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Optimality of Monetary and Fiscal Policies in Iran: An Application of the Stochastic Optimal Control Theory

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Abstract

This paper analyzes the optimality of macroeconomic policies in Iran during the third five year development plan (2000-2004). For this purpose, we develop and use a macro econometric model for Iran. We determine optimal monetary and fiscal policies as solutions of optimum control problems with a quadratic objective function and a macro econometric model as a constraint. The results show that, the optimal values of macroeconomic policies have deviation from those proposed in third development plan. So that, deviations in the variables of government current expenditures, government tax revenues and government oil revenues are low and in variables of government capital expenditures and money stock as monetary policy are high.

Keywords: Optimal monetary and fiscal policies, stochastic optimal control theory, Iran economy.

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1- Introduction

The great depression through 1929–32 questioned the fundamentals of classical economics in wage-price flexibility, full employment, inherent equilibrium and rendered policy-making decisions unnecessary. Keynes attempted to justify government intervention in economy by introducing general disequilibrium theory. However, according to ‘‘all or nothing demand for money theory’’, he recommended fiscal policies to improve economic situations. After three decades, Fridman [1] showed how monetary policies lead to incentive investment and output in the short run. Some economists such as Tobin [2], Peterson and Lerner [3] pointed out that increasing money supply lead to increase in the capital accumulation and economic growth. Robert Mundell [4–6] dealt with the impact of fiscal and monetary policies in an open economy. He showed that different exchange rate regimes as well as the degree of capital mobility influence the effectiveness of macroeconomic policies. In a new classical school framework, unanticipated policies will have real effects, even in a very short period. Some developments in macroeconomics such as central bank independence (CBI) as well as inflation targeting (IT) indicate that the conduct of economy is unavailable. Thus, until initially of 2000 decade intermediation and policy-making in economy, voided from visionary and tentative battles. However, due to the trade-off between the effects of macroeconomic policies, these policies must be optimal and coordinated. So, especially in middle of 1990 the more of studies related to economic policies, used the optimization models and on the basis of the recent developments in macroeconomics, determining optimal monetary and fiscal policies which those policies satisfy macro goals is of crucial significance in economic planning. During the last few decades, Iran’s economy has witnessed high inflation and unemployment, budget deficit and high fluctuations in economic growth. Combating the above problems has been one of the important goals of policy making in Iran . Therefore , at the end of the imposed war , the Iranian first, second and third development plan were launched . Due to lack of coordinating between the macroeconomic policies introduced some of the main important goals proposed in these plans were not accomplished.

In this paper, the stochastic optimal control algorithm "OPTCON" is used to calculate optimal fiscal and monetary policies for the third five years Iranian development plan (2000-2004). Also, the paper examines the effects of these policies on macroeconomics indexes, includes: economic growth, inflation rate, unemployment rate and the ratio of government budget deficit to GDP during the third economic plan (2000-2004).

To do so, first we have defined a dynamic nonlinear system of macroeconomic equation and calculated the effects of optimal macroeconomic policies during the third development plan on macroeconomic variables using by the optimal control algorithm "OPTCON". Finally we will compare the optimal monetary and fiscal policies and their effects on goal variables with whatever passed in objectivity and ending paper with concluding remarks.

2- The "Stochastic Optimal Control" Algorithm

We want to calculate time paths of macroeconomic policy instruments that are "optimal" according to an objective function of a hypothetical policy-maker for Iran. To obtain optimal economic policies, we apply the OPTCON algorithm, developed by Matulka and Neck [7] and Matulka, Neck and Karbuz [8]. OPTCON determines approximate solutions of optimum control problems with a quadratic objective function and a nonlinear multivariable model. The objective function has to be quadratic in the deviations of the state and control variables from their desired values. The objective function has the following form:

$$L = \frac{1}{2}\sum_{t=1}^{T}\begin{bmatrix} x_t - \overline{x}_t \\ u_t - \overline{u}_t \end{bmatrix}' . W_t . \begin{bmatrix} x_t - \overline{x}_t \\ u_t - \overline{u}_t \end{bmatrix}, \tag{1}$$

$$W_t = \alpha^{t-1} . W, \; t = 1,..., T \tag{2}$$

Where x_t denotes the vector of state variables, u_t denotes the vector of control variables, $\overline{x}_t$ and $\overline{u}_t$ are the desired values of the state and control variables, W_t is the matrix containing the weights given to the deviations of

the state and control variables from their desired values and α denotes the discount factor. The dynamic system has to be given in a state space representation. Although OPTCON can solve deterministic and stochastic optimum control problems, here we confine ourselves to deterministic optimizations only.

So the dynamic nonlinear system is defined as:

$$x_t = f\ (x_{t-1}, u_t, \hat{\theta}, z_t) + \varepsilon_t \qquad (3)$$

In this system $\hat{\theta}, z_t$ and ε_t are the estimated value of the stochastic parameter vector, exogenous variables vector and the matrix of the additive system noise respectively. As inputs of the algorithm, the user has to supply the followings: the system function, the initial value of the state vector, a tentative path for the control variables, the expected value and the covariance matrix of the stochastic parameter vector, the covariance matrix of the additive system noise, the weight matrices of the objective function, the planning horizon, the desired paths for the state and control variables, the tentative path for control and state variables and a discount rate of the objective function. This algorithm is executable in ‘‘GAUSS’’ programming system [9]. Therefore, we used the "OPTCON" algorithm in order to determine the optimality of monetary and fiscal policies for Iran during the third development plan. The constraint to the optimization problem is given by a macro econometric model of the Iran’s economy. The list of variables is shown in appendix. The dynamic nonlinear systems include two category of equation: behavioral equations and identities. Table 1 shows the estimated behavioral equations and identities. The behavioral equations of the model were estimated by 2SLS using time series data for the period 1959-1999 [10]. So, full covariance matrix of the parameters is available. Here, only a limited stochastic optimization can be run with the estimated standard errors of the coefficient and the standard errors of the regression equations taken into account [11, 12]. The correlations between model parameters being neglected.

This model is basically of a Keynesian type and includes goods, services market and money market from the aggregate demand side, labor market and exchange rate market. Also, whole of the behavioral equations

contain the lagged dependent variables, reflecting adaptive expectations and costs of adjustment[1]. The goods and services market contain private consumption function, private investment function, government consumption function, government investment function, imports and exports functions. Also, the function of the nominal long-term interest rate have written as a reduced form of money market equilibrium. The labor market is modeled by specifying a wag rate equation and an employment equation, whereas the labor supply is exogenous to the model and finally the money supply is on active policy instrument in the case of flexible exchange rate regime.

In order to determine the quantities of optimal fiscal and monetary policies, three "main" and one "minor" objectives are considered. The "main" objective variables are economic growth rate, inflation rate and unemployment rate. Also, the minor objective is ratio of budget deficit to GDP. The values of target for these variables are the values, which targeted in Iran's third development plan. So, the planning horizon for the control experiments has been chosen as 2000 to 2004. After several experiments sensitivity analysis we hare chosen a discount factor $\alpha = 1$, the weight 1000 for main and 1 for minor objective variables[2]. Then, in the weight matrix of the objective function, off diagonal elements were all set equal to zero. In addition, all state variables in the model not mentioned above, got the weight zero.

1- Regarding to dynamic system equation (epically lagged dependent variables) and also up dating the estimated parameters in iteration process , stationary test and logarithmic transformation don't come necessity .For more information , see : R. Neck, J. Matulka (1992)

2- For more information about constructing objective function and its coefficients, see: Neck Reinhard and Sohbet Karbuz (1995).

Table 1.The system equations:

Number	Equations
	Behavioral:
1	CPR =0.75CPR (-1) +0.16YDR-212.10LTIRN
	t: (9.08) (2.97) (-0.35) DW = 1.98 R^{-2} = %95
2	INVPR = 0.77INVPR (-1) + 0.33 INVGR+ 0.32ΔDEMAND
	t: (5.43) (1.39) (4.81) DW = 1.99 R^{-2} = %59
3	CGR = 0.18CGR (-1) + 0.79GCER
	t: (1.86) (8.12) DW = 1.81 R^{-2} = %90
4	INVGR = 0.35INVGR (-1) + 0.04GDPR + 0.55GMER
	t: (3.27) (3.61) (5.38) DW = 1.97 R^{-2} = %71
5	NOILEXPR = 0.89NOILEXPR (-1) + 0.31ERR
	t: (8.97) (1.48) DW = 2.04 R^{-2} = %72
6	IMPR = 0.68IMPR (-1) + 0.24GDPR - 2.51ERR - 347.62RPIMP
	t: (4.35) (1.71) (-1.20) (-1.09) DW = 1.30 R^{-2} = %57
7	AGWN = 0.75AGWN (-1) + 2.99CPI + 0.0016PROD
	t: (7.78) (5.19) (1.05) DW = 1.67 R^{-2} = %99
8	CPI = 0.55CPI (-1) + 0.0048ERN + 0.19IMPDEF
	t: (2.02) (5.04) (1.85) DW = 1.47 R^{-2} = %99
9	EMP = 1.004EMP (-1) + 0.0013GDPR - 0.04AGWR
	t: (69.26) (1.87) (-0.61) DW = 1.74 R^{-2} = %99
10	LTIRN = 0.96 LTIRN (-1) + 0.0000049 GDPR – 0.0000019 M2R
	t: (9.11) (0.61) (-0.20) DW = 1.84 R^{-2} = %99
11	ERN = 0.47ERN (-1) + 0.01M2N + 2088.97 PRICERATIO
	t: (1.89) (1.21) (1.42) DW = 1.52 R^{-2} = %98
12	GDPDEF = 0.99CPI
	t: (72.66) DW = 1.87 R^{-2} = %99

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Table 1: (continued)

Number	Equations
	Identities:
13	GDPR = CPR+CGR+INVR+EXPR-IMPR
14	INVR = INVPR+INVGR
15	EXPR = OILEXPR+NOILEXPR
16	DEMAND = GDPR+IMPR
17	GDPN = (GDPR*GDPDEF)/100
18	GRGDPR = ((GDPR-GDPR (-1))/GDPR (-1))*100
19	GRCPI = ((CPI-CPI (-1))/CPI (-1))*100
20	AGWR = (AGWN/CPI)*100
21	M2R = (M2N/CPI)*100
22	PROD = (GDPR/EMP)*100
23	ERR = (CPIF/CPI)*ERN
24	PRICERATIO = CPI/CPIF
25	UN = LFORCE-EMP
26	UR = (UN/LFORCE)*100
27	GCER = (GCEN/GDPDEF)*100
28	GMER = (GMEN/GDPDEF)*100
29	TAXRR = (TAXRN/GDPDEF)*100
30	DEF = GCEN+GMEN-TAXRN-OILRN-OTHERRN
31	DEFRATIO = (DEF/GDPN)*100
32	YDR = GDPR-TAXRR

***t, R^{-2} and D.W are the t statistic, adjusted R and Durbin Watson statistic respectively.**

3- The results of optimization

Table 2 shows the optimal monetary and fiscal policies. A comparison of the results show that, the optimal values of government current

expenditures are lower than those proposed in third development plan whereas the optimal values of government capital expenditures are greater than those realities on. The optimal values of government tax revenues in initial three years of plan are lower than those realities and in further tow years of plan greater than those realities on and the optimal values of government oil revenues in initial two years of plan are lower than those realities and in further three years of plan greater than those realities on. Also, the optimal values of money stock as monetary policy are lower than those realities in forth development plan.

Table 2: The values of optimal, third plan and reality control variables Milliard Rials

		2000	2001	2002	2003	2004
GCEN	Proposed in the plan	85082.3	98488.5	114907.7	136083.2	156481.2
	Optimal	70688.4	83901.0	109991.7	152318.5	221287.8
	Reality	82605.8	100918.2	147572.3	178255.2	231923.1
GCEN	Proposed in the plan	25906.3	31296.3	39123.3	49587.9	67123.0
	Optimal	50972.5	65037.6	85225.0	105822.0	123573.4
	Reality	22443.4	24379.5	54753.0	73799.7	72306.3
TAXRN	Proposed in the plan	32204.2	40060.3	49386.6	60130.1	72718.8
	Optimal	25813.5	33969.6	47880.2	67673.1	97901.8
	Reality	36585.2	41786.1	50141.1	65099.0	84421.1
OILRN	Proposed in the plan	56880.5	62298.9	70993.6	84822.0	99461.2
	Optimal	65412.0	74921.1	92354.6	117285.5	147498.7
	Reality	59794.2	72333.4	103101.6	129030.9	151413.0
M2N	Proposed in the plan	256931.0	303179.0	350778.0	400589.0	453066.0
	Optimal	241833.9	287522.6	335920.1	388796.5	446834.1
	Reality	249110.7	320958.3	417524.0	526596.4	685697.5

Source: authors calculations.

The study showed the optimal monetary and fiscal policies effects on the main and minor objective function variables under flexible exchange rate regime and the reality data of main and minor objective variables as in Table 3. Also, in order to more information about the proposed monetary and fiscal

policies in third plan effects on the main and minor objective variables, we used $MAPLE_{10}$ program for the simulation of the model. So, the comparison between the effects of the optimal macroeconomics policies on goal variables, show that using the optimal macroeconomics policies, without creating undesirable effects on inflation and unemployment rate and the ratio of budget deficit to GDP, was improving the economic growth rate and that was closed to third plan targets. Also, the results showed using the optimal macroeconomics policies obviation the fluctuations of the main and minor objective variables.

Table 3: The result of optimization

Percentage

		2000	**2001**	**2002**	**2003**	**2004**
GRGDPR	The third plan targets	4.5	5.5	6.5	6.7	6.8
	Simulation results	1.7	1.5	1.3	2.0	2.1
	Optimization results	4.5	5.5	6.5	6.7	6.8
	Reality results	5.0	3.3	7.6	6.8	4.8
GRCPI	The third plan targets	19.9	17.4	15.3	14.0	13.0
	Simulation results	12.6	14.7	15.6	15.7	15.4
	Optimization results	12.0	14.2	15.3	15.7	15.7
	Reality results	12.6	11.4	15.8	15.6	15.2
UR	The third plan targets	15.2	14.5	13.8	13.1	12.5
	Simulation results	13.6	14.0	14.4	14.9	15.4
	Optimization results	13.5	13.8	14.0	14.1	14.2
	Reality results	14.0	14.7	13.8	12.9	12.3
DEF%	The third plan targets	0.18	0.22	0.20	0.20	0.17
	Simulation results	0.19	0.22	0.22	0.23	0.22
	Optimization results	1.89	2.30	3.08	3.75	4.44
	Reality results	0.07	2.30	4.05	4.03	3.55

Source: authors calculations.

4- Concluding Remarks

In this paper we have tried to determine the optimal macroeconomic policies to achieve the major goals of the third five years Iranian development plan (2000–2004) this include economic growth rate, inflation rate, unemployment rate and the ratio of government budget deficit to GDP under flexible exchange rate regimes. To do so, first, we have defined a dynamic nonlinear system of macroeconomic equations and calculated the effects of macroeconomic policies imposed during the third development plan on the above mentioned macroeconomic variables using the simulation

technique. Then the optimal macroeconomic policies were calculated by the "OPTCON" algorithm in the programming language "GAUSS". An empirical optimization result show that the optimum monetary and fiscal policies could lead to a considerable stabilization of the time path of the rate of economic growth, without creating undesirable effects on inflation and unemployment rates and the ratio of budget deficit to GDP. Also, the results showed using the optimal macroeconomics policies reduce the fluctuations of the main and minor objective variables.

Appendix. List of variables

State (or endogenous) variables:

AGWN	Average gross wage rate per employee, nominal
AGWR	Average gross wage rate per employee, real
CGR	Government consumption, real
CPI	Consumer price index
CPR	Private consumption expenditures, real
DEF	Budget deficit, nominal
DEF%	Budget deficit as percentage of nominal GDP
DEMAND	Total final demand, real
EMP	Employment; 1,000 persons
ERN	Exchange rate, nominal (informal market)
ERR	Exchange rate, real
EXPR	Total export, real
GCER	Government current expenditure, real
GDPN	Gross domestic product, nominal
GDPR	Gross domestic product, real
GDPDEF	GDP deflator
GMER	Government capital expenditure, real
GRCPI	Annual growth rate of CPI (rate of inflation)
GRGDPR	Annual growth rate of real GDP
IMPR	Total imports, real
INVGR	Government investment, real
INVPR	Private investment, real
INVR	Total investment, real
LTIRN	Long-term interest rate, nominal
NOILEXPR	Non-oil export, real
M2R	Money stock M3, real
PRICERATIO	Ratio Iran CPI to USA CPI
PROD	Labor productivity
TAXRR	Government tax revenue, real
UN	Number of unemployed persons
UR	Unemployment rate, % of the labor force
YDR	Personal disposable income, real

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Appendix (continued)

Exogenous variables:

CPIUSA	USA CPI Consumer price index
IMPDEF	Import price level (import deflator)
LFORCE	Labor force; 1,000 persons
OILEXPR	Oil exports, real
OTHERRN	Government non-tax revenue, nominal

Control variable:

GCEN	Government currency expenditure, nominal
GMEN	Government capital expenditure, nominal
TAXRN	Government tax revenue, nominal
OILRN	Government oil revenue, nominal
M2N	Money stock M2, nominal

- **ERN data source : www.iran-economy.com**
- **AGWN data source: plan and budget organization . Different years.**

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