can be depicted as:

$$W = \sum_{t=1}^{T} (yt - at)^1 K_t (yt - at) \quad (2)$$

where $a(t)$ is a vector of targets for the variables $y(t)$ and $K(t)$ is a diagonal matrix giving the relative penalties for the squared deviations of the various variables from their targets. The problem becomes essentially one of minimizing the expected value of the loss function for T periods by choosing a strategy for $x(1), x(2) \ldots x(T)$. The control variables will be selected sequentially, the vector $x(t)$ for each period being determined only after the up-to-date information is available. This information consists mainly of $y(t-1)$ which includes the observations of all past endogenous variables and policy variables affecting the current endogenous variables at time (t).

It may be argued that decisions of the planners in Iran, particularly after the oil price increases, were not made in a context of marginal optimization. However, the manner in which the planning authorities approached their responsibilities can be approximated by the optimization of a well defined objective function. After all, the responsible officials on the regime's High Economic Council were all reasonably knowledgeable men and concerned with national income, the price level, the balance of payments and so on. Clearly a deviation between actual developments and the desired ones in any of these aspects can be regarded as having caused disutility to this group.

The application of optimal control to the problem of planning a development strategy after 1972 is presented below.[8] The approach is straightforward. The economic system is represented by an econometric model—namely a set of difference equations. There are constraints; for example inflation is not allowed to increase over a certain rate. The boundary conditions are the initial values of the variables while real non-oil GDP is maximized for 1980 in the objective function.

[6]Theil [9], pp 346–349.

[7]A complete description is given in G. C. Chow [1].

[8]It should be noted that the nature of the problem dealt with here is one of short-run stabilization over a period with known exogenous variables. For a longer-run forecast of the economy using an optimal approach see Homa Motamen [6].

A model of the Iranian economy

The model consists of a series of identities and estimated questions. For clarity a rough outline (Table 1) shows the major relationships. The model incorporates a foreign sector, the domestic banking system, the government, and the private sector (the basic identities of each are depicted in Equations (1)–(4), Table 1, respectively).

Each of the first three sectors involve income as well as financial transactions whereas the income transactions of the banking system are considered to be negligible. An increase in the deficit or a reduction in the non-financial net savings is assumed to result in either an increase in its financial liabilities or a decrease in its holdings of financial assets or both. Furthermore, given its non-financial asset only at the expense of accumulations to its holdings or one or more alternative financial assets or in exchange for increases in one or more financial liabilities.[9] The account for each sector is assumed balanced at the end of the year. The model therefore contains a set of sectoral balance sheet constraints. As usual in models of this type, certain behaviour relations are required to explain the economic and financial activities of various sectors.

The model's construction was constrained by lack of data on several variables. In particular, there are no figures on private savings or the capital stock. As an approximation the capital stock was simply assumed to be a summation of the total gross domestic capital formation in the current and two prior years:

Table 1. Iran: a macroeconomic framework.

Equation	Structural specification
(1)	$\Delta MSFAP = EXR - ZNP + GFP + PFP$
(2)	$\Delta MZP = \Delta MSFAP + \Delta MSDCP$
(3)	$\Delta MSGCP = GCNP + GITP - GREUP - GFP - \Delta GB$
(4)	$PITP = SP + \Delta PCP + PFP - \Delta M2P - \Delta B$
(5)	$\Delta PCP = \Delta MSDCP - \Delta GCP$
(6)	$SP = NOXNP - NOREUP - PCNP$
(7)	$KP = KPL + PITP + GITP - DEP$
(7′)	$KP = TINP + TINPL + TINPLZ$
(8)	$NOXNP = KP + L$
(9)	$P = EXCESS + EUUICA$
(10)	$MIP = NOXNP + INF$
(11)	$MZ = BMRM$
(12)	$ZNP = PC + PTINP + \Delta WPI$
(13)	$NOREUP = PENANP$
(14)	$PCNP = NOXNP - \Delta CPI$
(15)	$EXPECTNA = EUUCP + CCP$
(16)	$GEXPTNAP = GREUP$

Note: See text for description of symbols.

$$KPL = TINP + TINPL + TINPL2 \quad (3)$$

where $TINP + PITP - GITP$ (total private investment plus total government investment).

For convenience, non-oil *GDP* (Equation (8)) is specified in linear form in the optimum control exercises. Both the real capital (*KP*) stock and labour force (*L*) were assumed to make independent contributions to real non-oil (*NOXNP*) output.

The price level (Equation (9)) was assumed to reflect both excess real demand, monetary factors and world prices. Excess demand is measured as the ratio of liquidity to real output (*M*/*NOXNP*), while the export price index of the developed countries (*EUVICA*) was used as an approximation of world price trends. Since specification for the price level incorporates a disequilibrium relationship, it is easily converted into an inflation equation for empirical estimation. As noted earlier import prices are an important determinant of domestic prices. As formulated here, an increase in import prices may cause upward pressure on domestic prices mainly through their effect on: (i) the costs of production; and (ii) the substitution of domestic for imported goods (which creates demand pressure on domestic resources).

The demand for liquidity (Equation (10) simply states that the transaction demand (depicted by real non-oil *GDP*) as reinforced by the rate of inflation (or requirement for additional cash to finance expenditures during periods of price increases) determines desired real money (*MIP*) holdings.

The positive sign for inflation reflects the lack of attractive non-financial assets that the public could acquire during this period as the opportunity cost of holding money increased[10] (due to the price increases).

Imports (Equation (12)) are assumed to be related largely to the importation of machinery both by the public (*PIMP*) and the government (*GIMP*). This view of imports (*ZNP*) accepts the two gap theory assumptions that given the nature of Iran's import substitution strategy and the lack of a domestic capital goods industry, the country required a certain minimal amount of imports just to maintain a given level of income. The change in wholesale prices obviously indicates a shift away from domestic producers to cheaper foreign suppliers (of non-machinery goods) as local price increase.

The limited non-oil government revenues (Equation (13)) were largely duties of one sort or another, plus the income tax. They are assumed largely a function of private expenditure (*PENANP*).

Private consumption (Equation (14)) is a function

[9]For a detailed discussion of these assumptions, see C. H. Wong and O. Pettersen [11].

[10]Cf Galbis [4] for an empirical test of this assumption.

of real non-oil output. Consumption was also assumed to be affected by government activity whereby stepped-up government purchases may preempt a certain amount of expenditures, either through a forced savings mechanism or 'crowding out' effect through tightening of credit availability.[11]

Exports (Equation (15)) are largely a function of crude petroleum production (*CCP*) and the price of oil in world markets (depicted by the export price of oil *EUVCP*). Non-oil exports were largely disregarded (but are included in *EXPTNA*).

The main characteristics of the model include: (i) integration of the domestic economy with that of the world economic system; (ii) an active role played by both the banking system and government; (iii) the use of non-oil output and the rate of inflation as the optimal control targets; (iv) the adaptation of changes in the private banking system; and (v) government investment in machinery as the control variable.[12]

The major objective in formulating an optimal control simulation of the economy for the 1972–77 period is to examine whether and to what extent the government's stabilization programme could have been more successful in controlling inflation while at the same time less disruptive on the private sector than was actually the case.

The main tasks in formulation of the simulation were: were (i) estimating the structural equations; (ii) establishing desirable endpoint (1977) targets (level of real non-oil GDP, inflation); and (iii) estimating the required levels of the policy instruments year-by-year to attain these targets (with inflation treated as the welfare loss function).

The results of the econometric two-stage estimation of the structural equations (Table 2) are encouraging and need little further comment. The equations used in the actual stimulations are the first one listed for each variable (while the primed equations for each were alternates and are included here because the depict an interesting aspect of the variable).

The optimal control steps involved:

(i) Setting the values for the exogenous variables at their historical values (exogenous variables were: (a) *CPP*-index of crude petroleum production; (b) *EUVIC* export price index industrial countries; (c) *EUV*–Iranian export priced index, and (d) lagged variables in the estimated equations.

(ii) With (i) simulating values for the endogenous variables over the 1972–77 period.

(iii) Setting two values for 1977 for real non-oil *GDP* (*NOXNP*) to be optimised (Rials 1650 billion and Rials 1800 billion as opposed to the actual historical figure of Rials 1453.8 billion).

(iv) Simultaneously the rate of increase of the consumer price index was set at equal or less than 10% per annum for the 1971-77 period as a whole (the historical rate was 13.54%).

(v) Two instrument variables, government investment in machinery (*GIMP*) private credit from the banking system (*PCP*), were selected for control purposes.

(vi) No constraints were placed on government investment in machinery or private consumption although this could be introduced with no problem once a basis for their lower limit was established.

Logically, four policy variables could be chosen in the context of the stabilization model outlined above. In addition to the change in net domestic credit (private sector) of the banking system and government capital expenditure, government construction and government consumption expenditures were possible instruments of fiscal policy. Regardless of their choice the policy instruments included in the model must be well coordinated since the various sectors are interacting with one another. It can be seen from the simulation model that for instance a change in the rate of credit expansion would influence foreign reserves, output and prices through imports and investment. The change in output would also have an effect on imports and tax revenues and hence the balance of payments and the budget of the government. At the same time the change in credit and domestic liquidity through a change in the demand for money resulting from the changes in real income and in domestic credit creation would have affected imports and thus investment and the rate of growth.

Assessment of results

The results (Table 3) of the optimal control exercise were very satisfactory in that they confirmed the following facts concerning economic policy in Iran during the 1970s:

(i) Both government investment in machinery (total government investment could have been used as a policy variable just as easily) and

[11]An example of this mechanism and related ones for another country is described in E. V. K. Fitzgerald [3].

[12]Government capital expenditure is probably a more effective tool than consumption in the Iranian context because consumption was undoubtedly less amenable to control. Moreover, government capital expenditure not only constitutes a component in the aggregate demand, but enabled the economy to mitigate demand pressure.

Table 2. Iran: macroeconomic simulation model (two-stage least sources estimates).

Equation										Statistics
Non-oil GDP (constant price)										
(1)	*NOXNP*	=	0.91*KP*	+	0.04*L*	−	132.22			
			(10.78)		(2.06)		(− 0.89)			r^2 = 0.997; *F* = 1541.73
(1a)	*NOXNP*	=	4.86*PIMP*	+	4.46*GIMP*	=	15.50 *TIME*	+	140.05	
			(5.11)		(3.85)		(2.27)		(3.71)	r^2 = 0.990; *F* = 281.06
(1b)	*NOXNP*	=	0.94*KP*	+	7.41*TIME*	+	130.65			
			(12.83)		(1.90)		(7.19)			r^2 = 0.9970; *F* = 1490.81
(1c)	*NOXNP*	=	0.89*KP*	+	0.013*POP*	−	134.45			
			(10.04)		(2.15)		(− 0.98)			r^2 = 0.997; *F* = 1628.99
(1d)	*NOXNP*	=	1.07*KP*	−	14.39*ICOR*	+	198.96			
			(62.05)		(− 2.66)		(15.99)			r^2 = 0.998; *F* = 1932.27
Private consumption (constant price)										
(2)	*PCNP*	=	0.64*NOXNP*	−	1.62Δ*CPI*	+	59.08			
			(20.57)		(− 2.67)		(4.60)			r^2 = 0.995; *F* = 192.64
(2[1])	*PCNP*	=	0.69*NOXNP*	−	0.14*GENANP*	+	52.18			
			(9.42)		(− 2.30)		(2.67)			r^2 = 0.994; *F* = 734.28
Private expenditures										
(3)	*PENANP*	=	0.25*NOXNP*	+	1.51*PCP*	+	145.45			
			(2.29)		(3.30)		(4.33)			r^2 = 0.997; *F* = 445.55
Total savings										
(4)	*FSNP*	=	1.09*EXR*	−	28.73					
			(68.79)		(− 6.49)					r^2 = 0.9981; *F* = 4731.42
Private investment in machinery										
(5)	*PIMP*	=	0.32Δ*NOXNP*	+	0.11*PCPL*	−	0.72			
			(2.85)		(1.78)		(− 0.21)			r^2 = 0.939; *F* = 61.61
(5a)	*PIMP*	=	0.82Δ*M1P*	+	0.25Δ*NOXNP*	+	4.88			
			(3.56)		(3.21)		(1.99)			r^2 = 0.967; *F* = 117.74
(5b)	*PIMP*	=	0.16Δ*NOXNP*	+	0.53Δ*M2P*	+	4.86			
			(2.26)		(5.04)		(2.55)			r^2 = 0.980; *F* = 192.64
Private investment in construction										
(6)	*PICP*	=	0.16Δ*GENANP*	+	0.52Δ*PCP*	+	18.27			
			(9.19)		(7.14)		(11.61)			r^2 = 0.965; *F* = 111.49
(6a)	*PICP*	=	0.06Δ*GENANP*	+	0.14*PCP*	+	13.13			
			(2.84)		(8.55)		(7.28)			r^2 = 0.975; *F* = 154.69
(6b)	*PICP*	=	0.06*GENANP*	+	0.13Δ*NOXNP*	+	14.52			
			(4.06)		(3.52)		(3.98)			r^2 = 0.983; *F* = 229.61
Government consumption										
(7)	*GCNP*	=	0.15*GREVP*	+	0.80*GREVPL*	−	6.19			
			(8.54)		(17.53)		(− 1.73)			r^2 = 0.998; *F* = 2098.63
(7a)	*GCNP*	=	1.06*GREVPL*	+	0.36*GDEFP*	−	6.87			
			(24.62)		(3.68)		(− 0.93)			r^2 = 0.992; *F* = 553.81
Government investment in machinery										
(8)	*GZMP*	=	− 0.28*GDEFP*	+	0.11*GREUP*	−	2.18			
			(− 4.39)		(10.18)		(− 0.66)			r^2 = 0.951; *F* = 78.05

Table 2. Iran: macroeconomic simulation model (two-stage least sources estimates) (continued).

Equation								
Government investment in construction								
(9)	*GICP*	=	− 0.66*GDEFP*	+	0.24*GREUP*	−	1.87	
			(− 5.00)		(10.80)		(− 0.28)	r^2 = 0.954
								F = 83.40
Total government investment								
(10)	*GTTP*	=	0.31*GREVPL*	+	0.43*GREVPL2*	−	8.48	
			(1.75)		(1.83)		(− 1.25)	r^2 = 0.970
								F = 127.92
Imports								
(11)	*ZNP*	=	0.72*PCP*	+	0.07*EXW*	+	8.39	
			(4.57)		(2.80)		(0.64)	r^2 = 0.970
								F = 128.59
(11a)	*ZNP*	=	0.86*PCP*	+	0.28*BMFAP*	+	6.63	
			(12.23)		(5.10)		(0.78)	r^2 = 0.986
								F = 281.10
(11b)	*ZNP*	=	1.49*PIMP*	+	2.86*GIMP*	+	63.48*DFWPA*	
			(5.47)		(9.06)		(1.85)	r^2 = 0.9953
								F = 556.98
Exports (deflated with export deflator)								
(12)	*EXR*	=	0.42*VAG*	+	1.31*EUVP*	−	7.44	
			(35.44)		(7.73)		(− 0.74)	r^2 = 0.998
								F = 1994.38
(12a)	*EXR*	=	0.26*VAD*	+	6.83*RUVICA*	−	249.35	
			(8.28)		(7.21)		(− 5.70)	r^2 = 0.997
								F = 1764.29
Exports (deflated with world price deflator)								
(13)	*EXW*	=	0.95*VAD*	+	2.97*EUVP*	−	17.14	
			(35.54)		(7.77)		(− 0.75)	r^2 = 0.998
								F = 2007.05
(13a)	*EXW*	=	0.60*VAO*	+	15.53*EUVICA*	−	567.29	
			(8.29)		(7.22)		(− 5.72)	r^2 = 0.998
								F = 1768.33
(13b)	*EXW*	=	12.83*EUVICA*	+	0.66*EXPTNA*	−	453.87	
			(6.12)		(9.74)		(− 4.75)	r^2 =
								F =
Exports (current price)								
(14)	*EXPTNA*	=	1.04*VAO*	+	15.94			
			(86.69)		(2.75)			r^2 = 0.9988
								F = 7515.16
(14a)	*EXPTNA*	=	3.95*EUVCP*	+	14.22*CPP*	−	280.66	
			(4.95)		(13.85)		(− 5.94)	r^2 =
								F =
Private sector credit from banking system								
(15)	*PCP*	=	0.88*BMRMP*	+	0.47*PCPL*	+	1.98	
			(2.91)		(1.96)		(0.44)	r^2 = 0.994
								F = 612.70
(15a)	*PCP*	=	0.39Δ*NONXNP*	+	0.97*PCPL*	+	0.68	
			(2.48)		(10.92)		(0.14)	r^2 = 0.992
								F = 525.35
PC (current price)								
(16)	*PC*	=	2.70*BMRMP*	−	58.60			
			(26.41)		(− 5.76)			r^2 = 0.986
								F = 697.54
(16a)	*PC*	=	1.12*BMRM*	+	0.15*NOXNP*	−	38.22	
			(16.75)		(5.16)		(− 4.23)	r^2 = 0.999
								F = 4232.63
Balance of payments current account (current price)								
(17)	*CURE*	=	0.41*EXW*	−	13.74			
			(26.63)		(− 1.39)			r^2 = 0.986
								F = 708.99

Table 2. Iran: macroeconomic simulation model (two-stage least sources estimates) (continued).

Equation								
CUREP (constant price)								
(18)	*CUREP*	=	0.47*EXWL*	−	23.82			
			(27.56)		(− 3.69)			r^2 = 0.987
								F = 759.72
Government oil revenues								
(19)	*OREVP*	=	1.11*EUVP*	+	7.06*CPP*	−	103.46	
			(15.28)		(80.55)		(23.31)	r^2 = 0.999
								F = 6688.93
(19a)	*OREVP*	=	0.46*VAO*	+	5.38			
			(22.99)		(0.56)			r^2 = 0.983
								F = 528.33
(19b)	*OREVP*	=	5.86*CPP*	+	13.82*CPPL*	−	214.08	
			(7.73)		(2.86)		(− 3.58)	r^2 = 0.9911
								F = 444.23
Government non-oil revenues								
(20)	*NOREVP*	=	0.17*PENANP*	−	16.38			
			(17.23)		(− 3.27)			r^2 = 0.971
								F = 297.03
(20a)	*NOREVP*	=	0.20*PENANP*	−	1.50*INFC*	−	27.74	
			(15.08)		(− 3.12)		(− 5.45)	r^2 = 0.987
								F = 298.55
Government deficit								
(21)	*GDEFP*	=	1.07*CUREP*	+	0.68*GREUP*	−	12.40	
			(− 5.10)		(− 6.34)		(− 1.61)	r^2 = 0.926
								F = 50.28
Bank Markazi revenue money								
(22)	*BMRM* (current price)							
	BMRM	=	0.64*GENANP*	−	9.99			
			(17.21)		(− 1.07)			r^2 = 0.971
								F = 296.08
Bank Markazi reserve money (constant price)								
(23)	*BMRMP*	=	0.04*EXR*	+	0.27*PENANP*	−	45.71	
							(− 4.80)	r^2 =
								F =
Bank Markazi net foreign assets								
(24)	*BMRMFAP*	=	0.560*REUP*	−	0.227*NP*	+	8.91	
			(14.89)		(− 2.54)		(1.05)	r^2 = 0.990
								F = 411.68
Supply of narrow money (current price)								
(25)	*M*1	=	1.09*BMRM*	+	16.15			
			(65.26)		(6.31)			r^2 = 0.998
								F = 4258.5
Supply of broad money (current price)								
(26)	*M*2	=	2.34*BMRM*	−	4.72			
			(55.40)		(− 0.73)			r^2 = 0.997
								F = 3069.47
Demand for narrow money								
(27)	*M*1*P*	=	0.22*NOXNP*	+	1.70*INFC*	−	17.09	
			(12.87)		(2.15)		(− 2.44)	r^2 = 0.991
								F = 442.44
Demand for broad money								
(28)	*M2P*	=	0.49*NOXNP*	+	3.33*INFC*	−	84.75	
			(27.98)		(4.00)		(− 11.51)	r^2 = 0.998
								F = 2014.39
Bank Markazi currency in circulation								
(29)	*BMCP*	=	2.22*BMCPL*	+	0.05*GENANP*	−	16.83	
			(2.08)		(1.64)		(2.85)	r^2 = 0.833
								F = 22.46

Table 2. Iran: macroeconomic simulation model (two-stage least sources estimates) (continued).

Equation								
Value added by oil sector								
(30)	*VAO*	=	14.23*CPP*	+ 3.29*EUVCP*	− 263.02			
			(15.14)	(4.51)	(− 6.09)			r^2 = 0.986
								F = 273.39
(30a)	*VAO*	=	3.91*CPP*	+ 2.06*VAOL*	− 136.83			
			(1.92)	(6.61)	(− 7.46)			r^2 = 0.992
								F = 501.79
Wholesale price index								
(31)	*WPI*	=	193.82*EXCESSA*	+ 0.06*M2L*	+ 66.08			
			(3.17)	(2.16)	(6.94)			r^2 = 0.987
								F = 342.70
(31a)	*WPI*	=	183.11*EXCESSA*	+ 0.13*M1L*	+ 65.39			
			(2.95)	(2.30)	(7.53)			r^2 = 0.988
								F = 359.08
Consumer price index								
(32)	*CPI*	=	87.92*EXCESSD*	+ 0.21*M1L*	+ 101.75			
			(2.79)	(7.12)	(87.50)			r^2 = 0.994
								F = 729.60
(32a)	*CPI*	=	0.07*M2L*	+ 0.69*EUVICA*	+ 81.09			
			(4.69)	(4.22)	(14.08)			r^2 = 0.995
								F = 960.92
(32b)	*CPI*	=	0.07*M2L*	+ 1.18*EUVICAL*	+ 59.45			
			(4.61)	(4.74)	(5.98)			r^2 = 0.996
								F = 1085.03
Wholesale price inflation								
(33)	*INFW*	=	0.19*GM2L*	+ 0.33*GM2L2*	+ 0.35*WINF*	− 6.54		
			(2.51)	(2.97)	(4.06)	(− 4.08)		r^2 = 0.903
								F = 31.78
Consumer price inflation								
(34)	*INFC*	=	17.94*EXCESSD*	+ 105.74 *EXCESSDL*	+ 0.18*WINF*	− 1.18		
			(2.65)	(12.42)	(2.11)	(− 1.40)		r^2 = 0.995
								F = 71.14
Excess demand (M1/NOXNP)								
(35)	*EXCESSA*	=	0.00078*M2L*	− 0.0003*NOXNPL*	+ 0.22			
			(7.76)	(− 3.65)	(11.23)			r^2 = 0.984
								F = 267.43
Excess demand (/M2/NOXNP)								
(36)	*EXCESSD*	=	0.0012Δ*M1*	+ 0.00028Δ *GENANP*	+ 0.00067Δ*PCP*	+ 0.026		
			(10.52)	(2.40)	(4.34)	(4.02)		r^2 = 0.995
								F = 478.83
Agriculture sector output								
(37)	*AGP*	=	0.097*NOXNP*	+ 68.81				
			(4.58)	(5.53)				r^2 = 0.678
								F = 21.02
Manufacturing sector output								
(38)	*MANP*	=	0.23*NOXUP*	− 25.94				
			(31.36)	(− 6.14)				r^2 = 0.989
								F = 983.71
Construction sector value added								
(39)	*CONP*	=	0.038*NOXNP*	+ 8.09				
			(3.96)	(1.46)				r^2 = 0.610
								F = 15.66
Value added by water and power sectors								
(40)	*WPP*	=	0.046*NOXNP*	− 10.63				
			(31.50)	(− 12.55)				r^2 = 0.9900
								F = 992.31

Table 2. Iran: macroeconomic simulation model (two-stage least sources estimates) (continued).

Equation					
Value added in transport and communications sectors					
(41)	*TCP*	= 0.065*NOXNP* +	8.12		
		(16.58)	(3.52)	r^2 = 0.965	
				F = 275.04	
Value added in trade sector					
(42)	*TP*	= 0.086*NOXNP* +	2.23		
		(9.71)	(0.43)	r^2 = 0.904	
				F = 94.24	
Value added by ownership of dwellings					
(43)	*ODP*	= 0.052*NOXNP* +	5.37		
		(13.35)	(2.38)	r^2 = 0.947	
				F = 178.35	
Value added by private services					
(44)	*PRIVP*	= 0.068*NOXNP* −	6.12		
		(12.24)	(− 1.88)	r^2 = 0.937	
				F = 149.84	
Value added by public services					
(45)	*PUBP*	= 0.20*NOXNP* −	33.79		
		(15.17)	(− 4.36)	r^2 = 0.958	
				F = 229.98	
Incremental capital–output ratio					
(46)	*ICOR*	= 14.82*GNOXNP* +	4.04		
		(− 2.88)	(7.93)	r^2 = 0.455	
				F = 8.35	

Note: See text for description of symbols.

private credit would have been sufficient in obtaining considerably higher rates of real non-oil *GDP* than was actually obtained.

(ii) The fall in government investment in machinery was not excessive in the high *NOXNP* target case (optimal II), averaging 24.17% per year increase (1971–77) versus the historical rate of 25.67%. However, in reducing non-oil *GDP* from 1800.0 in 1977 to 1650.0 would require a drastic fall in government investment in machinery (real growth falling from 24.17% to 5.38%) and not an appreciable reduction in inflation, 10.00% to 9.77%.

(iii) Private credit had to bear most of the burden in controlling inflation, falling from the actual annual rate of growth of 17.87% to 7.67% and 11.82% for the 1650.0 *NOXNP* and 1800.0 *NOXNP*, respectively. The fall in growth was needed largely to control the inflation associated with these rates.

(iv) The overall importance of the private and government sectors was not altered in moving from 1453.8 to 1650.0 and 1800.0 *NOXNP* in 1977 with the actual increase in real private expenditure (*PENANP*) 15.28%, falling to 15.24% or increasing to 17.27% in optimal I and optimal II, respectively, whereas the increase in real government expenditure (*GENANP*) fell from an actual 23.71% to 21.83% in optimal I or rose to 23.52% in optimal II.

(v) While the overall levels of government and private sector expenditures are not altered significantly in the optimal paths over their actual values, their compositions are with the most significant being a shift away from private construction (*PICP*) to private consumption (*PCNP*) with real private construction falling from an actual 28.76% over the 1971–77 period to 3.78% and 7.04%, respectively, in optimal I and optimal II and *PCNP* increasing from a historical 12.32% to 15.63% in optimal I and 17.67% in optimal II.

More generally (and despite the size and simplicity of the econometric model), the experimental results do provide at least some crude lessons for stabilization policy in Iran. For example, when government consumption and construction expenditures were permitted to remain at their desired levels, private credit had to be cut back fairly drastically to contain inflation within a range of 10% per annum. Apparently the lag between money and prices that

Table 3. Iran: actual and optimal growth rates, 1971–77 (billion Rials).

	Actual 1971	Actual 1972	Simulated 1972	Actual 1977	Optimal I 1977	Optimal II 1977	Average annual growth 1971–77 Actual	Optimal I	Optimal II
NOXNP	635.8	735.7	710.6	1453.8	1650.0	1800.0	14.78	17.23	18.94
PCNP	440.6	504.6	496.0	884.9	1053.0	1169.9	12.32	15.63	17.67
PICP	38.1	48.7	43.9	173.6	47.6	57.3	28.76	3.78	7.04
PIMP	34.0	57.1	47.9	144.6	142.1	151.3	27.29	26.92	28.25
PCP	159.0	195.4	195.4	426.3	247.7	310.8	17.87	7.67	11.82
PITP	72.1	105.8	91.8	318.1	189.8	208.6	28.07	17.51	19.37
GIMP	29.8	25.8	25.9	117.4	40.8	109.2	25.67	5.38	24.17
GICP	66.1	66.1	79.5	314.7	314.7	314.7	29.70	29.70	29.70
GCNP	147.2	185.6	185.6	439.8	439.8	439.8	20.01	20.01	20.01
GITP	96.0	105.3	105.3	432.1	355.5	355.5	28.49	24.38	24.38
ZNP	159.4	195.6	190.5	600.9	529.6	578.2	24.25	22.15	23.96
SNP	164.7	214.7	221.2	865.4	865.3	865.3	31.85	31.85	31.85
TINP	168.4	211.1	197.2	750.3	545.3	632.5	28.28	21.63	24.68
EXR	192.5	226.3	253.8	732.8	854.8	854.8	24.96	28.21	28.21
EXW	437.4	514.2	522.3	1665.3	1866.8	1866.8	24.96	27.36	27.36
EXPTNA	240.6	308.5	366.8	1815.2	1804.7	1804.7	40.05	39.91	39.91
RP	439.2	517.5	503.6	2016.7	1475.1	1691.2	28.92	22.38	25.20
M1P	120.4	157.5	145.2	273.6	347.6	390.1	14.66	19.33	21.64
M2P	240.6	307.6	284.1	618.7	745.3	842.1	17.05	20.74	23.22
BMRMP	102.0			300.2	286.9	317.5	19.71	18.81	20.83
BMFAP	37.5			369.7	367.1	358.1	46.43	46.26	45.66
M1	154.93	214.33	207.7	668.0	554.4	601.4	27.58	23.67	25.36
INFC	4.24	6.47	5.70	27.31	8.07	8.59	—	—	—
PENANP	512.7	610.2	596.2	1203.1	1200.8	1333.3	15.28	15.24	17.27
GENANP	243.2	290.9	290.9	871.9	795.3	863.7	23.71	21.83	23.52
OREUP	120.7	130.9	138.6	613.4	836.9	836.9	31.12	38.09	38.09
NOREUP	80.5	90.8	88.0	219.7	209.7	236.3	18.21	17.30	19.60
GDEFP	–25.6	–41.9	–54.7	–159.1	–260.0	–241.1	35.59	47.16	45.32
GREUP	201.2	221.9	226.7	833.1	1046.5	1073.2	26.72	31.63	32.18
CPI	136.07	144.88	144.29	290.36	238.09	241.06	13.47	9.77	10.00

Note: See text for description of symbols.

existed in Iran at this time required policy instruments to be applied in strong bursts.

One might argue that lags were a distinguishing factor between monetary and fiscal policy and should in practice have determined the proper mix and timing of the two. In actuality monetary and fiscal policy in Iran were probably not substitutes, but complements, and should have been used in combination.

In any case it is clear why the authorities were frustrated in stabilizing the price level. In addition to being related to liquidity, inflation was also affected by world price trends. There were therefore natural limits below which further reductions in the inflation rate were not productive.

The results indicate that the practical design of stabilization policies during this time were critically dependent on the proper phasing of monetary and fiscal policy. It was clearly not just a question of how much monetary restraint or fiscal austerity were desirable but more importantly at what point in time each should have been altered. Fiscal policy appears to have operated with short lags and monetary policy over a longer period of time.

Finally, it appears therefore that from what we know of the mechanisms at work in the Iranian economy involving the relationships between credit, money, and the balance of payments, that although having only a limited number of tools at its disposal, Bank Markazi, through monitoring reserves and controlling private credit, was able to perform all of the functions necessary for successful stabilization of the economy.

Conclusions

Even with the aid of econometric models in the early 1970s, policy formulation in Iran remained suboptimal. A major problem stemmed from the fact that all of the models developed for policy-making were structured for the analysis of medium- and long-term problems. Apparently, no short-run models existed that systematically accounted for the incorporated financial flows stemming from the monetary impacts of alternative budgets on inflation.

The absence of a systematic treatment of the inflationary impacts of domestic expenditures was undoubtedly a holdover from the 1960s when inflation was not a real problem and growth was the primary consideration of policy-makers. At that time, the government's efforts were largely concentrated on obtaining the financial resources with which to implement their development plans. Foreign exchange was relatively scarce, and thus Iran's international credit worthiness did not permit significant capital inflows on a scale capable of creating serious inflationary pressures.

Because the country's decision-makers apparently did not have a clear view of the inflationary and balance of payments impacts of the government budget, stabilization policy after the oil price increases continued to be conducted on largely an *ad hoc* intuitive basis as in the past.

The second problem facing decision-makers (even after the development of the large-scale economy-wide models) was the fact that the means of determining what policy was in some sense 'best' remained unclear.[13] Part of the problem was that of quantifying the objectives of the policy in a precise way (assuming that the objectives of the policy were indeed known). Because the Plan Organization models never incorporated an objective function to be maximized, policy-makers and other officials were forced (again on an *ad hoc* basis) to choose among a number of feasible scenarios without the knowledge of how and if each of these options could be improved upon. While computer simulations were in fact often used to learn more about the dynamic behaviour of the economy and to study the effects of different policies on its key variables, they represented an extremely inefficient effort in this regard.

In retrospect it is clear that after 1973 Iranian planners should have focused on shorter-run stabilization issues and contributed more actively to the budgetary decision-making process. This is true with regard not only to the longer-run supply effects of the government's programmes but also the shorter-run demand and stabilization difficulties posed by the rapidly accelerating level of expenditures.

[13]A discussion of this problem for the USA is given in L. R. Klein [5].

Secondly, the planners should have clarified more precisely the goals of the regime and together with the constraints facing the economy developed an objective cost or utility function for the near term.

Finally, given that both monetary and fiscal actions had a fairly strong impact on the major macroeconomic aggregates, there should have been much closer cooperation between the Bank Markazi and Treasury. As noted earlier, too much pressure too late was placed on the central bank to control inflation.

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