CHAPTER 7

VECTOR AUTOREGRESSIVE MODEL

7.1 Vector Autoregressive Model

We have sought to enquire into the interrelationship between government expenditure & government revenue in all chosen countries by establishing a structural model of revenues and expenditures. For this purpose, we have applied the Vector Autoregession Model. This model has desirable property that it treats all variables symmetrically. In our analysis, we have taken two important macroeconomic variables, namely, government expenditure & government revenue. Both these variables are endogeneous in the VAR system.

The model of VAR for government expenditure & government revenue consists of the following equations.

$$\Delta R_t = c_1 + \sum_{i=1}^{k} a_{1i}\,\Delta R_{t-i} + \sum_{i=1}^{k} b_{1i}\,\Delta E_{t-i} + e_1 \ldots\ldots (8)$$

$$\Delta E_t = c_2 + \sum_{i=1}^{k} a_{2i}\,\Delta E_{t-i} + \sum_{i=1}^{k} b_{2i}\Delta R_{t-i} + e_2 \ldots\ldots\ldots (9)$$

where a_{1i}, b_{1i} and c_i are the parameters to be estimated. Here, E_t and R_t represent government expenditure and government revenue at time t respectively.E_{t-i} and R_{t-i} represent government expenditure and government revenue at time t- i, i=1,2,3,…, respectively. e_1 and e_2 are the stochastic error terms, called impulse or innovations or shocks in the VAR model.

These equations do not represent any joint relationship between E_t and R_t .These equations, therefore, represent seemingly unrelated regression SUR model. The estimation of the model considers and uses the contemporaneous Var-Covariace matrix(Ω) of the error terms involved such that Ω =Var-Cov(u,u) where Ω is a positive matrix.

Now, we report the Granger causality test results obtained by vector Auto Regression (VAR) for all sample countries. Due to the use of annual data, the lag order of 1, 2 1nd 3 years are estimated. Results are reported in the Tables 7.1, 7.2, 7.3 & 7.4.

Table 7.1 Granger Causality Test Results via VAR (Indonesia)

Lag length of VAR	Dependable Variable	Explantory variable	Coefficients	Standard Error	t- Statistics
VAR(1)	ΔE_t	Constant	0.098614	0.02432	4.055505
		ΔE_{t-1}	-0.095485	0.25734	-0.37105
		ΔR_{t-1}	-0.070541	0.28421	-0.24820
	R^2 = 0.04, $Adj.\ R^2$ = -0.01 $F-Stat$ = 0.77 ,$D-W\ Stat$ = 1.55 , LRR = 27.02 , AIC = −1.23SBC = −1.10				
	ΔR_t	Constant	0.106256	0.02281	4.65797
		ΔE_{t-1}	0.085905	0.24139	0.35589
		ΔR_{t-1}	-0.261694	0.266659	-0.98162
	R^2 = 0.05 $Adj.\ R^2$ = 0.01 ,$F-Stat$ = 1.02, $D-W\ Stat$ = 1.66, LRR=29.52 AIC=-1.36 ,SBC=-1.23				
VAR(2)	ΔE_t	Constant	0.063613	0.02899	2.19467
		ΔE_{t-1}	-0.046439	0.25409	-0.18277
		ΔE_{t-2}	-0.444070	0.25090	-1.76991
		ΔR_{t-1}	0.116400	0.27498	0.42330
		ΔR_{t-2}	0.612498	0.27759	**2.20651***
	R^2 = 013 $Adj.\ R^2$ = 0.02 ,$F-Stat$ = 1.25,$D-W\ Stat$ = 1.92 , LRR=29.91 ,AIC=-1.31,SBC= -1.09				
	ΔR_t	Constant	0.083610	0.02877	2.90575
		ΔE_{t-1}	0.095617	0.25224	0.37907
		ΔE_{t-2}	-0.331664	0.24907	-1.33160
		ΔR_{t-1}	-0.142265	0.27298	-0.52116
		ΔR_{t-2}	0.451672	0.27556	1.63908
	R^2 = 0.09 $Adj.\ R^2$ = −0.02, $F-Stat$ = 0.85,$D-W\ Stat$ = 2.01 , LRR= 30.19, AIC=-1.32, SBC=-1.11				
VAR(3)	ΔE_t	Constant	0.067481	0.03380	1.99670
		ΔE_{t-1}	-0.072788	0.28133	-0.25873
		ΔE_{t-2}	-0.488758	0.27411	-1.78309
		ΔE_{t-3}	-0.191561	0.27666	-0.69421
		ΔR_{t-1}	0.108222	0.28783	0.37600
		ΔR_{t-2}	0.639030	0.30032	**2.12783***
		ΔR_{t-3}	0.180363	0.31278	0.57664
	R^2 = 0.13 $Adj.\ R^2$ = 0.03, $F-Stat$ = 0.81,$D-W\ Stat$ = 1.92 ,LRR=28.94, AIC=-1.18, SBC=-0.86				
	ΔR_t	Constant	0.82578	0.33734	2.44822
		ΔE_{t-1}	0.117029	0.28077	0.41681
		ΔE_{t-2}	-0.352036	0.27357	-1.28683
		ΔE_{t-3}	0.014132	0.27611	0.05118
		ΔR_{t-1}	-0.153091	0.28726	-0.53293
		ΔR_{t-2}	0.434650	0.29973	1.45014
		ΔR_{t-3}	0.009695	0.31217	0.03106
	R^2 = 0.08 $Adj.\ R^2$ = 0.09, $F-Stat$ = 0.48, $D-W\ Stat$ = 1.93 LRR=29.01 AIC=-1.18, SBC=-0.88				

*denotes significance at 5% level. / Δ denotes first difference order.

7.2 Findings

It is observed from the Table 7.1 that in both revenue and expenditure equations with lag order 1 all the coefficients of first period lagged independent variables are insignificant at 5% level of significance. For lag order 2, in expenditure equation the first period lagged revenue is not significant at 5% level but second period lagged revenue i.e ΔR_{t-2} is significant at 5% level. In revenue equation all the coefficients of first and second period lagged independent variables are insignificant at 5% level of significance. In case of lag order 3 the coefficient of second period lagged revenue $i.e\ \Delta R_{t-2}$ is significant at 5% level in expenditure equation but all the coefficients of first, second and third period lagged independent variables are not significant at 5% level in revenue equation. Hence the Table 7.1 reports that revenue Granger causes expenditure suggesting tax-and- spend doctrine being followed in the country concerned.

Table 7.2: Granger Causality Test Results via VAR (Malaysia)

Lag length of VAR	Dependable Variable	Explantory variable	Coefficients	Standard Error	t- Statistics
VAR (1)	ΔE_t	Constant	0.047439	0.01605	2.95494
		ΔE_{t-1}	0.377791	0.17888	2.11195*
		ΔR_{t-1}	-0.084455	0.17717	-0.47670
	R^2 = 0.12 $Adj.\ R^2$ = 0.08 $F-Stat$ = 2.85 $D-W\ Stat$ = 1.92 LRR=51.30 AIC=-2.24, SBC=-2.21				
	ΔR_t	Constant	0.062643	0.01706	3.67257
		ΔE_{t-1}	0.167888	0.19006	0.88336
		ΔR_{t-1}	-0.081842	0.18823	-0.43479
	R^2 = 0.01, $Adj.\ R^2$ = −0.02 , $F-Stat$ = 0.40 ,$D-W\ Stat$ = 2.01, LRR=48.70, AIC= -2.12SBC=-2				
VAR(2)	ΔE_t	Constant	0.052334	0.01938	2.70041
		ΔE_{t-1}	0.421163	0.19961	2.10995*
		ΔE_{t-2}	-0.113825	0.19527	-0.58292
		ΔR_{t-1}	-0.099724	0.18793	-0.53066
		ΔR_{t-2}	0.017505	0.18410	0.09509
	R^2 = 01, $Adj.\ R^2$ = 0.02 , $F-Stati$ = 1.29 ,$D-W\ Stat$ = 2.01 LRR=49.88, AIC=-2.13 SBC=-1.93				
	ΔR_t	Constant	0.059937	0.02050	2.92319
		ΔE_{t-1}	0.120106	0.21119	0.56872
		ΔE_{t-2}	0.179361	0.20659	0.86819
		ΔR_{t-1}	-0.065787	0.19883	-0.33088
		ΔR_{t-2}	-0.108095	0.19478	-0.55496
	R^2 = 0.04, $Adj.\ R^2$ = −0.06, $F-Stat$ =0.38 ,$D-W\ Stat$ = 2.02 LRR=47.51 AIC=-2.02 SBC=-1.81				
VAR(3)	ΔE_t	Constant	0.061333	0.02238	2.74036
		ΔE_{t-1}	0.396715	0.20991	1.88994*
		ΔE_{t-2}	-0.036762	0.21836	-0.16836
		ΔE_{t-3}	-0.067341	0.20794	-0.32385
		ΔR_{t-1}	-0.080350	0.19871	-0.40436
		ΔR_{t-2}	0.015025	0.19353	0.07764
		ΔR_{t-3}	-0.109290	0.18998	-0.57527
	R^2 = 0.15, $Adj.\ R^2$ = 0.01 , $F-Stat$ = 1.02 ,$D-W\ Stat$ = 2.00 LRR=48.97, AIC= -2.04,SBC=-1.75				
	ΔR_t	Constant	0.067730	0.02351	2.88144
		ΔE_{t-1}	0.136291	0.22045	0.61824
		ΔE_{t-2}	0.202470	0.22933	0.88289
		ΔE_{t-3}	0.120170	0.21838	0.55028
		ΔR_{t-1}	-0.090642	0.20869	-0.43434
		ΔR_{t-2}	-0.095960	0.20325	-0.47213
		ΔR_{t-3}	-0.236462	0.19952	-1.18513
	R^2 = 0.08, $Adj.\ R^2$ = −0.07, $F-Stat$ = 0.53,$D-W\ Stat$ = 2.02 LRR=46.92, AIC= -1.94, SBC=-1.65				

*denotes significance at 5% level/ Δ denotes first difference order.

7.3 Findings

Table 7.2 reports that with lag order 1, all coefficients of first period lagged independent variables are not significant at 5% level in both revenue and expenditure equations. For lag order 2, first period lagged expenditure is significant at 5% level in expenditure equation. In revenue equation with lag order 2, all coefficients of first and second period lagged explantory variables are insignificant at 5% level. For lag order 3, all the coefficients of lagged independent variables in revenue equation are insignificant at 5% level but the coefficient of first period lagged expenditure in expenditure equation is significant at 5% level. So it is evident from the results that revenue decisions are made from expenditure decisions in Malaysia over the period of study. This outcome suggests that fiscal neutrality principle was followed in Malaysia over the period concerned.

Table 7.3: Granger Causality Test Results via VAR (Singapore)

Lag length of VAR	Dependable variable	**Explantory variable**	Coefficients	Standard Error	t-Statistics
VAR(1)	ΔE_t	Constant	0.045229	0.02332	1.93942
		ΔE_{t-1}	-0.071012	0.15492	-0.45839
		ΔR_{t-1}	0.361314	0.14090	2.56427*
	R^2 = 0.01, $Adj.\ R^2$ = −0.02 , $F-Stat$ = 0.40 ,$D-W\ Stat$ = 2.13 LRR=30.34 AIC=-1.36 SBC=-1.24				
	ΔR_t	Constant	0.067278	0.02716	2.47700
		ΔE_{t-1}	-0.124812	0.18043	-0.69176
		ΔR_{t-1}	0.335030	0.16411	2.04155*
	R^2 = 0.10, $Adj.\ R^2$ = 0.05 , $F-Stat$ = 2.12 ,$D-W\ Stat$ = 2.05 LRR= 24.24, AIC=-1.06, SBC=-0.93				
VAR(2)	ΔE_t	Constant	0.048598	0.02648	1.83526
		ΔE_{t-1}	-0.145995	0.16875	-0.86514
		ΔE_{t-2}	-0.137010	0.15934	-0.85984
		ΔR_{t-1}	0.316264	0.14711	2.14979*
		ΔR_{t-2}	0.204767	0.16241	1.26078
	R^2 = 0.19, $Adj.\ R^2$ = 0.10 , $F-Stat$ = 2.07 ,$D-W\ Stat$ = 1.92 LRR=30.16 AIC=-1.29 SBC=-1.07				
VAR(2)	ΔR_t	Constant	0.071969	0.03085	2.33257
		ΔE_{t-1}	-0.194975	0.19662	-0.99162
		ΔE_{t-2}	-0.175944	0.18566	-0.94766
		ΔR_{t-1}	0.291847	0.17141	1.70261
		ΔR_{t-2}	0.181101	0.18924	0.95700
	R^2 = 0.15, $Adj.\ R^2$ = 0.03 , $F-Stat$ = 1.38 ,$D-W\ Stat$ = 1.99 LRR=24.20 AIC= -.98,SBC=-0.77				
		Constant	0.053298	0.30044	1.75068
		ΔE_{t-1}	-0.117877	0.17782	-0.66363

VAR(3)	ΔE_t	ΔE_{t-2}	-0.062316	0.17804	-0.35002
		ΔE_{t-3}	-0.004131	0.16779	-0.02462
		ΔR_{t-1}	0.342812	0.15393	2.22709*
		ΔR_{t-2}	0.223163	0.16723	1.33445
		ΔR_{t-3}	-0.175770	0.17231	-1.02006
	R^2 = 0.23, $Adj.\ R^2$ = 0.08 , $F-Stat$ = 1.59 ,$D-W\ Stat$ = 1.70 LRR=29.75 AIC=-1.19, SBC=--0.89				
	ΔR_t	Constant	0.072413	0.03604	2.00944
		ΔE_{t-1}	-0.223266	0.21025	-1.06190
		ΔE_{t-2}	-0.229718	0.21074	-1.09005
		ΔE_{t-3}	-0.033665	0.19861	-0.16950
		ΔR_{t-1}	0.277318	0.18220	1.52203
		ΔR_{t-2}	0.169384	0.19795	0.85569
		ΔR_{t-3}	0.131742	0.20396	0.64591
	R^2 = 0.15, $Adj.\ R^2$ = −0.01 , $F-Stat$ = 0.91,$D-W\ Stat$ = 1.99, LRR= 23.34 AIC=-0.86 SBC=-0.55				

*denotes significance at 5% level / Δ denotes first difference order.

7.4 Findings

The results in Table 7.3 indicate that in expenditure equation with lag order 1, the coefficient of first period lagged revenue is significant at 5% level and in revenue equation, the coefficient of first period lagged revenue is significant at 5% level. So the results indicate that revenue causes expenditure in Singapore during the period of study. For lag order 2 all coefficients of lagged independent variables in revenue equation are insignificant at 5%level. In expenditure equation the coefficient of first period lagged revenue is significant at 5% level. The result implies that there is a one way direction of causal link running from revenue to expenditure in Singapore during the study period. In case of lag order 3, in expenditure equation the coefficient of first period lagged revenue is significant at 5% level and in revenue equation all coefficients of lagged independent variables are insignificant at 5% level. The results indicate that tax-and-spend principle was followed in Singapore during the period of study.

Table 7.4: Granger Causality Test Results via VAR (Thailand)

Lag length of VAR	Dependable variable	**Explantory variable**	Coefficients	Standard Error	t-Statistics
VAR(1)	ΔE_t	Constant	0.052526	0.01633	3.21619
		ΔE_{t-1}	0.008014	0.14970	0.05353
		ΔR_{t-1}	0.107078	0.16013	0.66869
	R^2 = 0.01, $Adj.\ R^2$ = −0.02 , $F-Stat$ = 0.27,$D-W\ Stat$ = 1.93 LRR=60.09, AIC=-2.11, SBC=-1.96				
		Constant	0.055018	0.01563	3.51938

	ΔR_t	ΔE_{t-1}	0.191879	0.15328	1.25185
		ΔR_{t-1}	0.009337	0.14329	0.06516
	R^2 = 0.03, $Adj.\ R^2$ = −0.01 , $F-Stat$ = 0.93 ,$D-W\ Stat$ = 1.89 LRR=58.18, AIC=-2.04 SBC=-1.89				
VAR(2)	ΔE_t	Constant	0.050321	0.01708	2.94688
		ΔE_{t-1}	-0.057772	0.13577	-0.42551
		ΔE_{t-2}	-0.038775	0.13508	-0.28706
		ΔR_{t-1}	0.106052	0.14857	0.71383
		ΔR_{t-2}	0.204699	0.15150	1.35111
	R^2 = 0.05, $Adj.R^2$ = −0.03 , $F-Stat$ = 0.74,$D-W\ Stati$ = 2.08 LRR= 61.38, AIC=-2.16, SBC=-1.98				
	ΔR_t	Constant	0.058750	0.01840	3.19317
		ΔE_{t-1}	-0.014764	0.14629	-0.10093
		ΔE_{t-2}	-0.064883	0.14554	-0.44580
		ΔR_{t-1}	0.204093	0.16007	1.27499
		ΔR_{t-2}	0.041656	0.16324	0.25518
	R^2 = 0.04, $Adj.\ R^2$ = −0.03 , $F-Stat$ = 0.54 ,$D-W\ Stat$ = 1.89 LRR=57.50 AIC=-2.01 SBC=-1.83				
VAR(3)	ΔE_t	Constant	0.037935	0.01965	1.93932
		ΔE_{t-1}	-0.110424	0.15333	-0.72018
		ΔE_{t-2}	-0.039616	0.13626	-029073
		ΔE_{t-3}	0.048140	0.13513	0.35624
		ΔR_{t-1}	0.130549	0.14910	0.,87560
		ΔR_{t-2}	0.138544	0.15731	0.88069
		ΔR_{t-3}	0.235078	0.15532	1.51349
	R^2 = 0.12, $Adj.\ R^2$ = −0.03 , $F-Stat$ = 1.02 ,$D-W\ Stat$ = 1.83 LRR=61.49, AIC=-2.13 SBC=-1.87				
	ΔR_t	Constant	0.053272	0.02171	2.45353
		ΔE_{t-1}	0.022386	0.17019	0.13154
		ΔE_{t-2}	-0.055565	0.15125	-0.36738
		ΔE_{t-3}	0.074029	0.14999	0.49356
		ΔR_{t-1}	0.211059	0.16549	1.27535
		ΔR_{t-2}	0.032355	0.17461	0.18530
		ΔR_{t-3}	-0.036605	0.17240	-0.21233
	R^2 = 0.05, $Adj.\ R^2$ = −0.07 , $F-Stat$ = 0.40,$D-W\ Stat$ = 1.80 LRR=56.17, AIC=-1.92, SBC=-1.66				

*denotes significance at 5% level./ Δ denotes first difference order.

7.5 Findings

It is observed from Table 7.4 that in both revenue and expenditure equation with three different lag orders 1, 2 and 3 all coefficients of lagged independent variables are not significant at 5% level. The results imply that there is no causality link between revenue and expenditure in Thailand during the period of study. This outcome suggests that fiscal neutrality principle was followed in Thailand over the period concerned.

7.6 Summary of the Findings in section 7.2-7.5

All the empirical findings suggest that unidirectional causality running from revenue to expenditure exists in Indonesia and Singapore over the period of study and there is no evidence in support of the causality link in any direction between government expenditure and government revenue for Malaysia and Thailand over the period of study. This implies that revenue consideration was the main guiding factor behind the formation of expenditure profile in Indonesia and Singapore during the period of study. However, in case of Malaysia and Thailand government takes the decision of revenue and expenditure independently for preparing budget over the period of study.

In order to confirm the Granger causality link between revenue and expenditure on the basis of VECM and VAR model the standard Granger Causality Test have been performed on the basis of F-Statistics. Table 7.5 reports the results of Granger Causality Test.

Table-7.5: Results of Standard Granger Causality Test

Lag Length	1		2		3		
Null Hypothesis	F-Statistics	Probability	F-Statistics	Probability	F-Statistics	Probability	Decision
Indonesia							
ΔE *does not Granger cause* ΔR	0.13	0.72	1.07	0.35	0.67	.57	Accepted
ΔR *does not Granger cause* ΔE	0.06	0.80	2.43	**0.10***	1.51	.23	Rejected
Malaysia							
ΔE *does not Granger cause* ΔR	0.78	0.38	0.74	0.48	0.78	0.51	Accepted
ΔR *does not Granger cause* ΔE	0.22	0.63	0.14	0.86	0.15	0.92	Accepted
Singapore							
ΔE *does not Granger cause* ΔR	0.67	0.57	0.87	0.42	0.67	0.57	Accepted
ΔR *does not Granger cause* ΔE	2.89	**0.05***	3.95	**0.02***	2.89	**0.05***	Rejected
Thailand							
ΔE *does not Granger cause* ΔR	0.01	0.95	0.10	0.90	1.70	0.18	Accepted
ΔR *does not Granger cause* ΔE	0.44	0.50	1.54	0.24	0.13	0.94	Accepted

* denotes rejection of null hypothesis.

7.7 Findings

It is evident from the Table 7.5 that there is no causal relationship between government revenue and government expenditure in Malaysia and Thailand over the period of study which confirms our findings as reported from VAR and also VECM. However it is clear from the table 7.5 that principle of tax- and- spend was persistent for Indonesia and Singapore over the chosen period and the finding reinforces our results obtained from VAR and also VECM. Therefore, it may be held that fiscal neutrality principle did exist in Malaysia and Thailand and Tax-and- Spend Principle held good in Indonesia and Singapore over the respective periods of study.