

TWIN DEFICITS PHENOMENON IN MALDIVES -AN ECONOMETRIC ENQUIRY

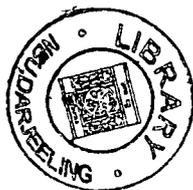
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Twin Deficits phenomenon has received greater attention during the 1980s, 1990s and early 2000s in macroeconomic literature. Econometric verification of this problem with the help of latest methodology has not been found on Maldivian economy. This research is an attempt in this direction. This is expected to provide valuable policy prescriptions and an addition to a stock of knowledge about the Maldivian Economy.

Initial birth of an idea of doing research in this area goes to respected supervisor Professor Chandan Kumar Mukhopadhyay. I would like to express my deep sense of gratitude and my respectful pronam to Professor Chandan Kumar Mukhopadhyay, Ph.D (Illinois, USA) of the Department of Economics, North Bengal University. I thank God, for giving me an opportunity for doing research under such a great academic personality and great human being with magnificent magnanimity. The present work would have never been complete without his able guidance, valuable suggestions, advice and encouragements. He regularly inspired me during the course of my present study and went through each and every step of the present work and suggested many improvements despite the heavy pressure of his academic and personal research involvements. I not only got the chances of receiving academic insights from him but also learnt how a sensitive person can think for the weaker and poorer sections of the society. I also learnt how self-esteem is essential for accelerating the pace of self-confidence. I am inspired with his advice "No one comes to the earth with complete knowledge, One acquires it through relentless effort and dedication".

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CHAPTER-I

INTRODUCTION

1.1 Twin Deficits and Twin Deficit Hypothesis

The macroeconomic structure of trading economies and the evolution of the ideas of the economists about it since 1971 constitute fascinating topic of interest to a researcher who seeks to know whether events shape ideas or ideas modify the course of events. The period since 1970s in economic history is made colorful by the growth of unprecedented events and subsequent development of important innovative ideas. The events which took place in this period are perplexing and enormously important for international economic community. The ideas too changed markedly in the past decades. The focus of analysis has changed. The validity of some of the underlying assumptions of the prevalent models has been questioned. Some well-known theories have been subject to skepticism. New assumptions have been introduced. The Macroeconomic structures of trading economies have been re-examined.

The most important events in the history of international economics during 1970's is the breakdown of '*fixed exchange rate*' system and the adoption of '*flexible exchange rate*' system instead. It is significant because it spelled the end of the spirit of '*Bretton Woods System*' as incorporated in the IMF Chapter. With the adoption of flexible exchange rate system since 1970s, another important event emerged. This is known as the '*Twin deficits Phenomenon*' in economic literature.

The phenomenon of '*Twin Deficits*' is a recent development in macroeconomic structure of trading economies. Its origin dates back to 1980's when *flexible exchange rate* virtually replaced the system of *fixed exchange rate*. The simultaneous upsurge of the *budget deficit* and *trade (current account) deficit* in a relatively large number of countries was observed in 1980s. The close correlation observed between these two deficits is usually known as '*Twin Deficits*'.

'*Twin Deficits*', therefore, refer to the long run relationship between '*budget deficit*' and '*trade deficit*' (or Current Account Deficit). *The proposition that budget deficit has positive and significant effect on trade deficit is usually referred to as 'Twin Deficit Hypothesis'*. *The hypothesis basically implies that the main cause of trade deficit is the excessive budget deficit. However, some economists also argue that budget deficit may also be the resultant of trade deficit. Consequently, the direction of causality between these two macroeconomic variables appears to be a subject of contention among the economists.*

1.2 Origin Of the Problem:

During 1980's, 1990's and early 2000s, the US economy experienced large trade deficits. These *trade deficits* had to be financed through borrowing from abroad. As a result, United States, the world's largest creditor emerged as world's largest debtor. It was argued that huge trade deficit also coincided with a fall in national saving. Such fall was due to expansionary fiscal policy in 1980's, in which substantial cut in personal income taxes remained unmatched by equal cuts in government spending. Consequently, government budgets ran into deficit. Since the government budgets and trade balances went into deficit simultaneously, these shortfalls were called the 'Twin Deficits'.

1.3 Twin Deficits: Theoretical Basis

A simple study of the '*National Income Identity*' for any open economy exhibits a link between '*budget deficit*' and '*trade deficit*'. The identity is

$$Y = C + I + G + (X-M) \quad (1.1)$$

where, Y = National Income

C = Consumption

I = Investment

G = Government Expenditure

X = Export

M = Import and

X-M = Net Export.

From (1.1) we have,

$$Y - C - G = I + (X - M)$$

$$\text{Or, } (Y - T - C) + (T - G) = I + (X - M)$$

$$\text{Or, } S_p + S_{pub} = I + (X-M) \quad (1.2)$$

where S_p = Private Savings

S_{pub} = Public Savings

$$S = \text{National Savings} = S_p + S_{pub}$$

Equation (1.2) states that national savings, which is the sum of private savings ($S_p = Y - T - C$) and public savings ($S_{pub} = T - G$) equals investment plus net export (X-M). From equation (1.2) we further obtain

$$(M - X) = (I - S) + (G - T) \quad (1.3)$$

where, M - X implies '*Trade Deficit*' when $M > X$

and $G - T$ implies '*budget deficit*' when government expenditure exceeds tax revenue (i.e. $G > T$).

Equation (1.3) states that trade balance is virtually the sum of *Investment – Savings Gap* and the '*budget deficit*'. Thus given a stable investment- savings gap, an increase in *budget deficit* raises the *trade deficit*. Thus

Trade Deficit = Excess of Investment over Savings + Budget Deficit

An economy requires the equality between investment and savings for reaching equilibrium. But the equation (1.3) shows that there may exist an excess of investment over savings such that $I > S$. This is an indirect pointer to the disequilibrium of the economy. Consequently, one may wonder if '*twin deficits phenomenon*' is an inevitable feature of an '*Economy under disequilibrium*'.

It may be noted that even if $I = S$ in the economy, two deficits may still exist. In that event, volume of *trade deficit* equals the volume of *budget deficit*. If *budget deficit* does not arise, then *trade deficit* also withers away. The emergence of one deficit also leads to the appearance of another deficit in the economy, irrespective of whether the economy is in equilibrium or not. Feldstein (1992), therefore, coins two deficits as '**Twin Tower Deficits**' or '**Twin Deficits**'.

1.4 Twin Deficits: Transmission Mechanism:

Theoretically, the mechanism behind the twin deficits could simply be explained through the '*Keynesian Income-Expenditure Approach*'. An increase in *budget deficits* will increase '*domestic absorption*' and, therefore, the domestic income. Increased income will raise import demand and eventually will reduce the surplus or worsen the external balance. That is how the government sector and external sector deficits becomes twins.

In *Keynesian Open Economy Models* with high '*capital mobility*' such as '*Mundel-Fleming Model*', an additional linkage can explain the deterioration in the *trade balance* owing to higher *budget deficit*. An increase in the budget deficit will cause an increase in aggregate demand and domestic interest rates. High interest rate will attract foreign investors and net *capital inflow* will take place. This results in an appreciation of the domestic currency. This, in turn, adversely affects net export and thus there will be deterioration in the current account.

1.5 Ricardian Equivalence Hypotheses (REH)

Alternative to '*Twin Deficit Hypothesis*' is the '*Ricardian Equivalence Hypothesis*' which holds that there is no *causal link* between budget deficit and trade deficit. Therefore, the deficits are not '*twin*'. According to this hypothesis, the equilibrium levels of current accounts, interest rates, investment and consumption remain unaffected by the changes in the level of budget deficit. This can be regarded as an extension of the *Permanent Income-Life Cycle Hypothesis* including government expenditures, taxes and debt.

In this framework a change in the level of budget deficit will not change the life-time budget constraint and real wealth of the consumer. If agents can borrow at a constant interest rate, a reduction in taxes will be regarded as an increase in the present value of future tax liabilities. The consumers will adjust their savings to the change in the budget deficit and, therefore, the amount of desired national savings will not differ. In this model, it is assumed that consumers have infinite horizon and altruistic bequest motives. All these are not liquidity constraints and there is no uncertainty about the public sector behavior.

As a consequence of intertemporal consumption behavior, according to **REH**, temporary changes in the level of government expenditure and marginal tax rates are much more important than the ways of financing it. **REH** proposes that for the explanation of the trade deficit, interest rate along with productivity differential and temporary increase in the public sector spending could be considered as alternative explanatory variables besides budget deficits.

1.6 Objectives of the Study:

Both budget deficit and trade deficit exist simultaneously in the economy of Maldives. There exist theoretical and analytical relations between these two deficits. Consequently, it becomes pertinent for researcher to enquire if there exists any degree of association between these deficits. In the event of such association being present, it becomes a task for a researcher to examine the nature and direction of *causal* relation between two deficits. The close correlation between these two deficits does not imply any *causal* relation between the variables. Therefore, identifying the *causal* relation between these two deficits is important and that would have different policy implications.

Theoretically, there are four possibilities about the relationship between budget deficits and trade deficits.

First, there is the ‘**Twin Deficit Hypothesis**’. According to which budget deficit has positive and significant effect on trade deficit. This means that the main cause of trade deficit is the excessive budget deficit.

Second, reverse of the relationship is also possible. Trade deficits might cause budget deficits.

Third, a natural deduction from the above two possibilities is that the two deficits might also be *mutually interdependent*.

Finally, the alternative to all the three possibilities is that there exists ‘no relationship’ between these two deficits. So these deficits are *independent*. This is the ‘**Ricardian Equivalent Hypothesis**’.

All these possible relationships between these two deficits necessitate an empirical study for ascertaining the nature of ‘*causal relation*’, if any, between budget deficit and trade deficit in Maldives. The present study is devoted to address this issue. More specifically, in this study we seek to examine the relationship between budget deficit and trade deficit in the economy of Maldives for the period 1979-2003 with yearly datasets.

We seek to focus, by using this dataset, on testing two main hypotheses. These hypotheses are

- (i) **Twin Deficit Hypothesis** : Budget Deficit *Granger Causes* Trade Deficit
- (ii) **Ricardian Equivalence Hypothesis**: Two Deficits are *Independent*

We seek to test these hypotheses in our study and examine the nature as well as the direction of *causal relation* between budget deficit and trade deficit in the economy of Maldives.

1.7 Plan of the Study:

The present study is accordingly divided into the following chapters.

Chapter-II presents the outline of the economy of Maldives.

Chapter-III presents the review of literature.

Chapter-IV deals with source and nature of the data, methodological issues and periods of study. It also contains an elaborate discussion on time series methods used in the present study.

Chapter -V is devoted to the study of *stationarity* of variables concerned and this enables us to ascertain the *Integrability* of the variables.

Chapter-VI is devoted to study of ‘*Cointegration*’ between the variables concerned in order to examine if any long-run relationship between the variables exist.

Chapter-VII deals with the *stability of the long-run relationship* through ‘*Vector Error Correction Modeling*’ (VECM).

Chapter-VIII presents our attempt for examining the ‘*Causal*’ relationship between these two deficits through the estimation of an ‘*Unrestricted Vector Autoregressive (UVAR) Model*’

Chapter– IX presents the *Intervention Analysis* through the study of *Impulse Response Functions* of the variables concerned.

Chapter– X focuses on *Intervention Analysis* through the study of ‘*Variance Decomposition*’ of the ‘*Forecast Errors*’ for the variables concerned.

Chapter– XI is devoted to the study of ‘Granger Causality’ between the budget deficit and trade deficit through the estimation of a ‘**Restricted Vector Autoregression (RVAR) Model.**’ This is done in order to ensure confirmation of our findings about the nature and direction of ‘Causality’ between the variables in Chapter (VIII).

Chapter – XII deals with the ‘*Spectral Analysis*’ which is expected to ensure further confirmation of our findings about the causal relationship between the budget and trade deficits

Chapter – XIII presents the *summary, concluding remarks* and *policy implications* of the findings.

CHAPTER- II

AN OUTLINE OF MALDIVIAN ECONOMIC ENVIRONMENT

2.1 Introduction

The Maldivian archipelago, located 300 miles south west of the southern tip of India and 450 miles west of Sri Lanka, is a beautiful string of 1,192 coral islands scattered across the equator in vast expanse of the Indian Ocean. Few of the islands have a land area in excess of 1 sq km and only 199 are inhabited.

The country was never colonized, though the Portuguese sought to impose their sovereignty on Maldives in the 16th century. From 1887 to 1965, Maldives was a British protectorate but there was no interference in the internal affairs of the country. Maldives gained independence and became a **Republic** on November 11, 1968.

The main economic and social indicators of Maldives in year 2000 are shown below.

Table¹ 2.1

Land area	300 q. km
Population	270101
Annual population growth	1.9 %
Life expectancy at birth	71 years
Infant mortality rate per '000	21
Adult literacy rate	99 %
Urban share of population	27%
Sectoral Composition of GDP	
Primary	9 %
Manufacturing	9 %
Services	82 %
Enrolment Ratio in Education	
Pre-school	85 %
Primary	99 %
Secondary	36 %
UN Human Development Index (1999)	
Overall ranking	77 th
Within category	Medium human development

UN Human Poverty Index in Developing Countries (1999)	
Overall ranking	25 th
Within category	22 nd

1. Source: UNDP (2001), Human Development Report 2001: World Bank (2001), World Development Indicators, 2001, Report of Maldives Monetary Authority.

Despite the number and severity of constraints, the economic performance of Maldives has been impressive in recent years. Only a few developing countries are able to report the progress recorded by Maldives in the past two decades. Gross domestic product (GDP) growth exceeded 10 % p.a. through most of the 1980s, averaging 8.77 % p.a. during 1986-96 and moderating to a more sustainable 6.2 % in 1996-97. The GDP per capita increased in real terms from \$ 470 in 1985 to \$ 837 in 1997. The rate of increase was more than twice that of the population growth. This progress recorded by Maldives has been considered the highest among the countries of the South Asian Association for Regional Co-operation (SAARC).

High priority accorded to social development and a high proportion of government spending allocated to social sectors brought about a rapid transformation in several aspects of the quality of life to the entire population. Crude birth rate, crude death rate and infant mortality rate have halved.

With a global Human Development Index (HDI) of 0.739, Maldives ranks 77th out of 162 countries. The country's impressive economic progress has largely been attributed to the judicious exploitation of its marine resources and potentials, with fisheries and tourism having established as the dominant sectors of the economy. Though the tsunami on December 26, 2004 inflicted severe damage with an estimated loss of at \$450 million (approximately 60% of GDP). As a result of interrupted tourist inflows and livelihoods, Maldives' economy fell by about 5% in 2005. However the World Bank predicts positive growth should resume relatively quickly, as the tourist trade picks up.

2.2 Important Sectors of The Economy of Maldives:

Some important sectors of the economy of Maldives are being briefly described below.

2.2.1 Tourism

In recent years, Maldives has successfully marketed its natural assets for tourism--beautiful, unpolluted beaches on small coral islands, diving in blue waters abundant with tropical fish, and glorious sunsets. Tourism now brings in about \$210 million a year.

2.2.2 Fishing

This sector employs about 11% of the labor force and contributes 6% of GDP, including fish preparation. The use of nets is illegal. So all fishing is done by line. Production was about 158,000 metric tons in 2004, most of which was *skipjack tuna*. About 50% of the harvest is exported, largely to Sri Lanka, Japan, Hong Kong, Thailand, and the European Union. Fresh, chilled, frozen, dried, salted, and canned tuna exports accounted for 94% of all marine product exports. Total export proceeds from fish were about \$85 million in 2004.

2.2.3 Agriculture

Poor soil and scarce arable land have historically limited agriculture to a few subsistence crops, such as coconut, banana, papayas, mangoes, taro, betel, chilies, sweet potatoes, and onions. Almost all the food, including staples, has to be imported. The December 2004 tsunami inundated several agricultural islands, and it could take a significant amount of time for the recovery. Agriculture provides about 2.5% of GDP.

2.2.4 Industry and Manufacturing.

The industrial sector provides only about 8% of GDP. Traditional industry consists of boat building and Handicrafts, while modern industry is limited to a few tuna canneries, a bottling plant, and a few enterprises in the capital producing PVC pipe, soap, furniture, and food products. Five garment factories which had mainly exported to the United States closed in 2005, following the expiration of the Multi-Fiber Agreement (MFA) that had set quotas on developing country garment exports to developed countries.

2.2.5 Production, Prices and Employment

It is, therefore, clear that the Maldivian economy is heavily dependent on fisheries and tourism, which are the major sources of foreign exchange earnings and government revenue, and which together account for about 40 % of gross domestic product. The economy prospered in the 1990s with the rapid expansion of tourism and the modernization of the fishery sector together with the expansion of basic economic and social infrastructure to more inhabited islands. As a result, annual GDP growth averaged around 8% during the decade. Due to heavy reliance on imports for most economic activities and daily needs, coupled with the dependence on tourism, Maldives is very vulnerable to external shocks.

Inflation has remained low in recent years and in past, reflecting the appreciation of the nominal exchange rate against major trading partners since 1995. In 2000, deflation was recorded, with prices of imported food and beverages and clothing and footwear declining sharply.

In terms of employment, the fisheries and tourism sector alone account for more than a third of total employment. The total labor force of the country is estimated at around 50% of the working age population, which, coupled with the low level of educated labor, has led to a high proportion of expatriate workforce in the country. Categories in which expatriate labor has been employed mostly include teachers, medical personnel and other professional categories, as well as semi skilled and unskilled workers such as domestic helpers and construction workers.

2.2.6 Fiscal Policy

The public sector consists of the government and public enterprises. Fiscal policy of the country aims at sustainable growth without undermining macro economic stability. Tax revenues account for around 45% of the total revenue (excluding grant) and the balance consists of profit transfers from public enterprises and resort lease rent. The bulk of tax revenue comprises of import duties (63%) and tourism tax (28%), while there are no taxes on personal income, capital gains, business profits, wealth or real estate. Non-tax revenues come from public enterprise profit (31%), lease rent on resort islands (35%), royalties and charges. Grants have been the other source of inflows and have averaged around 10% of total revenue between 1995 and 2001. External donor assistance has also played an important role in the development projects. Although in recent years this has had a fluctuating trend. Yet on average, external funding accounts for around 28% of development expenditure.

On the expenditure side, social services and public services make up the major areas of expenditure reflecting around 40% and 42% respectively of expenditure and net lending. Payments on economic services account for roughly 15% of expenditure and net lending. On the social sector, education and health take up the major portion of expenditures and account for around 46% and 26% respectively of the expenditure on social services. The government also invests heavily in the development of infrastructure of the country.

The record of fiscal performance of the country has been one of mixed achievements. While fiscal performance was relatively well kept in the mid 1990s with considerable fiscal restraint and sizeable repayments of the debt taken from the central bank, the late 1990s experienced a somewhat expansionary trend in the public enterprises with expenditure outstripping the growth in government revenue. During this period since 1998, sizeable resource mobilization of the deficit through the central bank financing took place, adding to the government debt.

Keeping in mind the importance of fiscal sustainability and efficient expenditure management for the sustainable growth and development of the economy, the government is currently pursuing a number of efforts to address these issues. '*The Public Expenditure Review*', a joint

exercise by the World Bank, International Monetary Fund, Asian development bank, and the Government of Maldives which was initiated in 2001. It will recommend ways to better prioritize and rationalize expenditure programs. The '*Public Accounting Systems Project*', coming into effect in 2003, will overhaul the current single entry accounting system to introduce a centralized double entry based computerized public accounting system. In addition to this effort to rationalize and more efficiently manage the public expenditures and improve the transparency of the public sector, the government also recognizes the need to diversify and broaden the revenue base. In this context, the government plans to introduce a business profit tax to be levied on business activities and a property rental value system to rationalize fees and administrative charges.

2.2.7 Financial sector and Monetary developments

The financial sector of Maldives is very narrow and dominated by the banking sector, which consists of one locally owned commercial bank, branches of three South Asian partly state owned commercial banks and a branch of a widely known international bank, HSBC. Non-bank financial institutions in the country consist of a provident fund, a finance leasing company, two insurance companies registered in the country, while Maldives Monetary Authority (MMA) is the primary source of domestic financing for the government's fiscal operation. At present the commercial banks are the principal institutions for mobilizing savings and for providing foreign exchange to the private sector.

All financial institutions currently operate under the supervision of the MMA, which has the mandate to function as a central banking authority. Monetary policy in Maldives has been targeted towards supporting growth and development with a stable macro-economic environment. In the past, MMA has mainly employed direct instruments of monetary policy to achieve this objective. However there has been a movement towards an indirect mechanism in the last few years. There is currently no organized capital market in Maldives. Government, through the capital market development section and the MMA, is working towards creating the institutional mechanism to facilitate a structured market for generating the capital required by the economy. There is some secondary market tradings of the limited number of shares in the bank of Maldives, and two other state owned public companies- the Maldives transport and contracting company and the state trading organization. This constitutes the only publicly available equity stock at present.

2.2.8 Balance of Payments and the External sector:

As Maldives has a narrow export base but high dependence on imports, foreign merchandise trade normally records a large deficit. Imports have averaged around 61% of GDP in the last 7

years, while domestic exports, consisting primarily of fish and fish products, have ranged between 11-15 % of GDP. Services and transfers have shown a net surplus that has averaged around 34% of GDP in recent years, with service receipts being dominated by tourism and related activities. Nevertheless, there is also a significant outflow of transfers from the economy owing to the large expatriate work force that is resident in the country.

Official medium and long term debt flows of capital for direct investments dominate the capital accounts of the balance of payments as no portfolio investments flow into the Maldives yet, because of the lack of a formal capital market. Information on the country's external debt is limited to that of the public sector and commercial banks. In terms of the magnitude, external debt stock of the public sector and the banking system has averaged around 38% of GDP during 1995-2002, with a large portion of official debt being received on highly concessional terms.

There is no exchange control legislation in Maldives. Both residents and non residents may freely import and export capital through the foreign exchange market, and residents do not require permission to maintain foreign currency accounts either at home or abroad.

The Maldives has a pegged exchange rate system, whereby the rufiyaa is pegged to the US dollar at a market reflective rate.

2.2.9 Trade and Economic Policy Objectives:

Trade and economic liberalization are considered by the Maldivian authorities to be means of promoting private-sector investment and development. However, trade liberalization, such as tariff reductions, is not specifically included in the current development plan. Recently, high tariffs are maintained, mainly for revenue reasons. Nevertheless, the government is committed to further outward orientation of the economy to improve trade and economic performance, and to diversify the economy away from fishing and tourism. It maintains few non-tariff measures, and its industrial strategy is aimed at removing bottlenecks to private sector growth. This strategy entails reducing the heavy role of SOEs in the commercial sector and fisheries. Greater competition in the provision of key services, such as telecommunications is also envisaged. The government is committed to greater regional integration, including with its SAARC neighbors.

Economic growth is seen as an important means of alleviating poverty and improving living standards for Maldivians. The government is committed to fostering private-sector development by liberalizing trade and investment and strengthening the country's economic, legal social, administrative and physical infrastructure. Private, including foreign, direct investment and international trade are seen as important catalysts for growth. Economic

development is to be based on sustainable management of key natural resources, such as fisheries and those related to tourism.

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Development is guided by rolling government plans. The sixth national development plan, the first plan that extends for five years instead of three (2001-05), embodies the long-term vision of the Maldives becoming a top ranking middle income nation by 2020 (*Vision 2020*). It aims at achieving conducive conditions for brisk commerce and economic activity and for the country to become a '*hub for regional free trade*' as well as a '*more diversified economy with export oriented services trade.*' National prosperity is to be equitably distributed and *environmental friendly policies* are to be taken to protect the environment against global ecological degradation. An important means of raising prosperity is to develop a more educated and skilled workforce using modern information technology.

2.2.10 Trade Agreements and Arrangements:

The Maldives became an original member of the **WTO** on 31 May 1995. It had been a **GATT** contracting party since 19 April 1983. Maldives is a founding member of the *South Asian Association for Regional cooperation (SAARC)*, *South Asian Preferential Trading Arrangements (SAPTA)*, signed in April 1993 and effective from 7 December 1995. Leaders recently reaffirmed their vision for a *South Asian Economic Union* and for *South Asian Free Trade Area (SAFTA)*.

The Maldives ' only bilateral trade agreement is with India. It became effective on 31 March 1981. It stipulates that the countries provide each other no less favorable treatment than extended to any trading partner. However, it excludes privileges granted to neighboring countries to facilitate trade like customs unions, free-trade areas or similar arrangements and preferences accorded under any general scheme for expanding among developing countries.

2.2.11 Investment policies and Procedures

Although there are no minimum investment levels, all FDI must have a capital level "acceptable to the Government". There are no joint venture requirements. 100% of foreign ownership is permitted. No activities are excluded or restricted from foreign investment. Foreign applicants must have their financial status guaranteed by a bank or institution acceptable to the government. Foreign investors must use local raw materials which are locally available and commercially viable. This rarely operates in practice since the Maldives has limited raw materials. Most incentives apply equally to foreign and domestic investors. Investment incentives depend upon the level of foreign investment.

2.2.12 Supply side constraints

Supply-side constraints are also major obstacles to the Maldives's trade expansion. These include its small and many dispersed islands, which greatly compound the problems of regional development. These include heavy dependence on fishing and tourism, limited natural resources, smallness of the domestic market; limited technology, limited *trade, industry, and export financing*, inadequate skilled manpower, lack of adequate trade representation network abroad, limited knowledge of export opportunities, weak infrastructure including transportation facilities, weak human and resource capacities of support institutions, inadequate investment regime, inefficient legal system, and heavy reliance on imported inputs. These problems are interlinked and compounded, impairing the overall trading environment. Other infrastructural bottlenecks, relating to comprehensive but expansive telecommunications and utility services such as electricity, water and sewerage facilities, may be linked to inappropriate technology, non-competitive market structure and inadequate investment. The government has taken some action to address supply-side constraints. However numerous needs still exist.

2.2.13 Environments

There is growing concern about coral reef and marine life damage because of coral mining (used for building and jewelry making), sand dredging, and solid waste pollution. Mining of sand and coral have removed the natural coral reef that protected several important islands, making them highly susceptible to the erosive effects of the sea. These practices have recently been banned. In April 1987, high tides swept over the Maldives, inundating many islands. That event prompted high-level Maldivian interest in global climatic changes, as its highest point is about 8 feet above sea level. The *Asian Brown Cloud of Pollution* over the Indian Ocean has the potentiality of wreaking havoc on the tourism and fishery-based Maldivian economy.

2.2.14 The Macro-Variables for the Study:

The present study involves the examination of '*Causal*' relation between budget deficit and trade deficit in Maldives. Consequently, these variables have become the focus of our attention in this study.

We have identified major three macro-economic variables with priori support, which would enlighten on general understanding of the direction of Maldivian economy too. Time representations of these variables range from 1979 to 2003. These 25 years of time span is believed to be adequate for drawing an appropriate inference on the basis of compatible empirical findings on the issues of interest. Included variables are budget deficit (BD_t), and Trade Deficit (TD_t).

CHAPTER- III

LITERATURE SURVEY

3.1 Introduction

This Chapter throws light on empirical works done before on *twin deficit hypothesis*. Relevant models with interpretation of empirical findings are being presented in subsequent sections.

3.2 Twin Deficit Hypothesis

In economic literature, two different theories exist in regard to the relation between trade deficit and budget deficit. One of them, the **Twin Deficit Hypothesis, (TDH)** which argues that budget deficit causes trade deficit and hence, the two deficits are twins. Therefore, this theory advocates for regulating budget deficit to achieve balance in the external sector

The **Ricardian Equivalence Hypothesis (REH)** is the other which contradicts the *twin deficits hypothesis* and claims that increase in government expenditure is absorbed by rise in private savings, causing no external sector deficit. In other words, according to (REH), if government runs a deficit by borrowing, the economic agents expect that government will raise future taxes to finance the budget deficit and so they increase their saving to meet the future tax burden. Similarly, a cut in taxes, though increases the disposable income of the individuals, will not lead to higher private consumption in anticipation of higher future tax rates. Thus savings will respond positively to the changes in budget deficit, leaving the trade deficits unaltered. It is, therefore, held that the two deficits are not systematically related to each other.

3.3 Empirical Models and Findings

The relation between two deficits becomes an important topic of debate after the emergence of secular nature of simultaneous movement of the twins in the United States from the early 1980s. The debate has led to a large number of studies for US, but they have yielded conflicting conclusions. This is shown in the table below.

Table 3.1

Findings on the Relationship Between Twin Deficits in the USA

Researcher/s	Sample countries	Findings
Darrat (1988)	USA	Bi-directional-causality between-BD and TD
Bahmani-Oskooee (1989), & Latif- Zaman & Do Costa (1990)	USA	Uni-directional causality from BD to CAD
Enders and Lee (1990), Dewald and Ulan (1990)	USA	No causal link between the two deficits
Miller and Russek (1989), Abell (1990) and Bachman (1992)	USA	Uni-directional causality from BD to CAD.

The empirical studies on twin deficits in the context of **other countries** also produced a mixture of results. These results are also shown in the table below.

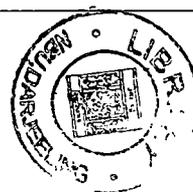
Table 3.2

Findings On Twin Deficits

Researcher/s	Sample countries	Findings
Khalid & Guan (1999)	10 countries	<i>Uni-directional causality</i> from BD to CAD in USA, France & Canada. <i>No causality</i> between BD and CAD, in UK & Australia. Weaker support for <i>bi-directional causality</i> too in Canada. <i>Two Way causality</i> for India. <i>Causality from CAD to BD</i> in Pakistan and Indonesia. <i>Unidirectional causality</i> from BD to CAD for Egypt and Mexico
Vamvoukas (1999)	Greece	<i>One way causality</i> from BD to TD
Kearney & Monadjemi (1990)	8 countries	<i>Causality from CAD to BD</i> in Germany, Australia and France.
Laney (1984)	58 countries	<i>Causality from BD to CAD</i> in developing countries. Amongst

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		the world's largest economies, Canada & Italy only demonstrate a statistically significant
Bernheim (1988)	6 countries	<i>Positive relationship between BD and CAD.</i> \$ 1.00 increase in the BD is associated with roughly a \$0.30 decline in the CA Surplus for USA, UK, CANADA and West Germany, but \$ 0 .85 decline in CA for Mexico. <i>No effect</i> on CA for Japan.
Islam (1998)	Brazil	<i>Bilateral causality</i> between Trade deficit and budget deficits.
Alkswani (2000)	Saudi Arabia	<i>Causality</i> from trade deficit to budget deficit.
Olga vyshnyak (2001)	Ukraine	BD <i>Granger causes</i> to CAD
Akbostanci and Tunc (2002)	Turkey	<i>Twin deficit hypothesis</i> holds and <i>Ricardian Equivalence Hypothesis</i> is not validated both in long run and short run as well.
Ali-salman-saleh ,Mahendhiran Nair & Tikiri Agalewatte (2005)	Sri Lanka	<i>Causality from budget deficit to Current account deficit.</i>

Since researchers have formulated and experimented different modeling patterns with different time horizon, test results are not unanimous in many cases. Such diversified and contradictory results might have arisen because of country wise economic policy divergence, nature of data and their definitions, model specification, constraint e.g. partial modeling instead of full modeling, variables identification problem and their best fit and the time span. This can be explained in detail in the next section.

3.4 Several Important Studies:

Olga Vyshnyak (2001) himself found for Ukrainian data that past movements in government budget *Granger Cause* movement in current account deficit (CAD) showing *unidirectional relationship* for long run. For this verification, the researcher had run a bi-variate regression model as

$$CAB_t = c(1) + c(2)BB_{t-1} + u_t \quad (3.1)$$

The study involves *co-integration test* between model variables and *Granger Causality* between them. In verifying the *Granger Causality*, he had been studied with the following specification.

$$BB_t = \alpha + \sum_{j=1}^l \beta_j CAB_{t-1} + \sum_{j=1}^l \gamma_j BB_{t-1} + \mu_{1t} \quad (3.2)$$

$$CAB_t = \theta + \sum_{j=1}^l \delta_j BB_{t-1} + \sum_{j=1}^l \lambda_j CAB_{t-1} + \mu_{2t} \quad (3.3)$$

However, no *Error Correction Mechanism* (ECM) has been studied for examining the short-run relationship between BD and CAD. The data used in the study were just for eight years.

In Turkish case, as summarized by **Elif Akbostanci and Gul Ipec Tunk (2002)**, on their “**Turkish Twin Deficits: An Error Correction Model of the Trade Balance**”, *Ricardian Equivalence Hypothesis* (REH) is not validated both in the long-run and short-run. They had used Error Correction Model (ECM) by specifying following equations.

$$\Delta X_t = \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \mu + \varepsilon_t \quad (3.4)$$

$$\Pi = \alpha \beta' \quad (3.5)$$

where X_t is a (p x 1) vector of stochastic variables, which are I(1), μ represents the intercept term, and the error term ε_t is assumed to be white noise. Since X_t is I(1), if a linear combination of these I(1) variables exists, then these variables are said to be *cointegrated*. If *cointegration* exists, an *Error Correction Representation* exists for these variables. In equation (3.5) $\Pi = \alpha \beta'$ is the impact matrix where α is the vector of adjustment coefficients and β is the vector of co-integrating relations and both are p x r matrices.

The variables in his model consist of the budget balance as a percentage of GDP, trade balance as a percentage of GDP, industrial production index, and narrow money as a percentage of GDP. The model includes an output term, and a monetary term, to account for different channels of interaction between the budget deficit and current account deficit. This model has supported *persistence of Twin Deficit Hypothesis* both for short run and long run with sample data of Turkey for 15 years (1987-2001) of the model variables.

Another empirical study was carried out by **Zengin (2002)** using ‘*Vector Autoregressive Model*’ (VAR). The evidence from the eight variables (budget deficit, trade deficit, seasonal adjusted internal and external revenue, trade weighted effective real exchange rate, average interest rates on securities, money supply M2, and GNP deflator). VAR system also supports the *Twin Deficit* notion that budget deficits influence trade balance.

Mamdouh Alkswani (2000) in his paper on “**The Twin Deficits Phenomenon in Petroleum Economy: Evidence from Saudi Arabia**” holds that Saudi Arabian database does not support *causality* running from budget deficit to trade deficit. He used two steps ECM where first stage regressions were run on

$$BD_t = \alpha_0 + \alpha_1 TD_t + \varepsilon_t \text{ and} \quad (3.6)$$

$$TD_t = \beta_0 + \beta_1 BD_t + u_t \quad (3.7)$$

The second steps to estimate the ECM representation were,

$$\Delta BD_t = \alpha_0 + \sum \alpha_{1t} \Delta TD_{t-j} + \sum \alpha_{2t} \Delta BD_{t-j} + \lambda e_{t-1} \quad (3.8)$$

$$\Delta TD_t = \beta_0 + \sum \beta_{1t} \Delta TD_{t-j} + \sum \beta_{2t} \Delta BD_{t-j} + \delta \mu_{t-1} \quad (3.9)$$

And, for *Granger Causality* verification, following specifications were studied

$$X_t = \sum_{i=1}^m a_i X_{t-i} + \sum_{j=1}^n b_j Y_{t-j} + u_t \quad (3.10)$$

And

$$Y_t = \sum_{i=1}^r c_i Y_{t-i} + \sum_{j=1}^s d_j X_{t-j} + v_t \quad (3.11)$$

where X_t and Y_t were replaced by BD_t and TD_t respectively. Saudi Arabian data for 30 Years (1970- 1999) were used in the study.

Stilianos Fountas and Christopher Tsukis (2000), on their cross-country study on ‘**Twin Deficits, Real Interest Rate and International Capital Mobility**’, conclude that the TDH is upheld only in the cases of Germany and the UK and only in the short run. The opposite hypothesis of current account targeting carries some weight in case of Canada in the short run. In case of Netherlands, there are some evidences consistent with current account targeting according to the sign of cointegrating vector. A result not supported by the long run exogeneity tests.

Abdul Nasser Hatimi J and Ghaji Shukur (1999) have tested *twin deficit hypothesis* in “**Multivariate – Based Causality Tests of Twin Deficits in the US**”. This paper possesses alternate method for testing the causality direction between US twin deficits involving Rao’s Multivariate F test combined with ‘*Bootstrap Simulation Technique*’. For this, they have identified the VAR model as

$$Y_t = \eta + A_1 Y_{t-1} + \dots + A_p Y_{t-p} + \varepsilon_t \quad (3.12)$$

where, $\varepsilon_{jt} = (\varepsilon_{1t}, \dots, \varepsilon_{kt})$ is a zero mean independent white noise process with non singular covariance matrix $\sum \varepsilon$ and, for $J = 1, \dots, k$, $E / \varepsilon_{jt} / 2^{+t} < \infty$ for some $t > 0$

Using quarterly US data from 1975 Q1 to 1998Q2 from The International Financial Statistics (IFS) with *Multivariate Rao's F test* and *Bootstrap Test* applying VAR (2), they found very interesting result that twin deficits do not *Granger Cause* each other for sample period. While identifying structural break and using sub- period's data separately, first sub- period time supported BD *Granger causing* CAD while second sub- period supports CAD *Granger causing* BD. However, the '*Lucas Critique*' might have been in effect owing to internal policy shifts and international economic shocks.

Michel Normandin (1999) in "**Budget Deficit persistence and the Twin Deficit Hypothesis**", used '*Blanchard's Overlapping Generation Model*', and held "..... *The relevant Canadian consumer's horizon and the persistence of the Canadian budget deficit produce responses that are statistically positive. In contrast, the relevant U.S. consumer's horizon and the dynamic behavior of the U.S. budget deficit yield responses that are statistically insignificant.*"

G. Karras and F. Song (1994) in "**Government Spending and the Current Account: Some International Evidence**" have shown through their empirical research with a neoclassical frame work that *transitory (permanent) changes in Government spending reduce (leave unaffected) the trade balances*. It means that transitory change in Government spending motivates the *utility maximizing consumers* to consume out of their permanent income which remains almost unaffected by government spending. Changes of this nature, therefore, create a desire for smoothing consumption, which is accommodated by the current accounts. Permanent changes, on the other hand, create no such smoothing motivating and hence, leave no impact on current accounts.

Using data for Australia, Italy, Sweden the UK and the US, they find that the current effects of permanent changes in government spending in all five countries are *statistically not different from zero*, as predicted by the theory. The effects of the transitory changes in government spending, however, are found to be consistent with the model only for the UK and the USA. The Australian, Italian and Swedish current accounts are not statistically related to transitory changes in Government spendings. They also show that adopting a text book Keynesian Model or a model with liquidity constraints cannot resolve these puzzling findings.

Daniel L. Thornton (2003) in '**Do Government Deficits matter?**' first explores the relations of deficits to private saving, interest rates, trade deficit, output and inflation. Then he further considers the *Keynesian Hypothesis* and *Ricardian Equivalence* as well. He uses the data for 16

OECD countries over the period 1975-86. His data are of pooled time series / cross section by nature. He introduces first the general equation as

$$DV_{it} = \alpha_{it} + \beta_{it} DEF_{it} + \varepsilon_{it} \quad (3.13)$$

where $I = 1, \dots, k$, and $t = 1, \dots, T$, DV_{it} and DEF_{it} denote the t^{th} observation for the i^{th} country of the dependent variable and the deficit measure respectively. α and β denote fixed parameters and ε_{it} denote a random variable.

Equation (3.13) is impossible for testing because the numbers of the parameters exceed the numbers of observations. This problem had been circumvented by obtaining time series and $\alpha_{it} = \alpha_t$ and $\beta_{it} = \beta_t$ for all t for time series and $\alpha_{it} = \alpha_i$ and $\beta_{it} = \beta_i$, for all I for cross sectional data. Thus these specifications are,

$$DV_{it} = \alpha_i + \beta_i DEF_{it} + \varepsilon_{it} \quad \text{and} \quad (3.14)$$

$$DV_{it} = \alpha_t + \beta_t DEF_{it} + \varepsilon_{it} \quad (3.15)$$

A pooled time series / Cross section representation can be obtained by imposing the restrictions $\alpha_{it} = \alpha$ and $\beta_{it} = \beta$ for all i and t to obtain equation (3.16) i.e.

$$DV_{it} = \alpha + \beta DEF_{it} + \varepsilon_{it} \quad (3.16)$$

This is just equivalent to imposing the restrictions $\alpha_{it} = \alpha$ and $\beta_{it} = \beta$ for all I on the time series model or $\alpha_{it} = \alpha$ and $\beta_{it} = \beta$ for all t on the cross sectional model.

Equations (3.14) - (3.16) are estimated with annual observations on the Government deficits, nominal interest rate, the Trade deficits, the price level (1980 = 100), the inflation rate, real output growth and private saving of the 16 OECD countries ($k = 16$ and $T = 12$). The equations are estimated both at levels and first differences.

Estimates of equation for both the levels and first differences data suggested that increase in deficit spending are associated with decrease in personal saving. It means that following decrease in the public savings also decline and so does the private saving. The result is not consistent with the *Ricardian view* that public and private savings are substitutes. Thus the research paper suggests the prevalence of *twin deficit hypothesis*.

Amelie Clement (2002) enquires into *REH and TDH* in '*Twin Deficits: A Cyclical Phenomenon?*' In explaining REH, in a two-period economy, consumers are assumed to maximize their utility function

$$U(C_1) + \beta U(C_2) \quad (3.17)$$

which is subject to an intertemporal budget constraint as follows

$$C_1 + (1/1+r) C_2 = (Y_1 - T_1) + (1/1+r) (Y_2 - T_2) + (1+r) \beta^P_1 \quad (3.18)$$

Here r is the interest rate, β is a subjective discount factor and β^P_1 is the individual holding of financial assets at the end of period $T = 0$.

The Government, for its part, has also to respect its budget constraint as,

$$G_1 + (1/1+r) G_2 = T_1 + (1/1+r) T_2 + (1+r) \beta^G_1$$

This means that present value of government expenditures should be equal to the present value of its revenues, i.e., taxes, added to the discounted value of its financial assets at the end of the previous period.

Consumers are assumed to be the perfectly informed and forward looking so that they can see 'through' the government budget deficit constraint by understanding the relation between spending and taxation. Consequently, they integrate it to their own budget constraint

$$C_1 + (1/1+r) C_2 = (Y_1 - G_1) + (1/1+r) (Y_2 - G_2) + (1+r) (\beta^P_1 + \beta^G_1) \quad (3.19)$$

where $(\beta^P_1 + \beta^G_1) = \beta_1$ is the stock of foreign assets of the whole economy.

REH has a very strong assumption that taxes have no effect on budget constraint of consumers. In the long-run, present value of taxes remains the same and no effect on current account through consumption channel exists. Again variation in government spending allowing taxes unchanged with zero CAB in small economy does not affect CAB. In this new fiscal policy shift, government's saving will decrease because it issues debt or sell assets matching the spending in order to esteem the following budget constraint,

$$(\beta^G_2 - \beta^G_1) = r \beta^G_1 + T_1 - G_1 \quad (3.20)$$

Private sector adjusts their consumption and saving to match expected tax rise in the future to meet the newly issued debt.

He again tries to verify the TDH in the framework of the stated model. In conclusion, this study shows that neither REH nor TDH were able to explain correctly the strong assumption on which they rely on, given that they are not likely to hold often.

In '**Ricardian Equivalence: An Empirical Application to the Portuguese Economy**', **Carlous Fonseca Marinheiro (2003)** has gone through various models scrutinized before. These include the '*Reduced Form Consumption Functions*' of Kormendi (1983), Modigliani and Sterling (1986), Bernheim (1987 a), Pereleman and Pestieau (1993), Cardia (1997), Leachman (1996) and '*Euler Equation Approach*' on a *Generalized Permanent Income Hypothesis etc.* The author

had run *ADF* test to check the order of integration of the data series as following, Suppose that the X_t is generated by the following process as

$X_t = \delta + \Phi_1 X_{t-1} + \varepsilon_t$ where, ε_t is a white noise. If X_t is a stationary process, it has a constant average $E(X_t) = E(X_{t-1}) = \mu$, therefore, $\mu = \delta + \Phi_1 \mu$ and $\mu = \delta / (1 - \Phi_1)$.

In order to have finite average, one should have $\Phi_1 \neq 1$, with $\Phi_1 = 1 + \alpha$, we obtain :

$$\Delta X_t = \delta + \alpha X_{t-1} + \varepsilon_t.$$

When $\alpha = 0$, the variable is a random walk, and therefore is not stationary. Stationarity implies a negative value for α . In order to fulfill this requirement one adds lagged difference of the series until the residuals of the regression are white noise. This is the *ADF* test. The null of the non-stationary is tested by

$$\Delta X_t = \delta + \alpha X_{t-1} + \sum \Delta X_{t-1} + \varepsilon_t$$

When the model was tested for the Portuguese economy, the Komerandi (1983) specification of Ricardian Predictions are rejected. The standard Keynesian view that public expenditures have negative influence on consumption' is accepted.

Andrew B Abel and Ben S Bernanke (2003) have analyzed in 'Macro Economics' into relationship between the US government budget deficit and Current account deficit for the period 1960- 1998. This found that the twin deficit relation has gone in opposite direction barring the period of whole 1980s and first half of the 1990s. However, has shown strong support in favor of '*twin deficit hypothesis*'.

The same authors also mentioned some evidences on this issue from other countries in the same book referring the paper on investigating U.S. Government and Trade deficits '. The results for the other countries have observed mixed. For example, revealing the twin deficits idea, Germany's budget deficit and current account deficit both increased in the early 1990s following the reunification of Germany. During mid 1980s, however, Canada and Italy both ran government budget deficits that were considerably larger than those in the United States (as % of GDP), without experiencing severe current account problems. Finally the renowned authors conclude for sure that if an increase in the government budget deficit is not offset by an equal increase in private saving, the result must be a decline in domestic investment, rise in the current account deficit or both.

Walter Enders and Bong- Soo Lee (1990) in '**Current Account and Budget Deficits: Twins or Distant Cousins?**' develop a two country microtheoretic model consistent with the *Ricardian Equivalence Hypothesis (REH)*. An '*Unconstrained Vector Autoregression*' (UVAR) shows some patterns in the recent US data which appear to be inconsistent with the *REH*. Rigorous testing of

the model, however, does not allow them to reject the *independence* of the record federal government budget and current account deficits.

Anjum Aqueel and Mohammed Nishat (2000) in ‘**The Twin Deficits Phenomenon: Evidence from Pakistan**’ use annual data, and the study is based on *Cointegration Analysis*, *ECM* strategy and ‘*Granger Trivariate Causality Tests*’. The empirical results indicate that the Budget deficit has positive and significant long-run effect on the trade deficit in Pakistan. However, the short-run causal effect is negative between budget deficit and current account balances. Furthermore, except for interest rate, other policy variables like economic growth, exchange rate and money supply affect current account deficit directly.

Ali Salman Saleh, Mahendhiran Nair and Tikiri Agalewatte, (2005) in “**The Twin Deficits Problem in Sri-Lanka: An Econometric Analysis**”, argued that prolonged fiscal expansions contributed to current account imbalances. In case of Srilanka during the period 1970 to 2003 in this study, the *Auto Regressive Distributed Lag (ARDL)* model and ‘*bound tests*’ for *cointegration* have been used to assess the long-run dynamics between *twin deficits* in Srilanka. The empirical analysis of this paper supported the *Keynesian View* that there was a long-run relationship between current account imbalances and budget deficit. The empirical results also showed that the direction of causality runs from the budget deficit to current account deficit. Thus any policy measures to reduce the budget deficit in Srilanka could well assist in reducing the current account imbalances.

Suparna Basu and Debabrata Datta (2005) undertook an econometric study to examine the impact of the fiscal deficit on India’s external accounts since mid 1980s and form an absence of *cointegration* between these two deficits. Further, an absence of cointegration between the saving rate and the fiscal deficit –GDP ratio also negated the *REH in Indian circumstances*. These findings suggested that the ratios of trade deficit, fiscal deficit and net savings had randomly maintained the national income identity and that a high fiscal deficit had been sustained by a simultaneous as well as an independent increase in the saving ratios.

Shankar Prasad Acharya and Arjun Kumar Baral (2006) in their paper ‘**Twin Deficit Hypothesis: An Empirical Investigation on Nepalese Time Series, 1964-2000**’, found that Trade Deficit and Budget Deficit were stationary at first differences. These were *cointegrated* and there was *unidirectional causality* from budget deficit to trade deficit in the economy of Nepal.

3.5 Chapter Summary

This Chapter presents a survey of some relevant literatures regarding the *Twin Deficit Hypothesis (TDH)*. Researchers used different methodologies, models and estimated the models with different time horizons. Accordingly, test results were not unanimous and on the contrary, the

findings varied widely. Such diversified and contradictory results might be due to country-wise economic policy divergence, nature of data and their definitions (possibility of lacking uniform practices of aggregation in countries), model specification constraints (e.g. partial modeling instead of full modeling), variable identification problem and the time span. All The empirical studies mentioned in this chapter had gone through some battery of tests, which ranged from *sequential order of stationary testing to causality verification* under time series econometric framework.

CHAPTER- IV

DATA AND METHODOLOGY

4.1. Introduction

This chapter deals with the nature and source of data sets used in the study. Methodological issues are also being considered and explained. Explanations of some estimation procedures along with their implications are being incorporated in this chapter.

4.2 Nature, Period of Study and Source of Data

The study is based on time series datasets. Annual time-series data for *budget deficit* and *trade deficit* for the country of Maldives have been used. The base period is 1995 (1995 = 100). The datasets cover the period 1979-2003. The datasets have been collected from different Year Books of *International Financial Statistics*, published by the IMF.

4.3 Methodology:

The methodology used for the study is basically econometric and time series analysis. Time series methods encompasses both the '*Time Domain*' and '*Frequency Domain*' analyses. The time series methodology involves the tests for '*Stationarity*', '*Integrability*', '*Cointegration*', '*Vector Error Correction Modeling (VECM)*' , application of '*Unrestricted*' and '*Restricted Vector Autoregression (VAR) Models*', '*Intervention Analysis*' through the applications of '*Impulse Response Functions*', as well as '*Variance Decomposition*', '*Spectral Analysis*' involving the study of '*Periodograms*', '*Autospectrum*', '*Cospectrum*' '*Coherency Spectrum*,' '*Gain Spectrum*', '*Phase Spectrum*' etc.

A brief features of some of the estimation techniques and methodological issues are being described below.

4.4 Stationarity and Unit Root Test :Relevance

Econometric analysis requires that the time series data-sets be 'stationary'. Non-stationary data contain unit roots. The main objective of unit root tests is to determine the degrees of integration of each individual time series. Various methods for unit root tests have been applied in this study. Some of these are being explained below.

4.5 Dickey-Fuller Unit Root Test

For the Dickey- Fuller tests, the relevant model is

$$y_t = \beta_0 + \beta_1 t + u_t \quad (4.1)$$

$$\text{where } u_t = \alpha u_{t-1} + \epsilon_t \quad (4.2)$$

Here ϵ_t is a covariance stationary process with zero mean. the reduced form for this model is,

$$y_t = \gamma + \delta t + \alpha y_{t-1} + \epsilon_t \quad (4.3)$$

$$\text{where } \gamma = \beta_0(1 - \alpha) \text{ and } \delta = \beta_1(1 - \alpha)$$

This equation is said to have a unit root if $\alpha = 1$ (in which case $\delta = 0$)

4.6 Augmented Dickey-Fuller Unit Root Test

In order to test for the existence of unit roots, and to determine the degree of differencing necessary to induce stationarity, we have applied the 'Augmented Dickey-Fuller test'. Dickey and Fuller (1976, 1979), Said and Dickey (1984), Phillips (1987), Phillips and Perron (1988), and others developed modified version of the Dickey-Fuller tests when the error term i.e ϵ_t is not *white noise*. These tests are called 'Augmented Dickey-Fuller test' (ADF). The results of the *Augmented Dickey-Fuller test* (ADF) help to determine the form in which the data should be applied in any econometric analysis. The alternative forms are as follows.

$$\Delta y_t = \gamma + \alpha y_{t-1} + \sum_{j=2}^k \theta_j \Delta y_{t-j+1} + e_t \quad (4.4)$$

$$\Delta y_t = \gamma + \delta_t + \alpha y_{t-1} + \sum_{j=2}^k \theta_j \Delta y_{t-j+1} + e_t \quad (4.5)$$

$$\Delta y_t = \alpha y_{t-1} + \sum_{j=2}^k \theta_j \Delta y_{t-j+1} + e_t \quad (4.6)$$

where, y_t = Model Variables (TD_t and BD_t) of Maldives;

Δy_t = First differenced series of y_t .

Δy_{t-j+1} = First differenced series of y_t at $(t-j+1)^{\text{th}}$ lags. ($j = 2 \text{---} k$)

The equation (4.4) contains a constant as exogenous, while equation (4.5) bears a constant along with a linear trend. However, equation (4.11) presents an auto-regressive process with no constant and linear trend.

4.7 The Dickey-Fuller- GLS Unit Root Test

The DF-GLS test has been developed by Elliott, Rothenberg and Stock (1996), and the test possesses greater precision than ADF test in identifying *non-stationarity*. The DF-GLS t-test is performed by testing the hypothesis $a_0 = 0$ in the regression equation.

$$\Delta y_t^d = a_0 y_t^d + a_1 \Delta y_{t-1}^d + \text{-----} + a_p \Delta y_{t-p}^d + \text{error} \quad (4.7)$$

where y_t^d is the locally de-trended series y_t . The local de-trending depends on whether we consider a model with drift only or a linear trend.

- (i) DF-GLS unit root test without time trends (a model with drift only):

$$y_t^\mu = \alpha y_{t-1}^\mu + \sum_{i=1}^k \Psi_i \Delta y_{t-i}^\mu + u_t \quad (4.8)$$

(ii) DF-GLS unit root test with time trends (a model with linear trend):

$$y_t^\tau = \alpha y_{t-1}^\tau + \sum_{i=1}^k \Psi_i \Delta y_{t-i}^\tau + u_t \quad (4.9)$$

4.8 Phillips –Perron Unit Root Test

Phillips (1987), Phillips and Perron (1988) have generalized the Dickey –Fuller (DF) tests to the situations where disturbance processes, ϵ_t are serially correlated. The PP is intended to add a ‘correction factor’ to the DF test statistic.

Let the AR (1) model be,

$$Y_t = \mu + \Phi_1 Y_{t-1} + \epsilon_t, [t = 1 \text{ --- } T] \quad (4.10)$$

with $\text{Var}(\epsilon_t) \equiv \sigma_\epsilon^2$

If ϵ_t is serially correlated , the ADF approach is to add lagged ΔY_t to ‘whiten’ the residuals . The test statistic $T(\Phi_1-1)$ has been considered which is distributed as ρ_μ in the maintained regression with an intercept but with no time trend. The PP modified version is

$$Z_{\rho_\mu} = T(\Phi_1-1)\text{-CF} \quad (4.11)$$

where the correction factor CF is

$$CF = 0.5 (s_{T1}^2 - s_\epsilon^2) / (\sum_{t=2}^T (Y_{t-1} - \bar{Y}_{-1})^2 / T^2) \quad (4.12)$$

$$\text{and, } s_\epsilon^2 = T^{-1} \sum_{t=1}^T \epsilon_t^2 \quad (4.13)$$

$$s_{T1}^2 = s_{2\epsilon}^2 + 2 \sum_{s=1}^l W_{sl} \sum_{t=s+1}^T \epsilon_t \epsilon_{t-s} / T \quad (4.14)$$

where $W_{sl} = 1-s/(1+l)$ and $\epsilon_t = Y_{t-\mu} - \Phi_1 Y_{t-1}$

$$\bar{Y}_{-1} = (\sum_{t=2}^T Y_t) / (T-1) \quad (4.15)$$

4.9 KPSS Unit Root Test

Another frequently used method for the test of stationarity is the KPSS test developed by Kwiatkowski et al. the KPSS test is an analog of Phillips –Perron test. The model for KPSS test is:

$$\Phi(L)y_t = \alpha_t + \beta t + \epsilon_t \quad (4.16)$$

where $\alpha_t = \alpha_{t-1} + \eta_t, \alpha_0 = \alpha \quad (t = 1, 2, \dots, T)$

and $\epsilon_t \sim \text{IID}(0, \sigma_\epsilon^2), \eta_t \sim \text{IID}(0, \sigma_\eta^2)$

ϵ_t and η_t are independent and $\Phi(L)$ is a p^{th} order lag polynomial. The relevant hypothesis for the test of stationarity in this model are,

$$H_0 : \sigma_{\eta}^2 = 0$$

Against,

$$H_1 > 0$$

Under H_1 the process defines an ARIMA (p,d,q) model structure.

It has been argued that tests with stationarity as null can be used to confirm the results of the usual unit root tests. The relevant two tests are

Test 1 (usual test)	Test 2 (KPSS test)
$H_0 : y_t$ is nonstationary (unit root)	$H_0 : y_t$ is stationary
$H_1 : y_t$ is stationary	$H_1 : y_t$ is nonstationary (unit root)

If both tests reject their nulls, there will be no confirmation. But if test 1 rejects the null but test 2 does not (or vice versa) the confirmation can be drawn (G.S.Maddala 2001:553).

4.10 ERS Point Optimal Test

The *ERS point Optimal* test is largely based on the following quasi-differencing regression equation:

$$d(y_t / \alpha) = d(x_t / \alpha)' \delta(\alpha) + \eta_t \quad (4.17)$$

where x_t stands for either a constant or a constant along with trend and $\delta(\alpha)$ be the ordinary least square (OLS) estimates. The residual from this equation is

$$\eta_t(\alpha) = d(y_t / \alpha) - d(x_t / \alpha)' \delta(\alpha) \quad (4.18)$$

let, $SSR(\alpha) = \sum \eta_t^2(\alpha)$ be the sum of squared residuals function. The ERS point optimal test statistic of the “null that $\alpha=1$ ” against “the alternative that $\alpha = \bar{\alpha}$ ”, is then defined as

$$P_T = SSR(\bar{\alpha}) - \bar{\alpha} SSR(1) / f_0 \quad (4.19)$$

where, f_0 is an estimator of the residual spectrum at frequency zero. In order to compute the ERS test, it is necessary to specify the underlying set of exogenous regressors x_t and a technique for estimating f_0 .

4.11 NG and Perron (NP) Test

Ng and Perron (2001) estimate four test statistics that are based upon the GLS de-trended data y_t^d . These test statistics are modified forms of Phillips and Perron Z_{α} and Z_t statistics, the Bhargava (1986) R_1 statistics and the ERS Point Optimal statistic. The terms are defined as

$$k = \sum_{t=2}^T (y_{t-1}^d)^2 / T^2 \quad (4.20)$$

The modified statistics can be represented as

$$\begin{aligned}
 MZ_{\alpha}^d &= [T^{-1}(y_t^d)^2 - f_0] / 2k \\
 MZ_{\alpha}^d &= MZ_{\alpha} \times MSB \\
 MSB^d &= (k / f_0)^{1/2} \\
 MP_t^d &= \{\bar{c}^2 k - \bar{c} T^{-1}(y_t^d)^2 / f_0 \quad \text{if } x_t = \{1\}\} \\
 &= \{\bar{c}^2 k - (1 - \bar{c}) T^{-1}(y_t^d)^2 / f_0 \quad \text{if } x_t = \{1, t\}\} \\
 &\text{where, } \bar{c} = -7 \quad \text{if } x_t = \{1\} \\
 &= -13.5 \quad \text{if } x_t = \{1\}
 \end{aligned}
 \tag{4.21}$$

The NP tests require a specification for x_t and a choice of method for estimating f_0 .

4.12 Correlogram

One of the simple, intuitive and interesting methods of testing ‘stationarity’ is running a correlogram. Correlogram is nothing but simply a graphical representation of Auto-correlation Function (ACF) and Partial Auto-correlation Function (PACF). The nature of stationarity can also be found almost accurately in most of the cases with the help of Correlogram.

4.13 Cointegration Test

The *cointegration* test represents the gesticulation of long- run equilibrium relationship between two variables say y_t and x_t . Let both be integrated at one, that is $y_t \sim I(1)$ and $x_t \sim I(1)$. Then y_t and x_t are said to be cointegrated if there exist some β such that $y_t - \beta x_t$ is $I(0)$. This is denoted by saying y_t and x_t are CI (1,1) i.e y_t and x_t are *cointegrated*. Different types of *cointegration* techniques are available for the time series analysis. These tests include the *Engle and Granger Test* (1987), *Stock and Watson Procedure* (1988) and *Johansen’s Method* (1988, 1990, 1991)

4.14 Engle Granger Cointegration Test

This approach is also known as a residual test. If the variables included in an equation are integrated of the same order, say (1), the error term should be stationary, i.e. $I(0)$. Let us consider M time horizon time series ($Y_{t1} \dots Y_{tM}$), each of which is $I(1)$, Let one of the two regression model include a drift and no trend while the second one contains a drift and trend such that

$$Y_{t1} = \beta_0 + \sum_{j=2}^M \beta_j y_{t-j+1} + \varepsilon_t
 \tag{4.22}$$

$$Y_{it} = \beta_0 + \beta_1 t + \sum_{j=2}^M \beta_j y_{t-j+1} + \varepsilon_t \quad (4.23)$$

A test for no co-integration is assigned by a test for a unit root in the estimated error e_t . This can be achieved by applying ADF test to the residuals using the following equation:

$$\Delta e_t = \alpha e_{t-1} + \sum_{j=1}^p \Phi_j e_{t-j} + v_t \quad (4.24)$$

The null hypothesis $\alpha = 0$ is tested using the τ statistic.

4.15 Johansen Maximum Likelihood Cointegration Test

The *Johansen Maximum Likelihood Procedure* examines the relationship among stationary or non-stationary variables using the following equation:

$$x_t = \sum_{i=1}^p \Pi_i x_{t-i} + \varepsilon_t \quad (4.25)$$

The function can be presented according to the following VAR system:

$$\Delta x_t = \Pi x_{t-1} + \sum_{i=1}^p \Phi_i \Delta x_{t-i} + \mu + \varepsilon_t \quad (4.26)$$

In which x_t is an $n \times 1$ random vector, ε_t is NIID $(0, \sigma^2_\varepsilon)$, and μ is deterministic terms. The long run relationships are derived through the coefficient Matrix of Π , denoted by r , which is between 0 and n . Then there are r linear combinations of the variables in the system that are $I(0)$ or *cointegrated*. Under Johansen (1991), and Johansen and Juselius (1990) procedures, two tests are available for the determination of *cointegrating vectors* and for the estimation of their values. These tests are the *Trace Test* and the *Eigen Value Test*. In this method a two-stage testing procedure has been followed. In the first stage, the '*null hypothesis of no Cointegration*' hypothesis is tested against the alternative hypothesis that the data are cointegrated with an unknown cointegrating vector. If the null hypothesis is rejected, a second stage test is implemented with Cointegration maintained under both the null and alternative. Gonzalo (1994) has suggested that Johansen's procedure has certain properties which are superior to alternative cointegrating testing methods.

4.16 Vector Error Correction Modeling

Vector Error Correction Modeling provides important information on the short run relationship (short run dynamics) between any two cointegrated variables. *Vector Error Correction* test has provided empirical evidence on the short-run causality between the trade deficits and budget deficits in Maldives.

In the present study the vector error correction estimates have been specified using the following models.

$$\Delta TD_t = \gamma_1 + \rho_1 z_{t-1} + \alpha_1 \Delta TD_{t-1} + \alpha_2 \Delta TD_{t-2} + \alpha_3 \Delta BD_{t-1} + \alpha_4 \Delta BD_{t-2} + \epsilon_{1t} \quad (4.27)$$

$$\Delta BD_t = \gamma_2 + \rho_2 z_{t-1} + \beta_1 \Delta TD_{t-1} + \beta_2 \Delta TD_{t-2} + \beta_3 \Delta BD_{t-1} + \beta_4 \Delta BD_{t-2} + \epsilon_{2t} \quad (4.28)$$

where, ΔTD_t = first difference of the trade deficit (real); ΔBD_t = first difference of Budget deficit (real); z_{t-1} = first lag of error term of cointegrating equation, ϵ_{1t} and ϵ_{2t} are white noise errors; $\alpha_1, \alpha_2, \alpha_3,$ and α_4 and $\beta_1, \beta_2, \beta_3, \beta_4$ are the coefficients of lagged variables in the above models.

The focus of the vector error correction analysis is on the lagged z_t terms. These lagged terms are the residuals from the previously estimated cointegrating equations. In the present case the residuals from two lag specifications of the cointegrating equations have been used in the vector error correction estimates. Lagged z_t terms provide an explanation of short-run deviations from the long-run equilibrium for the test equations above. Lagging these terms means that disturbance of the last period impacts upon the current time period. Statistical significance tests are conducted on each of the lagged z_t terms in equations (4.27) and (4.28) in general. Finding a statistically insignificant coefficient of the z_t term implies that the system under investigation is in the short-run equilibrium as there are no disturbances present. If the coefficient of the z_t term is found to be statistically significant, and then the system is in the state of the short-run disequilibrium. In such a case the sign of z_t term gives an indication of the causal direction between the two test variables.

4.17 Granger Causality Tests:

For the sake of simplicity, let γ_{1t} and γ_{2t} be the two variables under study. Along this course, the focal idea 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 squared 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.

$$\gamma_{1t} = \mu_{10} + \pi_{11.1} \gamma_{1t-1} + \dots + \pi_{11.p} \gamma_{1t-p} + \pi_{12.1} \gamma_{2t-1} + \dots + \pi_{12.p} \gamma_{2t-p} + \epsilon_{1t} \quad (4.29)$$

$$\gamma_{2t} = \mu_{20} + \pi_{21.1} \gamma_{1t-1} + \dots + \pi_{21.p} \gamma_{1t-p} + \pi_{22.1} \gamma_{2t-1} + \dots + \pi_{22.p} \gamma_{2t-p} + \epsilon_{2t} \quad (4.30)$$

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 a system of two

equations (4.29) and (4.30), the errors may be contemporaneously correlated. Therefore, any shock to one of the equations would have ‘*ripple effect*’ on the other equation.

For the specification of the ϵ_{it} , $i=1,2$; is assumed to have an innovation with zero mean, constant variance and no serial correlation that is $E\{\epsilon_{it}\} = 0$; $E\{\epsilon_{it}^2\} = \sigma^2_i$ for $i=1,2$ and $E\{\epsilon_{it}, \epsilon_{is}\} = 0$ for $t \neq s$ and $i=1,2$. Again it is also assumed that $E\{\epsilon_{1t}, \epsilon_{2s}\} = 0$ for $t \neq s$ for no serial correlation. Additionally, the ‘*ripple effect*’ is captured by the covariance between ϵ_{1t} and ϵ_{2t} , denoted by 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

$$\Omega(\epsilon, p) \equiv E \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{pmatrix} (\epsilon_{1t} \epsilon_{2t}) = \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{bmatrix} \quad (4.31)$$

The equations (4.29) and (4.30) may be presented in a matrix form;

$$\begin{pmatrix} \gamma_t^1 \\ \gamma_t^2 \end{pmatrix} = \begin{pmatrix} \mu_{10} \\ \mu_{20} \end{pmatrix} + \begin{bmatrix} \pi_{11.1} & \pi_{12.1} \\ \pi_{21.1} & \pi_{22.1} \end{bmatrix} \begin{pmatrix} \gamma_{t-1}^1 \\ \gamma_{t-1}^2 \end{pmatrix} + \dots + \begin{bmatrix} \pi_{11.p} & \pi_{12.p} \\ \pi_{21.p} & \pi_{22.p} \end{bmatrix} \begin{pmatrix} \gamma_{t-p}^1 \\ \gamma_{t-p}^2 \end{pmatrix} + \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{pmatrix} \quad (4.32)$$

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

$$\gamma_t = \mu + \Pi_1 \gamma_{t-1} + \dots + \Pi_p \gamma_{t-p} + \epsilon_t \quad (4.33)$$

where, $\gamma_t = (\gamma_{1t}, \gamma_{2t})$, $\mu = (\mu_{10}, \mu_{20})$ and Π_i are 2×2 matrices defined in response to equation (4.32). If any of the coefficients of γ_{2t-1} ($i=1 \dots \beta$) significant, that γ_{2t} *Granger Causes* to γ_{1t} . Similarly, if any of the coefficients of γ_{1t-1} ($i=1 \dots \beta$) is significant, then γ_{2t} is *Granger Caused* by γ_{1t} .

4.18 Vector Auto-regression (VAR) Modeling

While testing the long-run dynamic relationship between model variables concerned, we may not make any *a priori* assumption of endogeneity and exogeneity of variables concerned. In such situation, *Vector Auto-regressive Model (VAR)* can be applied. This model treats all variables systematically without making reference to the issue of dependence or independence. A *VAR* additionally offers a scope for *Intervention Analysis* through the study of ‘*Impulse Response Functions*’ for the endogenous variables in the model. Moreover, a *VAR* model allows us to study the ‘*Variance Decompositions*’ for these variables and this help us understand the inter-relationships among the variables concerned. We, therefore, seek to develop following models for the Twin Deficit Relationship for the economy of Maldives.

4.18.1 The VAR Model

The *Vector Autoregression (VAR)* model for trade deficit and budget deficit for the economy of Maldives consists of the equation (4.34) and (4.35)

$$\Delta TD_t = \alpha_1 + \sum_{i=1}^k \beta_{1i} \Delta TD_{t-i} + \sum_{i=1}^k \gamma_{1i} \Delta BD_{t-i} + u_{1t} \quad (4.34)$$

$$\Delta BD_t = \alpha_2 + \sum_{i=1}^k \beta_{2i} \Delta BD_{t-i} + \sum_{i=1}^k \gamma_{2i} \Delta TD_{t-i} + u_{2t} \quad (4.35)$$

where, α_i , $i=1,2$ intercepts,

u_{1t} and u_{2t} = Stochastic error terms (alternatively called as impulses or innovations or shocks

in VAR Modeling), $\sum_{i=1}^k \beta_{1i} \Delta TD_{t-i}$ and $\sum_{i=1}^k \gamma_{2i} \Delta TD_{t-i}$ represent all summation values of

lagged terms of trade deficit in the model.

$\sum_{i=1}^k \gamma_{1i} \Delta BD_{t-i}$ and $\sum_{i=1}^k \beta_{2i} \Delta BD_{t-i}$ represent all summation values of lagged variables of

budget deficit in the model.

Furthermore, the VAR model consisting of equations (4.34) and (4.35) which requires that

- (i) ΔTD_t and ΔBD_t be stationary, and
- (ii) u_{1t} and u_{2t} be white noise terms such that

$$u_{1t} \sim \text{iid } N(0, \sigma^2 u_1), \text{ and}$$

$$u_{2t} \sim \text{iid } N(0, \sigma^2 u_2)$$

4.19 Impulse Response Function

Any shocks to any variables not only directly affects the respective variable only, but also it would be transmitted to all of the endogenous variables in the model through dynamic (lag) structure of VAR. An Impulse Response Function tries to find out the effect of one time shock to one of the innovations on current and future values of the endogenous variables. Due to this feature, Impulse Response Function (IRS) in VAR System is widely used in describing the dynamic behavior variables in the system concerned to shocks in the residual of the time series under study.

Innovations are normally correlated and may be viewed as having common properties which cannot be associated only to a specific variable. In order to explain the impulses, it is widely applied for a transformation (P) to the innovations so that they become uncorrelated such that

$$V_t = P\varepsilon_t \sim (0, D)$$

where, $D = \text{Diagonal co-variance matrix}$.

4.20 Variance Decomposition

Specifically, *Impulse Response Function* discovers the effects of a shock to one and thereby transmitted to other endogenous variables in the VAR System. However it cannot tell us the magnitude of shocks in the system. To overcome this problem, Variance Decomposition mechanism is applied to separate out the variation in an endogenous variable into the constituent shocks to the VAR System. So Variance Decomposition is applied in the models to find out the information about relative importance of every random innovation in the question of its effects to the variables concerned in the VAR system.

CHAPTER -V

STATIONARITY AND INTEGRABILITY OF BUDGET DEFICIT AND TRADE DEFICIT

5.1 Introduction

Macroeconomic variables like '*budget deficit*' and '*trade deficit*' which are used in econometric studies are usually of time series in nature. These are no longer to be considered as deterministic variable. On the contrary, these are considered to be generated by some underlying stochastic process. In any time series Y_t , each value Y_1, Y_2, \dots, Y_t is assumed to be drawn randomly from a probability distribution. To be completely general the observed series Y_1, Y_2, \dots, Y_t is assumed to be drawn from a set of jointly distributed random variables. Thus if the underlying probability distribution function of the series could be specified, then one can determine the probability of one or another future outcome. But the complete specification of the probability distribution function for any time series is usually impossible. However, it is possible to construct a simplified model of the time series, which explains its nature of randomness in a manner useful for econometric studies. The simple model may be a reasonable approximation of the actual and more complicated underlying stochastic process.

Specification of the underlying stochastic process is preceded by the identification of the nature of the stochastic process. More specifically, if the stochastic process that generates the time series data is invariant with respect to time, and then it is '*stationary*'. If the process is '*non-stationary*', it will be difficult to represent time series over past and future intervals of time by an algebraic model. By contrast, if the stochastic process is fixed in time, i.e. if it is '*stationary*', then one can model the process through an equation with fixed coefficients that can be estimated from the past data. This is possible because, for a stationary process, both the joint probability distribution and conditional probability distribution are '*invariant*' with respect to time.

It, therefore, becomes pertinent for enquiring into the nature of the stochastic processes for the macroeconomic variables, like '*budget deficit*' and '*trade deficit*' used in this study. We seek to examine if these macroeconomic variables are really '*Deterministic Trend-Reverting Non-Stationary*' series or '*Random Walk*' processes. If these processes were '*Random Walks*' by nature, then econometric studies would require appropriate technical and theoretical adjustments. We seek to address this issue in this chapter.

5.2 Time Plots of Budget Deficit (BD_t) and Trade Deficit (TD_t)

The Figure 5.1 below shows the time plots of Budget Deficit and Trade Deficit (at levels).

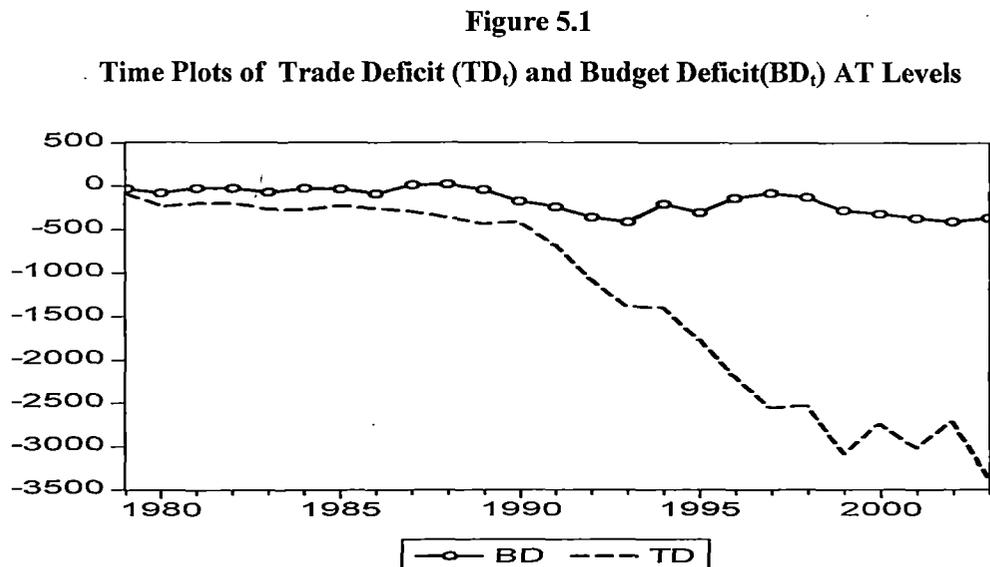
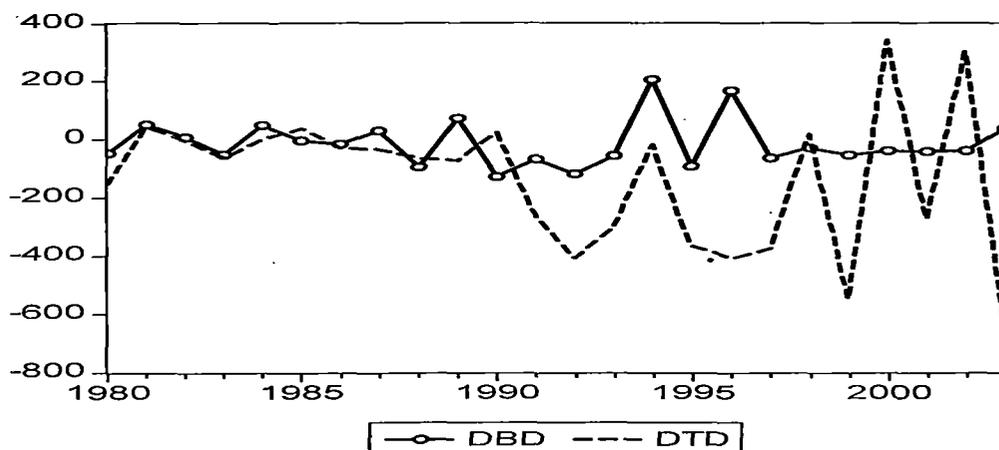


Figure 5.1*

Time Plots of Budget Deficit and Trade Deficit (At First Difference)



It is observed from the figure 5.4 that both the series exhibit stochastic trend along their time paths with minimal ups and downs over the period concerned. This feature of the series is a pointer to their non-stationarity. This leads us to examine the nature of 'stationarity' of BD_t and TD_t series at levels.

5.3 Test of Stationarity: Augmented Dickey-Fuller (ADF) Test

Stationarity of Budget Deficit (BD_t) and Trade Deficit (TD_t) has been studied through the 'Augmented Dickey Fuller' tests. The relevant ADF Test equations are

$$\Delta BD_t = \alpha_1 + \beta_1 t + \gamma_1 BD_{t-1} + \delta_{1i} \sum_{i=1}^m \Delta BD_{t-i} + \varepsilon_{1t} \quad (5.1)$$

$$\Delta TD_t = \alpha_2 + \beta_{2t} + \gamma_2 TD_{t-1} + \delta_{2i} \sum_{i=1}^m \Delta TD_{t-i} + \varepsilon_{2t} \quad (5.2)$$

where $\varepsilon_{1t}, \varepsilon_{2t}$ are white noise error terms, m is the optimum lag length and

$$\Delta BD_t = (BD_t - BD_{t-1})$$

$$\Delta TD_t = (TD_t - TD_{t-1}) \text{ etc.}$$

The optimum lag (m) length may be determined by *Akaike Information Criterion*, *Schwartz Information Criterion* etc. Again the estimable ADF Test equation for the differenced series for BD_t and TD_t are

$$\Delta^2 BD_t = \alpha_3 + \gamma_3 \Delta BD_t + \delta_{3i} \sum_{i=1}^m \Delta^2 BD_{t-i} + \varepsilon_{3t} \quad (5.3)$$

$$\Delta^2 TD_t = \alpha_4 + \gamma_4 \Delta TD_t + \delta_{4i} \sum_{i=1}^m \Delta^2 TD_{t-i} + \varepsilon_{4t} \quad (5.4)$$

where ε_{3t} and ε_{4t} are white noise error terms and

$$\Delta^2 BD_{t-1} = (\Delta BD_t - \Delta BD_{t-1})$$

$$\Delta^2 TD_{t-1} = (\Delta TD_t - \Delta TD_{t-1}) \text{ etc.}$$

5.4 Results of ADF Tests

The results of *ADF* test for the presence of unit root in the series concerned are being summarized through the Table 5.1

Table 5.1

Results of Estimation of ADF Unit Root Test on BD_t and TD_t

Exogenous: Constant

Null Hypothesis: The variable has a unit root

Lag length: (Automatic based on SIC, Max lag =8)

[Sample 1979-2003]

Variable	ADF test statistic	Prob* Value	Lag Length**	Test Critical Values		
				1%	5%	10%
BD_t	-1.590165	0.4720	0	-3.737853	-2.991878	-2.635542
ΔBD_t	-5.280867	0.0003	0	-3.752946	-2.998064	-2.638752
TD_t	0.764362	0.9907	3	-3.788030	-3.012363	-2.646119
ΔTD_t	-4.564264	0.0018	2	-3.788030	-3.012363	-2.646119

Exogenous : Constant and Linear Trend

Variable	ADF test	Prob*	Lag	Test Critical Values		
	statistic	Value	Length**	1%	5%	10%
BD_t	-2.805966	0.2097	2	-4.440739	-3.632896	-3.254671
ΔBD_t	-3.603090	0.0644	8	-4.728363	-3.759743	-3.324976
TD_t	-2.980220	0.1593	2	-4.440739	-3.632896	-3.254671
ΔTD_t	-4.777211	0.0054	2	-4.467895	-3.644963	-3.261452

Exogenous: None

Variable	ADF test	Prob*	Lag	Test Critical Values		
	statistic	Value	Length**	1%	5%	10%
BD_t	-0.499872	0.4890	0	-2.664853	-1.955681	-1.608793
ΔBD_t	-5.337854	0.0000	0	-2.669359	-1.956406	-1.608495
TD_t	2.560891	0.9960	1	-2.669359	-1.956406	-1.608495
ΔTD_t	-1.018342	0.2666	3	-2.685718	-1.959071	-1.607456

* Mac Kinnon (1996) one sided P-values

** Automatic based on SIC, Max Lag=8

5.5 Findings From ADF Tests (Table 5.1):

The table 5.1 shows that

- (i) the 'null hypothesis of 'Unit Roots' has been accepted even at 10% level for BD_t series (at levels) in the presence of a *constant (intercept term)* and of an *intercept term* along with '*linear trend*' in the maintained equations [since the relevant ADF test statistics (absolute) exceed the corresponding absolute critical values at 10% level.]
- (ii) for the TD_t series at level, the null hypothesis of 'unit roots' with exogenous '*intercept*' term and with *intercept term* along with '*linear time trend*' is accepted even at 10% level [since the relevant ADF Test statistics (absolute value) exceed the corresponding critical values at 10% level.]
- (iii) the null hypotheses of unit root have been rejected at 10% level for the first differenced series of BD_t and TD_t given the exogenous '*intercept*' term and with an intercept term along with '*linear time trend*' in the maintained regression equations. This is so because the relevant ADF test statistics (*absolute values*) exceed the corresponding critical values at 1% level.

All these findings confirm that

- (i) BD_t and TD_t series are ‘non-stationary’ even (at 10% level).
- (ii) BD_t and TD_t series follow ‘random walks’ without a ‘drift’.
- (iii) ΔBD_t and ΔTD_t series are ‘Stationary’.
- (iv) BD_t and TD_t series are ‘Differenced Stationary’ (DS) and not ‘Trend Stationary’ (TS).
- (v) BD_t and TD_t are I(1) series.

These findings, therefore, lead us to examine if the exhibited ‘non-stationarity’ in the series concerned (BD_t and TD_t) is due to ‘structural shift’. With this end in view, the ‘Phillips-Perron Unit Root Test’ has been performed.

5.6 Results of the Phillips-Perron Unit Root Tests

Results of the Phillips –Perron Unit Root Tests are being presented through the Table 5.2.

Table -5.2

Results of Phillips –Perron Unit Root Test on BD_t and TD_t

Exogenous : Constant

Null Hypothesis : The variable has a unit root

Variable	P-P test- statistic	Probability* value	Band width**	Test critical values		
				1%	5%	10%
BD_t	-1.695230	0.4208	2	-3.737853	-2.991878	-2.635542
ΔBD_t	-5.274298	0.0003	1	-3.752946	-2.998064	-2.638752
TD_t	0.640772	0.9879	2	-3.737853	-2.991878	-2.635542
ΔTD_t	-6.601869	00000	3	-3.752946	-2.998064	-2.638752

Exogenous : Constant and Linear Trend

Variable	P-P test- statistic	Probability* value	Bandwidth**	Test critical values		
				1%	5%	10%
BD_t	-2.494004	0.3277	2	-4.394309	-3.612199	-3.243079
ΔBD_t	-5.223766	0.0018	1	-4.416345	-3.622033	-3.248592
TD_t	-3.345005	0.0831	0	-4.394309	-3.612199	-3.243079
ΔTD_t	-7.078441	0.0000	4	-4.416345	-3.622033	-3.248592

Exogenous : None

Variable	P-P test- statistic	Probability* value	Bandwidth**	Test critical values		
				1%	5%	10%
BD_t	-0.414781	0.5231	1	-2.664853	-1.955681	-1.608793
ΔBD_t	-5.330200	0.0000	1	-2.664853	-1.955681	-1.608793
TD_t	2.529467	0.9958	1	-2.664853	-1.955681	-1.608793
ΔTD_t	-4.961327	0.0000	2	-2.669359	-1.956406	-1.608495

* MacKinnon(1996)One sided P -values

** Newey- West Using Bartlett Kernel

5.7 Findings from the Phillips- Perron Tests:

It is observed from the Table 5.2 that,

- (i) for BD_t and TD_t series the null hypothesis of *Unit root* are being accepted even at 10% level, given the intercept term in the maintained regression equation. This occurs because the (absolute) values of the *PP statistics* falls short of corresponding critical values (absolute) at 10% level of significance.
- (ii) the null hypothesis of unit roots in BD_t and TD_t have been accepted even at 10% level when the maintained equation contains the '*intercept*' term along with a '*linear trend term*, given that the absolute values of the *PP statistics* are lower than the corresponding critical values (absolute) at 10% level of significance.
- (iii) the null hypotheses of 'unit roots' have been rejected for ΔBD_t and ΔTD_t series even at 1% level when the maintained regression equations contain '*intercept term*' where the absolute values of the *PP statistics* exceed the corresponding critical values (absolute) at 1% level of significance.
- (iv) the null hypotheses of 'unit roots' have been rejected in ΔBD_t and ΔTD_t series even at 1% level when an *intercept* term and a '*linear trend*' term appear in the maintained regression equations such that the absolute values of the *PP statistics* exceed the corresponding absolute critical values at 1% level of significance.

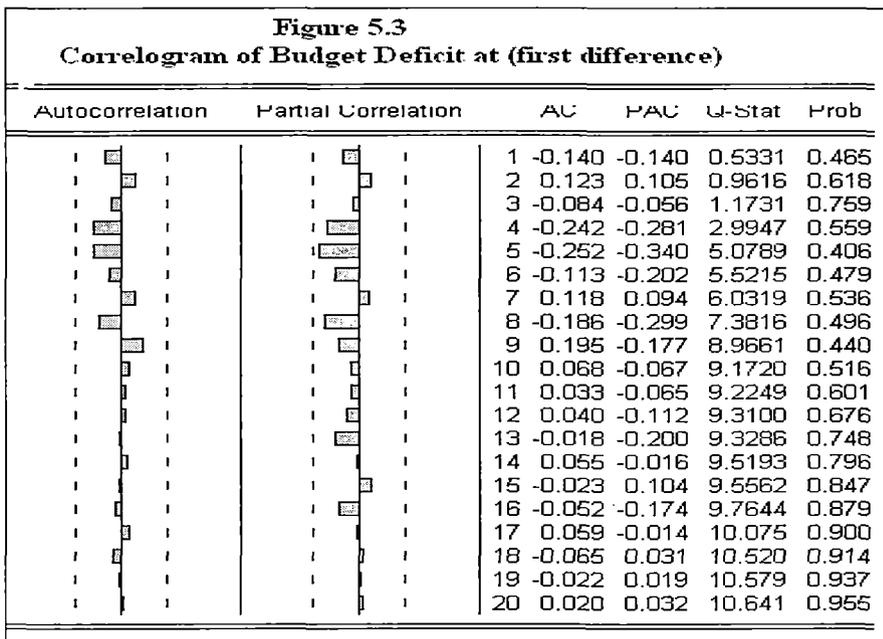
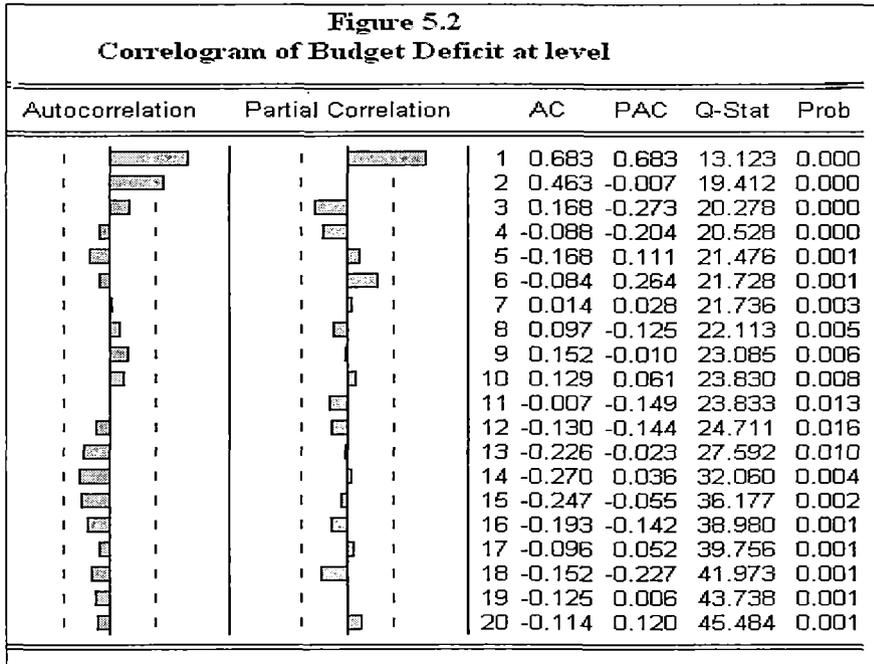
These observations indicate that

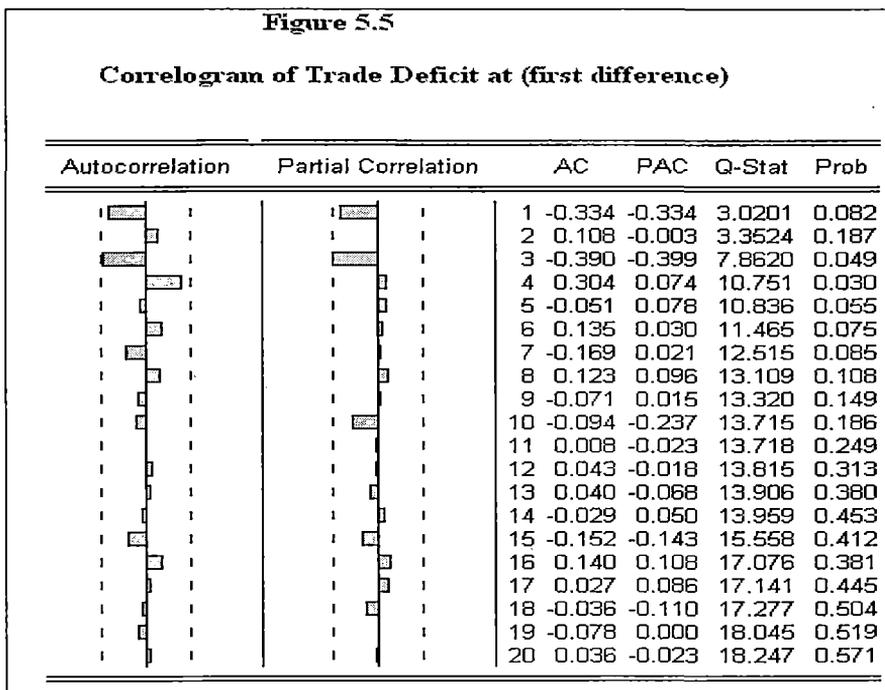
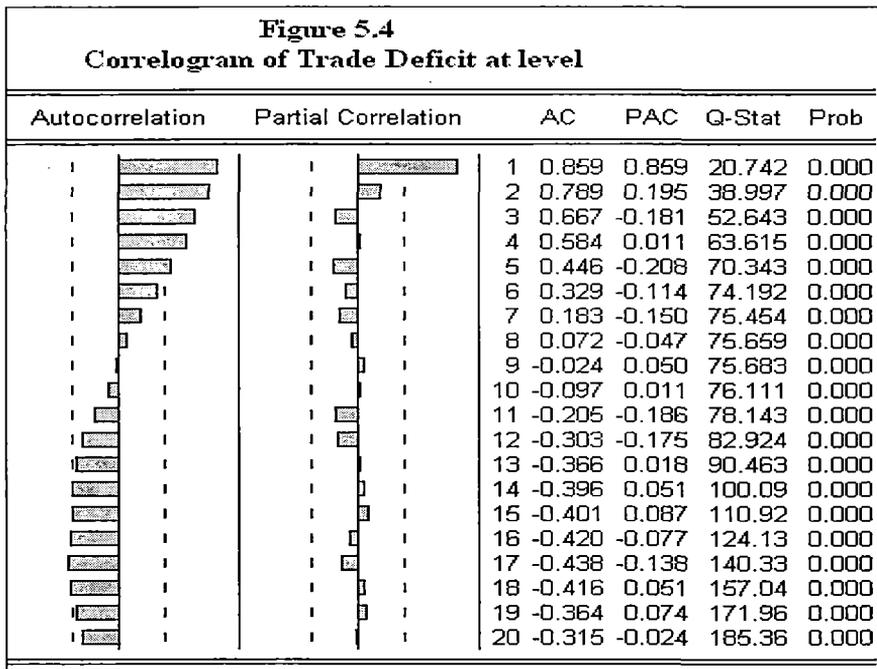
- (i) BD_t and TD_t series are non stationary at levels.
- (ii) Non-stationarity of the series at levels is not due to the '*structural shifts*' in the stochastic structures.
- (iii) BD_t and TD_t series attain stationarity upon first differencing.
- (iv) BD_t and TD_t series are $I(1)$

Thus the *Phillips-Perron* Test results corroborate the findings from the *ADF unit root tests*.

5.8 Correlogram Analysis for Stationarity.

Correlogram is a graphical representation of Autocorrelation Function (ACF) and Partial Auto correlation Function (PACF) for any variable. The ACFs and PACFs of the Budget Deficit (BD_t) at level and at first difference are being presented through figures 5.2 and 5.3. Similarly, the correlogram for TD_t at level and at first difference are being presented through the Figures 5.4 and 5.5.





5.9 Findings from the Figures 5.2 and 5.3

(A) The corresponding *Correlogram* of the BD_t series at level shows that

- (i) the *ACF* contains a short dying out pattern of spikes and
- (ii) the *PACF* contain a singular significant spike at lag1.

These observations are pointers to ‘non-stationarity’ of BD_t series at level. Consequently, the correlogram for ΔBD_t is being considered for the confirmation of ‘stationarity’ of the series concerned.

(B) It is observed from the figure 5.3 that in the correlogram for ΔBD_t series

- (i) the *ACF* is free from any dying out pattern of spikes and spikes in all the lags are completely insignificant.
- (ii) the *PACF* is marked by the presence of insignificant spikes at lag 1 through lag 20.

These observations further confirm that ΔBD_t series is ‘stationary’ and BD_t attains stationarity upon first differencing. Consequently BD_t series is $I(1)$.

5.10 Findings From the Figures 5.4 and 5.5

(A) The Figure 5.4 shows that

- (i) the corresponding *ACF* of the TD_t series (at level) display a dying out pattern of the significant spikes, and
- (ii) The corresponding *PACF* contains only one significant spike at lag one while all other lags contain very insignificant spikes.

All these observations confirm that TD_t series at level are non-stationary. Consequently, the correlogram of TD_t series upon first differencing as given by the Figure 5.5, is being examined.

(B) It is observed further Figure 5.5 that in the ΔTD_t series

- (i) The *ACF* is marked by the absence of any dying out pattern of spikes
- (ii) No singularly significant spike appears at lag 1 either in the *ACF* or in the *PACF*.

These observations testify for the stationarity of TD_t upon first differencing.

5.11 Time plots of DBD_t and DTD_t series

Time plots of DBD_t and DTD_t series are given by the Figures 5.6 and 5.7 below.

Figure 5.6
Time plots of Budget deficit at (first difference)

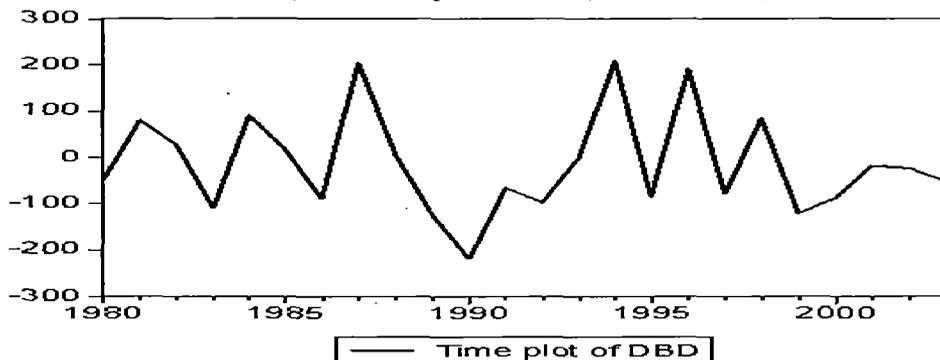
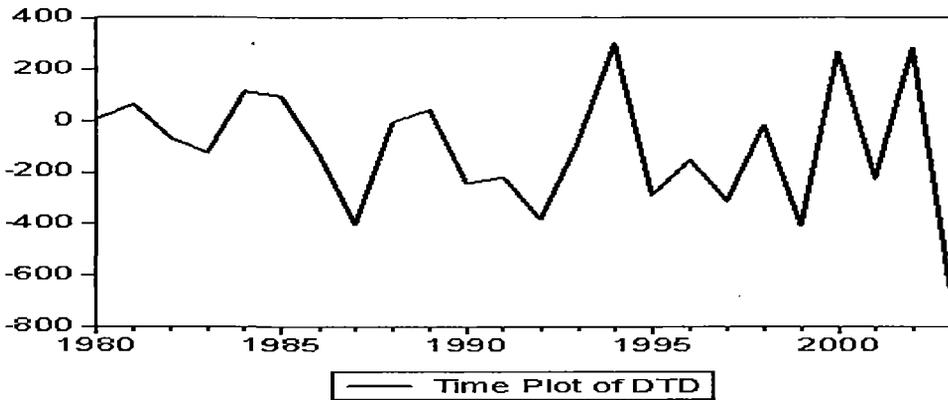


Figure 5.7
Time plots of Trade deficit at (first difference)



These figure show that

- (i) time plots of both ΔBD_t and ΔTD_t series do not exhibit any trend,
- (ii) time plots of both ΔBD_t and ΔTD_t contain several ups and downs along their time paths.

Consequently, *the time plots testify for the stationarity of the first differenced series for BD_t and TD_t .*

5.12 Summary of Findings on Stationarity:

The findings in Sections (5.2) – (5.11) indicate that

- (i) *both BD_t and TD_t are 'non-stationary' at levels.*
- (ii) *'non-stationarity' in BD_t and TD_t series at level is not due to any structural shifts in their stochastic structures.*
- (iii) *both BD_t and TD_t attain stationarity upon first differencing.*
- (iv) *both BD_t and TD_t are 'Difference Stationary' (DS) and not 'Trend Stationary' (TS)*
- (v) *both BD_t and TD_t series at level are $I(1)$ i.e. $BD_t \sim I(1)$ and $TD_t \sim I(1)$*
- (vi) *both ΔBD_t and ΔTD_t are $I(0)$ i.e. $\Delta BD_t \sim I(0)$ and $\Delta TD_t \sim I(0)$.*

CHAPTER –VI

STUDY OF COINTEGRATION

6.1 Introduction

In economic analysis it is imperative to examine the existence of long-run equilibrium relationship among macroeconomic variables concerned. Engle and Granger (1987) established that long run relationship among variables could exist if and only if the variables are 'cointegrated'. As a matter of fact, 'cointegration' is the study concerning the existence of long run equilibrium relationship among variables. The study allows the researcher to examine the existence of an equilibrium relationship among two or more time series, each of which is individually non-stationary. According to Engle and Granger, the variables will be *cointegrated* when the linear combination of non-stationary variables is stationary. *Cointegration* provides the elimination of the cost of differencing by rationalizing terms in levels. However the non-stationary variables involved must be 'integrable' of the same order.

In our study both budget deficit (BD_t) and trade deficit (TD_t) define random walk processes. These variables attain stationarity upon first differencing indicating that these are I(1) variables. It, therefore, becomes pertinent on our part to examine if these variables were cointegrated. The present Chapter is devoted to address this issue.

6.2 Engle- Granger Cointegration Test: The Model

According to Engle and Granger (1987) the variables will be cointegrated when the linear combination of non-stationary variables is stationary. In this study, BD_t and TD_t are found to be integrated of order one i.e. I(1). The linear combination of the two variables are:

$$TD_t = \alpha + \beta BD_t + u_t \quad (6.1)$$

$$\text{Or, } u_t = TD_t - \alpha - \beta BD_t \quad (6.2)$$

$$\text{Again } BD_t = \gamma + \delta TD_t + v_t \quad (6.3)$$

$$\text{Or, } v_t = BD_t - \gamma - \delta TD_t \quad (6.4)$$

Now if any of u_t and v_t were stationary, i.e. I(0), then BD_t and TD_t are cointegrated at level i.e. CI(1,0). Consequently, the *Cointegration* between BD_t and TD_t may be studied through the estimation of the equations (6.1) or equation (6.3).

6.3 Results of Estimation of the Equation (6.1)

Results of estimation of the equation (6.1) are given below.

$$\hat{T}D_t = -677.2999 + 3.774828 BD_t$$

S.E: (214.4711) (0.892902)

t- stat. : [-3.1580] [4.2276]

prob.: (0.0044) (0.0003)

$R^2 = 0.4373$

Adj. $R^2 = 0.4128$

Durbin-Watson stat. = 0.4196

Akaike info Criterion = 15.89072

Schwarz Criterion = 15.98823

6.4 Test of Stationarity of Residuals

Stationarity of the corresponding residuals \hat{u}_t has been examined through the *ADF* and *PP* tests. Results of the tests are given by Tables 6.1 and 6.2

Table -6.1

Augmented Dickey Fuller Unit Root Test on Residuals ($\hat{\mu}_t$)

Null Hypothesis: *The residual has a unit root*

Exogenous: Constant **Lag length ;-(Automatic based on SIC, Max Lag =8)**

Variable	ADF test statistic	Prob* value	Lag length	Test critical Values		
				1%	5%	10%
$\hat{\mu}_t$	-1.545442	0.4940	0	-3.737853	-2.991878	-2.635542
Exogenous : None						
$\hat{\mu}_t$	-1.599763	0.1017	0	-2.664853	-1.955681	-1.608793

* Mac Kinon (1996) One- sided P-values

Table - 6.2

Phillips-Perron Unit Root Test on Residuals ($\hat{\mu}_t$)

Null Hypothesis: *The residual has a unit root*

Exogenous: Constant **Bandwidth ;-(Newey-West using Bartlett kernel)**

Variable	P-P test statistic	Prob* value	Band Width**	Test critical Values		
				1%	5%	10%

$\hat{\mu}_t$	-1.533575	0.4999	1	-3.737853	-2.991878	-2.635542
Exogenous : None						
$\hat{\mu}_t$	-1.601040	0.1015	1	-2.664853	-1.955681	-1.608793

* Mac Kinon(1996) One- sided P-values

** Newey-West using Bartlett kernel

6.5 Findings From the Tables 6.1- 6.2

It is observed from the tables 6.1- 6.2 that,

- (i) level since the ADF test statistics (absolute value) falls short of the corresponding initial values at 10 % level of significance.
- (ii) *the null hypothesis of unit root in \hat{u}_t has been accepted even at 10 % level, since the PP test statistics (absolute value) is lower than the corresponding critical value at 10 % level of significance.*

It, therefore, follows that both the ADF test and Phillips–Perron tests testify for ‘non-stationarity’ of the residuals \hat{u}_t . Consequently, BD_t and TD_t are not Cointegrated at level.

6.6 Stationarity of residuals \hat{u}_t : Correlogram Study.

The stationarity of residuals \hat{u}_t has been examined through the plots of *Autocorrelation Function (ACF)* and *Partial Autocorrelation Function (PACF)* across different lags. Figure 6.1 presents the Correlogram of the residuals \hat{u}_t ,

Figure 6.1
Correlogram of the \hat{u}_t (at level)

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	0.744	0.744	15.580	0.000
		2	0.545	-0.020	24.295	0.000
		3	0.326	-0.163	27.560	0.000
		4	0.170	-0.028	28.484	0.000
		5	0.065	0.002	28.626	0.000
		6	-0.042	-0.110	28.689	0.000
		7	-0.058	0.083	28.815	0.000
		8	-0.124	-0.134	29.422	0.000
		9	0.021	0.374	29.440	0.001
		10	0.057	-0.141	29.588	0.001
		11	0.056	-0.121	29.739	0.002
		12	-0.022	-0.162	29.763	0.003
		13	-0.128	-0.077	30.692	0.004
		14	-0.143	0.078	31.944	0.004
		15	-0.215	-0.096	35.073	0.002
		16	-0.263	-0.211	40.275	0.001
		17	-0.350	0.010	50.629	0.000
		18	-0.316	0.063	60.239	0.000
		19	-0.264	-0.049	68.072	0.000
		20	-0.205	-0.101	73.744	0.000

6.7 Findings From the Correlogram

The Correlogram of the residual is given by the Fig 6.1. The plots of the *ACF* and *PACF* of the residual show that

- (i) there is declining step spike pattern in the *ACF* before it crosses the base, and
- (ii) there exists a significant spike at lag in the *PACF*.

These findings indicate non-stationarity of the residuals \hat{u}_t . Consequently, BD_t and TD_t series at level are not cointegrated and there exists no long-run relationship between the variables concerned at level.

6.8 Cointegration Between BD_t and TD_t : The CRDW Method:

An alternative method of testing *Cointegration* among variables is the CRDW Test. The CRDW Test has been performed to examine if BD_t and TD_t were *cointegrated*. The results of the CRDW test along with critical values have been presented in the Table 6.3.

Table-6.3

Results of Durbin –Watson Test Results of Co-integrating Regression (CRDW)

Null Hypothesis	D-W statistic	Critical Values		
		1%	5%	10%
No Co-integration between TD_t & BD_t	0.4196	0.511	0.386	0.322

6.9 Findings From the CRDW Test

The Table 6.3 show that

- (i) DW statistics = 0.4196 is below the corresponding critical value at 1% level of significance. Consequently, the '*null hypothesis of the no Cointegration*' between BD_t and TD_t (at level) has been accepted at 1% level.
- (ii) BD_t and TD_t (at levels) are, therefore, not cointegrated (at 1% level) and there did exist no long run relationship between BD_t and TD_t (at level).

These findings from the CRDW Test also corroborate the findings from the *ADF* Test, *PP* Test and *Correlogram Analysis*.

6.10 Cointegration Between BD_t and TD_t : Johansen Cointegration Test.

The *Johansen Method of Cointegration* has been performed for further confirmation of our findings of '*No Cointegration*' between BD_t and TD_t at levels. The results of the Test (based on the Johansen Method) have been presented through the Tables (6.3) and (6.4).

Table- 6.4

Johansen Cointegration Test

Unrestricted Cointegration Rank Test

Lags interval (in 1st differences): 1 to 2

Series: BD_t TD_t

Trend assumption: Linear deterministic trend

Null Hypothesis	Alternative Hypothesis	Eigen Value	Trace Statistic	5% Critical Value	1% Critical Value	Max-eigen statistic	5% Critical Value	1% Critical Value
	λ_{max} tests	Trace tests						
$r = 0$	$r = 1$	$r \geq 1$	0.329967	8.826838	15.41	20.04	8.809421	14.07
$r \leq 1$	$r = 2$	$r \geq 2$	0.000791	0.017418	3.76	6.65	0.017418	3.76

(**) denotes rejection of the hypothesis at the 5% (1%) level
 Trace test indicates no Cointegration at both 5% and 1% level
 Max-eigen value test indicates no Cointegration at both 5% and 1% levels.

Table- 6.5

Johansen Cointegration Test

Unrestricted Cointegration Rank Test

Lags interval (in 1st differences): 1 to 2

Series: BD_t TD_t

Trend assumption: No deterministic trend (restricted constant)

Null Hypothesis	Alternative Hypothesis	Eigen Value	Trace Statistic	5% Critical Value	1% Critical Value	Max-eigen statistic	5% Critical Value	1% Critical Value
	λ_{max} tests	Trace tests						
$r = 0$	$r = 1$	$r \geq 1$	0.344433	14.88376	19.96	24.60	9.289608	15.67
$r \leq 1$	$r = 2$	$r \geq 2$	0.224525	5.594152	9.24	12.97	5.594152	9.24

(**) denotes rejection of the hypothesis at the 5% (1%) level
 Trace test indicates no Cointegration at both 5% and 1% level
 Max-eigen value test indicates no Cointegration at both 5% and 1% levels.

6.11 Findings From the Table (6.4)

Table (6.4) shows that

- (i) trace statistics $\lambda_{trace} = 8.826838$ for the *maintained regression equation* with '*linear deterministic trend*' is lower than the critical value at 5% level of significance. Consequently, the '*null hypothesis of no cointegration*' be $r = 0$ has been accepted at 5% level.

- (ii) $\lambda_{max} = 8.809421$ for the *maintained regression equation* with ‘*No Deterministic Trend*’ falls short of the critical value at 5% level. Consequently, *the null hypothesis of ‘no-cointegration’* ($r = 0$) has been accepted at 5% level.

These findings testify for the fact that BD_t and TD_t are *not cointegrated* at level and there exists no long-run relationship between BD_t and TD_t when the estimated maintained regression equations contain *linear deterministic trend*.

6.12 Findings From The Table 6.5

The Table 6.5 presents the results of the *Johansen Test* where the *maintained regression equation* contains no ‘*deterministic trend*’. The Table 6.5 shows that

- (i) trace statistic $\lambda_{trace} = 14.88376$ for $r = 0$ is lower than the critical value even at 5% level.
- (ii) $\lambda_{max} = 9.28908$ for $r = 0$ falls short of the critical value even at 5% level.

Consequently the ‘*null hypothesis of no cointegration*’ between BD_t and TD_t (at level) i.e. $r = 0$ is being accepted even at 5 % level.

6.13 Overview of Findings in Sections 6.11 and 6.12

The findings in Sections 6.11 and 6.12 indicate that *there exists no cointegration between BD_t and TD_t at level*. This confirms the findings on cointegration between BD_t and TD_t through the Engle-Granger and *CRDW* methods.

6.14 Engle-Granger Test of Cointegration Between BD_t and TD_t (with First Differenced Data sets): The Model

The *cointegration* between BD_t and TD_t has been enquired into with first differenced data sets. The relevant estimable model is as follows

$$\Delta TD_t = \alpha + \beta \Delta BD_t + v_t \quad (6.5)$$

$$v_t = \Delta TD_t - \alpha - \beta \Delta BD_t \quad (6.6)$$

where,

ΔTD_t = First Difference of Trade Deficit (DTD_t)

ΔBD_t = First Difference of Budget Deficit (DBD_t), and

$$v_t \sim \text{iid } N(0, \sigma^2_v)$$

6.15 Results of Estimation of the Equation (6.5):

The corresponding estimated equation is given by equation (6.7) below

$$\Delta TD_t = -97.812 + 0.577117 \Delta BD_t \quad (6.7)$$

S.E : (48.359) (0.4434)

t- stat. : [-2.0225] [1.3015]

prob.: (0.0554) (0.2066)

$R^2 = 0.071$

Adj. $R^2 = 0.029$

Durbin-Watson stat. = 2.348

Akaike Info Criterion = 13.8384

Schwarz Criterion = 13.9365

6.16 Stationarity of the Residuals (\hat{v}_t).

Stationarity of the residual (\hat{v}_t) of the estimated equation (6.7) has been examined through the *ADF* and *Phillips –Perron* Tests. Results of such tests are given below by the Tables (6.6) – (6.7).

Table -6.6

Augmented Dickey Fuller Unit Root Test on Residuals (\hat{v}_t)

Null Hypothesis: The residual has a unit root

Exogenous: Constant

Lag length: (Automatic based on SIC, Max Lag =8)

Variable	ADF test	Prob*	Lag length	Test critical Values		
	statistic			value	1%	5%
\hat{v}_t	-4.691328	0.0014	2	-3.788030	-3.012363	-2.646119
Exogenous : None						
\hat{v}_t	-4.841086	0.0000	2	-2.679735	-1.958088	-1.607830

* Mac Kinon (1996) One- sided P-values

Table - 6.7

Phillips-Perron Unit Root Test on Residuals

Null Hypothesis: The residual has a unit root

Exogenous: Constant

Bandwidth ;-(Newey-West using Bartlett kernel)

Variable	P-P test	Prob*	Band Width**	Test critical Values		
	statistic			value	1%	5%
\hat{v}_t	-6.318631	0.0000	3	-3.752946	-2.998064	-2.638752

Exogenous : None						
\hat{v}_t	-6.547354	0.0000	3	-2.669359	-1.956406	-1.608495

* Mac Kinon(1996) One- sided P-values

** Newey-West using Bartlett kernel

6.17 Findings From the Table (6.6) – (6.7)

The Tables (6.6) – (6.7) show that

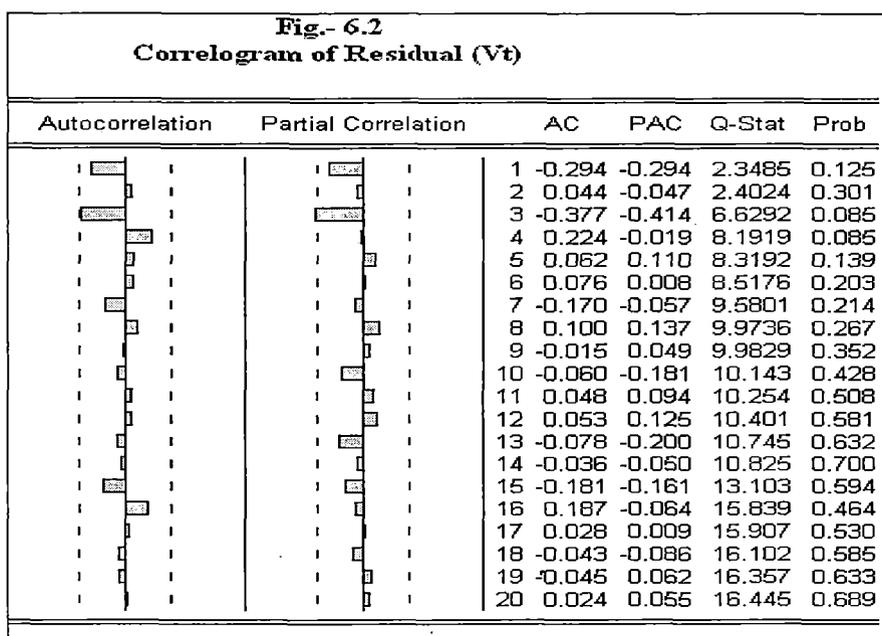
(i) absolute values of *ADF Test statistics* exceed the (absolute) critical values at 1% level, when the maintained regression equation is estimated with or with out an exogenous constant (intercept) term. Consequently, the ‘*null hypothesis of unit root*’ in \hat{v}_t is rejected at 1% level and \hat{v}_t is found to be stationary.

(ii) absolute values of *PP-Test* statistics also exceed the (absolute) critical values at 1% level when the maintained regression equation is estimated with or without an intercept term. As a result, the null hypothesis of unit root in \hat{v}_t is found to be stationary.

Consequently ΔBD_t and ΔTD_t appear to be cointegrated signifying the existence of long-run equilibrium relationship between first differenced series for BD_t and TD_t .

6.18 Stationarity of \hat{v}_t Through the Study of Correlogram:

The stationarity of \hat{v}_t has further been examined through the study of its correlogram. The Figure 6.2 presents the correlogram of \hat{v}_t



6.19. Findings From the Correlogram of the Residuals (\hat{v}_t)

The plots of the *ACF* and *PACF* of the residual (\hat{v}_t) show that

- (i) the residual (\hat{v}_t) dataset display no significant spike in the *ACF* at the first lag.
- (ii) the *PACF* is free from any significant spike at the first lag.

These findings confirm stationarity of dataset for (\hat{v}_t). Consequently ΔTD_t and ΔBD_t are Cointegrated.

6.20 Cointegration Between ΔBD_t and ΔTD_t through the Johansen Method.

Results of the corresponding tests are being presented through the Tables – (6.8).

Table- 6.8

Johansen Cointegration Test of ΔBD_t and ΔTD_t

Trend assumption: Linear deterministic trend				
Series: DBD DTD				
Lags interval (in first differences): 1 to 2 Unrestricted Cointegration Rank Test				
Hypothesized No. of CE(s)	Eigen value	Trace Statistic	5 % Critical Value	1 % Critical Value
None **	0.574533	24.45897	15.41	20.04
At most 1 *	0.266659	6.513032	3.76	6.65
Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	5 % Critical Value	1 % Critical Value
None *	0.574533	17.94594	14.07	18.63
At most 1 *	0.266659	6.513032	3.76	6.65

6.21 Findings From the Table 6.8

(A) It is observed from the Table 6.8 that

- (i) for the *null hypothesis of $r = 0$* against $r = 1$, $\lambda_{trace} = 24.45$ exceeds the corresponding critical values even at 1% level. Consequently the '*null hypothesis of no cointegration*' between ΔBD_t and ΔTD_t has been rejected at 1% level.
- (ii) for the *null hypothesis of $r = 0$* against $r = 1$, $\lambda_{max} = 17.9459$ exceeds the corresponding critical value at 5% level. Consequently, '*the null hypothesis of 'no cointegration*' between ΔBD_t and ΔTD_t is being rejected at 5% level.

All these observations indicate that ΔBD_t and ΔTD_t are cointegrated at 5% level.

(B) It is further observed from the Table 6.8 that

- (i) for the null hypothesis of $r \leq 1$ against $r=2$ (i.e. there exists not more than one cointegrating equation), $\lambda_{trace} = 6.513032$ falls short of the corresponding critical value at 1% level and λ_{trace} exceeds the corresponding critical value at 5% level.
- (ii) for the null hypothesis of $r \leq 1$ against $r = 2$, $\lambda_{max} = 6.513032$ falls short of the corresponding critical value at 1% level though it exceeds the corresponding critical value at 5% level.

All these observations testify for the fact that

- (i) ΔBD_t and ΔTD_t are cointegrated at 5% level
- (ii) there exists only one cointegrating equation at 5% level of significance.

6.22 Summary of the Findings in Chapter VI

Findings in Section (6.2) through Section (6.22) may be summarized as follows.

- (i) study of co-integration between budget deficit (BD_t) and Trade Deficit (TD_t) is possible since $BD_t \sim I(1)$ and $TD_t \sim I(1)$.
- (ii) BD_t and TD_t series at levels are not cointegrated. Consequently, long-run equilibrium relation between Budget Deficit (BD_t) and Trade Deficit (TD_t) can not be expected to exist.
- (iii) ΔBD_t and ΔTD_t series are cointegrated. Consequently, a long-run equilibrium relationship exists between first differenced series for Budget deficits (BD_t) and Trade Deficit (TD_t).
- (iv) the Cointegration relation between budget deficit and trade deficit is $CI(1,1)$ in the economy of Maldives.

CHAPTER –VII

STABILITY OF THE LONG-RUN RELATIONSHIP BETWEEN TRADE DEFICIT AND BUDGET DEFICIT IN MALDIVES

7.1 Introduction:

The study of cointegration in Chapter VI confirms the existence of long-run relationship between ‘budget deficit’ and ‘trade deficit’ series in the Maldives. However, it is imperative to know if the relationship is stable. Stability of the long-run relationship is established if the short-run shocks transmitted through BD_t or TD_t channel converge before long. The stability of the long-run relationship is being studied through the estimation of ‘*Vector Error Correction Model*’ (VECM).

The ‘*Vector Error Correction Specification*’ restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing a wide range of short-run dynamics. The *Cointegration* term is known as the ‘*error correction*’ term since the deviation from the long-run equilibrium is corrected gradually through a series of partial short run adjustments. Therefore, *VEC* modeling gives important information about the short-run relationship between the cointegrated variables. We, therefore, seek to study the stability of the long-run relationship between ΔBD_t and ΔTD_t series. The study in this Chapter is devoted to address this issue.

7.2 The Estimable VEC Model.

The estimable *Vector Error Correction Model* consists of the following equations..

$$\Delta TD_t = \gamma_1 + \rho_1 z_{t-1} + \alpha_1 \Delta TD_{t-1} + \alpha_2 \Delta TD_{t-2} + \alpha_3 \Delta BD_{t-1} + \alpha_4 \Delta BD_{t-2} + \hat{\varepsilon}_{1t} \quad (7.1) \quad \text{and}$$

$$\Delta BD_t = \gamma_2 + \rho_2 z_{t-1} + \beta_1 \Delta BD_{t-1} + \beta_2 \Delta BD_{t-2} + \beta_3 \Delta TD_{t-1} + \beta_4 \Delta TD_{t-2} + \hat{\varepsilon}_{2t} \quad (7.2)$$

where,

ΔTD_t = first difference of trade deficit

ΔBD_t = first difference of budget deficit

z_{t-1} = first lag of error term of the co-integrating equation.

ε_{1t} and ε_{2t} are white noise errors, α_1 , α_2 , α_3 and α_4 are the coefficients of lagged (ΔTD_t , ΔBD_t) respectively in equation (7.1) and β_1 , β_2 , β_3 and β_4 are the coefficients of lagged (ΔBD_t , ΔTD_t) respectively in equation (7.2), γ_1 and γ_2 are constants of regression in equations (7.1) and (7.2).

In the estimation of '*Vector Error Correction Model*', at least one of ρ_1 , or ρ_2 of cointegrating terms in (7.1) and (7.2) should be nonzero. The lag-length in estimation is determined through AIC and SIC.

7.3 Results of the Estimation [Equations (7.1)-(7.2)]

The results of estimation of the '*Vector Error Correction Models*' consisting of equations (7.1) and (7.2) have been presented in the Table 7.1 below.

Table-7.1

Results of the estimation of Vector Error Correction Model [Equation (7.1) and (7.2)]

Dependent Variable	Explanatory Variables	Coefficients	S.E	't'-statistics	
ΔTD_t	γ_1	-30.20246	50.2855	-0.60062	
	\hat{e}_{t-1}^{***}	0.870190	0.21638	-4.02154	
	ΔTD_{t-1}^*	0.603546	0.40991	1.47240	
	ΔTD_{t-2}^{**}	0.541488	0.27021	2.00394	
	ΔBD_{t-1}	-0.406938	0.42167	-0.96507	
	ΔBD_{t-2}	-0.024259	0.39263	-0.06179	
	ΔBD_t	γ_2	-6.035795	31.7669	-0.19000
		\hat{e}_{t-1}	-0.046085	0.13670	-0.33714
ΔBD_{t-1}^{**}		-0.707773	0.26638	-2.65701	
ΔBD_{t-2}		-0.225807	0.24804	-0.91038	
ΔTD_{t-1}		-0.234442	0.25895	-0.90535	
ΔTD_{t-2}		-0.150139	0.17070	-0.87954	

*, **, *** indicates statistical significance at the 10%, 5% and 1% level respectively. S.E = Standard Error

7.4 Stability of the VEC Model

The roots of the *Characteristic Polynomials* corresponding to *Autoregressive Structures* in equations (7.1) and (7.2) are given by the Table 7.2.

Table 7.2

Roots of Characteristic Polynomial

Endogenous variables: DBD DTD Exogenous variables: Lag specification: 1 2	
Root	Modulus

1.000000	1.000000
-0.973176	0.973176
0.228651 - 0.750664i	0.784715
0.228651 + 0.750664i	0.784715
-0.354209 - 0.290944i	0.458380
-0.354209 + 0.290944i	0.458380

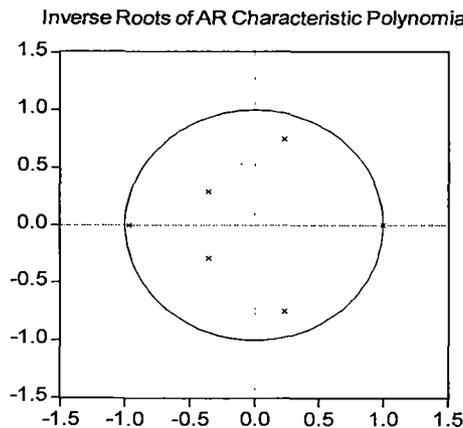
It is observed from the Table 7.2 that

- (i) the absolute values of the *characteristic roots* are less than unity.
- (ii) three of the *characteristic roots* are positive (statistically greater than zero)
- (iii) two of the characteristic roots are negative (statistically lower than zero)
- (iv) one of the roots has been pegged to unity because of the constraints of the system.

Again the inverse roots of the **AR characteristic polynomials** lie with in the unit circle. This is shown in the Figure 7.1

Figure 7.1

Inverse roots of AR characteristic polynomials



All these testify for the **stability of the estimated VEC model consisting of the equations (7.1) and (7.2)**

7.5 Findings From the Table 7.1 [Equation 7.1]

The Table (7.1) shows that

- (i) $\hat{\rho}_1$ the coefficient of \hat{e}_{t-1} is significant at 1% level.
- (ii) $\hat{\rho}_1$ is positive and less than unity.
- (iii) $\hat{\alpha}_3 \hat{\alpha}_4$ are not significant even at 10% level.

7.6 Economic Interpretations of The Findings About The Short Run dynamics [Equation (7.1)]

These findings provide valuable implications about short-run dynamics and the nature of short-run causality between TD_t and BD_t in the economy of Maldives. These are as follows:

- (i) the significant coefficient of Z_{t-1} in the cointegrating equation (7.1) indicates that the short-run shocks, transmitted through the trade deficit channel, affect the long-run dynamic relationship between budget deficit and trade deficit in Maldives.
- (ii) coefficient of Z_{t-1} being positive, i.e. $\hat{\rho} > 0$ indicates that, following shocks transmitted through the trade deficit channel, budget deficit registers a rise above the long-run equilibrium level.
- (iii) $\hat{\rho} < 1$ i.e. the coefficient of Z_{t-1} being less than unity indicates that such deviation of trade deficit from its long-run equilibrium level are temporary and convergent. Thus the long-run relationship between trade deficit (dependent variable) and budget deficit (independent variable) is **stable**. Consequently, the corresponding short-run dynamics defines '*stable equilibrium process*'.
- (iv) All the coefficients of lagged budget deficit terms in the equation (7.1) are statistically insignificant (even at 10% level). It indicates that, in the short run adjustment process, budget deficit fails to *Granger Cause* trade deficit.

7.7 Findings from the Table 7.1 (Equation 7.2)

The Table 7.1 shows that in the equation (7.2)

- (i) $\hat{\rho}_2$ the coefficient of Z_{t-1} is not significant even at 10% level.
- (ii) $\hat{\beta}_1$, the coefficient of ΔBD_{t-1} , is significant even at 1% level.
- (iii) all other coefficients ($\hat{\beta}_2, \hat{\beta}_3, \hat{\beta}_4$) fail to be significant even at 10% level.

7.8 Economic Interpretation of The Findings From the Table 7.1 [Equation 7.2]

The economic significance of these findings is as follows.

- (i) $\hat{\rho}_2$ being insignificant (even at 10% level), indicates that the shocks, transmitted through the budget deficit channel, fail to disturb the long-run relationship that budget deficit maintained with trade deficit.

(ii) $\hat{\beta}_3$ and $\hat{\beta}_4$, the coefficients of $\Delta TD_{t,i}$ ($i = 1, 2$) respectively, are not significant even at 10% level. This indicates that trade deficit fails to *Granger Cause* budget deficit in the short-run in the economy of Maldives over the period of study.

7.9 Summary of the Chapter VII

This Chapter is devoted to the study of *stability of long-run equilibrium relationship* between Trade Deficits (TDt) and Budget Deficit (BDt). The findings of our study in this chapter are as follows.

- (i) *There exists no cointegration and, therefore, a long run equilibrium relationship between budget deficit (BDt) and Trade Deficit (TDt) series at level.*
- (ii) *Cointegration exists between first differenced data-sets for budget deficit and trade deficit.*
- (iii) *Budget deficit and trade deficit series are CI (1, 1).*
- (iv) *The short run shocks, transmitted through the trade deficit channel, affect the long run dynamic relationship that trade deficit maintains with budget deficit.*
- (v) *The deviations of trade deficit from its long- run equilibrium level are temporary and convergent.*
- (vi) *The long- run relationship that trade deficit maintains with budget deficit is stable.*
- (vii) *Consequently, the short-run dynamics for the trade deficit defines a 'stable equilibrium process.*
- (viii) *The shocks, transmitted through the budget deficit channel, fails to disturb the long -run relationship that budget deficit maintains with trade deficit.*
- (ix) *Budget deficit fails to 'Granger Cause' trade deficit in the short run.*
- (x) *Trade deficit fails to 'Granger Cause' budget deficit in the short run.*
- (xi) *Budget deficit and trade deficit, therefore, appear to be independent of each other in the short-run in the economy of Maldives.*
- (xii) *The Ricardian Equivalence Hypothesis seems to be valid in the short-run.*

CHAPTER –VIII

DYNAMIC RELATIONSHIP BETWEEN TRADE DEFICIT AND BUDGET DEFICIT IN MALDIVES

-VECTOR AUTO REGRESSION (VAR) MODEL

8.1 Introduction

Cointegration is essentially based on ‘*Single Equation Estimation*’. Here we have one equation for budget deficit (BD_t) where trade deficit (TD_t) appears as the exogenous variable. Consequently, the ‘two way linkage’ between budget deficit and trade deficit remains ignored. Again in the *VEC Model* we consider how shocks in the endogenous variable affects the long-run relationship that it maintains with another endogenous variable. For example, the *VEC model* estimations show how shocks in BD_t in the short-run affect BD_t and how short-run shocks in TD_t affect TD_t .

In economic analysis it becomes imperative for a researcher to examine the ‘two way linkage’ between endogenous variables. In such a case BD_t and TD_t must be made endogenous in a ‘*Simultaneous Equation System*’. Moreover, it is important in any economic research to examine the effects of any short-run shocks in any endogenous variable on another endogenous variable. This is because of the fact that the ‘*Contemporaneous Variance-Covariance Matrix*’ for error terms across equations may be ‘*positive definite*’ by nature.

All these considerations have been taken care of in the ‘*Vector Autoregressive (VAR) Model*’ where equations are jointly estimated. The equation for any endogenous variables is specified as ‘p’ period ‘*autoregressive lag equation*’ with a *distributed lag structure* of another endogenous variable. Thus we have several autoregressive equations in a *VAR Model*, and these equations are estimated jointly.

Vector Autoregression (VAR) Model is, therefore, applied for finding the long-run dynamic relationship among macroeconomic variables. The model does not make any *a priori* assumption of the endogeneity and exogeneity of variables. This model treats all variables symmetrically without making reference to the issue of dependence versus independence and offers a scope for ‘*Intervention Analysis*’ through the study of ‘*Impulse Response Functions*’ for the endogenous variables in the model. ‘*Variance Decomposition*’ allows us to study the *variance decomposition* for these variables and thus helps us understand the interrelationships among the variables concerned. We, therefore, seek to develop a *VAR* model for ‘Budget Deficit’ (BD_t) and ‘Trade Deficit’ (TD_t) for the economy of Maldives in this chapter.

8.2 The VAR Model

The *Vector Autoregression (VAR)* Model for the trade deficit (TD_t) and budget deficit (BD_t) for the economy of Maldives consists of the following equations.

$$\Delta TD_t = \alpha_1 + \sum_{i=1}^k \beta_{1i} \Delta TD_{t-i} + \sum_{i=1}^k \gamma_{1i} \Delta BD_{t-i} + u_{1t} \quad (8.1)$$

$$\Delta BD_t = \alpha_2 + \sum_{i=1}^k \beta_{2i} \Delta BD_{t-i} + \sum_{i=1}^k \gamma_{2i} \Delta TD_{t-i} + u_{2t} \quad (8.2)$$

Here BD_t and TD_t represent Budget Deficit and Trade Deficit at time t respectively. Again BD_{t-i} and TD_{t-i} represent budget deficit and trade deficit at time t-i (i=1,2,3...) respectively. u_{1t}, u_{2t} are the stochastic error terms, called ‘*impulse*’ or ‘*innovations*’ or shocks in the *VAR* models such that

$$u_{1t} \sim \text{iid } N(0, \sigma^2 u_1)$$

$$\text{and } u_{2t} \sim \text{iid } N(0, \sigma^2 u_2)$$

These equations constitute ‘*Seemingly Unrelated Regression (SUR) Model*’. The estimation of the model considers and uses the ‘*Contemporaneous Variance-Covariance Matrix (Ω)*’ of the error terms involved such that (Ω) = Var-Covar (u_{1t}, u_{2t}) is a ‘*positive definite*’ matrix.

8.3 Features of the VAR Model.

The *VAR Model* consisting of equations (8.1) and (8.2) requires that

- (i) ΔBD_t and ΔTD_t be stationary, and
- (ii) u_{1t} and u_{2t} be Gaussian White-Noise Process (GWNP) such that

$$u_{1t} \sim \text{iid } N(0, \sigma^2 u_1)$$

$$\text{and } u_{2t} \sim \text{iid } N(0, \sigma^2 u_2).$$

In this model ΔBD_t and ΔTD_t are stationary since BD_t ~ I(1) and TD_t ~ I(1). Consequently, the first requirement is satisfied. However the properties of u_{1t} and u_{2t} need to be studied. This will enable us to find if u_{1t} and u_{2t} follow really white noise processes.

8.4 Selection of Lag Length :

The appropriate lag-length needs to be determined before the estimation of *VAR* model. The lag-length may be selected through some ‘*Selection Criteria*’ like AIC, SIC, LR, FRE, HQIC etc. The Table 8.1 gives forth the statistics corresponding to different criteria across different lags.

Table -8.1
VAR Lag Order Selection Criteria

Exogenous Variable: C		Endogenous Variables: DTD DBD			
		Included Observations : 17			
Lag	LR	FPE	AIC	SIC	HQ
	NA*	9.31E+08*	26.32700	26.42503	26.33675
1	6.106986	9.70E+08	26.36138	26.65545	26.39061
2	1.664749	1.39E+09	26.69324	27.18336	26.74196
3	3.249267	1.72E+09	26.83890	27.52507	26.90711
4	5.278571	1.63E+09	26.64966	27.53189	26.73736
5	1.630564	2.57E+09	26.84849	27.92677	26.95568
6	4.243957	2.29E+09	26.25809	27.53242	26.38476
7	4.108774	1.34E+09	24.67429*	26.14467*	24.82045*

*indicates lag order selected by the criterion LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error AIC: Akaike information criterion ,SC: Schwarz information criterion ,HQ: Hannan-Quinn information criterion

It is observed from the Table 8.1 that

- (i) LR and FPE statistics for lag 0(zero) are significant at 5% level. However, lag 0 specification is not entertained by the VAR model, since *Autoregressive structure* withers away with lag 0 specifications.
- (ii) AIC, SIC and HQ statistics at lag 7 are significant at 5% level.

It may be noted that lag 7 specification entails too much '*parameterization*' of the VAR model which leads to severe loss of degrees of freedom. Such loss will distort the desirable '*asymptotic properties*' of the estimators.

We have, therefore, followed Ender's method and started with seven lags. We have reduced the lags by one and carried out the test, given that the estimated statistics for the coefficient involved is insignificant at 5% level. In the 3rd lag specification, several estimators were found statistically significant at 5% level.

8.5 The Estimable VAR Model

The estimable VAR model, therefore, consists of the following equations:

$$\Delta TD_t = \alpha_1 + \beta_{11}\Delta TD_{t-1} + \beta_{12}\Delta TD_{t-2} + \beta_{13}\Delta TD_{t-3} + \gamma_{11}\Delta BD_{t-1} + \gamma_{12}\Delta BD_{t-2} + \gamma_{13}\Delta BD_{t-3} + u_{1t} \quad (8.3)$$

$$\Delta BD_t = \alpha_2 + \beta_{21}\Delta BD_{t-1} + \beta_{22}\Delta BD_{t-2} + \beta_{23}\Delta BD_{t-3} + \gamma_{21}\Delta TD_{t-1} + \gamma_{22}\Delta TD_{t-2} + \gamma_{23}\Delta TD_{t-3} + u_{2t} \quad (8.4)$$

The model may be presented as

$$\Delta TD_t = \alpha_1 + \sum_{i=1}^3 \beta_{1i} \Delta TD_{t-i} + \sum_{i=1}^3 \gamma_{1i} \Delta BD_{t-i} + \mu_{1t} \quad (8.5)$$

$$\Delta BD_t = \alpha_2 + \sum_{i=1}^3 \beta_{2i} \Delta BD_{t-i} + \sum_{i=1}^3 \gamma_{2i} \Delta TD_{t-i} + \mu_{2t} \quad (8.6)$$

8.6 Results of Estimation of the VAR Model [Equations (8.3)-(8.4)]

The results of estimation of the VAR model consisting of equations (8.3) and (8.4) are given in the Tables (8.2) and (8.3).

Table 8.2
Results of the Estimations of the VAR [Equation (8.3)]

Dependent variable	Explanatory Variables	Coefficients	Standard errors	't' statistics
	Constant	-187.2349	81.4671	-2.29829
	ΔTD_{t-1}	-0.156765	0.26968	-0.58130
	ΔTD_{t-2}	0.319730	0.27974	1.14296
	ΔTD_{t-3}	-0.414960	0.28681	-1.44684*
ΔTD_t	ΔBD_{t-1}	-0.339629	0.66766	-0.50868
	ΔBD_{t-2}	-0.070591	0.67685	-0.10429
	ΔBD_{t-3}	-0.146315	0.70044	-0.20889
R-squared	0.413134	Akaike AIC		14.13880
Adj. R-squared	0.161620	Schwarz SC		14.48698
Sum sq. resids	872207.2	Mean dependent		-149.9745
S.E. equation	249.6007	S.D. dependent		272.5997
F-statistic	1.642590			
Log likelihood	-141.4574			

*, indicate that the coefficients are significant at 5% level

Table 8.3

Results of the Estimations of the VAR [Equation (8.4)]

Dependent variable	Explanatory Variables	Coefficients	Standard errors	't' statistics
	Constant	-25.22305	33.0339	-0.76355
	ΔTD_{t-1}	-0.060000	0.10935	-0.54868
	ΔTD_{t-2}	0.001776	0.11343	-0.15658
ΔBD_t	ΔTD_{t-3}	0.051001	0.11630	0.43854
	ΔBD_{t-1}	-0.158998	0.27073	-0.58729
	ΔBD_{t-2}	0.269421	0.27446	0.98165
	ΔBD_{t-3}	-0.126415	0.28402	-0.44509
R-squared	0.205016	Akaike AIC		12.33348
Adj. R-squared	-0.135692	Schwarz SC		12.68165
Sum sq. resids	143408.9	Mean dependent		-21.19048
S.E. equation	101.2101	S.D. dependent		94.97160
F-statistic	0.601735			
Log likelihood	-122.5015			

8.7 Conditions of Stability for the VAR Model

From the equation (8.3) we have,

$$\Delta TD_t - \sum_{i=1}^3 \beta_{1i} \Delta TD_{t-i} = \alpha_1 + \sum_{i=1}^3 \gamma_{1i} \Delta BD_{t-i} + \mu_{1t}$$

$$\text{Or, } \Delta TD_t - \sum_{i=1}^3 \beta_{1i} L^i \Delta TD_t = \alpha_1 + \sum_{i=1}^3 \gamma_{1i} \Delta BD_{t-i} + \mu_{1t}$$

$$\text{Or, } \Delta TD_t - \Delta TD_t \sum_{i=1}^3 \beta_{1i} L^i = \alpha_1 + \sum_{i=1}^3 \gamma_{1i} \Delta BD_{t-i} + \mu_{1t}$$

$$\text{Or, } \Delta TD_t (1 - \sum_{i=1}^3 \beta_{1i} L^i) = \alpha_1 + \sum_{i=1}^3 \gamma_{1i} \Delta BD_{t-i} + \mu_{1t}$$

$$\text{Or, } \Delta TD_t (1 - \beta_{11} L - \beta_{12} L^2 - \beta_{13} L^3) = \alpha_1 + \sum_{i=1}^3 \gamma_{1i} \Delta BD_{t-i} + \mu_{1t}$$

$$\text{Or, } A(L) \Delta TD_t = \alpha_1 + \sum_{i=1}^3 \gamma_{1i} \Delta BD_{t-i} + \mu_{1t}$$

$$\text{Or, } \Delta TD_t = [A(L)]^{-1} [\alpha_1 + \sum_{i=1}^3 \gamma_{1i} \Delta BD_{t-i} + \mu_{1t}] \quad (8.7)$$

$$\text{where, } A(L) = (1 - \beta_{11}L - \beta_{12}L^2 - \beta_{13}L^3)$$

The modulus of each of the values of the **Characteristic Polynomials A(L)** must be less than unity for the stability of the equation (8.3)

Similarly, from the equation (8.4) we have,

$$\Delta BD_t = [B(L)]^{-1} [\alpha_2 + \sum_{i=1}^3 \gamma_{2i} \Delta TD_{t-i} + \mu_{1t}] \quad (8.8)$$

$$\text{where, } B(L) = (1 - \beta_{11}L - \beta_{12}L^2 - \beta_{13}L^3)$$

The modulus of the Eigen Value of the **Characteristic Polynomial B(L)** must be less than unity for the stability of the equation 8.4

It, therefore, follows that the estimated VAR model, consisting of equations (8.3) and (8.4) will be stable iff

- (i) the roots of the **Characteristic Polynomial A(L)** are less than unity, and
- (ii) the roots of the **Characteristic Polynomial B(L)** are less than unity.

8.8 Stability of the Estimated VAR Model

The roots of the estimated **Characteristic Polynomials A(L)** and **B(L)** are given in the Table 8.4

Table- 8.4

VAR Stability Condition Roots of the Characteristic Polynomial A(L) and B(L)

Endogenous Variable: $\Delta TD_t, \Delta BD_t$; Exogenous Variable: C

Lag Specification: 1-3

Root	Modulus
-0.942976	0.942976
-0.770250	0.770250
0.403578 - 0.488069i	0.633314
0.403578 + 0.488069i	0.633314
0.295153 - 0.344335i	0.453522
0.295153 + 0.344335i	0.453522

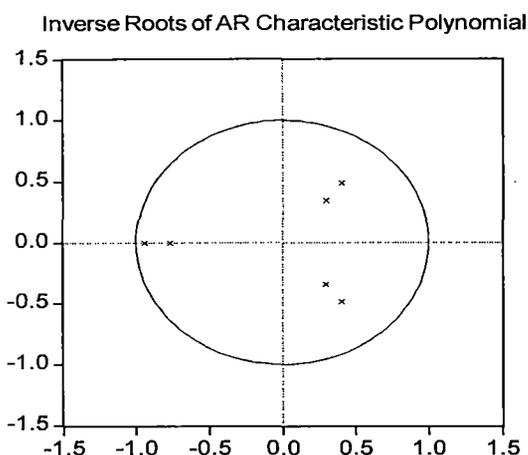
It is observed from the Table 8.4 that

- (i) there are three **Characteristic roots** (eigen values) for **A(L)**
- (ii) there are three **Characteristic roots** (eigen values) for **B(L)**

- (iii) absolute values of the roots are less than unity.
- (iv) two of the roots are positive, and
- (v) two of the roots have negative values.
- (vi) two the roots are not statistically different (at 5% level) from zero.

All these observations testify for the stability of the VAR model consisting of equations (8.3) and (8.3).

Figure-8.1



Again the Figure 8.1 shows that the inverse roots of AR Characteristic Polynomials $A(L)$ and $B(L)$ lie within the unit circle. Consequently, the estimated VAR Model is found to be Stable.

8.9 Normality of the VAR Residuals $\hat{\mu}_{1t}$ and \hat{v}_{2t}

The Table 8.5 presents the results of VAR Residual Normality Tests

Table 8.5
Results of the VAR Residual Normality Tests

VAR Residual Normality Tests		Orthogonalization: Cholesky (Lutkepohl)		
H0: residuals are multivariate normal,		Included observation:21		
Component	Skewness	Chi-sq	df	Prob.
1	0.035307	0.003532	1	0.9526
2	0.053779	0.008195	1	0.9279
Joint		0.011726	2	0.9942
Component	Kurtosis	Chi-sq	df	Prob.
1	0.098313	5.964017	1	0.0146

2	0.064799	6.102576	1	0.0135
Joint		12.06659	2	0.0024
Component	Jarque-Bera	df	Prob.	
1	5.967549	2	0.0506	
2	6.110771	2	0.0471	
Joint	12.07832	4	0.0168	

It is observed from the Table 8.5 that,

- (i) the *JB statistic* = 12.0783 which indicates that the *null hypothesis (that $\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$ are multivariate normal)* is accepted at 1% level.
- (ii) The *JB statistics* for $\hat{\mu}_{1t}$ =5.967549. It indicates that the *null hypothesis of $\hat{\mu}_{1t}$ being normal is being accepted at 5% level.*
- (iii) The *JB statistics* for $\hat{\mu}_{2t}$ =6.110771. It indicates that the *null hypothesis of normality for $\hat{\mu}_{2t}$ is accepted at 5% level.*

This findings testify for the normality of the individual and joint distribution of the residuals $\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$.

8.10 Serial Independence of VAR Residuals ($\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$):

The *correlograms* of the VAR residuals $\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$ are being presented through the Figures 8.2 and 8.3 respectively.

Figure -8.2

Correlogram of \hat{u}_{1t}

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	-0.085	-0.085	0.1471	0.701
		2	0.060	0.053	0.2235	0.894
		3	-0.422	-0.417	4.3328	0.228
		4	0.050	-0.014	4.3954	0.355
		5	-0.155	-0.147	5.0439	0.411
		6	-0.011	-0.257	5.0473	0.538
		7	0.084	0.100	5.2745	0.627
		8	0.038	-0.109	5.3272	0.722
		9	-0.113	-0.297	5.8399	0.756
		10	-0.078	-0.054	6.1227	0.805
		11	0.016	-0.118	6.1373	0.864
		12	0.084	-0.136	6.5975	0.883
		13	0.069	-0.035	6.9823	0.903
		14	0.046	-0.077	7.2057	0.926
		15	0.021	-0.063	7.2796	0.949

Figure -8.3
Correlogram of \hat{u}_{2t}

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	-0.632	-0.632	8.0700	0.005
		2	0.198	-0.336	8.9128	0.012
		3	-0.022	-0.127	8.9242	0.030
		4	-0.203	-0.411	9.9438	0.041
		5	0.292	-0.170	12.245	0.032
		6	-0.146	-0.007	12.873	0.045
		7	-0.068	-0.264	13.024	0.072
		8	0.257	0.070	15.396	0.052
		9	-0.267	0.116	18.271	0.032
		10	0.082	-0.176	18.582	0.046
		11	-0.009	-0.224	18.586	0.069
		12	-0.057	-0.163	18.800	0.093
		13	0.230	-0.001	23.083	0.041
		14	-0.199	-0.007	27.345	0.017
		15	0.026	-0.028	27.454	0.025

It has been observed from the Correlograms [Figures (8.2) and (8.3)] that

- (i) the corresponding ACFs are marked by the absence of any dying out pattern of spikes, and
- (ii) the corresponding PACFs are also free from the presence of any singular spectacular spike at any lag.

These observations testify for the fact that $\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$ residuals are free from autocorrelation of any order.

8.11 Further Confirmation of Serial Independence for the VAR Residuals ($\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$)

Serial Independence of the VAR residuals, $\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$, has further been examined through the 'VAR Residuals Portmanteau Tests'. Results of the tests for auto-correlations are being presented through the Table 8.5

Table 8.6
VAR Residuals Portmanteau Tests for Autocorrelation

VAR Residual Portmanteau Tests for Autocorrelations					
H0: no residual autocorrelations up to lag h					
Included observations: 21					
Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	10.73787	NA*	11.40899	NA*	NA*
2	18.47324	NA*	20.17574	NA*	NA*
3	21.64101	NA*	24.02231	NA*	NA*

4	22.56985	NA*	25.23695	NA*	NA*
5	24.91543	NA*	28.55986	NA*	NA*
6	25.28456	NA*	29.13034	NA*	NA*
7	25.57222	NA*	29.61936	NA*	NA*
8	26.86305	0.0000	32.05760	0.0000	4
9	28.34658	0.0004	35.21010	0.0000	8
10	29.28369	0.0036	37.48593	0.0002	12
11	29.58188	0.0203	38.33080	0.0014	16
12	30.09821	0.0683	40.08631	0.0049	20

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

The adjusted Q-Statistics for the corresponding Chi-Square value, given the degrees freedom, in the Table 8.5 show that, *the null hypothesis of 'no residual autocorrelation'* have been accepted up to the 12th lag at 1% level.

Consequently, Portmanteau Tests confirm the correlogram findings that VAR residuals $\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$ are 'serially independent'.

8.12 Test of Homoscedasticity of the VAR residuals ($\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$)

Time plots of the VAR residuals ($\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$) are given by the Figures (8.4) and (8.5) respectively. .

Figure 8.4
Time Plot of Residuals $\hat{\mu}_{1t}$

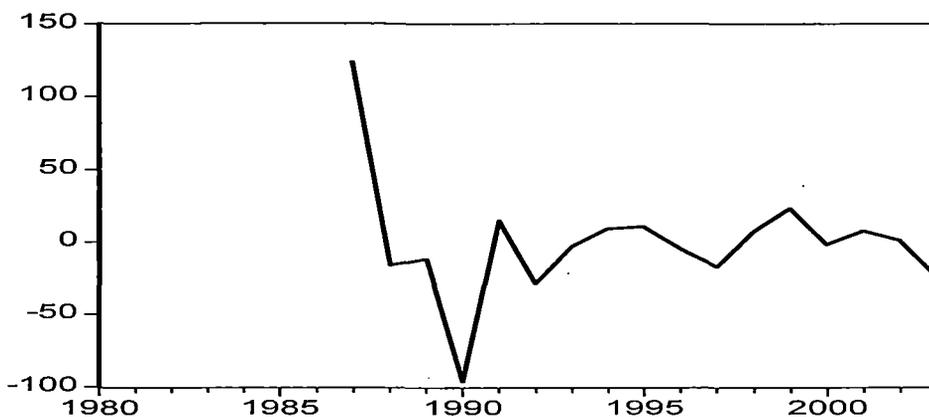
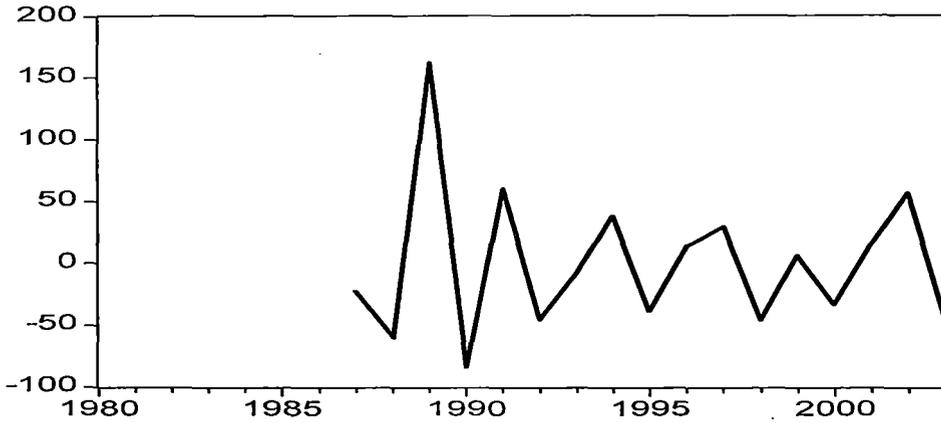


Figure 8.5
Time Plot of VAR Residuals ($\hat{\mu}_{2t}$)



These figures 8.5 and 8.6 show that,

- (i) there exists **no cluster** in the time plot of $\hat{\mu}_{1t}$, and
- (ii) the time plot of $\hat{\mu}_{2t}$ is also marked by the absence of any cluster.

These observations testify for the ‘**homoscedasticity**’ of the residual concerned.

8.13 Further Confirmation of Homoscedasticity of the VAR Residuals ($\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$):

The *correlograms* of the VAR residuals ($\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$) variances are given by Figures 8.8 and 8.7

Figure- 8.6

Correlogram of Variance of VAR Residuals ($\hat{\mu}_{1t}$)

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1 -0.053	-0.053	0.0565	0.812
		2 -0.044	-0.047	0.0976	0.952
		3 0.418	0.415	4.1212	0.249
		4 -0.034	0.003	4.1492	0.386
		5 -0.006	0.025	4.1502	0.528
		6 -0.059	-0.282	4.2514	0.643
		7 -0.052	-0.064	4.3402	0.740
		8 -0.068	-0.118	4.5067	0.809
		9 -0.065	0.097	4.6799	0.861
		10 -0.079	-0.054	4.9683	0.893
		11 -0.095	-0.018	5.4585	0.907
		12 -0.076	-0.150	5.8291	0.924

Figure- 8.7

Correlogram of Variance of VAR Residuals ($\hat{\mu}_{2t}$)

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.227	0.227	1.0441	0.307	
2	-0.023	-0.079	1.0553	0.590	
3	-0.018	0.006	1.0625	0.786	
4	-0.074	-0.077	1.1985	0.878	
5	-0.032	0.003	1.2259	0.942	
6	-0.033	-0.036	1.2583	0.974	
7	-0.091	-0.082	1.5278	0.981	
8	-0.070	-0.040	1.7014	0.989	
9	-0.044	-0.032	1.7779	0.995	
10	-0.121	-0.123	2.4512	0.992	
11	-0.094	-0.061	2.9294	0.992	
12	-0.102	-0.102	3.6027	0.990	

it is observed from the Figures 8.6 and 8.7 that

- (i) the corresponding ACFs are free from any dying out pattern of spikes, and
- (ii) the corresponding PACFs do not contain any singularity significant spike at lag one or at any other lags onward.

These observations indicate that

- (i) variances of residuals ($\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$) are free from *autoregressive structure*, and
- (ii) the residuals do not exhibit **Autoregressive Conditional Heteroscedasticity (ARCH)**.

All these observations further confirm **Homoscedasticity of VAR residuals**, ($\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$).

8.14 Findings From Estimation of the VAR Model in the Table 8.2 [Equation (8.3)] It

is observed from the Table 8.2 that in the estimated equation (8.3) that

$$(i) \sum_{i=1}^3 \hat{\beta}_{1i} < 1 \text{ and } \sum_{i=1}^3 \hat{\gamma}_{1i} < 1$$

These indicate that the **auto-regressive and distributed lag structures** in equation (8.3) are **consistent**.

- (ii) $\hat{\beta}_{13}$ is significant at 5% level
- (iii) $\hat{\beta}_{13} < 0$ and $|\hat{\beta}_{13}| < 1$
- (iv) $\hat{\gamma}_1, \hat{\gamma}_2$ and $\hat{\gamma}_3$ are not significant even at 10% level.

8.15 Economic Interpretations of the Findings [For Equation (8.3)]

The economic significance of these findings is as follows:

- (i) Significant $\hat{\beta}_{13}$ (at 5% level) indicates that current period trade deficit is significantly affected by the three period back trade deficit.
- (ii) $\hat{\beta}_{13} < 0$ and $|\hat{\beta}_{13}| < 1$ indicate that variation in three period back trade deficit affect the current period trade deficit in opposite direction. Three- period back adverse trade deficit leads to a reduction in trade deficit at the current period. This relation appears to act as deterrent for the escalation of trade deficit over time.
- (iii) $\hat{\gamma}_{1i}$ ($i = 1,2,3$) being insignificant (even at 10% level) indicates that budget deficit *fails to 'Granger Cause'* trade deficit in the economy of Maldives over the period of study.

8.16 Findings From the Table 8.3 [For Equation (8.4)]

It is observed from the Table 8.3 for the estimated equation (8.4) that

- (i) $\sum_{i=1}^3 \hat{\beta}_{2i} < 1$ and $\sum_{i=1}^3 \hat{\gamma}_{2i} < 1$. These indicate that the *autoregressive and distributive*

lag structures in equation (8.4) are *consistent*.

- (ii) $\hat{\beta}_{2i}$ ($i=1,2,3$) are not significant even at 10% level.
- (iii) $\hat{\gamma}_{2i}$ ($i=1,2,3$) are not significant even at 10% level.

8.17 Economic Interpretation of the Findings From the Estimation of the Equation (8.3)

These findings have the following economic significance.

- (i) $\hat{\beta}_{2i}$ ($i=1,2,3$), being insignificant even at 10% level, indicate that the budget deficits in past periods have no bearing upon the current budget deficit at all.
- (ii) $\hat{\gamma}_{2i}$, being insignificant at even 10% level, indicates that trade deficits *fail to Granger Cause* budget deficit over the period of the study in the economy of Maldives.
- (iii) Trade deficit appears to be an exogenous variable in the system.

8.18 Over view of Findings :

The findings in Section 8.14 through Section 8.17 indicate that in the economy of Maldives over the period of study

- (i) *Trade deficit is negatively related to three-period back budget deficit. Consequently, three period back budget deficit exerts a corrective impact on the current period budget deficit.*
 - (ii) *trade deficit fails to 'Granger Cause' budget deficit.*
 - (iii) *budget deficit also fails to 'Granger Cause' trade deficit.*
 - (iv) *there was no 'causal' relation between budget deficit and trade deficit,*
 - (v) *budget deficit is 'exogenous' to the system.*
 - (vi) *the 'Ricardian Equivalence Hypothesis' is accepted and confirmed.*
-

CHAPTER –IX

INTERVENTION ANALYSIS THROUGH THE STUDY OF IMPULSE RESPONSE FUNCTIONS

9.1 Introduction:

VAR model represents a '*Simultaneous Equation System*' where for each 'endogenous variable' one equation is specified. Again each equation contains the *autoregressive*' structure of the endogenous variable along with *distributed lag structures* of other endogenous variables. Consequently, a shock to the ' i^{th} ' variable not only directly affects the ' i^{th} ' variable itself but the shock is also transmitted to all other endogenous variables through the dynamic (lag) structure of the VAR.

An '*Impulse Response Function*' traces the effects of a one time shock to one of the innovations on current and future values of the endogenous variables. In other words, *Impulse Response Function* traces the response of a variable through time to an unanticipated change in 'itself' or other inter-related variables. Therefore, the *Impulse Response Function* may be used in any VAR system to describe the dynamic behaviors of the whole system with respect to shocks in the residuals of the time series.

The VAR model estimated in Chapter 8 contains two endogenous variables, namely, budget deficit (BD_t) and trade deficit (TD_t). We, therefore, seek to study in this Chapter the dynamic responses of BD_t and TD_t across different time periods in response to shocks transmitted through channels of different endogenous variables concerned.

9.2 Graphical Presentations of Impulse Response Functions for Trade Deficit (TD_t)

The relevant *Impulse Response Functions* of trade deficit in response to impulses, transmitted through the channels of budget deficit and trade deficit, are being presented through the Figures (9.1) and (9.2). The numerical values of these responses across different periods are given by the Table 9.1

Figure - 9.1

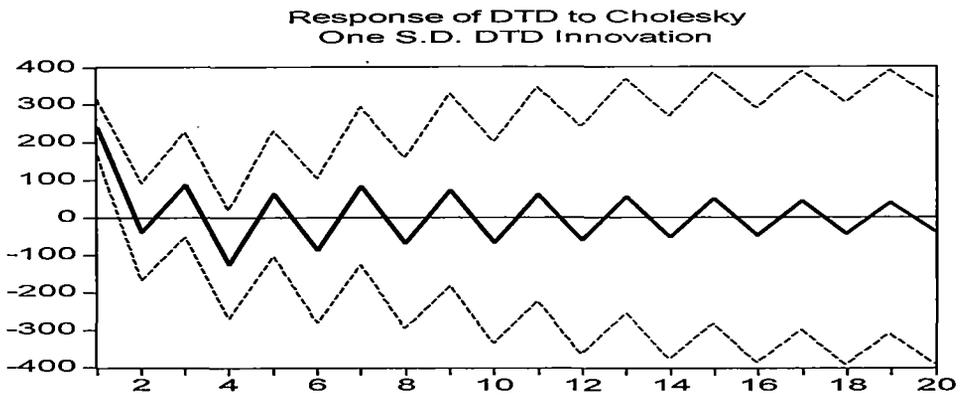


Figure - 9.2

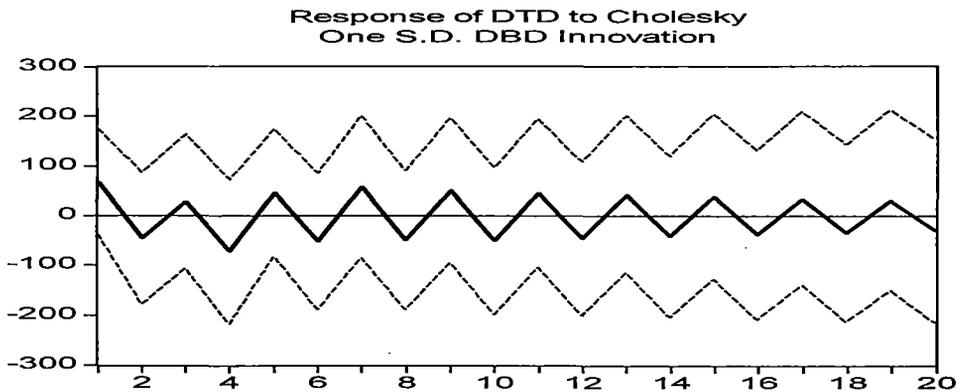


Table 9.1

Response of TD_t to Cholesky (d.f adjusted) One SD Innovations

Period	Response of DTD	
	DTD	DBD
1	240.0623 (37.0424)	68.34169 (53.4368)
2	-37.63345 (65.0003)	-45.08746 (66.5536)
3	87.54666 (69.8478)	28.63256 (67.8272)
4	-124.4529 (72.2713)	-71.50458 (72.6221)
5	63.93711 (83.3061)	46.81849 (64.4241)
6	-88.24686 (96.6402)	-50.71224 (68.9066)
7	83.99190 (104.840)	58.66018 (71.6295)
8	-68.31905 (113.961)	-48.83063 (70.0466)
9	73.80560 (127.975)	51.00622 (72.9779)

10	-67.09446 (134.358)	-49.89449 (74.1109)
11	62.03017 (142.580)	45.97552 (74.8959)
12	-60.90677 (151.734)	-45.36765 (77.2806)
13	56.29334 (156.333)	43.01792 (78.9962)
14	-53.27376 (162.047)	-40.66320 (80.8884)
15	50.72491 (166.863)	39.01987 (83.3161)
16	-47.50325 (169.654)	-36.86330 (85.3026)
17	44.97339 (172.590)	34.93806 (87.3539)
18	-42.48080 (174.470)	-33.16334 (89.3665)
19	39.99343 (175.424)	31.32418 (91.0141)
20	-37.78643 (176.064)	-29.63872 (92.5351)
Cholesky Ordering: DBD DTD		Standard Errors: Analytic

9.3 Findings From The Figure 9.1

It is observed from the Figure 9.1 and Table 9.1 that, following shocks, transmitted through the trade deficit channel, trade deficit

- (i) responds immediately by rising above the base line at $t=1$.
- (ii) fell below the base line at $t=2$
- (iii) touched the base line at $t=3$
- (iv) remained above the base-line at $t=5,7,9,11---$
- (v) remained above base line at $t=4,6,8,10,12,---$
- (vi) exhibit almost uniform oscillation among the base line.
- (vii) responses are significant between $0 \leq t \leq 3$

9.4 Findings From the Figure 9.2

The Figure 9.2 and Table 9.1 show that, following shocks transmitted through budget deficit channel, trade deficit

- (i) exhibits immediate response by rising above the base line at $t=1$
- (ii) declines and collapses on the base line at $t=3$
- (iii) exhibits upswings and downswings between $4 \leq t \leq 20$
- (iv) remains above the base line at $t=5,7,9,11---$

- (v) falls below the base line at $t = 4, 6, 8, 10, 12, \dots$
- (vi) responses become statistically insignificant (at 5% level) after $t = 2$

9.5 Overall Findings on the Nature of Trade Deficit Responses.

The findings in Section 9.3 indicate that shocks, transmitted through the channel of trade deficit and budget deficit

- (i) are short-lived
- (ii) fail to change the long-run equilibrium base of trade deficit.
- (iii) produce insignificant uniform oscillation in trade deficit around the long-run between $4 \leq t \leq 20$

9.6 Economic Interpretations of the Findings in Section 9.3-9.5

It is, therefore, observed that

- (i) short-run variations in trade deficit are mainly due to impulses transmitted through the channel of trade deficit.
- (ii) both types of shocks are short-lived since these fail to change the long-run equilibrium base of trade deficit.

9.7 Graphical Presentations of Impulse Response Functions for Budget Deficit (BD_t)

The *Impulse Response Functions* of budget deficit (BD_t) corresponding to equation (8.4) in the VAR system and, in response to impulses transmitted through the channels of budget deficit and trade deficit, are being presented through the Figures 9.3 and 9.4. The corresponding numerical values of these responses are given by the Table-9.2.

Figure - 9.3

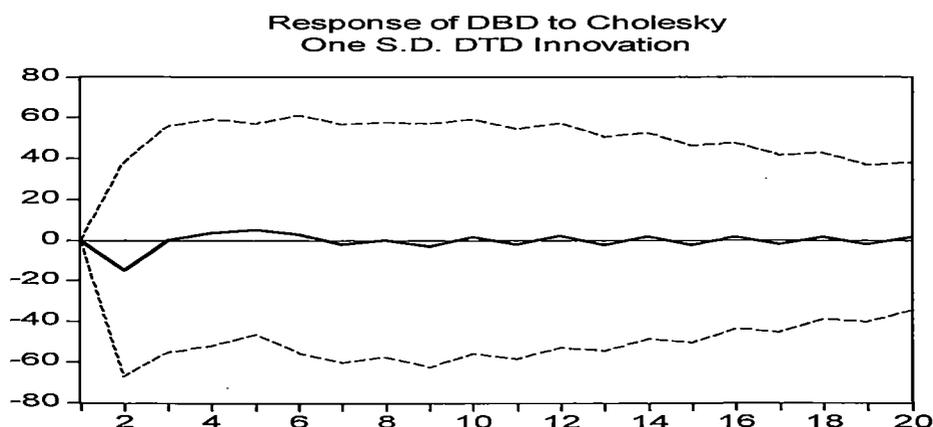


Figure - 9.4

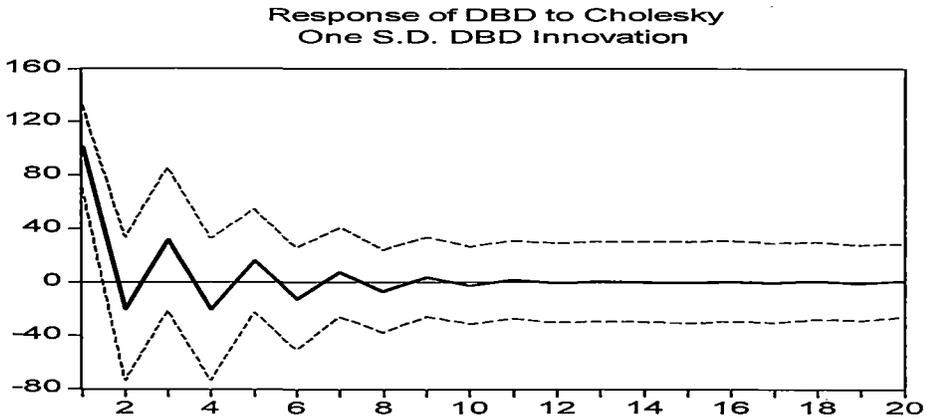


Table 9.2

Response of BDT to Cholesky (d.f adjusted) One SD Innovations

Period	Response of DBD	
	DTD	DBD
1	0.000000 (0.00000)	101.2101 (15.6171)
2	-14.40375 (26.3454)	-20.19269 (26.9967)
3	0.284379 (27.8480)	31.97018 (26.8471)
4	3.733038 (27.9153)	-20.74968 (26.7334)
5	5.296836 (25.8955)	15.94750 (19.2698)
6	2.966758 (29.2200)	-12.24636 (19.2303)
7	-1.704492 (29.3462)	7.431217 (16.8419)
8	0.189402 (28.8710)	-6.728110 (15.5343)
9	-2.757675 (29.9825)	3.921616 (14.8499)
10	1.773691 (28.8881)	-2.577022 (14.5425)
11	-1.818449 (28.3115)	1.914190 (14.5717)
12	2.349605 (27.6338)	-0.765408 (14.9051)
13	-1.956910 (26.4064)	0.324029 (15.0639)
14	(26.4064) (25.3722)	0.069766 (15.2227)
15	-2.058591 (24.1653)	-0.465066 (15.2933)
16	1.898502 (22.9205)	0.626751 (15.1591)

17	-1.882332 (21.7176)	-0.788857 (14.9535)
18	1.803329 (20.4826)	0.901565 (14.6219)
19	-1.706489 (19.2989)	-0.945902 (14.1932)
20	1.643709 (18.1488)	0.984450 (13.7074)
Cholesky Ordering: DBD DTD		Standard Errors: Analytic

9.8 Findings From the Figure 9.3

The Figure 9.3 shows that, following shocks transmitted through the channel of trade deficit, budget deficit

- (i) exhibits a delayed response by declining below the long-run base level at $t=1$
- (ii) declines at $t=3$, touches the base line at $t=5$ and falls below it at $t=6$.
- (iii) collapses on the base line at $t=10$

9.9 Findings From the Figure 9.4

The Figure 9.4 shows that, following impulses transmitted through the budget deficit channel, budget deficit

- (i) exhibits an immediate rise above the base line at $t=1$.
- (ii) declines below the long-run equilibrium base at $t=2$.
- (iii) displays very damped oscillations around the base line between $3 \leq t \leq 10$
- (iv) collapses on the base line at $t=11$.

9.10 Economic Interpretations of the Findings From the Joint Study of the Figures (9.3) and (9.4)

The joint study of the Figures 9.3 and 9.4 indicates that

- (i) both types of shocks are short-lived and these fails to generate significant short-run variations around the base level for budget deficit.
- (ii) budget deficit responses to budget deficit innovations are immediate though this responses to trade deficit innovations are delayed by nature.
- (iii) budget deficit, as a matter of fact, appears to be insulated to both types of shocks.

9.11 Overall Findings From the Study With Impulse Response Functions

It is, therefore, observed from the findings in Sections 9.3-9.9 that

- (i) *trade deficit shocks constitute the predominant cause behind the short-run variations in trade deficit.*
 - (ii) *budget deficit shocks fail to generate significant variations around the long-run equilibrium level of trade deficit.*
 - (iii) *budget deficit remains insulated to both types of shocks.*
 - (iv) *both types of shocks are short-lived by nature. These fail to change the equilibrium base of trade deficit and also that of budget deficit.*
-

CHAPTER- X

INTERVENTION ANALYSIS THROUGH THE STUDY OF VARIANCE DECOMPOSITION

10.1 Introduction:

The '*Forecast Error Variance Decompositions*' reflects the proportion of '*error variance*' of a variable which is explained by an *unanticipated* change in itself as opposed to that proportion attributable to change in other interrelated variables. In other words, the '*Forecast Error Variance Decomposition*' tells us the proportion of the movement in a sequence due to its own shocks versus shocks of other variables. Variations in trade deficit over the period of study were basically the effects of responses of trade deficit to the shocks transmitted through both trade deficit and budget deficit channels, i.e. part of total variations in trade deficit was due to trade deficit and another part of the variations was due to budget deficit shocks. The break-up of the total variations in trade deficit into two different parts across different periods ($i=1,2,\dots$) constitutes the '*Variance Decomposition*' of trade deficit. Such '*Variance Decomposition*' of trade deficit is given by the Table 10.1. The Graphical presentation of the '*Variance Decomposition*' for TD_t is being presented through the Figure 10.1.

Figure 10.1

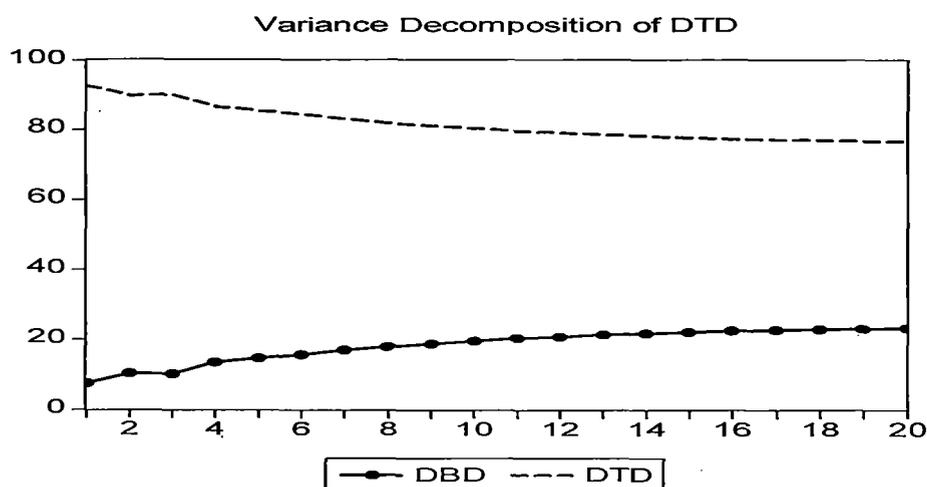


Table 10.1
Variance Decomposition of Trade Deficit (DTD_t)

Periods	S.E	DTD _t	DBD _t
1	249.6007	92.50313	7.496868
2	256.4170	89.80456	10.19544
3	272.4590	89.86543	10.13457
4	307.9535	86.67565	13.32435
5	317.9863	85.33538	14.66462
6	333.8780	84.39114	15.60886
7	349.2423	82.91310	17.08690
8	359.1964	81.99894	18.00106
9	370.2310	81.15795	18.84205
10	379.5551	80.34428	19.65572
11	387.3288	79.71640	20.28360
12	394.7043	79.14622	20.85378
13	401.0124	78.64638	21.35362
14	406.5741	78.22632	21.77368
15	411.5800	77.85394	22.14606
16	415.9490	77.53130	22.46870
17	419.8295	77.25219	22.74781
18	423.2744	77.00709	22.99291
19	426.3120	76.79370	23.20630
20	429.0084	76.60719	23.39281
Cholesky Ordering:		DTD _t	DBD _t

10.2 Findings From the Table (10.1) and Figure (10.1)

It is observed from the Table 10.1 and Figure 10.1 that

- (i) variations in trade deficit level in $1 \leq t \leq 20$ are mainly due to shocks transmitted through the channel of trade deficit.
- (ii) contribution of budget deficit shocks to trade deficit variations begin to increase in subsequent periods for $t \geq 3$
- (iii) trade deficit shocks to trade deficit account for at least 87% of total variations in trade deficit over the forecast period.

- (iv) contribution of budget deficit shocks to variations in trade deficit does not exceed 13% over the forecast period.

10.3 Variance Decomposition of Budget Deficit

The percentile decompositions of variance of budget deficit representing contributions of shocks, transmitted through the channels of budget deficit and trade deficit, are given by the Table 10.2. The corresponding graphical presentations are given by the Figure 10.2.

Figure 10.2

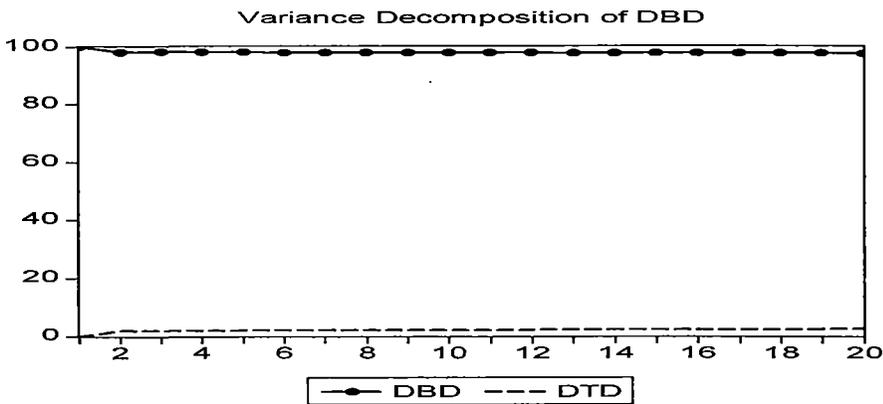


Table 10.2

Variance Decomposition of Budget Deficit (DBD_t)

Periods	S.E	DBD _t	DTD _t
1	101.2101	100.0000	0.000000
2	104.2051	98.08939	1.910614
3	108.9994	98.25309	1.746914
4	111.0196	98.20302	1.796980
5	112.2842	98.02073	1.979267
6	112.9890	97.97641	2.023594
7	113.2459	97.96292	2.037076
8	113.4458	97.96982	2.030184
9	113.5470	97.91445	2.085549
10	113.5901	97.89165	2.108349
11	113.6208	97.86717	2.132825
12	113.6477	97.82544	2.174560
13	113.6650	97.79646	2.203539
14	113.6833	97.76492	2.235085
15	113.7029	97.73291	2.267094

16	113.7205	97.70574	2.294264
17	113.7388	97.67909	2.320914
18	113.7567	97.65468	2.345315
19	113.7734	97.63288	2.367122
20	113.7896	97.61268	2.387318
Cholesky Ordering: DBD (Real)		DTD(Real)	

10.4 Findings From the Figure 10.2 and Table 10.2.

It is observed from the Table 10.2 and Figure 10.2 that

- (i) short-run variations in budget deficit for $t = 1$ is entirely due to budget deficit shocks.
- (ii) contributions of trade deficit shocks to short-run variations in budget deficit remain almost stable at about 8% for $2 \leq t \leq 5$ periods.
- (iii) trade deficit shocks account for at most 9.6% of total short-run variations in budget deficit for $t \geq 5$ periods.
- (iv) budget deficits shocks, on the other hand, account for at least 90% of total short-run variations in budget deficit for $t \geq 5$ forecast periods.

10.5 Summary of the Findings:

It, therefore, appears from Sections 10.2-10.4 that

- (i) *trade deficits shocks are the predominant factor behind the short-run variation in trade deficit.*
- (ii) *budget deficit shocks account for only an insignificant part of variations in trade deficit.*
- (iii) *variations in budget deficit are mainly due to shocks transmitted through budget deficit channel.*
- (iv) *trade deficit shocks, on the other hand, account for an insignificant part of variations in budget deficit.*

These observations also testify for the 'absence of any causal relation' between budget deficit and trade deficit in the economy of Maldives over the period of study. Consequently, these findings confirm the validity of the 'Ricardian Equivalence Hypothesis' in this economy.

CHAPTER- XI

GRANGER CAUSALITY BETWEEN TRADE DEFICIT AND BUDGET DEFICIT: RESTRICTED VAR MODEL

11.1 Introduction:

The study of '*Granger Causality*' between trade deficit and budget deficit in Chapter VIII is based on the estimation of an '**Unrestricted VAR (UVAR) Model**'. In such models all the equations for endogenous variables contain same *Autoregressive and Distributed Lag Structures*. If any of the equations is of AR (p) structure, then each equation in the system will consist of AR (p) structure for the endogenous variable concerned along with the same distributed lag structure for each of the endogenous variables of the system. Zero restriction for any of the coefficients in any equation is untenable in the '*Unrestricted VAR (UVAR) Model*'.

The '*Unrestricted VAR Model*' therefore, results in '*over parameterization*' leading to unnecessary loss of degree of freedom. Moreover, such models become '*atheoretic*' in view of the fact that very often the '*Autoregressive Structure*' in any constituent equation in the system may not be in conformity with the '*Univariate*' i.e. ARIMA (p,d,q) stochastic structure for the endogenous variable concerned. Moreover, any extended '*Distributed Lag Structure*' may be captured by AR (1) structure through '*Koyck Transformation*'. This usually results in the attainment of '*parsimony*' of estimable coefficients and improvement in degrees of freedom.

An alternative method of studying '*Granger Causality*' among variables involves the use of '*Restricted VAR Model*' (RVAR), where '*Autoregressive*' and '*Distributed Lag Structures*' vary across different constituent equations of the model. Different equations of the model entail different '*Autoregressive*' and '*Distributed Lag Structures*'. Consequently '*zero restrictions*' for coefficients are permissible in such a '*Restricted VAR Model*'.

It, therefore, becomes pertinent for us to study nature and direction of *Causal relation* between trade deficit and budget deficit through the estimation of a '*Restricted VAR Model*.' Such study is expected to supplement and supplant the findings in Chapter 8. Our study in this chapter is an attempt in this direction.

11.2 The Estimable Model:

The estimable 'Restricted VAR Model' consists of the following equations.

$$\Delta TD_t = \alpha_1 + \beta_1 \Delta TD_{t-1} + \gamma_1 \Delta BD_{t-1} + \gamma_2 \Delta BD_{t-2} + \gamma_3 \Delta BD_{t-3} + u_{1t} \quad (11.1)$$

$$\Delta BD_t = \alpha_2 + \beta_2 \Delta BD_{t-1} + \theta_1 \Delta TD_{t-1} + \theta_2 \Delta TD_{t-2} + \theta_3 \Delta TD_{t-3} + u_{2t} \quad (11.2)$$

where $u_{1t} \sim iidN(0, \sigma^2 u_1)$

$u_{2t} \sim iidN(0, \sigma^2 u_2)$

11.3 Results of the Estimation of the Model [Equations (11.1) and (11.2)]

Results of the estimation of the model are being presented through the Tables (11.1)-(11.2)

**Table -11.1
Results of Estimation of the Equation (11.1)**

Dependent Variable: DTD(Real)		Sample (adjusted) : 1983-2003		
Included observations :21				
Variable	Coefficient	Std.Error	t-Statistic	Prob.
C	-162.0572	58.82904	-2.754715	0.1113
DTD _{t-1}	-0.440829	0.261529	-1.685581	0.1113
DBD _{t-1}	0.149788	0.493975	0.303229	0.7656
DBD _{t-2}	0.238342	0.474757	0.502029	0.6225
DBD _{t-3}	-0.445573	0.477871	-0.932412	0.3650
R-squared	0.233721	Mean dependent variable		-120.6776
Adjusted R-squared	0.042151	S.D dependent var		251.2776
S.E of regression	245.9247	Akaike info criterion		14.05218
Sum squared resid	967663.5	Schwarz criterion		14.30088
Log likelihood	-142.5479	F-statistic		1.220030
Durbin-Watson stat	1.774166	Prob(F-statistic)		0.341148

Table -11.2
Results of Estimation of the Equation (11.2)

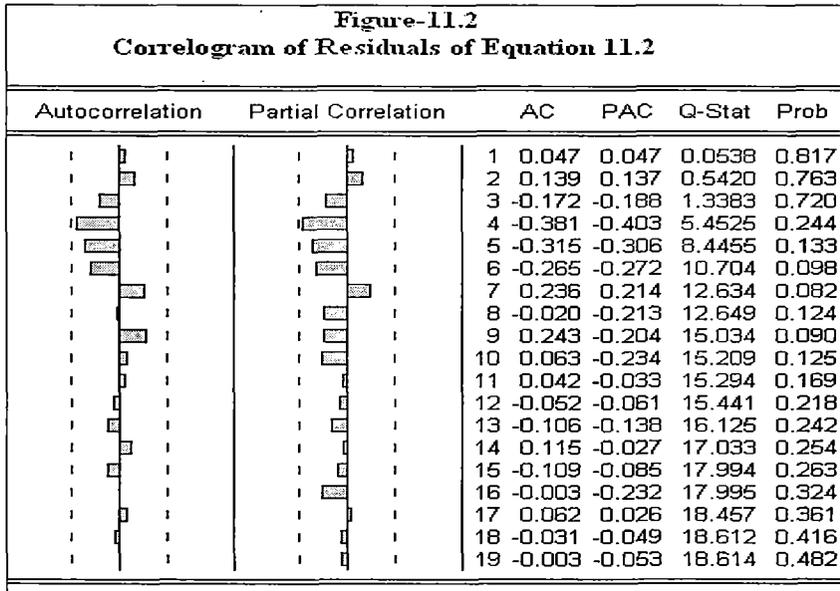
Dependent Variable: DTD(Real)		Sample (adjusted) :1983-2003		
Included observations :21				
Variable	Coefficient	Std.Error	t-Statistic	Prob.
C	-12.55988	37.04310	-0.339061	0.7390
DBD _{t-1}	-0.095494	0.247881	-0.385241	0.7051
DTD _{t-1}	-0.116490	0.131277	-0.887362	0.3880
DTD _{t-2}	0.065507	0.141802	0.461957	0.6503
DTD _{t-3}	0.113752	0.136588	0.832809	0.4172
R-squared	0.118630	Mean dependent variable		-17.68185
Adjusted R-squared	-0.101712	S.D dependent var		116.0564
S.E of regression	121.8156	Akaike info criterion		12.64715
Sum squared resid	237424.8	Schwarz criterion		12.89585
Log likelihood	-127.7951	F-statistic		0.538391
Durbin-Watson stat	1.854704	Prob (F-statistic)		0.709718

11.4 Correlograms of Residuals $\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$:

The *Correlograms* of residuals $\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$ are given by the Figures 11.1 and 11.2 respectively.

Figure-11.1
Correlogram Of Residuals of Equation 11.1

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	0.032	0.032	0.0245	0.876
		2	-0.308	-0.309	2.4383	0.295
		3	-0.330	-0.340	5.3609	0.147
		4	0.132	0.039	5.8571	0.210
		5	0.123	-0.087	6.3113	0.277
		6	0.135	0.096	6.9000	0.330
		7	-0.146	-0.084	7.6317	0.366
		8	-0.043	0.034	7.7000	0.463
		9	-0.153	-0.183	8.6388	0.471
		10	0.074	-0.023	8.8770	0.544
		11	0.058	-0.033	9.0394	0.618
		12	0.023	-0.091	9.0672	0.697
		13	-0.093	-0.029	9.5930	0.727
		14	-0.155	-0.238	11.260	0.665
		15	-0.040	-0.092	11.388	0.725
		16	0.215	0.033	15.839	0.464
		17	0.136	0.026	18.078	0.384
		18	-0.052	0.006	18.518	0.422
		19	-0.121	0.025	22.073	0.281



11.5 Serial Independence of Residuals $\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$:

It is observed from these figures that

- (i) the corresponding ACFs are free from the dying out pattern of spikes, and
- (ii) the corresponding PACFs are marked by the absence of any singularly significant spike at lag 1.

All these observations testify for the 'Serial Independence' of the residuals $\hat{\mu}_{1t}$ and $\hat{\mu}_{2t}$.

11.6 Findings From the Table 11.1 [Equation 11.1]

The Table 11.1 shows that

- (i) $|\hat{\beta}_1| < 1$. So the 'Autoregressive Structure' is 'stable'
- (ii) $\hat{\beta}_1$ is not significant even at 10% level.
- (iii) $\hat{\gamma}_i$ ($i = 1,2,3$) are insignificant even at 10% level.

11.7 Economic Interpretations of the Findings in Section 11.6

The economic significance of the findings is as follows.

- (i) $\hat{\beta}_1$, being insignificant (even at 10% level), indicates that trade deficit does not follow the AR (1) structure.
- (ii) $\hat{\gamma}_i$ ($i = 1,2,3$) being insignificant even at 10% level in the presence of ΔTD_{t-1} in the vector of regressors in equation (11.1), indicate that budget deficit fails to 'Granger Cause' trade deficit.

11.8 Findings From the Table 11.2 [Equation 11.2]

It is observed from the Table 11.2 that

- (i) $|\hat{\beta}_2| < 1$ indicates the 'Stability' of the 'Auto-regressive' structure for ΔBD_t
- (ii) $\hat{\beta}_2$ is not significant even at 10% level
- (iii) $\hat{\theta}_i$ ($i = 1,2,3$) are not significant even at 10% level.

11.9 Economic Interpretations of the Findings in Section 11.7

These findings have the following economic significance.

- (i) $\hat{\beta}_2$, being insignificant (even at 10% level), indicates that budget deficit does not follow the AR (1) structure.
- (ii) $\hat{\theta}_i$ ($i = 1, 2, 3$) being insignificant (even at 10% level) in the presence of ΔBD_{t-1} in the vector of regressors in equation (11.2), indicate that trade deficit fails to 'Granger Cause' budget deficit.
- (iii) the budget deficit becomes an 'exogenous' variable in the system.

11.10 Overview of Findings in Chapter XI.

It is observed from the findings in sections 11.5-11.8 that in the economy of Maldives

- (i) *'budget deficit' fails to 'Granger Cause' trade deficit over the period concerned.*
- (ii) *trade deficit fails to 'Granger Cause' budget deficit in the economy of Maldives.*
- (iii) *budget deficit and trade deficit are independent of each other in Maldives over the period of study.*
- (iv) *budget deficit appears to be an 'exogenous' variable in the system.*

All these findings are in conformity of findings in our study with an 'Unrestricted VAR Model' in Chapter VIII.

All these findings further confirm that in the economy of Maldives

- (i) **there exists no 'causal relation' of any kind between budget deficit and trade deficit. Consequently, 'Twin Deficit Hypothesis' remains invalidated by these findings.**
- (ii) **the 'Ricardian Equivalence Hypothesis' is a valid phenomenon.**

CHAPTER- XII

SPECTRAL ANALYSIS FOR CONFIRMATION OF THE NATURE OF GRANGER CAUSALITY

12.1 Introduction:

The spectral representation of a stationary time series $\{X_t\}$ essentially decomposes $\{X_t\}$ into a sum of sinusoidal components with uncorrelated random coefficients. In conjunction with this decomposition, there is a corresponding decomposition into the sinusoids of the autocovariance function of $\{X_t\}$. The spectral decomposition is thus an analogue for stationary processes of the more familiar '*Fourier Representation*' of deterministic functions. The analysis of stationary processes by means of their spectral representation is often referred to as the '*Frequency Domain Analysis*' of time series or '*Spectral Analysis*'. It is essential to '*Time Domain*' analysis based on the '*Autocovariance Functions*', but provides an alternative way of viewing the process.

The '*Spectral Analysis*' has been a very useful tool for studying econometric issues like *trade cycle separation, the analysis of co-movements of series, inspecting cyclical phenomenon* and highlighting '*lead-lag relations*' among series. It also provides a rigorous and versatile way to define formally and quantitatively each series components and by means of filtering. It provides a reliable extraction method. In particular, '*Cross Spectral Analysis*' allows a detailed study of the correlation among series.

In Chapter V through Chapter XI we have undertaken '*time domain*' analysis of the series like budget deficit and trade deficit in the economy of Maldives. The '*time domain*' analysis is based on '*Auto-correlation Function*' and '*Correlogram*' enabled us to examine, '*Stationarity*', '*Integrability*', '*Cointegration*', and '*Granger Causality*' between the variables concerned. We seek to reexamine all these aspects of the concerned macroeconomic variables through the '*Spectral Analysis*' in this Chapter.

12.2 Spectral Estimation: Methodology

12.2.1 Fourier Transformation

Given a function $h(t)$ of real variable t , the Fourier Transformation of $h(t)$ can be defined as

$$H(w) = \int_{-\infty}^{+\infty} h(t)e^{hwt} dt \quad (12.1)$$

provided the integral exists for real w .

A sufficient condition for $H(w)$ to exist is

$$\int_{-\infty}^{+\infty} h(t) dt < \infty$$

If (11.1) is regarded as an integral equation for $h(t)$ given $H(w)$, then a simple inversion formula exists of the form

$$h(t) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} H(w) e^{iwt} dw$$

and $h(t)$ is called the *Fourier Transform* of $H(w)$

In time series the discrete form of the *Fourier Transform* is used when $h(t)$ is only defined for integral values of t .

Then we have
$$H(w) = \sum_{-\infty}^{+\infty} h(t) e^{-iwt}, \quad -\pi \leq w \leq \pi$$

It is the *Fourier Transform* of $h(t)$, here $H(w)$ is defined only in the interval $[-\pi, \pi]$. The *Inverse Fourier Transform* is given by

$$h(t) = \frac{1}{2\pi} \int_{-\pi}^{+\pi} H(w) e^{iwt} dw \quad (12.2)$$

12.2.2 Periodogram and Auto-Spectrum

Let us consider a finite series $U(j)$ of length $T = N \Delta t$

where $N =$ Number of data

$\Delta t =$ the sampling periodicity

$v_k =$ the frequency $= \frac{k}{N\Delta t}$

$t_j =$ the time $= j \Delta t$

The Discrete Fourier Transform (DFT) $U(k)$ of $U(j)$ and its inverse (IDFT) for finite series are

$$U(k) = \frac{1}{N} \sum_{j=0}^{N-1} u(j) e^{-i2\pi jk / N} \quad (12.3)$$

$$U(j) = \frac{1}{N} \sum_{k=0}^{[n-1]/2} u(k) e^{-i2\pi jk / N} \quad (12.4)$$

where, $k \in [-(N/2), (\frac{N-1}{2})]$ and $j = 0, \dots, N-1$

Equation (12.3) can only be an approximation of the corresponding real quantity, since it provides only for finite set of discrete frequencies. The quantity

$P_u(k) = |U(K)|^2$ is the power Spectrum and its estimator is '*Schuster's periodograms*'

$$\begin{aligned}
P_u(K) &= \Delta t \sum_{j=-[N-1]0}^{[N-1]} \gamma_{uu}(J) e^{-i2\pi jk/N} \\
&= \sum_{j=-[N-1]0}^{[N-1]} \gamma_{uu}(J) \text{Cos} \frac{2\pi jk}{N} \quad (12.5)
\end{aligned}$$

where, $\gamma_{uu}(-J) = \gamma_{uu}(J)$ $N^{-1} \sum_{j=-(N-j)}^{N-j} [\{u(j) - u\} \{u(j+J) - u\}]$ (12.6)

and $\gamma_{uu}(J)$ is 'Standard Sample Estimation' at lag J of the 'Auto Co-variance Function'.

The technique of 'Windowing' is applied for building a 'Spectral Estimation' which has a smaller variance than $P_u(k)$. The result of 'Windowing' is the 'Smoothed Spectrum.'

$$\hat{S}_u(k) = \Delta t \sum_{j=-(N-1)}^{N-1} w(j) \gamma_{uu}(j) \text{Cos} \frac{2\pi jk}{N} \quad (12.7)$$

Here the Convolution of the Periodogram $P_u(k)$ with Fourier Transformation of $W_M(J)$ is the 'Spectral Window' $W_M(K)$ of width $M' = M^{-1}$

Thus the 'Smoothed Spectrum' is nothing but the Periodogram seen through a window opened on a covariant interval around k.

12.2.3 Cross Spectrum

Cross Spectrum is obtained by substituting the Cross-Covariance Function in equation (12.6) for the Autocovariance Function. Thus we have two time series $u_1(J)$ and $u_2(J)$ and their Cross Covariance Function $\gamma_{21}(J) = \gamma_{12}(-J)$, the Cross Spectrum is

$$\begin{aligned}
\hat{S}_{u_1 u_2}(k) &= \Delta t \sum_{j=-(N-1)}^{N-1} w(j) \gamma_{12}(j) e^{-i2\pi jk/N} \\
&= \hat{Q}_{12}(k) - i\hat{Q}(k) \quad (12.8)
\end{aligned}$$

The real part $\hat{Q}_{12}(k)$ is the 'Cospectrum' and the imaginary $\hat{Q}(k)$ the 'Quadrature Spectrum'.

Here the 'Coherence Spectrum' is

$$K_{12}(k) = \frac{|\hat{S}_{12}(k)|}{\sqrt{\hat{S}_1(k)}} \quad (12.9)$$

And the 'Phase Spectrum' is

$$\hat{Q}_1(k) = \arctan\left(-\frac{\hat{Q}_1(k)}{\hat{Q}_1(k)}\right) \quad (12.10)$$

Again the 'Gain Spectrum' is

$$\hat{G}_{12}(k) = \frac{|\hat{S}_{12}(k)|}{\hat{S}_1(k)} \quad (12.11)$$

12.3 Features of Spectral Estimation

We have estimated 'Periodograms by Frequency', 'Periodograms by Period', 'Spectral Densities by Frequency', 'Spectral Densities by Periods', 'Cospectral Densities by Frequency', 'Cospectral Densities by Period', 'Coherence Spectrum', 'Gain Spectrum', 'Phase Spectrum' for the Analysis. Appropriate care has been undertaken with respect to

- a. Aliasing
- b. Filtering
- c. Tapering
- d. Window Closing, and
- e. Fast Fourier Transformation (FFT)

12.4 Univariate Periodograms : Nature and Significance

The 'Univariate Periodograms by frequency' for trade deficit (DTD_t) and budget deficit (DBD_t) are given by the figures 12.1-12.2. Corresponding 'Univariate Periodograms by Periods' are being presented through Figures 12.3-12.4

Figure 12.1
Periodograms of DTD_t by Frequency

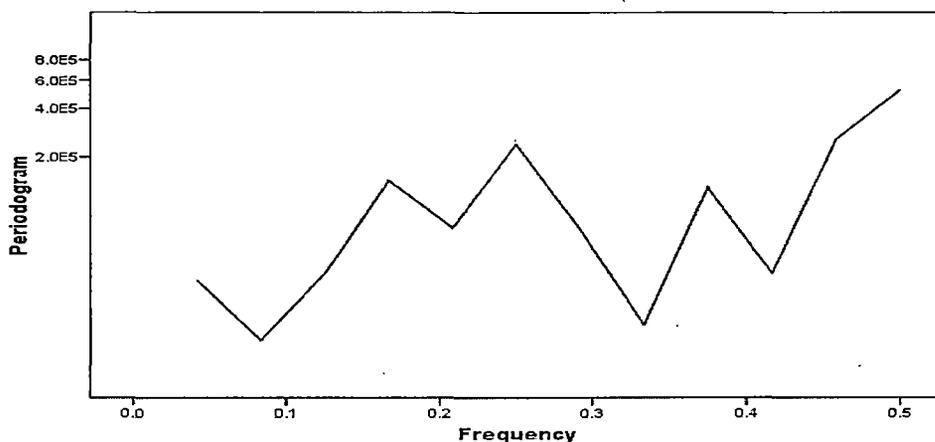


Figure 12.2
Periodograms of DBD_t by Frequency

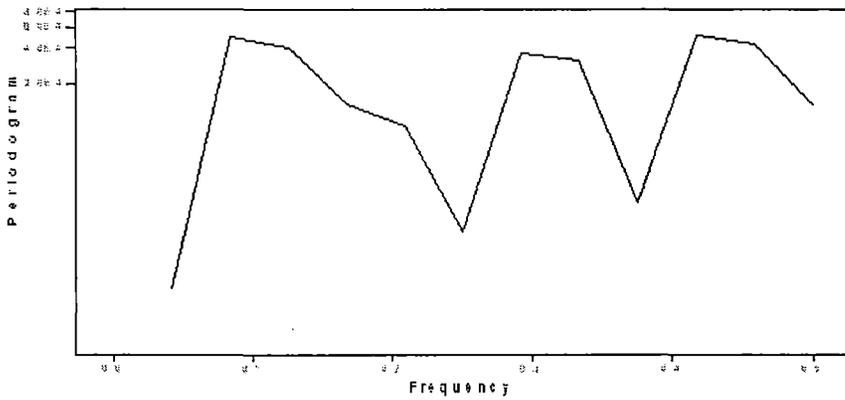


Figure 12.3
Periodograms of DTD_t by Period

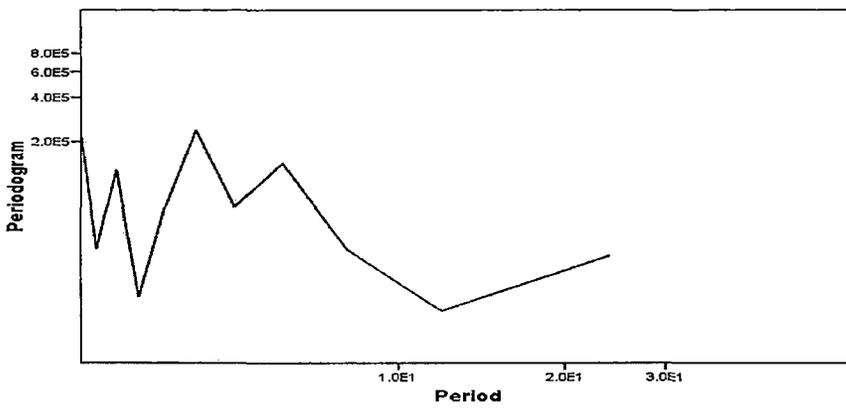
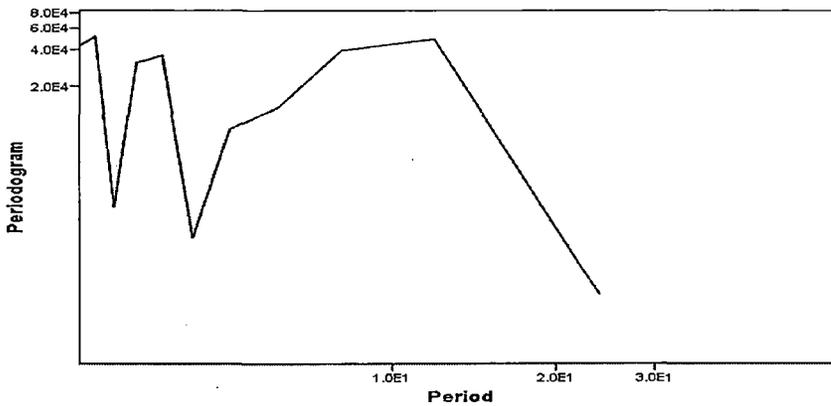


Figure 12.4
Periodograms of DBD_t by Period



12.4.1 'Periodogram by frequency' for Trade Deficit (DTD_t) Series.

The Figure 12.1 indicates that

- (i) the *Periodogram* of trade deficit (DTD_t) is not a horizontal straight line and it has several peaks at different frequencies. Consequently, trade deficit series exhibited periodicity in it.
- (ii) the existence of several peaks indicates that variances were decomposed without '*uniformity*' over different frequencies. Consequently, the trade deficit series (DTD_t) were not a '*White noise*' one.
- (iii) several upswings and downswings in the series across different frequencies testify for the stationarity of the series concerned.
- (iv) several upswings and downswings also testify for the presence of AR(p) stochastic structure for the trade deficit series (DTD_t).

12.4.2 'Periodogram By Period' for Trade Deficit (DTD_t) Series

The Figure 12.3 presents the 'Periodogram' of trade deficit series (DTD_t) by periods. It shows

- (i) the concentration of ups and downs in the early periods (1-5 periods) indicating an AR(p) stochastic structure of the trade deficit series (DTD_t).
- (ii) the existence of a prominent and predominant peak at period 3 (or close to it) hints at the possibility of AR(3) structure for the trade deficit series.

This is supported by the finding in our study with the VAR Model in Chapter VIII. The estimated equation (8.2) in the table 8.2 shows AR (3) structure for the trade deficit series.

12.4.3 'Periodogram by Frequency' of Budget Deficit (DBD_t) Series

The Figure 12.2 presents the '*Periodogram of Budget Deficit*' by frequency. It shows that

- (i) the '*Periodogram of Budget deficit*' is not a horizontal straight line. Consequently, the budget deficit series displays periodicities.
- (ii) the existence of ups and downs indicates that variances were decomposed without '*Uniformity*' over different frequencies.
- (iii) the absence of any sharp peak in the '*Periodogram*' and the existence of some plateaus over some frequencies. These hint at the '*White Noise*' property of the series concerned.

12.4.4 'Periodogram by Period' for Budget Deficit (DBD_t) Series

The Figure 12.4 presents the 'Periodogram' of budget deficit series by period. It shows

- (i) the absence of any predominant peak at any period.
- (ii) also the existence of *plateau* over some periods. This also testifies for the absence of any AR (p) stochastic structure for the budget deficit (DBD_t) series.

'White Noise' property of the DBD_t series seems to be plausible in view of the insignificant estimated auto-regressive coefficients for DBD_t in equation (8.4) presented in the Table (8.3) for the VAR model. Moreover, the *Correlogram* for the DBD_t series (BD_t series at first difference) as given by the Figure 5.3 in Chapter V also testifies for the absence of any AR (p) structure for the series concerned. The BD_t series is ARIMA (0,1, 0) by nature.

12.5 Spectral Density Representations: Nature and Significance.

Figures (12.5)-(12.6) present the 'Spectral Density by Frequency' for DTD_t and DBD_t respectively. These figures also indicate that each 'Spectral Density' is free from any noticeable 'Periodicity'. Absence of sharp peaks in the 'Spectral Densities' at regular intervals of frequencies indicates that the Auto-Spectra of the variables (DTD_t and DBD_t) do not exhibit any cyclical behavior.

Figure 12.5

Spectral Density of DTD_t by Frequency.

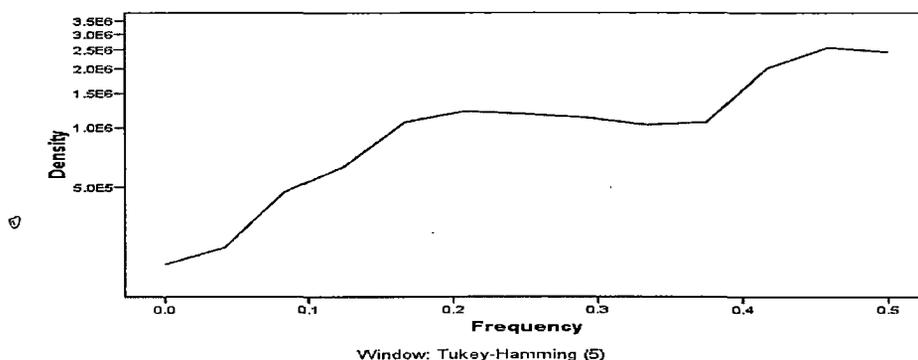


Figure 12.6

Spectral Density of DBD_t by Frequency.

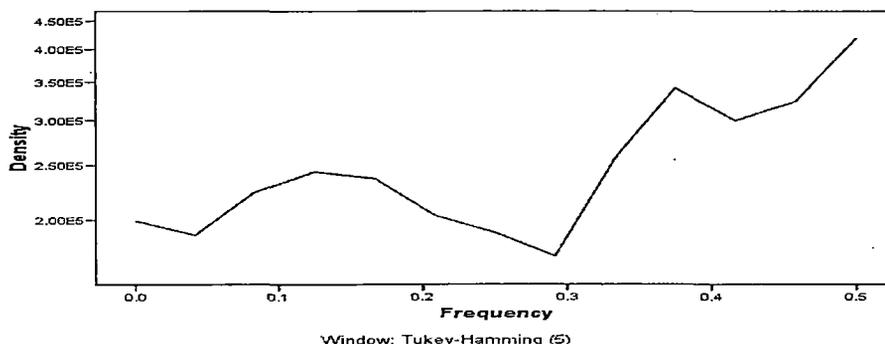


Figure 12.7
Spectral Density of DTD_t by Period

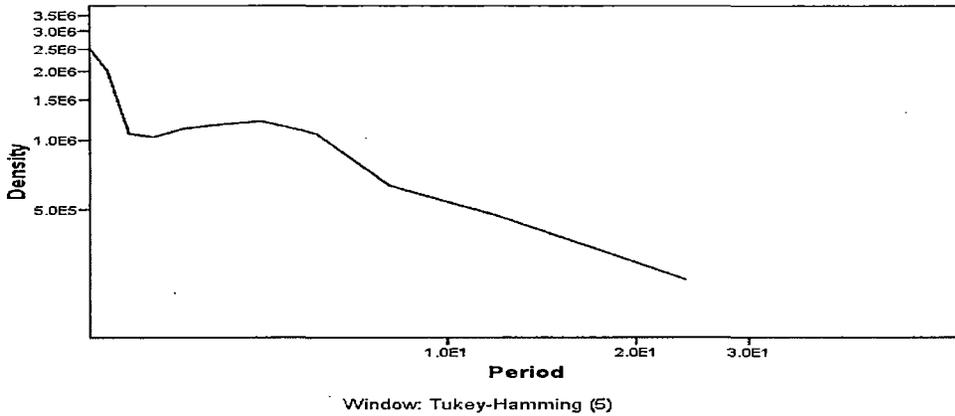
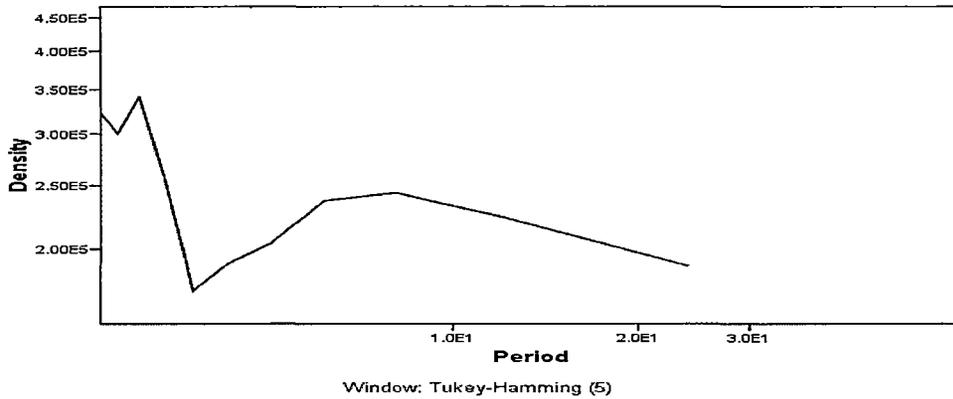


Figure 12.8
Spectral Density of DBD_t by Period



The Corresponding '*Spectral Densities*' (*Auto-Spectra*) by period for trade deficit and budget deficit series are given by the Figures 12.7 and 12.8. These figure exhibit no '*Periodicity*' in the '*Spectral Densities*' concerned. Cyclical behaviors are also absent in the series.

12.6 The 'Cospectral Densities by Frequency' for Trade Deficit (DTD_t) and Budget Deficit (BD_t)

The '*Cospectral Density by Frequency*' for DTD_t and DBD_t is given by the Figure 12.9 below.

Figure 12.9

Cospectral Density of DBD_t and DTD_t by Frequency

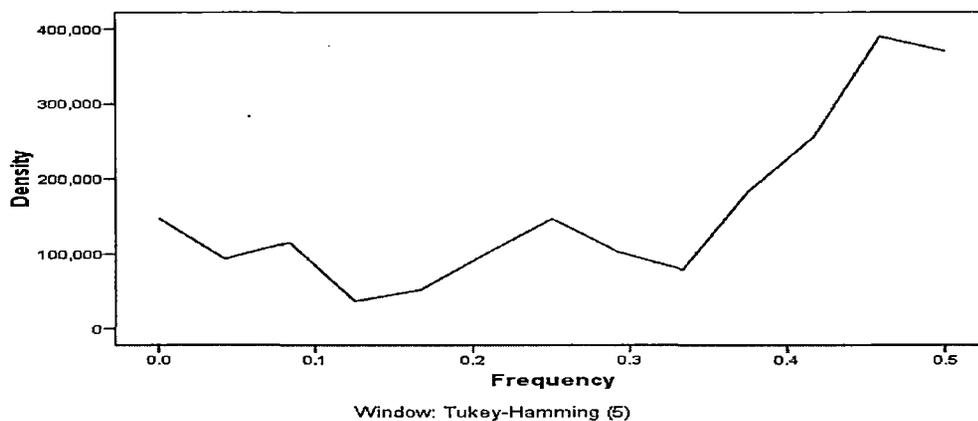
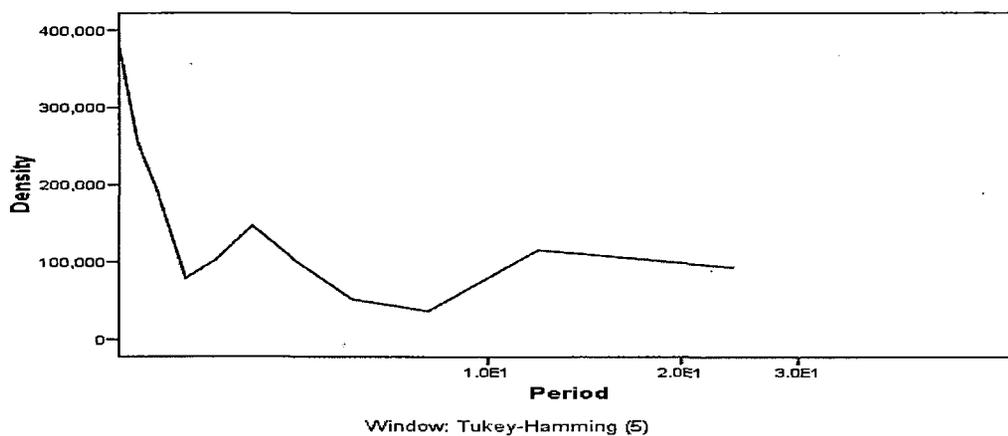


Figure 12.10

Cospectral Density of DBD_t and DTD_t by period



The Figure 12.9 shows that the ‘*Cospectral Density*’

- (i) is not a horizontal straight line
- (ii) is marked by the presence of several ups and downs
- (iii) contains no sharp peak at any frequency.

The ‘*Cospectral Density*’ by periods for these variables, as given by the Figure 12.10, also exhibit the features stated above.

All these observations indicate that

- (i) there are co-movements of DTD_t and DBD_t over the period of study.
- (ii) the co-movements is marked by the absence of periodicity.

These findings confirm that DTD_t and DBD_t are ‘*Cointegrated*’ and the long-run relationship between these variables is ‘stable’.

12.7 'Coherency Spectrum' for DTD_t and DBD_t

The 'Coherency Spectrum' by frequency for DTD_t and DBD_t is being presented through Figure 12.11 while the Figure 12.12 presents the corresponding 'Coherency Spectrum' by period.

Figure 12.11

Coherencies of DTD_t and DBD_t by Frequency

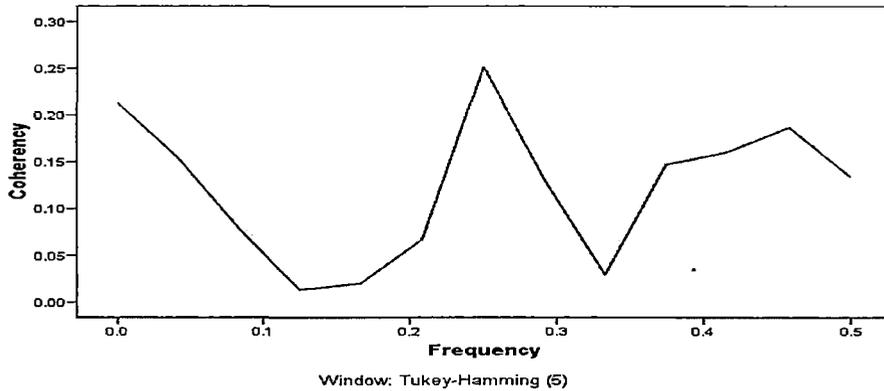
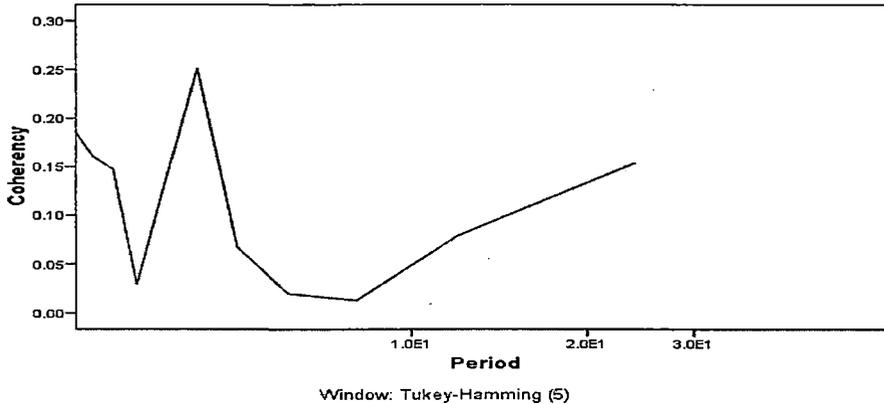


Figure 12.12

Coherencies of DTD_t and DBD_t by Period



The Figure 12.11 shows that

- (i) the 'Coherency Spectrum' of the variables DTD_t and DBD_t is only 0.25 at frequency 0.275 (approx)
- (ii) the 'Coherency' is lower than 0.25 at all other frequencies.

The 'Coherency Spectrum' in Figure 12.12 correspondingly shows that

- (i) the 'Coherency' is as high as 0.25 at period 3, and
- (ii) the 'Coherency' is lower than 0.25 at all other periods.

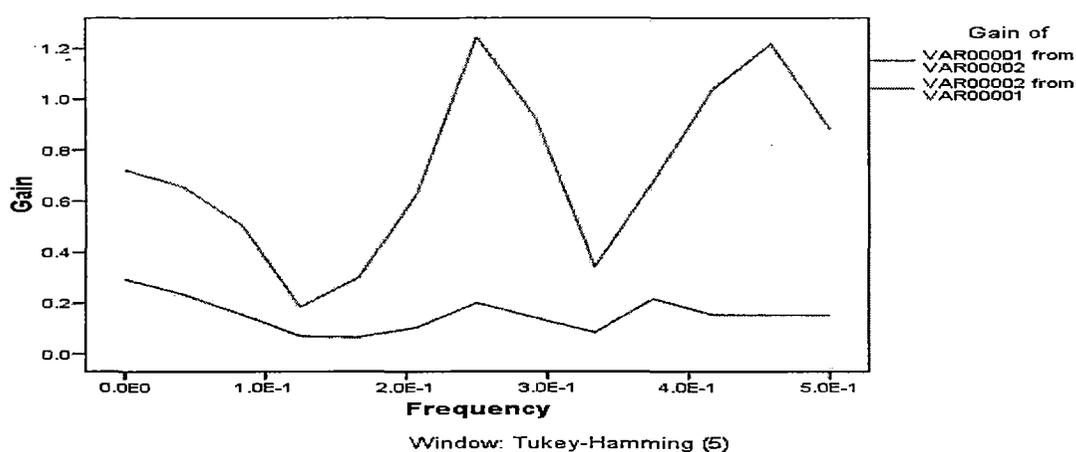
All these observations confirm that

- (i) there does not exist high intensity of co-movements of the variables concerned.
- (ii) there does exist a 'stable' long-run relationship between these series
- (iii) no significant 'Periodicity' exists in such relationship over the period of study or over the corresponding frequencies.

12.8 'Gain Spectrum' For DTD_t and DBD_t

The 'Gain Spectrum' for DTD_t and DBD_t by frequency is given by the Figure 12.13

Figure 12.13
Gain of DTD_t and DBD_t by Frequency



The 'Gain Spectrum' in the Figure 12.13 shows that

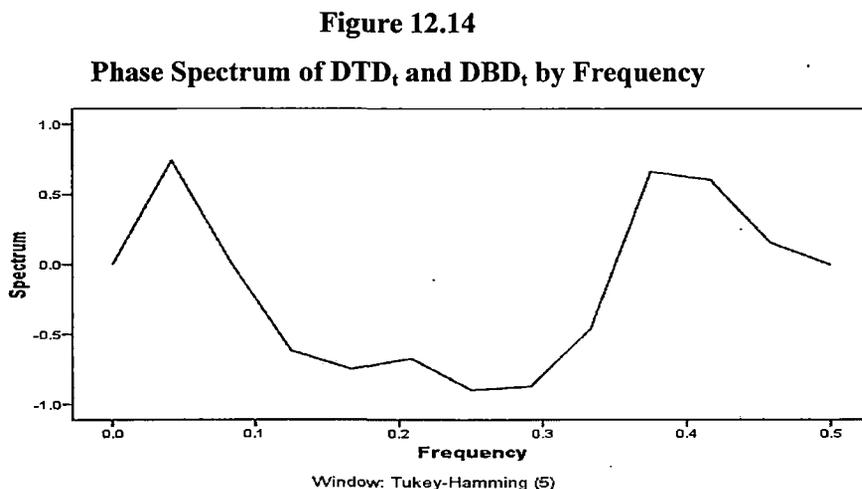
- (i) the 'Gain' of trade deficit (DTD_t) from budget deficit (DBD_t) lies over the 'Gains' of Budget Deficit (DBD_t) from trade deficit across all the frequencies.
- (ii) the 'Gain' of trade deficit (DTD_t) from budget deficit (DBD_t) is about 1.2 at frequency 0.25 (approx).

All these observations indicate that

- (i) the contribution of budget deficit (DBD_t) variations to those in trade deficit (DTD_t) was higher than the contribution of variations in trade deficit (DTD_t) to those in budget deficit (DBD_t) at all frequency levels.
- (ii) the highest 'Gain' of trade deficit (DTD_t) is insignificant. So the possibility of 'Unidirectional Causality' running budget deficit to trade deficit is not appreciable. Consequently, these two variables appear to be independent of each other. This finding confirms 'time domain' findings of 'absence of Granger Causality' between budget deficit and trade deficit in Chapters VII through Chapter XI.

12.9 'Phase Spectrum' for DTD_t and DBD_t

The 'Phase Spectrum' for DTD_t and DBD_t is being presented through the Figure 12.14



The 'Phase Spectrum' shows that

- (i) the 'phase difference' $[Q_{12}(k)]$ is negative over the frequency range (0.1 -0.350)
- (ii) the 'phase difference' $[Q_{12}(k)]$ is positive over the frequency range (0.0-0.1) and (0.350-5)
- (iii) the frequency range for the positive 'phase difference' almost equals the frequency range for the negative 'phase difference'.

All these observations indicate that both the budget deficit and trade deficit (DTD_t) possess almost equal dominance as the 'Lead' variable over the admissible ranges of frequencies.

These findings testify for the absence of 'Causal relation' between these variables. Budget Deficit (DBD_t) and Trade Deficit (DTD_t) appear to be 'independent' of each other. This finding of 'independence' is in conformity with our findings in Chapters VIII and XI.

12.10 Overview of Findings in the Spectral Analysis

The overall findings in the 'Spectral Analysis' are as follows:

- (i) 'Univariate Periodograms' for DTD_t and DBD_t confirm that DTD_t and DBD_t series are 'Stationary', i.e. $DTD_t \sim I(0)$ and $DBD_t \sim I(0)$. Consequently, $TD_t \sim I(1)$ and $BD_t \sim I(1)$.
- (ii) 'Auto-Spectra' confirm absence of periodicity in DTD_t and DBD_t series across different frequencies and the incidence of statistically significant auto-regressive structure for DTD_t .

- (iii) *'Auto-Spectrum' for DBD_t confirms 'White Noise' property i.e. ARIMA (0, 1, 0) stochastic structure for the series.*
 - (iv) *The 'Cospectrum' for trade deficit (DTD_t) and budget deficit (DBD_t) confirms that the series are 'Cointegrated' and the long run relationship between these series is 'stable'.*
 - (v) *The 'Coherence Spectrum' for DTD_t and DBD_t series confirms that there exists no strong 'Coherence' in their co-movements over the period of study.*
 - (vi) *The 'Gain Spectrum' for the series confirms the absence of 'Granger Causality' between these variables.*
 - (vii) *The 'Phase Spectrum' for the variables further confirm that neither of the variables 'Granger Causes' the other in the economy of Maldives over the period of study.*
 - (viii) **The 'Ricardian Equivalence Hypothesis' is operationally valid in the economy of Maldives over the period of study.**
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CHAPTER- XIII

SUMMARY AND CONCLUSION

13.1 Introduction:

The relationship between budget deficit and trade deficit has been studied for the economy of Maldives over the period 1979-2003 in Chapter V through Chapter XII. A summary of the main findings on different aspects of such relationship is being presented below.

13.2 Stationarity of Budget Deficit and Trade Deficit Series

Chapter 5 presents the study on 'Stationarity' and 'Integrability' of budget deficit and trade deficit series. The main findings of this chapter are

- (i) both BD_t and TD_t at level are 'non-stationary' at levels.
- (ii) 'non-stationarity' in BD_t and TD_t series at level is not due to any structural shifts in their stochastic structures.
- (iii) both BD_t and TD_t attain stationarity upon first differencing.
- (iv) both BD_t and TD_t are 'Difference Stationary' (DS) and not 'Trend Stationary' (TS)
- (v) both BD_t and TD_t series at level are $I(1)$ i.e $BD_t \sim I(1)$ and $TD_t \sim I(1)$
- (vi) both ΔBD_t and ΔTD_t are $I(0)$ i.e $\Delta BD_t \sim I(0)$ and $\Delta TD_t \sim I(0)$.

13.3 Cointegration: Long-run Relationship Between Budget Deficit and Trade Deficit Series

Chapter VI has been devoted to examine the existence of *Cointegration* between budget deficit and trade deficit in Maldives. The study involves the use of the *Engle-Granger Method*, the *Johansen Method* and the *CRDW Method of Cointegration*. The study of *Cointegration* shows that

- (i) the study of co-integration between budget deficit (BD_t) and Trade Deficit (TD_t) is possible since $BD_t \sim I(1)$ and $TD_t \sim I(1)$.
- (ii) BD_t and TD_t series at levels are not cointegrated. Consequently, long run equilibrium relation between Budget Deficit (BD_t) and Trade Deficit (TD_t) can not be expected to exist.
- (iii) ΔBD_t and ΔTD_t series are cointegrated. Consequently, a long-run equilibrium relationship exists between first differenced series for Budget deficits (BD_t) and Trade Deficit (TD_t).

- (iv) *the Cointegration relation between budget deficit and trade deficit is $CI(1,1)$ in the economy of Maldives.*

13.4 Dynamics of Short-run shocks And Stability of Long-run Relationship Between Budget Deficit And Trade Deficit.

Cointegration study in Chapter VI confirms the existence of long-run relationship between budget deficit and trade deficit in Maldives. It is then imperative to know if such relationship is stable. Stability of the long-run relationship is established if the short-run shocks, transmitted through the TD_t or BD_t channels, converge before long. The stability of the long-run relationship is studied through the estimation of the relevant *Vector Error Correction Model (VECM)* in Chapter VII. It has been observed in Chapter VII that in the economy of Maldives over the period 1979-2003

- (i) *there exists no cointegration and, therefore, a long-run equilibrium relationship between budget deficit (BD_t) and Trade Deficit (TD_t) series at level.*
- (ii) *Cointegration exists between first differenced data-sets for budget deficit and trade deficit.*
- (iii) *budget deficit and trade deficit series are $CI(1,1)$.*
- (iv) *the short-run shocks, transmitted through the trade deficit channel, affect the long-run dynamic relationship that trade deficit maintains with budget deficit.*
- (v) *the deviations of trade deficit from its long-run equilibrium level are temporary and convergent.*
- (vi) *the long-run relationship that trade deficit maintains with budget deficit is **stable**.*
- (vii) *consequently, the short-run dynamics for the trade deficit defines a '**stable equilibrium process**.*
- (viii) *the shocks, transmitted through the budget deficit channel, fails to disturb the long-run relationship that budget deficit maintains with trade deficit.*
- (ix) *budget deficit fails to '**Granger Cause**' trade deficit in the short run.*
- (x) *Trade deficit fails to '**Granger Cause**' budget deficit in the short run.*
- (xi) *budget deficit and trade deficit, therefore, appear to be independent of each other in the short-run in the economy of Maldives*

13.5 Causal Relationship Between Budget Deficit and Trade Deficit

The *causal relationship* between budget deficit and trade deficit has been studied with the estimation of an appropriate *Unrestricted Vector Autoregressive (UVAR)* model in Chapter VIII. Main findings in Chapter VIII are as follows:

- (i) *trade deficit is negatively related to three-period back budget deficit .Consequently, three period back budget deficit exerts a corrective impact on the current period budget deficit.*
- (ii) *trade deficit fails to 'Granger Cause' budget deficit.*
- (iii) *budget deficit also fails to 'Granger Cause' trade deficit.*
- (iv) *there was no 'causal' relation between budget deficit and trade deficit,*
- (v) *budget deficit is 'exogenous' to the system.*
- (vi) *The 'Ricardian Equivalence Hypothesis' is accepted and confirmed.*

13.6 Intervention Analysis Through The Study of Impulse Response Functions

The UVAR model in Chapter VIII considers two types of shocks. Some shocks are transmitted through the trade deficit channel while others are transmitted through the channel of budget deficit. In Chapter IX we examined the responses of trade deficit and budget deficit to such shocks. Besides, we sought also to examine the relative importance of these shocks in explaining variations in these two deficits over time. From the *Intervention Analysis* through the study of *Impulse Response Functions* in Chapter IX, it is observed that

- (i) *trade deficit shocks constitute the predominant cause behind the short-run variations in trade deficit.*
- (ii) *budget deficit shocks fails to generate significant variations around the long-run equilibrium level of trade deficit.*
- (iii) *budget deficit remains insulated to both types of shocks.*
- (iv) *both types of shocks are short- lived by nature. These fail to change the equilibrium base of trade deficit and also that of budget deficit.*

13.7 Intervention Analysis Through the Study of Variance Decomposition

The *Intervention Analysis* through the *Variance Decomposition of Forecast Errors* for the deficits concerned has been done in Chapter X. The main findings are as follows:

- (i) *trade deficits shocks are the predominant factor behind the short-run variation in trade deficit.*

- (ii) *budget deficit shocks account for only an insignificant part of variations in trade deficit.*
- (iii) *variations in budget deficit are mainly due to shocks transmitted through budget deficit channel.*
- (iv) *trade deficit shocks, on the other hand, account for an insignificant part of variations in budget deficit.*

13.8 Study of Granger Causality Through The Restricted Vector Autoregressive Model

The estimated UVAR model in Chapter VIII gives a hint about the direction and nature of *causality* between the deficits concerned. In the UVAR model the specification of lag structures for both the variables requires to be uniform. Consequently, the model is ‘**Over parameterized**’. Such an ‘UVAR’ Model, therefore, appears to be less informative about the *causality* between the deficits concerned. In such case ‘**Restricted VAR Model**’ may of get help. A variant of such ‘**Restricted VAR Model**’ is used in ‘**Granger Causality Approach**’. We have, therefore, sought to study in Chapter XI, *causality* between the deficits in the line suggested by ‘*Granger Causality Tests*.’ The maintain findings are as follows:

- (i) *budget deficit fails to ‘Granger Cause’ trade deficit over the period concerned.*
- (ii) *trade deficit fails to ‘Granger Cause’ budget deficit in the economy of Maldives.*
- (iii) *budget deficit and trade deficit are independent of each other in Maldives over the period of study.*
- (iv) *budget deficit appears to be an ‘exogenous’ variable in the system*

13.9 Spectral Analysis For Further Confirmation of the Nature And Direction of Granger causality

We have sought to examine the causal relation between the deficits concerned through the ‘**Spectral Analysis**’ in Chapter XII. This enables us to reexamine the nature and direction of ‘*Granger Causality*’ between the deficits as obtained in Chapters VIII through XI. In the ‘**Spectral Analysis**’ we have the following findings

- (i) ‘*Univariate Periodograms*’ for DTD_t and DBD_t confirm that DTD_t and DBD_t series are ‘*Stationary*’, i.e. $DTD_t \sim I(0)$ and $DBD_t \sim I(0)$. Consequently, $TD_t \sim I(1)$ and $BD_t \sim I(1)$.
- (ii) ‘*Auto-Spectra*’ confirm absence of periodicity in DTD_t and DBD_t series across different frequencies and the incidence of statistically significant auto-regressive structure for DTD_t .

- (iii) *'Auto-Spectrum' for DBD_t confirms 'White Noise' property i.e ARIMA (0, 1, 0) stochastic structure for the series.*
- (iv) *The 'Co-spectrum' for trade deficit (DTD_t) and budget deficit (DBD_t) confirms that the series are 'Cointegrated' and the long run relationship between these series is 'stable'.*
- (v) *The 'Coherence Spectrum' for DTD_t and DBD_t series confirms that there exists no strong 'Coherence' in their co-movements over the period of study.*
- (vi) *The 'Gain Spectrum' for the series confirms the absence of 'Granger Causality' between these variables.*
- (vii) *The 'Phase Spectrum' for the variables further confirm that neither of the variable 'Granger Causes' the other in the economy of Maldives over the period of study.*
- (viii) *The 'Ricardian Equivalence Hypothesis' is operationally valid in the economy of Maldives over the period of study.*

13.10 Conclusion

On the basis of these findings we may draw the following conclusions.

First, both the trade deficit and fiscal deficits in Maldives over the period 1979-2003 have been showing a significant degree of hysteresis as shown by the 'Unit root' Tests.

Second, there exist significant co-movements of these deficits over time.

Third, the co-movements of these deficits do not exhibit any significant *causal relation* between them. As a matter of fact, no significant '*Granger Causality*' between these deficits has been observed over the period of study. Consequently, '**Twin Deficit Hypothesis**' is not validated by the study for the economy of Maldives.

Fourth, budget deficit is found to possess '*econometric exogeneity*' since it is not '*Granger Caused*' by trade deficit and DTD_t follows an ARIMA (0,1,0) stochastic structure.

Fifth, both the deficits are independent of each other. Emergence of one deficit is not found to contribute largely to the emergence of another deficit in Maldives over the period of study.

Sixth, '**The Ricardian Equivalence Hypothesis**' is operationally valid in the economy.

Consequently, the equilibrium levels of current accounts, interest rates, investment and consumption remain unaffected by the changes in the level of budget deficits.

Under this situation, a change in the level of budget deficit fails to bring in appreciable change in the life time budget constraint and in the volume as well as composition of real wealth of consumers. Given that agents have the opportunity of borrowing at a constant

interest rate, tax reduction will be considered as nothing but an increase in the present value of future tax liabilities. As a result thereof, consumers engage themselves in adjusting their savings to such changes in budget deficit. The desired level of national savings will, therefore, remain invariant over time.

In this frame work of the economy of Maldives, the '**absorption level**' following budget deficit, remains unchanged. In that event, the transmission link of budget deficit, through **absorption channel**, becomes inoperative. Consequently, 'budget deficit' fails to generate 'trade deficit'. Two deficits in this economy exists as independent of each other. They exist because of different and unrelated fiscal as well as exchange market management policies.

13.11 Policy Implications

These findings indicate that budget deficits in Maldives cannot be held responsible for the emergence of trade deficits over the period of study. The internal debt, therefore, has not been found to culminate into the external debt.

It further indicates that the problem of trade deficit is not intricately related with the problem of internal fiscal management. So trade deficit, even in the presence of fiscal imbalances may be expected to wither away in response to any corrective measures undertaken in foreign trade. Export promotion, import substitution etc may prove successful in the long-run.

Similarly, fiscal measures may be taken up for reducing budget deficit. It may however be noted that the budget deficit does not generate growth potentialities in the economy provided it leads to capital accumulation. Economic development may be ascertained if, budget deficit can successfully broaden the capital base of the economy. This would, in future, lead to growth in income and standard of living. This may ultimately help the government to meet the fiscal obligations created by budget deficits in previous years.

13.12 Scope For Future Studies

The findings are based on the estimation of different equations and models with a historical dataset ranging from 1979-2003. Over this period several economic plans have been undertaken and executed with varying degrees of success. Thus the period is marked by spectacular economic and social transformations together with varying rates of growth.

This long period, therefore, may be considered as a time span with heterogeneous process of growth. Consequently, the economy might have experienced some structural changes over the period concerned. Under these circumstances, a researcher may produce a regression-equation which is too closely tailored to the chosen sample by experimenting with too many formulations of the model. In this case, it is not certain whether the estimated function will

perform equally well outside the sample of the data. Again with structural changes, the coefficients again may not appear stable. These may be sensitive to changes in the sample composition.

This calls for the investigation into the '*Twin Deficit Hypothesis*' over shorter homogeneous sub-periods. It may then be expected to provide dynamic and better insights into the interrelationship between budget deficit and trade deficit in Maldives over the period of study concerned.

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