Estimation of Some Omani Macroeconomic Parameters – A Statistical Function Approach – Discussion

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ABSTRACT

The captioned article was earlier published in "Economic Horizons" volume 18, #72 – AH 1418 – 1997 (4) Pages (65-78). I had some concerns about the article regarding the methodology adopted for analysis in deriving the macroeconomic parameters and the derivation and interpretation of dynamic multipliers. The same data set was used for addressing these concerns.

The working paper demonstrated that in estimating model coefficients from aggregate data for macroeconomic purposes, system estimation and GLS methodology provided more robust estimates since there is gain in efficiency in the model coefficients which are more reliable for policy analysis.

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By

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1. Introduction

The captioned article was earlier published in "Economic Horizons" volume 18, No.72 – AH 1418 – 1997(4) (pages 65-78). The article was quite interesting as it shed insights succinctly on the following aspects of Omani economy:

(i) The parameters of marginal propensity to consume (MPC), marginal propensity to invest (MPI), and marginal propensity to import (MPM) derived from the static and dynamic models, and their relevance to future economic growth.

(ii) The role of imports in income generation of the economy, and

(iii) The derivation and implication of dynamic multiplier.

However, I have some concerns in the methodology adopted for the analysis in deriving the macroeconomic parameters, and the derivation & interpretation of dynamic multiplier. My concerns are mainly the following:

(a) Is the use of ordinary least square (OLS) regression model appropriate for equations in (4.6), (4.11) and (4.12) in the article, when one is talking about the economy as a whole?

(b) Is not the level of consumption, investments, and imports a system / joint decision process at the macro level?

(c) In the light of (b), is not the system equation or joint estimation system more appropriate methodology of estimation?

(d) Is the derivation and interpretation of dynamic multiplier the same as that of static multiplier? and

(e) Can one look at the impact of import on economy in isolation, without considering the international trade and rest of the world?

I have addressed these concerns in the present discussion. I have used the tables (2-2), (3-1), (3-2) and (4-1) for 25 years (1970-94) from the captioned article, for the estimation purposes and the data is reproduced in Table.1.

Table.1 Data of Omani Economy (Million Omani Riyals)

Year	Consumption	National Income	Invest-ments	Imports	% in National Income of: Imports	Net Exports
(t)	(C_t)	(Y_t)	(I_t)	(M_t)	(%)	(%)
1970	34.4	80.7	14.7	21.0	26.02	71.5
1971	47.4	100.0	35.6	40.2	40.20	42.1
1972	76.8	104.1	42.0	61.6	62.69	21.1
1973	103.6	127.5	44.4	80.9	63.45	16.8
1974	246.8	443.4	174.1	245.6	55.39	33.3
1975	344.1	590.1	258.0	367.1	62.20	20.7
1976	361.1	676.5	321.2	406.5	60.09	21.4
1977	426.9	745.5	310.8	417.0	55.90	19.1
1978	521.0	768.4	281.0	461.2	60.02	11.8
1979	592.1	1031.9	318.0	525.0	50.87	25.4
1980	1076.0	1851.5	465.7	598.2	26.52	28.2
1981	1247.0	2255.5	583.5	790.3	33.27	29.3
1982	1509.0	2375.6	706.7	926.5	39.00	16.7
1983	1582.0	2442.9	736.9	860.9	35.24	17.2
1984	1746.5	2696.7	913.2	949.2	35.20	14.4
1985	2065.8	3054.8	953.1	1088.9	35.65	14.3
1986	1949.0	2464.4	898.4	916.7	37.20	1.9
1987	1843.3	2727.6	564.3	700.7	25.69	23.6
1988	2135.8	2519.9	511.1	846.4	33.60	11.1
1989	2260.4	2826.6	444.2	867.9	30.70	18.6
1990	2625.5	3631.7	529.2	1030.9	28.40	24.7
1991	2880.0	3494.4	661.4	1228.1	35.10	10.8
1992	3210.2	3848.8	759.6	1449.2	37.70	11.7
1993	3238.0	3677.9	802.9	1581.2	42.90	6.9
1994	3186.3	3595.8	736.5	1505.3	41.90	11.8
Mean	1412.4	1781.5	482.7	718.7	42.20	20.9

2. Methodology

2.1 Model Specification (Seemingly Unrelated Regression Estimation (SURE)

I specify the model in the same way as those specified in equations (4.6), (4.11) & (4.12) in the article. But only thing is that, I use system specification using generalised least squares (GLS) method instead of OLS method. The system specification is as under:

C_t =f (Const, Y_{t-1}) + ε_{ct} (1) [refers to (4.6) in the journal article)

I_t =f (Const, Y_{t-1}) + ε_{it} (2) [refers to (4.11) in the journal article)

M_t =f (Const, Y_{t-1}) + ε_{mt} (3) [refers to (4.12) in the journal article)

Where, C = Consumption system;
I = Investment system;
M = Import system;
Y_{t-1} = One year lagged national income;
ε = The error terms in each equation; subscripts c, i and m on ε corresponds to systems of consumption, investment & import equations respectively;
t = Time subscript; t = 2, 3, ……….25.

There are two conditions under which, OLS is identical to GLS and therefore, there is nothing to be gained by treating the equations as a system (and the estimation method followed in the journal article is appropriate if these two conditions hold). The first condition is, when contemporaneous correlation is zero. This condition implies that in system equations (1), (2) and (3):

$$\sigma_{12} = \sigma_{13} = \sigma_{21} = \sigma_{23} = \sigma_{31} = \sigma_{32} = 0$$

This result is intuitively reasonable one since, it is the non-existence of these correlation in error terms across the equations that makes the three equations unrelated. The second condition is that explanatory (right hand side) variables are identical for all the equations.

The reason for specifying the models as in (1) to (3) is based on the premise that, error terms ε_{ct}, ε_{it}, ε_{mt} in each of these system equations are not independent. Firstly, disturbance ε_{ct} in (1) and ε_{it} in (2) are contemporaneously correlated i.e, covariance $(\varepsilon_{ct}, \varepsilon_{it}) = \sigma_{cit} \neq 0$. Secondly, disturbance ε_{it} in (2) and ε_{mt} in (3) are contemporaneously correlated i.e, covariance $(\varepsilon_{it}, \varepsilon_{mt}) = \sigma_{imt} \neq 0$. Thirdly, disturbance ε_{mt} in (3) and ε_{ct} in (1) are contemporaneously correlated i.e, covariance $(\varepsilon_{mt}, \varepsilon_{ct}) = \sigma_{mct} \neq 0$.

2.2 Contemporaneous correlation

Correlation between disturbances from different equations in a system at a given time is known as contemporaneous correlation. It is distinct from "Auto-correlation" which refers to correlation over time for the disturbances in a single equation. When contemporaneous correlation exists, it may be more efficient to estimate all equations in the system jointly using GLS method rather than to estimate each one using OLS method. The appropriate joint estimation technique is often known as Seemingly Unrelated Regression Estimation (SURE) [Judge et al p.442-451 [A-1].

2.3 Estimation procedure

The GLS estimator is the iterative Zellner procedure. Initially, least square estimates are obtained in each equation, and an estimate of disturbance variance covariance matrix is computed from OLS residuals. The GLS estimate is then obtained by stacking the equations. The estimated disturbance variance covariance matrix obtained at the GLS step is used to reenter the iteration to compute an updated parameter vector. This process is continued until the log-likelihood converges at the sixth significant digit which will usually be after 3 or 4 iterations. This is equivalent to maximum likelihood.

Since the log-likelihood function for the SURE model is globally concave, there is no question of uniqueness of the estimates, and the possibility of non-convergence is remote. It will arise at all if the data are extremely badly conditioned. (William H Greene page 188-189 [A-2].

2.4 Gain in Efficiency in GLS method over OLS method

GLS estimate has the lower variance than the OLS estimate, because, it takes into account the contemporaneous correlation between the disturbances in different equations. Since, a gain in efficiency can be achieved by combining a number of equations that, at first glance, seem unrelated, Zellner (1962) has given the equation the title of SURE [A-1 page 447].

3. Estimation Results using SURE (GLS) model

I used LIMDEP software version 5.1 developed by Greene [A-2] for my estimation purposes, on an IBM PC-586 system. The following tables provide variance covariance of error terms across equations (1) to (3) and the model coefficients and using SURE (GLS) method.

3.1 Discussion on contemporaneous correlation:

Table 3.1 The variance-covariance matrix of system error terms

	ε_{ct}	ε_{it}	ε_{mt}
ε_{ct}	44531.45		
ε_{it}	-16297.24	18766.85	
ε_{mt}	9872.28	4422.46	14850.76

Since variance-covariance matrix is symmetrical, only one half of the symmetrical portion is displayed in Table.3.1. From Table 3.1, the covariance of error terms imply that:

Covariance ($\varepsilon_{ct}, \varepsilon_{it}$) = σ_{cit} = -16297.24 $\neq 0$
Covariance ($\varepsilon_{ct}, \varepsilon_{mt}$) = $\sigma_{cm\,t}$ = 9872.28 $\neq 0$
Covariance ($\varepsilon_{mt}, \varepsilon_{it}$) = σ_{mit} = 4422.46 $\neq 0$

These results imply that, there exists contemporaneous correlation between error terms across system equations (1) to (3) and my first contention of error relation across system equations is justified.

3.2 System coefficients and gain in efficiency

The coefficient estimates (b, h, and m) are presented in Table 3.2 and are all highly significant (T-stats in parenthesis).

Table 3.2 System Coefficient Estimates

$$C_t = -36.9628 + 0.8136Y_{t-1}$$
$$\quad\quad -(0.52) \quad (5.06)$$

$$I_t = 136.3220 + 0.1944Y_{t-1}$$
$$\quad\quad (2.93) \quad (9.22)$$

$$M_t = 127.0390 + 0.3321Y_{t-1}$$
$$\quad\quad (3.07) \quad (17.71)$$

Table 3.3 shows the comparison of the coefficient estimates and their efficiency across the two methods (GLS and OLS). The results indicate that there is a gain in efficiency in the estimates (signified by higher T-statistics) in GLS estimation method than in OLS estimation method, implying greater stability of these coefficients. This further substantiates the merit of using system method of estimation than the OLS method.

Table 3.3 Comparison of System & OLS coefficients & efficiency

Coefficient estimates	GLS coefficients (System estimation)	OLS coefficients (OLS estimation)
MPC = b	0.8136 (25.06)	0.818 (22.76)
MPI = h	0.1936 (9.22)	0.106 (8.21)
MPM = m	0.3321 (17.71)	0.310 (15.19)

(Figures in parenthesis are T-statistics)

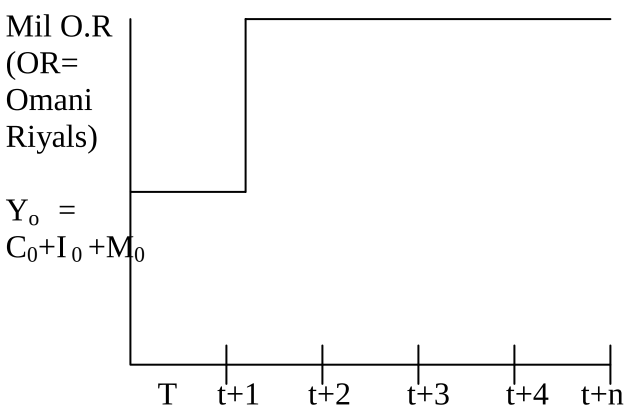
Index: MPC = Marginal Propensity to Consume.
MPI = Marginal Propensity to Invest.
MPM = Marginal Propensity to Import.

3.3 Dynamic and static multipliers

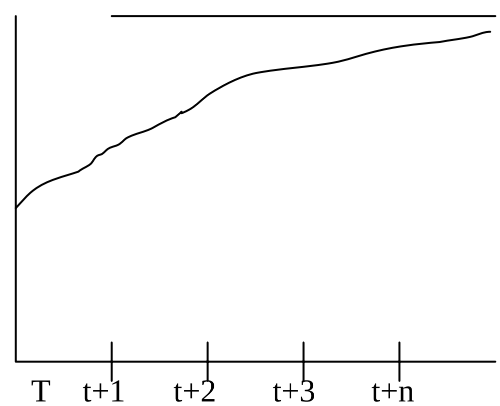
In dynamics, the focus is on time and therefore on the process of change. There must be a lag structure between a dependent and independent variable for there to be a "dynamic process of change" (what is the appropriate lag structure in the model is altogether a different question not addressed in the article). The static multiplier establishes the change in the level of income for a specified number of periods given no lag in induced investment, induced imports etc. On the other hand, the dynamic multiplier establishes the change in the level of income for a specified number of periods given a lag in induced investment, induced imports etc. From (4.5) on page 73 of the article, $k = 1 \div (1-b-h+m) = 1 \div [1-(b+h-m)]$. Let $\lambda = (b+h-m)$. The static multiplier is derived as $k_s = 1 \div (1-\lambda)$, k_s = static change in income. The dynamic multiplier process can be presented as a decreasing geometric series where change in income after n periods is $k_d = (1+\lambda+\lambda^2+\lambda^3+..+\lambda^n)$. The dimension of λ can be expanded to include other sectors in the economy like Export sector, Taxes, Government Transfer appropriately. The corresponding static and dynamic multipliers in both the methods of estimation (i.e., GLS and OLS) are as under:

Coefficient	GLS estimation	OLS estimation
Static multiplier$[1\div(1-\lambda)]$	3.080	2.590
Dynamic multiplier for		
1 period = $(1+\lambda)$	1.675	1.614
2 period = $(1+\lambda+\lambda^2)$	2.131	1.991
3 period = $(1+\lambda+\lambda^2+\lambda^3)$	2.439	2.222

The implication is that, in static form, the level of income reaches a new equilibrium position in the same period t+1 that, investment and import increased in t+1 for a given level of exports. On the other hand, in dynamic form, the income level moves closer to the level of static equilibrium, as the number of period t+n increases. This is represented graphically as below:



Static model (no lag structure)



Dynamic model (1-year lag structure

3.4 Impact of imports on national income

In the previous article (last paragraph on page 72), it is stated that, the value of imports once introduced into dynamic analysis, had lowered the multiplier from 3.56 to 2.53. I do not think that, this interpretation might be right. Because, while import represents a leakage, it has to be considered in an international perspective. The following illustration justifies my concern.

Suppose say, when Oman imports, it is buying goods from another country. We shall assume that these goods are paid for with Omani Riyals (O.R). The foreign exporting clients now own O.R currency and by assumption, do not use it to buy goods from Oman. That is, demand for Oman's goods has fallen since the foreign export clients have opted not to spend their export receipts in O.R from Oman. If the foreign exporters opt to spend their O.R from Oman, then exports from Oman increase and offsets the import leakage.

The level of exports and its behavioral impact on the national economy has so far not been introduced in the present analysis. Probably it is assumed that the level of exports is independent of changes in domestic level of income. Domestic exports could be related to domestic imports through changes in a second country's level of income. A linkage model of income level demonstrates that domestic imports affect the levels of domestic exports through a "feedback" effect.

Given, $C_t = C_0 + bY_t$; $I_t = I_0 + hY_t$; $M_t = M_0 + mY_t$; and $X = X_0$

(where X is domestic exports), equilibrium exists where:

$$Y = (C_0+I_0+X_0-M_0) \div [1-(b+h-m)] \qquad \text{(i)}$$

Assume that all of Oman's exports are sent to country B which represents rest of the world to Oman. Assume that B's imports from Oman can be represented by the linear function

$$H_R = H_0 + rY_R , \qquad \text{(ii)}$$

where, subscript $_R$ represents rest of the world-B, H_o represents exogenous imports of rest of the world-B from Oman, and r is rest of the world's (i.e., B's) marginal propensity to import from Oman. Since Oman is exporting to rest of the world-B,

$$X_0 = H_0 + rY_R \qquad \text{(iii).}$$

Substituting (iii) in (i) above,

$$Y = (C_0+I_0+H_0+ rY_R-M_0) \div [1-(b+h-m)] \qquad \text{(iv)}$$

The equilibrium equation in (iv) shows, ceteris paribus, the linkage of income in Oman to income in the rest of the world-B.

Now consider the changes in (iv). An increase in aggregate spending in Oman results in increased imports from rest of the world-B. Higher imports from B are, in effect, increased exports for B. As B's exports rise, so does its level of income. However a rise in B's income level, given the assumed marginal propensity to import from Oman, also increases B's imports from Oman., and therefore Oman's exports. Hence, an increase in aggregate spending in Oman raises both its level of imports and exports, the latter as a result of the feedback effect of Oman's increased imports.

The strength of the feedback effect depends upon the magnitude of B's marginal propensity to import (MPM) from Oman. If B's MPM from Oman is extremely small, the equilibrium equation for Oman is best presented by equation in (i) above, rather than the feedback model in (iv) above since the small value for h allows the term hY_R to be dropped from the model. A strong feedback effect shows how inflationary and deflationary conditions may spread through the economies of the world. Given a general condition of full employment and price stability, a substantial increase in aggregate spending in one country, ceteris paribus, would result in that country's inflation. Likewise, a substantial decrease in aggregate spending, ceteris paribus, would cause generally depressed economy in that country.

Table.1 shows that percentage of imports in national income averaged 42.2% between 1970-94. Net exports as percentage of national income averaged 20.9% between 1970-94, indicating that, Oman had balance of surplus in international trade. It is possible that, as the percentage of net exports was 20.9% of national income, the leakage effect of imports might have been offset by exports from Oman. This is not, however, justifiable at the moment since, export and import sector is not modeled in the article on the lines of equations (ii) to (iv) above. Availability of data about the rest of world's import from Oman and rest of world's income (whether in aggregate form or country-wise) could establish the direction of impact of Oman imports and exports on Omani economy through further research.

4. Conclusion

The discussion on the captioned article has demonstrated that:

(i) In estimating model coefficients from aggregate data for macroeconomic purposes, it would be advisable to use system estimation and GLS methodology than OLS methodology. The results would be more robust in GLS method since there is gain in efficiency in the model coefficients and, reliability on the coefficient estimates for policy analysis would be good.

(ii) The derivation and interpretation of static and dynamic multipliers is not the same. The dynamic multiplier follows a process of change in the level of income over a specified period of time. In dynamic form, the income level moves closer to the level of static equilibrium as the number of period t+n increases.

(iii) The impact of import and export on Oman's economy could be modeled in system context more realistically, when the data on rest of the world's income and imports from Oman are available.

A – References

[1] George G Judge, R. Carter Hill, William E. Griffiths, Helmut Lutkepohl, Tsoung-Chao Lee "Introduction to the Theory and Practice of Econometrics", John Wiley & sons, New York. 1988, [Pages 442-451.

[2] William H. Greene., LIMDEP (Limited Dependent Variable Models) version 5.1 (Revised August 1990), Econometric Software Inc, Box 3526, Church street station, New York, NY-10008-3526, [Pages 188-189].