CHAPTER – VII

TWIN DEFICITS IN NEPAL – CAUSALITY TESTS

7.1 Introduction

The disagreement of propositions[14] between Fisher (1926) and Phillips (1958) concerned to the appropriate direction of causation between inflation and unemployment (Fisher believed that '*causation runs from price inflation to unemployment*' and Phillips believed that '*causation runs from unemployment to wage inflation*') has led the foundation for causality test historically.

Fisher-Phillips dichotomy tells only two types of causation; however, direction of causation would have broadly five theoretical possibilities as presented below. Let Y_t be the Trade Deficit (TD) and X_t be the Budget Deficit (BD) under bi-variate postulates, the possible directions of casualty would be,

(i) $Yt \Rightarrow Xt$

(ii) $Xt \Rightarrow Yt$

(iii) $Yt \not\Rightarrow Xt$

(iv) $Xt \not\Rightarrow Yt$

(v) $Xt \Leftrightarrow Yt$

The symbols, $\Rightarrow$ implies one-way causation; $\not\Rightarrow$ implies no causation and $\Leftrightarrow$ implies mutual causations.

[14] See: Patterson K. (2000), "An Introduction to Applied Econometric – A Time Series Approach" Palgrave, NY, 2002 Reprint, Indian Edition, pp 518 - 551.

7.2 Grounds for Testing the Granger Causality in the Study

The estimated 'Error Correction Model' presented in Chapter - VI showed that, in the short-run Trade Deficit (TD) is Granger-caused by Budget Deficit (BD) while BD is not Granger-caused by TD. By the theoretical deductions discussed in section 5.1, it is possible to TD Granger-cause BD or 'no causation' at all or prevalence of possibility of 'bi-directional causation' too. So, we have decided to go for the 'Granger Causality Test' in its original form following the methodology presented below.

7.3 Granger-Causation Tests: Methodology

For the sake of simplicity, let γ_{1t} and γ_{2t} be the two variables under study. Along this course, the focal idea (hypothesis) is that γ_{1t} is not Granger-caused by γ_{2t} if the optimal predictor of γ_{1t} does not use information from γ_{2t}. While applying this idea, the predictor is usually restricted to be an optimal 'linear' predictor and optimality is defined as minimizing the mean square error (MSE) of the h-step predictor of γ_{1t}.

In order to be more specific, let γ_{1t} and γ_{2t} have vector autoregressive representation (VAR) in which γ_{1t} depends upon its own lags and lags of γ_{2t} and symmetrically γ_{2t} depends upon its own lags and lags of γ_{1t}.

Let us put the aforesaid VAR specification as following:

$$\gamma_{1t} = \mu_{10} + \pi_{t11.1}\,\gamma_{1t-1} + \cdots + \pi_{t11.p}\,\gamma_{1t-p} + \pi_{t12.1}\,\gamma_{2t-1} + \cdots + \pi_{t12.p}\,\gamma_{2t-p} + \varepsilon_{1t} \qquad (7.1)$$

$$\gamma_{2t} = \mu_{20} + \pi_{t21.1}\,\gamma_{1t-1} + \cdots + \pi_{t21.p}\,\gamma_{1t-p} + \pi_{t22.1}\,\gamma_{2t-1} + \cdots + \pi_{t22.p}\,\gamma_{2t-p} + \varepsilon_{2t} \qquad (7.2)$$

Here, first subscript denotes the variable and the second subscript denotes the observation index. This representation is bi-variate p^{th} order VAR.

Since we are having of a system of two equations (7.1) and (7.2), the errors may be contemporaneously correlated. Therefore, any shock to one of the equations would have 'ripple effect' on the other equation.

For specifications of the ε_{it}, $i = 1, 2$; is assumed to have an innovation with zero mean, constant variance, and no serial correlation, that is $E\{\varepsilon_{it}\} = 0$; $E\{\varepsilon^2_{it}\} = \sigma_i^2$ for $i = 1, 2$ and $E\{\varepsilon_{it}\ \varepsilon_{is}\} = 0$ for $t \neq s$ and $i = 1, 2$. Again it is also assumed that $E\{\varepsilon_{1t}\ \varepsilon_{2s}\} = 0$ for $t \neq s$ for no serial correlation. Additionally, the 'ripple effect' is captured by the covariance between ε_{1t} and ε_{2t}, denoted σ_{12}, which is assumed to be constant.

Along this course, for all t, the error variance matrix for the VAR with p lags will be,

$$\Omega(\varepsilon, p) \equiv E\begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix}\begin{pmatrix} \varepsilon_{1t} & \varepsilon_{2t} \end{pmatrix} = \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{bmatrix} \tag{7.3}$$

The equations (6.1) and (6.2), they may be replaced with the following matrix form:

$$\begin{pmatrix} \gamma_{1t} \\ \gamma_{2t} \end{pmatrix} = \begin{pmatrix} \mu_{10} \\ \mu_{20} \end{pmatrix} + \begin{bmatrix} \pi_{11.1} & \pi_{12.1} \\ \pi_{21.1} & \pi_{22.1} \end{bmatrix}\begin{pmatrix} \gamma_{1t-1} \\ \gamma_{2t-1} \end{pmatrix} + \dots + \begin{bmatrix} \pi_{11.p} & \pi_{12.p} \\ \pi_{21.p} & \pi_{22.p} \end{bmatrix}\begin{pmatrix} \gamma_{1t-p} \\ \gamma_{2t-p} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} \tag{7.4}$$

Now again, a third subscript is necessary on the coefficients to make a distinction of lag length which runs from 1 lag through p lags. In that case, it may be written as,

$$\gamma_t = \mu + \Pi_1\gamma_{t-1} + \dots + \Pi_p\gamma_{t-p} + \varepsilon_t \tag{7.5}$$

where, $\gamma_t' = (\gamma_{2t}, \gamma_{2t}), \mu' = (\mu_{10}, \mu_{20}), \varepsilon_t' = (\varepsilon_{1t}, \varepsilon_{2t})$ and Π_i are *2X2* matrices defined in response to equation (7.4).

7.4 Estimable Models for Granger Causality

Pursuing the methodology developed for Granger Causality Test in the section 7.3, we have developed 'causality equations' as presented below:

$$\Delta TD_t = \alpha_1 + \beta_1 \Delta TD_{t-1} + \gamma_1 \Delta BD_{t-1} + \gamma_2 \Delta BD_{t-2} + \gamma_3 \Delta BD_{t-3} + u_t \quad (7.6)$$

$$\Delta BD_t = \alpha_2 + \beta_2 \Delta BD_{t-1} + \theta_1 \Delta TD_{t-1} + \theta_2 \Delta TD_{t-2} + \theta_3 \Delta TD_{t-3} + w_t \quad (7.7)$$

7.5 Test Results of the Estimated Models for Granger Causality Test

We have obtained test results from the estimation of the models (7.6) and (7.7) which are being presented through the Tables 7.1 and 7.2:

Table - 7.1

Results of the Estimation of the Causality Equation (7.6)

$$\Delta TD_t = \alpha_1 + \beta_1 \Delta TD_{t-1} + \gamma_1 \Delta BD_{t-1} + \gamma_2 \Delta BD_{t-2} + \gamma_3 \Delta BD_{t-3} + u_t$$

Dependent Variable: DTD_REAL			**Sample (adjusted): 1968 2004**	
Included observations: 37 after adjusting endpoints				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-827.7407	376.4408	-2.198860	0.0352
DTD_REAL(-1)	-0.213085	0.184320	-1.156059	0.2562
DBD_REAL(-1)	-0.429874	0.498753	-0.861897	0.3952
DBD_REAL(-2)	-0.662719	0.526301	-1.259200	0.2171
DBD_REAL(-3)	-0.904591	0.512940	-1.763542	0.0874
R-squared	0.117538	Mean dependent var		-494.7297
Adjusted R-squared	0.007231	S.D. dependent var		2039.838
S.E. of regression	2032.450	Akaike info criterion		18.19696
Sum squared resid	1.32E+08	Schwarz criterion		18.41465
Log likelihood	-331.6438	F-statistic		1.065550
Durbin-Watson stat	1.906190	Prob(F-statistic)		0.389600

Table - 7.2

Results the Estimation of the Causality of Equation (7.7)

$$\Delta BD_t = \alpha_2 + \beta_2 \Delta BD_{t-1} + \theta_1 \Delta TD_{t-1} + \theta_2 \Delta TD_{t-2} + \theta_3 \Delta TD_{t-3} + w_t$$

Dependent Variable: DBD_REAL			**Sample (adjusted): 1968 2004**	
Included observations: 37 after adjusting endpoints				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-82.78322	135.9543	-0.608905	0.5469
DBD_REAL(-1)	-0.263712	0.183926	-1.433799	0.1613
DTD_REAL(-1)	0.007264	0.067752	0.107218	0.9153
DTD_REAL(-2)	0.080552	0.064637	1.246207	0.2217
DTD_REAL(-3)	-0.023496	0.066998	-0.350706	0.7281
R-squared	0.119479	Mean dependent var		-92.86486
Adjusted R-squared	0.009413	S.D. dependent var		768.0508
S.E. of regression	764.4273	Akaike info criterion		16.24122
Sum squared resid	18699170	Schwarz criterion		16.45891
Log likelihood	-295.4626	F-statistic		1.085525
Durbin-Watson stat	1.970702	Prob(F-statistic)		0.380171

7.6 Correlogram of the Residuals of the Estimated Models

We have obtained correlograms of the residuals (RES_1 and RES_2) of both the models (7.6 and 7.7) designed for Granger Causality test. The AC and PAC plots of the respective models are being presented through the following figures (Figs 7.1 and 7.2):

Figure - 7.1

Correlogram of Residual ($\hat{u}_t$) of Equation 7.6

RESI-1 of ($\Delta TD_t = \alpha_1 + \beta_1 \Delta TD_{t-1} + \gamma_1 \Delta BD_{t-1} + \gamma_2 \Delta BD_{t-2} + \gamma_3 \Delta BD_{t-3} + u_t$)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.039	0.039	0.0616	0.804
		2	0.070	0.068	0.2614	0.877
		3	0.093	0.088	0.6277	0.890
		4	-0.370	-0.387	6.6258	0.157
		5	-0.267	-0.290	9.8395	0.080
		6	0.093	0.195	10.240	0.115
		7	-0.139	-0.004	11.166	0.132
		8	0.105	-0.022	11.717	0.164
		9	0.211	0.001	14.001	0.122
		10	-0.105	-0.103	14.591	0.148
		11	0.039	0.019	14.675	0.198
		12	-0.006	-0.022	14.677	0.260
		13	-0.146	-0.004	15.952	0.252
		14	-0.009	-0.051	15.958	0.316
		15	-0.060	-0.142	16.193	0.369
		16	-0.042	0.021	16.316	0.431

Figure - 7.2

Correlogram of Residual ($\hat{w}_t$) of Equation 7.7

RESI-2 of ($\Delta BD_t = \alpha_2 + \beta_2 \Delta BD_{t-1} + \theta_1 \Delta TD_{t-1} + \theta_2 \Delta TD_{t-2} + \theta_3 \Delta TD_{t-3} + w_t$)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.012	0.012	0.0058	0.940
		2	0.011	0.010	0.0104	0.995
		3	-0.105	-0.106	0.4824	0.923
		4	-0.123	-0.122	1.1440	0.887
		5	-0.135	-0.134	1.9629	0.854
		6	0.088	0.081	2.3206	0.888
		7	0.050	0.029	2.4417	0.931
		8	-0.001	-0.046	2.4418	0.964
		9	0.176	0.168	4.0430	0.909
		10	-0.049	-0.041	4.1739	0.939
		11	-0.121	-0.106	4.9808	0.932
		12	-0.050	-0.017	5.1229	0.954
		13	0.040	0.066	5.2191	0.970
		14	-0.256	-0.268	9.3301	0.809
		15	0.081	0.017	9.7555	0.835
		16	0.015	0.005	9.7720	0.878

7.7 Findings from the Test Results and Correlograms of $\hat{u}_t$ and $\hat{w}_t$ of the Estimated Models

The Tables 7.1 and 7.2 and the correlogram (Figures 7.1 and 7.2) give forth the following findings:

(i) The residual datasets for $\hat{u}_t$ and $\hat{w}_t$ display no significant spike in the corresponding ACF at the first lag.

(ii) The corresponding $PACF_S$ are free from any significant spike at the first lag for the residuals $\hat{u}_t$ and $\hat{w}_t$. These confirm the stationarity of datasets for $\hat{u}_t$ and $\hat{w}_t$ of the equations 7.6 and 7.7.

(iii) In case of equation 7.6, $\hat{\gamma}_1$ and $\hat{\gamma}_2$ and $\hat{\beta}_1$ are insignificant though the coefficient of ΔBD_{t-3} (i.e. value of $\hat{\gamma}_3$) is significant at 10% level of significance. It indicates that BD_t Granger causes TD_t.

(iv) In case of equation 7.7, $\hat{\beta}_2$, $\hat{\theta}_1$, $\hat{\theta}_2$, $\hat{\theta}_3$ are insignificant even at 10% level. These indicate that TD_t does not Granger causes BD_t.

7.8 Conventional Granger Causality Tests

Conventional Granger Causality Test tells more about the causal relationships between trade deficit and budget deficit.

The estimable models for Granger Causality test, (reproduced from Chapter III) are being presented as following.

$$BD_t = \sum_{j=1}^{m} a_j TDt_{-j} + \sum_{j=1}^{m} b_j BD_{t-j} + \varepsilon_t \qquad (3.31)$$

$$TD_t = \sum_{j=1}^{m} a_j BD_{t-j} + \sum_{j=1}^{m} b_j TD_{t-j} + \eta_t \qquad (3.32)$$

Test results derived from the equations (3.31 and 3.32) are being presented in following table (Table - 7.3).

Table - 7.3

Results of Conventional Granger Causality Tests

Null Hypothesis	Observations	lags	F-statistics	Probability
TD_t does not Granger Cause BD_t	40	1	2.12568	0.15329
BD_t does not Granger Cause TD_t			3.75896*	0.06018
TD_t does not Granger Cause BD_t	39	2	0.44748	0.64294
BD_t does not Granger Cause TD_t			2.35569	0.11012
TD_t does not Granger Cause BD_t	38	3	0.80406	0.50119
BD_t does not Granger Cause TD_t			2.20002	0.10791
TD_t does not Granger Cause BD_t	37	4	0.64129	0.63751
BD_t does not Granger Cause TD_t			4.88646***	0.00408
TD_t does not Granger Cause BD_t	36	5	0.35137	0.87647
BD_t does not Granger Cause TD_t			3.77817**	0.01099

*, **, *** Indicates statistical significance at the 10%, 5% and 1% level respectively.

Source: Author's calculations based on data from various issues of International Financial Statistics, IMF.

7.9 Findings from the Conventional Granger Causality Test

From the Conventional Granger Causality tests, give forth the following observations:

(i) The F-statistics and its corresponding value of probability suggest that ***'TD does not Granger cause BD'*** hypothesis has been accepted in all lag values (up to 5 lags) for the real trade deficit (TD_t) and real budget deficit (BD_t). It now clearly hints out that the ***real budget deficit does not Granger cause real budget deficit.***

(ii) However, F-statistics have been found significant at first, fourth and fifth lag values at the level of 10%, 1% and 5% level of significance respectively of real budget deficit indicating ***unidirectional causality*** from budget to trade deficit.

7.10 Summary of Findings

This chapter is devoted to identify the direction of causality of the model variables concerned. The summary of findings is being presented belows:

(i) Trade Deficit has been found 'not to Granger Cause' Budget Deficit in the Nepalese economy over the period of study.

(ii) Budget Deficit, on the other hand, has been found to 'Granger Cause' the Trade Deficit in this economy.

Consequently, the ***'Unidirectional Causality'*** *is found to run from the 'Budget Deficit' to 'Trade Deficit'. However, Budget Deficit has been found to be 'exogenous' in the system. This also confirms our finding in Chapter VI.*

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