INVESTIGATING THE DEBT-GROWTH RELATIONSHIP FOR DEVELOPING COUNTRIES; A MULTI-COUNTRY ECONOMETRIC ANALYSIS.

THESIS SUBMITTED FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

AT THE

UNIVERSITY OF LEICESTER

By

BASEERIT NASA, BA, MSC (WARWICK)

Department of Economics
University of Leicester

March 2009

ABSTRACT

INVESTIGATING THE DEBT-GROWTH RELATIONSHIP FOR DEVELOPING COUNTRIES; A MULTI-COUNTRY ECONOMETRIC ANALYSIS.

Baseerit Nasa
March 2009

Debt which emerged as a result of excessive lending by the advanced nations to disorganised and badly managed economies is oppressing the world's poorest and most vulnerable whilst enriching wealthy creditors.

This study investigates the relationship between debt and the economic growth of 56 heavily indebted poor countries from 1969 to 2000 in three empirical chapters. The first empirical chapter examines the non-linearity of the debt-growth relationship, i.e. it estimates the threshold below which debt enhances growth whilst above which debt prevents growth. The preferred endogenous threshold model of Hansen (1996, 2000) suggests that debt becomes detrimental to growth when debt-to-GDP ratio approaches 45%. Hence a country's debt is considered sustainable, in the sense that it affects growth positively and can be serviced without any difficulty, as long as its debt-to-GDP ratio is below 45% threshold.

An alternative to threshold concept of debt sustainability is the concept of intertemporal sustainability, which defines debt as sustainable providing that actual debt level equals the present discounted value of future trade balance surpluses. This, in terms of the time series properties, implies that debt is sustainable if there is long-run economic relationship between debt stock and output.

The second empirical chapter investigates this using numerous integration and cointegration methods. The results from the best tests suggest that debt is unsustainable. Nonetheless, these methodologies have low power and categorise countries into a simple dichotomy of sustainable vs. unsustainable, whereas in reality sustainability is a continuum measure.

Thus, the final empirical chapter proposes the use of persistence techniques for assessing debt sustainability, i.e. estimating a Debt Sustainability Index (DSI). Estimates of the DSI conclude that Latin American and Caribbean (LAC) countries have less sustainable debt than Sub Saharan African (SSA) countries. Furthermore, the oil price, the interest rate and the commodity price shocks have played a substantial role in causing the debt crisis but the contribution of other factors unidentified is larger. The oil shocks are the most important for both groups whilst the interest rate is the least important for LAC and the commodity price for SSA.

EXECUTIVE SUMMARY

The debt-growth relationship has become particularly significant and at the heart of much political debate since the 1980s crisis. International financial organisations like the IMF and the World Bank are predominantly concerned with this issue. Furthermore, numerous voluntary organisations including the Jubilee Debt Campaign (JDC) and the World Development Movement (WDM) have emerged calling for the cancellation of the Third World Debt (TWD). Due to the political motives and the public pressure several debt management strategies have been employed in the hope of eliminating the debt crisis but none of them have had any positive effect. Subsection 1.3.3 and 1.3.4 provide details about the strategies that have been used till today.

After the 1980s debt crisis a large body of literature also emerged investigating the link between debt and growth. Section 2.2 reviews the theoretical and the empirical work being carried out in this field. The nature of the relationship between debt and growth is not straightforward. Simple macroeconomics growth models do not incorporate debt into the analysis as doing so complicates the model in several ways. Firstly, it gives rise to simultaneity issue as debt is dependant on growth and growth is also dependant on debt. Secondly, it raises the question of what level of debt is optimal for growth and how this should be estimated.

The actual experience of highly indebted Developing Countries (DCs) highlights the importance of understanding the debt-growth interaction for designing the appropriate policies in order to achieve economic growth and prosperity. This thesis contributes to a more comprehensive understanding of the debt-growth relationship in three empirical essays.

The first empirical chapter considers the extent to which debt influences growth. Consistent with the existing empirical literature, the analysis is based on the Debt-Overhang Hypothesis (DOH) of Krugman (1988) and Sachs (1986) that states that high debt is perceived as higher future taxes on investment thus it deters investment and reduces growth whilst low debt level reduces the investment-savings gap and hence increases its growth. This gives rise to a non-linear relationship between debt and growth such that there is a threshold below which debt is growth-enhancing but above which debt is a growth-deterrent. The focus of the applied work is to investigate whether such a threshold exists and at what level of debt using several econometric modelling strategies including the endogenous threshold model proposed by Hansen (1996, 2000).

The key result is that although the optimal debt-to-GDP ratio is different for different model specifications and across different estimators the preferred modelling approach of Hansen suggests that debt becomes detrimental to growth when debt-to-GDP ratio approaches 45%. This is smaller than the estimate (50%) used to provide debt relief by the International Monetary Funds and the World Bank (henceforth Fund-Bank) under the Heavily Indebted Poor Countries (HIPCs) initiative. The threshold estimate of 45% is similar to those found by other researchers such as Pattillo et al (2001), Cohen (1997) and Clements et al (2003).

However, the threshold concept of debt sustainability (DS) is limited as it only compares the current debt ratio with estimated threshold i.e. it only looks at the static position of the country whereas the sustainability of debt depends on whether the current debt can be serviced in the future, i.e. the future expectations of creditors and investors about the debtor's growth prospects over longer horizon. As long as creditors and investors expect debtor's growth to be sufficient to meet its debt obligations they will continue lending and investing. So debt in itself does not represent a problem.

Therefore, the subsequent substantive chapters consider DS in terms of a country's long-term horizon by assessing its Intertemporal Budget Constraint (IBC). According to IBC, debt is considered sustainable as long as debtor's trade balance (net export) surplus equals the current debt level, which in financial literature is referred to as satisfaction of "No Ponzi Game" (NPG) condition. In empirical terms this implies that debt and output have a long-run equilibrium relationship such that debt and output levels cannot move too far apart from each other, but these series themselves are subject to shocks which have persistent effect. Hence this concept of debt sustainability relates to the statistical concept of "stationarity" and "cointegration". These empirical techniques allow for a more enhanced and realistic type of interaction between debt and growth, such that debt effects growth and growth effects debt in a simultaneous system.

The second empirical chapter therefore employs the IBC concept of debt sustainability and uses the "integration" and "cointegration" time series techniques to investigate the debt sustainability of 56 developing countries. The overall results indicate that the debt levels are indeed *unsustainable*. This reconfirms the findings of the first substantive chapter that debt-to-GDP ration above 45% threshold is unsustainable and that most of the countries do have debt ratio above this threshold.

Even though the cointegration techniques are superior to the threshold models they fail to capture the complex nature of the long-run horizon of debt sustainability defined by IBC. They simply categorise each country either into a sustainable group or unsustainable group, whereas in reality debt-to-GDP ratio is a continuum measure. Hence a more realistic estimate of the debt sustainability should reflect the continuum nature of the debt ratio and the measure should indicate *how* sustainable a country's debt is. Thus, the final empirical chapter proposes the use of an alternative technique that accommodates the continuum nature of debt ratio and debt sustainability using the data for Latin America and Caribbean (LAC) and Sub Saharan Africa (SSA) countries. More precisely it measures the persistence of a shock to debt-to-GDP ratio and denotes this estimate as a *Debt Sustainability Index.* The chapter also considers which macroeconomic factors might warrant and justify a permanent change in debt-to-GDP ratio that is consistent with sustainable debt. Furthermore, it investigates the extent to which these factors explain the persistent of shocks in our cross-country analysis of TWD.

The results indicate that the debt of these countries is indeed *unsustainable*. Furthermore, the findings support the conception that interest rate, oil price and non-oil exporting commodity prices shocks have contributed to the debt crises. However, contrary to the common belief the contribution of these shocks is relatively small compared to other unidentified factors, indicating that one must consider factors beyond these 3 shocks in order to understand the causes of the crisis. The later findings also imply that debt of LAC and SSA is *unsustainable* even when we accommodate for the macroeconomic factors, such as oil price that have permanent effect on debt-to-GDP ratio.

ACKNOWLEDGMENT

All praises and thanks are to Allah who has made it possible for me to complete this thesis.

In researching and writing this PhD, I, like most students have experienced great challenges, and enormous frustration. Tempering these 'negative' aspects of research have been the moments of scientific euphoria and source of wonderful friendships. Although the front cover has my name on it, many others have assisted in various forms to complete this thesis. Here I will attempt to thank you all. (My sincere apologies to anyone inadvertently omitted).

This work would not have been possible without the help and the support of my principal supervisor Professor Kevin Lee. Please accept my thanks for all your contributions to bringing this thesis to its conclusion.

I also thank my former advisor Dr Roberto Leon-Gonzalez who is presently at National Graduate Institute for Policy Studies, Japan, for his support and guidance.

My special thanks go to the external examiner Prof. Oliver Morrissey from the University of Nottingham and the internal examiners, Dr Abbi Kedir for their very constructive comments.

I am also grateful to Professor Gianni De Fraja for serving on my thesis committee as the chair. Thank you for sitting in the meeting and reviewing my progress throughout the duration of the study.

I thank Dr. Rodney Strachan former member of the Department of Economics University of Leicester, presently at the School of Economics, University of Queensland, Australia for his very insightful comments as the discussant of 2nd chapter when presented at the 2nd PhD conference held at the University of Leicester in May 2005. I also thank Professor Stephen Hall for his comments as the discussant on the 3rd chapter presented at the 3rd PhD conference held at the University of Leicester in May 2006. Comment from Dr Strachan and Prof. Hall have made significant contributions to improve these two chapters of the thesis.

My special thanks go to Prof. Sourafel Girma, presently at the Nottingham University Business School for his invaluable help with Stata program. Prof Girma deserves an extra special mention, not only for his unfailing encouragement, support and guidance but also for his belief in me.

I thank my fellow graduate students and departmental admin staff especially Laden Baker, for their friendships and support. The past 5 years have been quite an experience and you all have made it a memorable time of my life. I will miss you all. Good luck to each of you in your future endeavours.

I thank the department for the Graduate Teaching Assistantship that sponsored my study and provided an excellent opportunity to gain invaluable teaching experience in academic atmosphere.

I owe a great debt of gratitude to my parents, for their never-ending love and support in all my efforts, and for giving me the foundation to be who I am. Thank-you, Mom and Dad.

I thank my brothers, Asrar, Abrar and Qasim, for their love and support throughout the years. Thank you for the laughing and the fighting, and everything in between.

Most of all I say thank you to Mohsin, my husband and soul mate for always being there for me. Thank you for your continual love, support, and patience as I went through this journey. I could not have made it through without you by my side.

DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University. To the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference has been made.

DEDICATION

This thesis is dedicated to my wonderful parents, Rashid and Sakhawat, grandma, Alema and Aunty Tabasam who have raised me to be the person I am today. Each of you have been with me through the good times and the bad. I can not thank you enough for all the unconditional love, guidance, and support that you have always given me, helping me to succeed and instilling in me the confidence that I am capable of doing anything I put my mind to. Thank you for everything. I love you!

This work is also dedicated to my beloved daughter Javairia, brother Qasim and darling husband Mohsin.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	Full description
ACF	Autocorrelation function
ADF	Augmented Dickey-Fuller
AfDF	African Development Funds
AR	Autoregressive
ARIMA	Autoregressive Integrated Moving Average
ARMA	Autoregressive Moving Average
BC	Bosworth and Collins
CA	Current Account
CM	Campbell and Mankiw
DC	Developing Countries
DGP	Data Generating Process
DOLS	Dynamic Ordinary Least Square
DS	Debt Sustainability
DSI	Debt Sustainability Indicator
ERS	Elliot, Rothenberg and Stock
FDI	Foreign Direct Investment
FE	Fixed Effects
FMOLS	Fully Modified Ordinary Least Square
Fund-Bank	International Monetary Fund and World Bank
GDF	Global Development Finance
HIPC	Heavily Indebted Poor Countries
IBC	Intertemporal Budget Constraint
IDA	International Development Association
IFS	International Financial Statistics
IMF	International Monetary Funds
IPS	Im, Pesaran and Shin
JDC	Jubilee Debt Campaign
LAC	Latin American Countries
LIBOR	London Interbank Offered Rate
LL	Lin and Levin

LM	Lagrange Multiplier
LPP	Lee, Pesaran and Pierse
LR	Likelihood Ratio
MA	Moving Average
MA	Moving Average
MW	Maddala and Wu
NIC	Newly Industrialised Countries
NPG	No Ponzi Game
OPEC	Organization of the Petroleum Exporting Countries
PACF	Partial Autocorrelation Function
PP	Phillip and Perron
PPL	Pesaran, Pierse and Lee
PRGF	Poverty Reduction and Growth Facility
PRSP	Poverty Reduction Strategy Paper
PVC	Present Value Constraint
PWT	Pen World Tables
SSA	Sub-Saharan Africa
SSE	Secondary School Enrolment
SURE	Seemingly Uncorrelated Regression Equation
TFP	Total Factor Productivity
TS	Time Series
VAR	Vector Autoregressive
VECM	Vector Error Correction Model
WDI	World Development Indicators

1 INTRODUCTORY CHAPTER

1.1 MOTIVATION

The foreign debt owed by low income countries to developed nations' governments financial institutions, commercial and regional banks (known as the Third World Debt (TWD)) is one of the greatest hardships and a force working towards promoting global poverty and inequality. TWD is preventing countless underdeveloped countries from developing to provide a decent standard of living for their citizens. This is not just because much-needed government revenues are being diverted from domestic spending on health and education to repaying creditors, but also because of the stringent conditions attached to debt as well as the adverse market conditions created by unsustainable debt. Many indebted countries pay more in debt servicing than on health, education and public infrastructure. At the same time unsustainable debt leads to market conditions that deter investments for two reasons: one is that large debt is perceived as higher future taxes on investment and two debt-servicing and debt-rescheduling create greater uncertainty about government policies.

The 1980s debt crisis that is still a major barrier to the growth and the development of Developing Countries (DCs) emerged as a result of a worldwide slowdown in economic growth due to several significant events that took place in 1970s. The first major factor was the breakdown of the Bretton Wood system when US president Nixon failed to exchange gold for dollars at the fixed rate in August 1971. The second was the change in the exchange rate regime in many countries from managed to floating in 1973. Both of these factors led to general deregulation of International Financial Systems (IFS) which had serious implications for the capital flow to DCs.

During the 1970s, not only the amount but also the predominant form of capital flow to DCs changed from Official Development Assistance (ODA) and Foreign Direct Investment (FDI) to private loans. Due to the deregulation of IFS, ODA became multilaterised and away from the direct control of US who thus preferred development to be financed by private funds from abroad. It was argued that commercial banks would fulfil the role more efficiently than the aid organisations. At the same time, banks were only too happy to lend for their own reasons including the recession that was taking place in industrialised countries due to the first oil shock in 1973 (Makin, 1984). The recession meant that banks were getting the deposit loans but they had no clients for loans especially as the largest corporations started to raise funds by issuing their own bonds and shares rather than taking high interest loans from commercial banks. This made the DCs an attractive client for commercial loans as it offered returns unavailable elsewhere. Moreover, these returns were seen to be secure; as the Citibank Chairman Wriston stated "*countries never go bankrupt"* (Wriston 1986). Other banks followed Wriston's philosophy, offering syndicated loans on variable interest (so borrowers bear most of the risk) that was significantly above LIBOR (so the banks were getting the risk-premium). Also, most loans were made to the public sector as it provided a guarantee which private debtors could not offer. Whether these were sound reasons for the large stock of 1980s debts is a debatable issue discussed in Corbridge (1993).

The above discussion highlights the importance of the TWD and provides a motivation for the study of the TWD crisis. The subsequent section, 1.2, presents a more detailed background to the TWD and the emergence of the 1980s debt crisis as well as the past and present debt management strategies which have been designed to solve the crisis. The next section, 1.3 outlines the scope of the thesis discussing the objectives of the study, the methodologies adopted, the contribution of the thesis and its contents and the structure.

1.2 CONTEXT OF THE STUDY

The discussion in this section is based on the review of the DCs foreign debt and growth experience over the last 40 years or so. The discussion consists of the DCs debt position in the 1970s and how the 1980s debt crisis emerged. Then it outlines various efforts that have been made by the Fund-Bank, general public, debtor governments and developed countries governments to resolve the crisis. Please note that the relevant academic literature is presented within each of the three substantives chapters.

1.2.1 DEBT OF DCS; THE POSITION IN THE 1970S

Private debt to DCs, especially to Latin America (LA) exploded from the 1970s to early 1980s. In the 1970s, over 48% of LA long-term public and publicly-guaranteed debt came from private creditors with nearly 20% from commercial banks. In 1982, over 77% of loans were from private creditors, over 71% of which were from commercial banks. LAC's total gross debt grew at a compound annual rate of 25% which was almost twice the growth rate of export earnings and about four times that of GNP between 1972 and 1982 (Kuczynski 1988). Three-quarter of this increase came from commercial banks, half of which was just to three countries (Brazil, Mexico and Venezuela). By contrast a large portion of debt in North Africa, SSA, Middle East and South Asia was by official creditors namely bilateral donors. In the 1970s, ODA increased extensively in SSA, which haunted the region in 1980s when several development failures caused problems for countries to meet their debt obligations.

The debt service obligations in the 1970s were met by large flows of foreign capital that were relatively cheap given high inflation and low interest rates until 1979. In fact these loans were contracted at interest below inflation (giving negative real interest rate) and their value was rapidly falling due to the very inflation that created these loans. They were also critical in closing the circle started by high oil price and weak dollar (Kucznski 1988). Through this decade, DCs with high debt levels had good growth rates when recession was hitting hard in developed nations. From 1974-1975, the GDP of advanced countries fell by 0.6% while in DCs it rose: 3% for LA and 7.4% for Asian countries (Maddison 1985). From 1973-1979, the growth rate in LA was although lower than the level during the 1950-1973, it was higher than in advanced countries. In Asia, average GDP growth in 1973-1979 was 6.8% a year whilst in 1950-1973 it was 6.1% a year. Accordingly, debt was asserted *good* for the growth and was encouraged over other forms of capital flow to DCs.

1.2.2 Causes of 1982 Debt Crisis in Wider Context

The exact causes and the interaction of various factors that led to the 1980s debt crisis are complex and interdependent. This section looks at the main historical events that took place during the 1970s which are attributed to the 1980s debt crisis. In a nutshell, debt crisis are associated to three main shocks. The first is the increase in the oil price in the mid and late 1970s. The second is the high interest rate and the final is the fall in the price of DCs' non-oil exporting commodities. Increasing oil price and falling commodity price caused DCs particularly LA to accumulate massive debt stocks. This coupled with the soaring World interest rate gave rise to the TWD crisis which emerged in August 1982 when Mexico defaulted on its external debt obligations.

Perhaps the chain of events started with the breakdown of the Bretton Wood agreement in August 1971 when US floated its currency and pulled out of the Gold Exchange Standard (whereby US dollar was pegged to the price of gold and all other currencies were pegged to the US dollar). Other industrialised countries immediately followed suit floating their respective currencies. In order to stabilise the fluctuation in currencies these nations increased their reserves (printing money) in amounts far greater than ever before. Consequently, US dollar along with other currencies depreciated. Since oil was priced in dollars, depreciating dollar meant that its real value was reducing and the oil producers were receiving less in real terms. The Organisation of the Petroleum Exporting Countries (OPEC)[1] did not have the appropriate institutional mechanisms to update prices rapidly enough to keep up with the changing market conditions. The price of oil had remained fairly stable relative to other commodities and currencies but suddenly became extremely volatile in the mid 1970s when OPEC started to peg oil price with gold. As a result the oil prices rose substantially to catch-up with the price of gold. This led to the mid 1970s "Oil Shock". During this period there was also a cut in the production of oil by OPEC on political basis whereby an embargo was placed on the shipment of oil to the West practically the US and the Netherlands for their military support to Israel. As oil demand is inelastic, prices had to rise substantially in order to equate the demand with the supply. Anticipating this led to a panic in the market causing a further sharp increase in oil prices.

This coupled with the breakdown of the Bretton Wood system led to a series of recessions and high inflation worldwide particularly in the developed nations. This promoted a reduced demand by developed nations leading to a fall in the exports of DCs and worsening of terms of trade for non-oil exporters. World export prices calculated in dollars fell in the 1980s whereas they had risen sharply from the 1973 to the early 1980s. Cline (1984) concludes that non-oil DCs suffered significant cumulative losses due to adverse international economic conditions. He estimates a total loss of \$141bn in lower export receipts, higher import costs and higher interest payments.

The World interest rate reached all time high when the US suddenly tightened the money supply in September 1978 after pursuing inflationary and devaluationist strategies throughout the 1970s. In June 1982 USA had a prime rate of 16.5% with an unemployment rate of 9.3% of total labour force. Other developed countries had similar economic indicators. The LIBOR rose from 9.2% to 16.63% from 1978 to 1981 increasing the real interest rates that remained high until 1986. The real interest rate on DCs' debt rose from -11.8% in 1977 to 16.7% in 1982 (Reisen 1985). Cline (1984) estimates that the unexpected total excess interest payment on DCs debt reached \$41bn for the first two years of 1980s. As debt was mainly in US dollars, it increased further due to the appreciating dollar from the

[1] OPEC is an intergovernmental organisation, originated in September 1960 following the Baghdad Conference by Iran, Iraq, Kuwait, Saudi Arabia and Venezuela. These members were later joined by other oil exporting nations including Qatar in 1961; Indonesia and Socialist Peoples Libyan Arab Jamahiriya in 1962; United Arab Emirates in 1967; Algeria in 1969; Nigeria in 1971; Ecuador in 1973 (December 1992 to October 2007 disjoint OPEC); Angola in 2007; and Gabon from 1975 to 1994.

early to mid 1980s. A large amount of capital flew out of the DCs during this period worsening their balance of payment.

Following this the nature and the terms of loans changed significantly. From 1971 to 1979 the interest rate was rather low, but this changed dramatically between 1979 and 1982. The maturity of loans also changed during this period: most debt was long-term in the mid 1970s but after 1978/9 debt maturities became shorter mainly less than a year as money was exhausted with high interest rates. Countries with large debt outstanding and high oil bills to pay had little choice but to restore to short-term loans with high interest rates. There was an explosion in short term borrowing at high interest rate during 1978 to 1982.

In summary, the debt crisis emerged as a result of three main shocks – the oil price increases in 1973/4 and 1979, the interest rate rise and the collapse in DCs' non-oil export commodities prices. During the early 1980s, positive net transfers were maintained through short-term borrowing. This was not a problem in itself – the problem arose with using these short-term funds to finance long-term public deficits. These short-term loans only delayed and perhaps worsened the debt crisis till August 1982. See chapter 4 for detailed explanation on the causes of the crisis.

1.2.3 Debt Management Strategies, 1982-1996

After observing the deleterious relationship between heavy debt and growth of DCs, the developed world started to take some action to reduce the debt burden in order to increase the growth of indebted nations. Throughout the debt crisis period, several debt management polices have emerged each promising the ultimate success in ending the crisis but actually only prolonging it. This subsection briefly summarizes the three main debt management strategies that have been used in the past to resolves the debt crisis. Namely it describes the containment, austerity and adjustment strategies during 1982 to 1985; the adjustment with growth strategy, known as the Baker years of 1985 to 1988; and the Brady initiative and the market menu of debt write-downs in 1988-1996.

The current scheme being employed to tackle the crisis is the Heavily Indebted Poor Countries (HIPC) initiative which was introduced in the 1996 and enhanced in the 1999. The details regarding the HIPC initiative are given in the next section 1.2.4

Containment, Austerity and Adjustment, 1982-1985

Although the details of each rescheduling differed from case to case, the structure of Mexico's deal was largely copied for most debt rescheduling during 1982-1985. Each deal involved: 1) rescheduling of amortisation[2] payments with longer maturities (interest payment continued as scheduled); 2) continuous involuntary lending to prevent countries from defaulting; and 3) significant cuts in debtors' public sectors to reduced public deficits and imports (instead of increase in its export) to improve their foreign reserves and service the debt in hard (foreign) currencies.

The strategy was mainly focused on solving the Mexican crisis but instead only kept the US banks solvent and significantly improved the Fund's role in the World financial system. It provided the banks with the time necessary to rebuild their capital and diversify their portfolios. Corbridge (1993, p60) states: *development had been sacrificed to secure the stability of the international banking system.* This occurred as debtors were prevented to default on their debt by taking on further loans and cutting public expenditure and imports to meet the debt obligations resulting in higher debt stock with lower growth of output.

During the containment years, investment fell sharply: For LA the rate of gross investment fell by nearly 34% from 1980s to 1984 while in SSA it fell by nearly 30% from 1982 to 1985. In the early 1980s, most LA and SSA countries started to 'underdevelop' as their growth rate of GDP became negative, GNP fell rapidly and their international reserves were being swiftly absorbed by large amounts of debt servicing. These nations experienced massive rises in unemployment and inflation as governments sought to minimise the political impact of austerity measures by borrowing at high interest rates and/or printing money. For example Brazil had an annual inflation of 242%, while Bolivia had an estimated inflation of over 8000% in 1985.

Baker Plan: Adjustment with Growth, 1985-1988

Given the failure of the containment strategy, James Baker, the secretary of the US Treasury, announced a new debt initiative in October 1985 at the joint Fund-Bank meeting. He proposed that the debt crisis could only be solved by sustained growth programme that incorporates macroeconomic structural polices promoting growth, overcoming balance of payment problem and reducing inflation. The plan required that the debtor countries adopted market oriented growth polices supported by continued key role of IMF coupled with further lending by Multilateral Development Banks (MDBs) and commercial banks to 15 heavily indebted middle-income countries including Argentina, Brazil, Mexico, Venezuela, Uruguay, Chile, Ecuador, Colombia, Peru, Bolivia, Yugoslavia, the Philippines, Nigeria, the Ivory Coast and Morocco.

[2] Instalments of principal (and interest) on loan to pay-off the debt over a set period of time.

Brady and Market Menu Approach, 1988-1996

The Baker plan did not manage to solve the debt problems of DCs after three years of its implementation. Consequently, Brady plan was announced in 1988 that replaced containment strategy with debt and debt-service write-downs on voluntary bases but the rescheduling of repayments continued. The new plan also entailed the Fund-Bank support for debt reduction operations for Severely Indebted Middle Income Countries (SIMICs).

The Baker plan was a country-based programme starting from deals with Mexico, the Philippines and Costa Rica and later with Venezuela, Morocco and Uruguay. Although the details of these programme differ from country to country, they aimed to reduce the uncertainty regarding the flows of funds and use market-based options like debt buybacks at discount rate, determined according to the secondary market value of debt, to solve the crisis.

1.2.4 Debt Management Strategies from 1996 Onwards

This sub-section outlines the current initiatives being employed by multilaterals to solve the debt crisis. The section details the emergence, the eligibility criteria, the debt sustainability analysis and the actual working of the HIPC initiative. Lastly, the section discusses another debt relief scheme that supplements the HIPC initiative known as the Multilateral Debt Relief Initiative (MDRI).

Emergence of HIPC Initiative

After failing for almost two decades to manage the explosive debt situation of many DCs, the Fund-Bank introduced HIPC Initiative in 1996 in response to growing public pressure[3]. Callaghy (2002) discusses in details the background to the emergence of the HIPC initiative. The causal hypothesis is that excessive debt is an obstacle to the growth and the development of HIPC countries for various reasons. These include the debt overhang hypothesis (whereby investors reduce investment because they perceive high debt as higher future taxes), crowding-out of public expenditure on health and education as well as country's infrastructure which further reduces investment. High debt situation also create much uncertainty surrounding debtor government's policies and their impact on the economy. For more details on how debt affects growth see chapter 2, sections 2.2 and 2.3.

The initiative shifts multilaterals' view of debt crisis being illiquidity to insolvency problem and thus requiring debt write-downs instead of short cash flows as a solution to the

[3] The original HIPC was proposed as a result of pressure from nongovernmental organisations and civil society around the world such as the Jubilee Debt Campaign.

crisis. HIPC is the first initiative that includes the write-down of debt of the Fund-Bank (the preferred creditors). HIPC was also the first attempt to analysis the total debt and have joint negotiation between the debtor and all its creditors.

However, by 1999 it came clear that HIPC was not achieving its goal of providing a "lasting exit" from unsustainable debt burdens. Hence the Enhanced HIPC (EHIPC) initiative emerged in 1999 to provide "deeper, broader and faster" debt reduction. The key innovation of the initiative was the notion of debt sustainability and poverty reduction. For the first time in nearly two decades of debt crisis, a link was created between debt relief and poverty reduction in EHIPC which took the form of spending the debt relief on social services. Under the EHIPC, the original focus of the initiative (eliminating debt overhang) was broadened to provide a permanent exit from debt crisis by encouraging growth and freeing up resources for public expenditure. The support of donor community for the initiative depended critically on its design to ensure that the debt relief is spent on social services.

Eligibility for the HIPC Initiative

To qualify for the HIPC initiative a debtor country has to satisfy three conditions:

1. be eligible for highly concessional assistance from the World Bank's International Development Association (IDA) and the IMF's Poverty Reduction and Growth Facility (PRGF);
2. have established a three year track record of macroeconomic stability, have prepared a Poverty Reduction Strategy Paper (PRSP) and have debt burden indicators above the HIPC initiative threshold using the most recent data. Once a country has done all these it reaches the "decision point".
3. face an unsustainable debt level after the traditional debt relief measures have been fully used. Traditional measures refer to the relief provided by the Paris Club[4] and other creditors.

Based on these criteria 42 countries qualify for debt relief under the initiative four (Kenya, Yemen, Angola and Vietman) of which are considered already sustainable and are unlikely to receive any debt relief. The Fund-Bank have adjusted the list of countries due to political pressure from creditor countries although the initiative is supposed to be

[4] An informal group of financial officials of 19 developed countries founded in 1956 to help manage the debt of indebted DCs. Since the HIPC initiative, the Club is increasingly concerned with HIPC countries only.

transparent. Nigeria, for example, was originally amongst the HIPC but in 1998 it was removed from the list without any explanation despite having similar debt-to-export and -income ratios to other HIPC countries. As of April 2009, 24 countries had reached the completion point, 11 had reached the decision point and 5 were assessed to be heavily indebted under the HIPC initiative and wished to receive debt relief under the initiative, so were the pre-decision countries. Table A1 in the appendix shows the list of completion, decision and pre-decision countries.

Debt Sustainability Analysis Under the HIPC Initiative

Countries are eligible for relief if a debt sustainability analysis showed that their debt would remain above specified threshold levels (see Table 1.1) for the foreseeable future even after full application of traditional debt relief mechanisms. These thresholds were tied primarily to expected export earnings and in some cases, to fiscal revenue.

TABLE 1.1
Debt Sustainability Targets under the Original & Enhanced HIPC Initiative

Criterion	Original	Enhanced
NPV of debt-to-export	200-250	150
Countries qualifying under fiscal route		
NPV of debt-to-government revenue	280	250
Export-to-GDP	40	30
Revenue-to-GDP	20	15
Assessment of debt relief	completion point	decision point

Author's compilation using information from Andrews, Boote, Rizavi and Singh (1999)

Under the original 1996 HIPC scheme the Fund-Bank set a debt-to-export ratio of 200-250% as unsustainable and argued that there is absolutely no analytical justification for reducing this threshold. However, later when it did reform the initiative in 1999 and reduced the ratio to 150% it claimed that this was "cushion effect" in case the country's export earning fell after it had received debt relief. No justification whatsoever is provided for the ad hoc sustainability threshold set under the enhanced HIPC initiative of 150% of export. See chapter 3 section 3.2.1 for further details regarding the debt sustainability analysis.

Working of the HIPC Initiative

The initiative involves two stages. During the first three-year stage the HIPC country works with the Fund-Bank to establish a record of economic reforms and poverty reduction strategies. In particular its government has to develop a comprehensive PRSP with the Fund-

Bank. After successfully implementing economic reforms and developing PRSP the Fund-Bank decides independently, without any involvement of a third party, if the country has reached the decision point.

Upon reaching the decision point, a debt sustainability analysis is undertaken to determine whether the country's debt is sustainable or not. If the debt is unsustainable, then a debt relief package is prepared and committed to by creditors. During the decision point and the completion point the country receives some debt relief from the Paris Club and multilateral creditors like the Fund-Bank but the full debt relief committed at the decision point is only delivered once the country has reached its completion point.

To reach the completion point, the country has to establish a further three-year record of economic reforms and poverty reduction plus to complete the implementation of PRSP for at least one year.

Multilateral Debt Relief Initiative

In 2006, following the G8 Gleneagels summit of 2005 the HIPC initiative was supplemented by the MDRI to accelerate progress towards the United Nations Millennium Development Goals (MDGs)[5]. The MDRI allows for 100% relief of eligible debt by the IMF, International Development Association (IDA) of the World Bank and the African Development Fund (AfDF) for countries completing the HIPC initiative process. IMF also provides debt relief to non-HIPC countries that have IMF debt and per capita income of less than US$380. In 2007, the Inter-American Development Bank also decided to provide debt relief to the 5 HIPCs in Western Hemisphere.

At present 23 countries that have completed the HIPC have had the promised debt cancelled under the MDRI. Two non-HIPC countries Tajikistan and Cambodia have also had their IMF debt cancelled because their per capita income is below US$380. However, their debt to the IDA still remains and they do not have any African Development Fund (AfDF). In the future 17 more countries could qualify for the assistance under the MDRI, but it could take many years to materialise. According to Pearce et al (2005) many other countries require at least partial cancellation in order to achieve the MDGs and at least 60 low-income countries require total debt cancellation if they are to meet the MDGs.

[5] At the Millennium Summit in 2000 eight MDGs were officially established and agreed by 189 UN member states and more than 23 international organisations in order to prompt development in DCs. The goals to be achieved by 2015 include eradicating extreme poverty and hunger, achieving universal primary education, promoting gender equality and empowering women, reducing child mortality, improving maternal health, combating HIV/AIDS, malaria, and other diseases, ensuring environmental sustainability and developing a global partnership for development

1.2.5 Public Pressure for the Debt Cancellation

The Jubilee Debt Campaign (JDC) is a coalition of more than 80 national organisation members, local and regional groups calling for 100% cancellation of unpayable and unfair third world debt. It originated to co-ordinate the lobbying of numerous individuals and organisations arguing for debt cancellation since the early 1980s as a Debt Crisis Network (DCN). In the mid 1990s, DCN raised the profile of the third world debt via a series of activities such as organising African leaders' tour of Britain, colluding with a large number of aid agencies, trade unions, churches and campaigning groups that led to an international movement in more than 40 countries, known as Jubilee 2000 campaign, calling for the cancellation of unpayable and illegitimate debt by 2000.

Responding to this pressure, the Fund-Bank launched the HIPC initiative to reduce the debt to sustainable levels for qualifying countries. However, the efforts by DCN and other organisations continued and in 1997 DCN became Jubilee 2000 Coalition with a wider base of membership. In 1998 at the G8 Summit in Birmingham, Jubilee 2000 campaigned with 70,000 people putting the debt cancellation at the top of the international leaders' agenda. The protests by JDC continued at the yearly G8 Summits. In June 1999 the G8 leaders committed to cancelling a total of $100bn of HIPC debt with a further increase of $10bn in December the same year under the pledge of 100% cancellation by bilateral creditors. Nonetheless $55bn of this amount had already been committed under the Paris Club and original HIPC schemes. In September 2002, a further $1bn was agreed to provide "topping up" for countries affected by worsening of commodity prices and thus lower than estimated export earnings at completion point.

At the end of year 2000 the Jubilee movement split, as intended, into UK's JDC, Jubilee Research, Jubilee USA and a network of national organisations under Jubilee Movement International. Currently the JDC is campaigning on a number of issues including "lift the lid", "stop the debt vultures", "end harmful conditions" and "break the chain of debt – set Haiiti and Liberia free". The campaign "lift the lid" is calling for an investigation and cancellation of debts which are the result of self-interested or irresponsible lending by developed world. "Stop the debt vulture campaign aims to prevent private companies from profiting 'bad' debt buy-backs at discounted price and then recovering the full amount by suing through the courts. The campaign focuses on Zambia. The "end harmful conditions" campaign seeks to pressurize the fund-bank to end the damaging and undemocratic conditions attached to loans and debt relief. The campaign on setting "Haiti and Liberia free" urges the UK government to break the chain of debt shackling Haiti and Liberia.

There are numerous other organisations and groups either working independently or with JDC on debt cancellation. The World Development Movement (WDM) founded in 1970 is another democratic movement of individual supporters, campaigners and local groups across the UK. It works with other organisations, such as JDC, to challenge the decisions/polices of powerful multinational companies/institutions and world leaders that hurt the world’s poor. It researches and develops alternative policies that support sustainable development. One area WDM has been campaigning on for the last two decades is the third world debt.

The group “50 Years is Enough: US Network for Global Economic Justice” is another coalition dedicated to transform the Fund-Bank. The Network works with some 200 international organisations in more than 63 countries to change the international financial institutions’ polices and practices to promote a democratic and accountable development process throughout the world. It was founded on the 50th anniversary of the Fund-Bank in 1994. Amongst other issues, the Network is calling for 100% debt cancellation without any conditions, the end of structural adjustments imposed through PRSPs or any other strategy, reparations for structural adjustments, and so on.

Despite all this effort, very little has been achieved in terms of actual debt cancellation and real benefit to the poor debtor nations. In fact it is difficult to evaluate how much relief has actually been granted as the Fund-Bank’s publicised figures about the debt relief delivered do not reflect the actual amount of relief provided. This is because their calculations include all debt committed to beyond the decision point which is only delivered at completion point. Their figures are overstated particularly since most countries are facing delays reaching completion point and nearly 1/3 of the countries between decision and completion point have had their interim cancellation suspended.

Hence it is not surprising that the debt of poor countries is rising despite the debt relief efforts of international communities. In many cases, the debt relief is less than the new borrowing by the county. From 1989 to 1997 total debt relief to 41 HIPCs amounted to US$33bn whilst the new borrowing by these countries totalled US$41bn. One explanation for this is that some governments like to have a certain level of debt so that any debt relief is simply replaced by further loans hence the debt-to-GDP ratio is unchanged (Easterly 2001). Using regression analysis, Easterly finds a significant relationship between debt relief and new borrowing. He concludes, “one percent point of GDP higher debt forgiveness translates into 0.34 percent of GDP new borrowing” (Easterly 2001 p16).

1.3 SCOPE OF THE THESIS

This section elaborates on the overview of the thesis presented in 1.2 by discussing in more details the precise objectives of the thesis in subsection 1.4.1 and describing the methodologies adopted in each of the three empirical chapters in subsection 1.4.2. The next subsection highlights the main contributions of the thesis to the existing literature in the debt-growth field. Finally the contents and the structure of the thesis are presented in sub-section 1.4.4.

1.3.1 OBJECTIVES OF THE THESIS

As the above discussion shows that in August 1982, the debt crisis burst onto the international agenda when Mexico defaulted on its foreign debt. Other parts of the developing world followed shortly, in particular SSA, LAC and parts of Asia. Since then a growing body of literature has emerged concerning the causes and the consequences of the crisis, policy measures and their effect on economic performance and so on. However, there remains a weak understanding of the interaction between debt and growth that is vital to formulating and implementing appropriate policies in order for a country to grow and prosper. The main objective of the thesis is to improve our understanding of the debt-growth relationship so that more appropriate policies can be designed and implemented to solve the debt crisis problem of DCs and to avoid any future crisis occurring.

In the existing literature on the debt-growth relationship there are three views, one stating that the relationship is linear and positive (Ramsey, 1928; Barro and Sala-i-Martin, 2003; Eaton, 1993; Uzawa, 1965; Lucas, 1988 amongst others), the second contending that the relationship is linear but negative (Krugman, 1988; Sachs, 1989; Corden, 1988; amongst others) and the final combining both of these two ideas and claiming that the relationship is nonlinear (Cohen and Sachs, 1986; Cohen, 1995; and others). The positive debt-growth models like the traditional neo-classical model argue that external borrowing increases debtor country's resources and closes the investment-savings gap and hence it increases the growth rate. This was a popular view held by many politicians, economisst, debtors and creditors especially since at the early stage of borrowing, during the 1970s, many DCs did experience higher growth whilst borrowing internationally. However, after the early 1980s when many of these countries started to face difficulty in servicing the debt, many academics and policymakers changed their view arguing that large debt hinders growth. Nowadays, a growing body of literature is claiming that the debt-growth relationship is nonlinear. (Section 2.2 of chapter 2 reviews the theoretical and the empirical literature related to the debt-growth relationship). Based on this increasing body of literature claming nonlinearity of the debt-growth relationship, there is a general consensus that debt is harming heavily indebted DCs and thus should be cancelled. In response to this a number of civil groups and non-governmental organisations have materialized pressurising the creditors to forgive the TWD (see subsection 1.3.5).

The latest effort to provide permanent exit from heavy debt burden is the HIPC scheme originated in 1996 and enhanced in 1999. The initiative uses thresholds to assess the Debt sustainability (DS) in order to determine whether a country qualifies for a debt relief and if so, by how much. However, these thresholds indicators are heavily criticised since they aren't based on any sound argument let alone economic theory/methodology. The thresholds are nothing more than random numbers reflecting only the common sense of the Fund-Bank (Hjertholm 2000). Indeed the very definition of debt sustainability is flawed according to Jubilee (2007) report. Therefore, the *first* objective of the thesis is to fill this gap by exploring the nature of the growth-debt relationship. More specifically, to investigate whether the relationship is linear or nonlinear and then find the threshold(s) at which debt becomes growth-deterrent. The main contribution of the first empirical chapter is the use of the *endogenous threshold model* proposed by Hansen (1996, 2000) to find the threshold level of debt below which debt-growth relationship is positive but above it the relationship becomes negative.

Although the threshold model determines the threshold level of debt endogenously and captures the various channels through which debt effects growth, it is not intertemporal and considers debt levels across countries at only a single point in time. As explained in 1.2 economic theory suggests that countries can have high debt as long as they can repay in the future. Hence the Intertemporal Budget Constraint (IBC) of a country should be considered to assess its DS rather than the threshold approach. Under the IBC approach a country's debt is sustainable as long as the No Ponzi Game (NPG) condition is satisfied. In empirical terms this implies that debt is sustainable if there is a long-run equilibrium relationship between debt and output known as cointegrating relationship in the time series literature. Thus the *second* objective of the thesis is to investigate the intertemporal sustainability of DCs' debt using various time series techniques that examine the long-run relationship between debt and GDP.

Even though the time series methodologies used in chapter 3 provide more insight into the DS of a country as they consider a country position in the long-run, they fail to capture the continuum nature of DS and simply classify each country into a dichotomy of sustainable or unsustainable. In reality a country's debt can range from zero to very high, changing by one cent. Thus a simple classification of a country into sustainable or unsustainable group is not very useful in reality. In the real world investors and policymakers for example would be more interested in knowing how vulnerable a country is to the crisis in order to make appropriate decisions. Furthermore, a country vey close to unsustainable debt is most likely to be classified as having unsustainable debt level by the techniques used in chapter 3, whereas the correct policies differ for the two groups widely. It is very important to know the exact debt position of a country in order to design and implement appropriate policies. If for example, a country is close to unsustainable debt the appropriate policy would be to eliminate any further borrowing, but if a country has unsustainable debt then the appropriate measure would be to reduce the debt by debt write-downs. Hence, the *third* objective is to employ an alternative methodology that can accommodate the continuum nature of debt in the DS analysis. This alternative measure (Debt sustainability Indicator, DSI) shows the extent to which a country's debt is sustainable or the degree to which a country is vulnerable to debt crisis.

The *final* aim of the study is to examine the factors that have permanent effects on the debt-to-GDP ratio but are still consistent with sustainable debt. In particular, it aims to quantify empirically the contribution of the non-oil exporting commodity prices, the oil price and the interest rate shocks to the sustainability of the TWD.

More formally, the specific research objectives can be listed as follows:

1. explore the existing literature on the debt-growth relationship,
2. investigate the nature of the debt-growth relationship,
3. identify the threshold at which debt becomes detrimental to growth using endogenous threshold model,
4. explore alternative approaches that exist in the current literature on the sustainability of debt,
5. assess the debt sustainability of DCs using newly proposed time series techniques, such as integration and co-integration,
6. propose a more practical measure of the debt sustainability that reflects the continuum nature of debt variables and hence views debt sustainability as an index,
7. identify the factors that have permanent effect on debt and output but are still consistent with sustainable debt level,
8. estimate the contribution of three shocks including the export non-oil commodity prices, oil price and interest rate shocks to the sustainability of the TWD.

1.3.2 An Overview of the Methodology

The overall methodology adopted for the thesis can be summarised as follows. In each of the three substantive chapters (2 to 4), an empirical model is developed using economic theory. For chapter 2 on the threshold effects in the debt-growth relationship, for example, the neo-classical growth model is utilised to develop the empirical framework for testing the non-linearity of the relationship. Then a number of different model specifications are used to estimate the debt threshold and test its significance.

For the subsequent two chapters on the DS analysis, the IBC is used to derive some empirically testable restrictions. These are then tested using a number of time series econometric techniques to ensure the robustness of the results.

One of the key contributions of the thesis is the use of new methodologies to a comprehensive set of data for DCs from 1969 to 2000. For each of three substantive chapters a recently developed empirical methodology is utilised. For the first substantive chapter on the threshold effects in the debt-growth relationship, the Hansen (1996) threshold model is employed alongside traditional approaches. It allows researchers to endogenously determine and test the significance of multiple thresholds whilst providing the estimates of the other coefficients in the model. Moreover it is a more flexible approach than the traditional methods for estimating nonlinear models as it does not impose a pre-determined threshold (like the dummy and spline models) nor does it impose a specific functional form (like the quadratic model). The detailed description of various approaches used, including the Hansen's threshold model are provided in chapter 2 subsection 2.3.2.

The next two chapters on the intertemporal DS use numerous time series techniques in panel data settings to investigate the DS implied by the IBC for DCs. Previously in the literature only the univariate time series methods, which have less power than the panel methods, have been used mostly for developed countries. Chapter 3 employs the multivariate cointegration tests of Johansen (1995) and the panel version of Johansen's tests proposed by Larsson, Lyhagen and Lothgren (2001). In order to test the restrictions imposed by economic theory on the cointegrating vector, the Johansen's framework is used and is further developed for panel settings.

Chapter 4 utilises univariate persistence measures proposed by Campbell and Mankiw (1987a, 1987b) and multi-country measures suggested by Pesaran et al (1993) to estimate the DSI for LAC and SSA countries. Please note that only a sub-sample of the 56 countries examined in the pervious two chapters are analysed in chapter 4. This was necessary because in order to estimate the DSI, (persistence of shock to debt-to-GDP ratio) one has to estimate a VAR consisting of one equation for each country in the group/sample and each equation containing x number of lags for all the countries. Hence, with 56 countries and only 2 lags each equation would have 112 parameters, and the full VAR would have 6272 parameters. Therefore, countries were split into two groups: LAC and SSA each consisting of the 10 largest countries (by population) from each area.

Furthermore, the decomposition techniques advocated by Lee et al (1992) are used to examine the effect of specific shocks, such as interest rate, to the debt positions of LAC and SSA countries. Such analysis not only shed light on the importance of these shocks to the DS of a country but also show if such shocks are consistent with sustainable level of debt whilst having permanent effect.

A detailed discussion of the persistence measures is provided in chapter 4 section 4.2.1 and the actual model(s) used is given in section 4.2.3.

1.3.3 CONTRIBUTIONS OF THE STUDY

This study attempts to make a number of contributions to the existing literature on the TWD topic. The study uses an extensive set of data ranging from 1969 to 2000 for 56 DCs. Further contributions can be divided into three main areas incorporating the nature of debt-growth relationship, various approaches to examining DS and factors that can causes a permanent shock to debt ratio but are still consistent with sustainable debt.

It contributes to the literature on the *debt-growth* relationship in two respects: *firstly* by formulating an empirical debt-growth model for investigating the nature of the relationship. *Secondly* by using a number of methodologies to determine the “optimal” and “sustainable” levels of debt, including the endogenous threshold models of Hansen (1996) which allows for multiple thresholds.

The study contributes to the literature on the *debt sustainability* analysis in five ways: *firstly,* by extending the use of intertemporal DS framework to the DCs’ foreign debt. Initially this literature focused on the government’s domestic debt. The work was extended to the analysis of foreign debt but the application remained confined to the developed countries only. Cuddington (1996) presents a survey of literature on the DS analysis and extends the framework to DCs but the extension is limited to fiscal deficit with very little empirical analysis. DCs’ DS is assessed rather informally not just academically but also in practice by the Fund-Bank as explained above. *Secondly,* by assessing the DS using univariate and multi-country unit root and cointegration methods. *Thirdly,* by developing panel version of Johansen’s identifying and overidentifying restriction tests using Fisher’s chi-square statistics. *Fourthly*, by introducing a Debt Sustainability Index which measures the degree of a country’s vulnerability to debt crisis rather than simply testing if a country’s debt is sustainable or not. *Lastly*, by measuring the Sustainability Index using univariate and multi-country persistence techniques proposed by Pesaran et al (1993).

The thesis contributes thirdly to the literature on the factors that have permanent effect on debt ratio but do not violate the DS of a country, in particular it makes two inputs: *firstly*, it identifies certain shocks that may have permanent effect on debt but do not cause the debt levels to become unsustainable. *Secondly*, it uses multi-country shock decomposition techniques proposed by Lee et al (1992) to estimate the contribution of interest rate, commodity price and oil price shocks to the 1980s debt level.

1.3.4 CONTENTS AND STRUCTURE OF THE THESIS

The thesis is organised into 5 chapters which progress in accordance with the identified objectives. It proceeds with this first introductory chapter which describes the context and the scope of the research as well as discussing the key objectives and the contributions of the study. Furthermore this chapter presents the motivation for the chosen topic – the TWD and gives an overview of the methodologies employed in the study. The remainder of the thesis is structured as follows:

Chapter 2 investigates empirically the issue arising from the 1980's debt crisis that too much debt is detrimental for growth whilst low or moderate level of debt is positive for growth. Since the crisis ,a growing body of literature emerged stating that there is a nonlinear relationship between debt and growth. Researchers such as Cohen and Sachs (1986), Sachs (1986), Krugman (1988), Cohen (1990) and Calvo (1998) amongst others argue that there is a certain level of debt that stimulates growth but after this critical or optimal level the effect becomes negative. The actual experience of DCs is consistent with this view. During the 1960s and the 1970s debt became a significant part of DCs' international capital flow and during these decades these countries had positive growth rate. But in the early 1980s debt became relatively large and countries started to have difficulties servicing their debt stocks. Since then the growth of these countries has been rather small or negative whilst their relatively high debt has been growing.

The key objective of the paper is to determine the threshold level of debt below which debt-growth relationship is positive but above it, the relationship is negative. It employs numerous methodologies including linear (dummy) model, quadratic model, spline specification and an endogenous threshold model proposed by Hansen (1996, 2000) in order to estimate the threshold and make comparison between the results from different models.

The chapter is divided into 6 sections. Section 2.1 gives an introduction while 2.2 reviews the literature on the debt-growth relationship. A description of the model and the econometric methodologies employed are given in section 2.3. The subsequently section, 2.4 describes the dataset and carries out some preliminary analysis. The key findings of the paper are presented in section 2.5 and concluding remarks are given in section 2.6.

Chapter 3 tests whether the external debt of DCs is sustainable or not using intertemporal sustainability concept. According to the IBC a country's debt is sustainable as long as its debt stock equals the trade balance surpluses. The intertemporal sustainability criterion has empirical implications in terms of the time series properties of debt and GDP that can be tested to assess the DS of a country. More specially, it implies that debt is sustainable as long as debt and GDP do not drift too far apart, i.e. they have an equilibrium long-run relationship. Thus, the main empirical analyses pursued in this paper involve testing for the long-run relationship between debt stock and GDP using panel data techniques.

This chapter is organised into 6 sections. Section 3.1 provides an introduction. Section 3.2 discusses the theoretical criteria for the DS. Section 3.3 presents the hypotheses and describes the techniques used to test the DS. Section 3.4 describes the data with some initial examinations. The main empirical results are presented and discussed in section 3.5 and the conclusion is given in 3.6.

Chapter 4 introduces a new methodology for assessing the DS that can accommodate the continuum nature of debt. The proposed measure called the "DSI" shows the vulnerability of a country to the debt crisis, i.e. it represents *how* sustainable the debt level of a country is? Furthermore, the chapter investigates the relative contribution of three shocks which are generally attributed to the debt crisis using shock decomposition techniques in a multi-country framework suggested by Lee et al (1992)

This chapter is organised into 6 sections. Section 4.1 provides an introduction and section 4.2 introduces the DSI. The subsequent section 4.3 looks at the occurrence of the debt crisis from an historical perspective. The empirical analyses of the DSI are presented in section 4.4 while the decomposition of the estimates of the DSI due to identified and unidentified factors is given in section 4.5. Section 4.6 concludes the paper.

Chapter 5 concludes the thesis and provides an overview of the key findings. It discusses the potential policy implications the results of this study have and makes appropriate policy recommendation in light of these results. Finally it suggests further research on the TWD topic.

2 THRESHOLD EFFECTS IN THE DEBT-GROWTH RELATIONSHIP

2.1 INTRODUCTION

Since the debt crisis of DCs in 1982, literature on the debt-growth relationship has pointed out a nonlinear impact of debt on growth. It suggests that in the early stage of borrowing when debt level is modest debt enhances growth, while in the later stage of borrowing when debt is at a high level debt becomes detrimental to growth. The former view is theoretically supported by neoclassical growth models, which encourage capital scarce countries to borrow in order to increase their capital accumulation and steady state level of output per capita. Many debtors and creditors prior to the 1982 debt crisis adopted this concept. However, after the crisis, this view changed giving rise to various models postulating a negative relationship between debt and growth. The leading of these is, perhaps, the Debt Overhang Hypothesis (DOH) suggested by Krugman (1988) and Sachs (1989). DOH implies that there is a *debt Laffer curve* such that low level of debt enhances growth but as debt becomes high, it deters growth. According to the DOH a debt overhang situation arises when investors become reluctant to undertake further investments because they associate these high debt levels with excessive future taxes on their investments due to high debt-service payment which is financed by higher future taxes. Similarly governments don't make the necessary adjustments to create investment inducive environment. Although the hypothesis does not explicitly analyse growth, the implication is that lower investment due to debt overhang and unfavourable investment environment (greater uncertainty combined with poor macroeconomic polices) leads to slower or even negative growth in debtor countries.

Cohen and Sachs (1986) and Cohen (1995) developed a nonlinear endogenous growth style model where growth is driven solely by capital accumulation. The model suggests that in the early stage, growth is boosted by foreign debt because it increases country's capital accumulation. However, as debt increases the marginal impact on capital accumulation and growth becomes smaller and debt starts to have negative effect on investment and growth once the debt has reached the critical level. The authors define this critical debt level to be such that any further increase in debt will promote the debtor country to default because the cost of default will be less than the direct cost of servicing the debt at this high debt level. They assume that the costs of default are financial autarky and loss in productivity following Eaton and Gersovitz (1981). Semmler and Sieveking (2000) also develop a nonlinear model whereby they state that the threshold level of debt is such that when debt is above this threshold, debt tends to infinity but when debt is below this threshold, debt approaches zero.

The nonlinear impact of debt on growth is supported by the practical experience of heavily indebted DCs. External borrowing was originally intended to finance domestic investment opportunities (as well as to smooth Terms of Trade (TOT) shocks) but poor policies, self-interested leadership and external shocks meant that the investment, if it actually took place, contributed little to growth. It is claimed that poor countries became so heavily indebted not because of their large primary deficits, in fact they had a primary surplus over 1975-1994, but because of their low growth rates during this period. For example HIPCs had a growth rate of 1.8% from 1975 to 1994 while non-HIPCs had a growth rate of 4.4% almost twice the growth rate of industrial countries (2.4%). Whilst the debt ratios of HIPCs almost doubled from 48% to 94%, the debt ratios of non-HIPCs increased by only 13% (Easterly 2001).

Given the above theoretical arguments and the practical experience of highly indebted DCs a consensus has emerged that the debt-growth relationship is nonmonotonic, i.e. there is a "critical" debt level below which the relationship is positive but above which the relationship becomes negative, i.e. there is a *Debt Laffer Curve*. Although, a nonlinear debt-growth relationship is generally accepted theoretically and in policy, it is not explored well empirically. In policy, the International Monetary Fund and the World Bank (henceforth the Fund-Bank) use certain debt ratios (thresholds) as unsustainable in the sense that debt above these thresholds becomes harmful to growth because of the DOH, and/or crowding out hypothesis. However, there is no sound reasoning provided by the Fund-Bank as to why these thresholds are selected (Hjertholm 2000). Academically most researchers have included a "high" and "low" debt dummy variable or considered a quadratic specification to capture the nonlinearity of debt in output growth equations (Elbadawi et al 1997 and Pattillo et al 2001, 2004 amongst others). Further, a number of researchers have calculated the growth maximising debt ratios using quadratic debt terms in growth regression. These ratios are equal to or smaller than the ones used under the HIPCs initiative (debt-to-GDP ratio of 50%) by the Fund-Bank. Smyth and Hsing (1995) estimated the growth maximising debt ratio to be 38.4 % while Jones (1991) reported it to be 40% and Eisner (1992) 47.1%. All of these estimates are less than the threshold debt ratio used by the Fund-Bank ratio for conducting the debt sustainability analysis of HIPCs in order to design a debt relief package. The actual debt-to-GDP ratio for most severely indebted nations is as much as over 20 times the Fund-Bank unsustainable threshold ratio.

Although, these studies provide a useful starting point to address an important question of what level of debt is good for a country's growth rate, and when it becomes detrimental to the growth and development of a debtor, they all lack a sound methodology of determining the threshold(s). No one, to our knowledge, has studied the threshold level of debt systematically determining the optimal level (or range) of debt endogenously. This study aims to fill this gap in the literature by using Hansen's (1996, 2000) endogenous threshold model alongside the more familiar methods including "high" and "low" dummy interaction model, a growth model quadratic in debt and a spline specification. Given the poor quality of data for DCs, three different estimators are used including OLS with robust standard errors, robust-weighted and quantile estimators. This would ensure the robustness of the results and check on their vulnerability to different estimators.

The empirical findings of the chapter can be summarised as follows. The dummy interaction model indicates that the debt-growth relationship is linear while the linear spline specification suggests that it is nonlinear. The quadratic specification implies that the relationship is inverted u-shaped relationship where debt starts to have negative impact on growth when debt-to-GDP ratio is as low as 9% for some estimators and as high as 46% for other estimators. This may be due to the fact that a rather restrictive functional form is imposed and only one threshold is allowed whereas in reality, there might be multiple thresholds as suggested by piece-wise linear functional form. Indeed the preferred threshold model of Hansen's which not only determines the threshold endogenously but also allows a more flexible functional form (i.e. multiple thresholds) shows that there are *two* thresholds both of which are significant. The first threshold occurs at 45% of debt-to-GDP ratio for the Fixed Effects (FE) model and at 53% for pooled regression. These are in line with the estimates of Pattillo et al (2001), Cohen (1997), Clements et al (2003), and Imbs and Ranciere (2005) but half the value suggested by Elbadawi et al (1997), 3 to 4 time the estimates of Reinhart et al (2003) and twice the estimates of Cordella et al (2005) all of which are obtained through simpler models like quadratic specification.

The chapter proceeds with this introduction to section 2.2, which reviews in more details the theoretical and the empirical literature on the debt-growth relationship. Section 2.3 presents the model and describes the econometric methodologies employed, while section 2.4 describes the data and carries out some preliminary data analyses. The key findings of the chapter are presented and discussed in section 2.5. Section 2.6 concludes the chapter pointing out any policy implications the results have.

2.2 WHAT THE LITERATURE STATES ABOUT THE DEBT-GROWTH RELATIONSHIP

This section discusses some of the theoretical studies postulating the debt-growth relationship and then reviews the empirical work on the subject.

2.2.1 THEORETICAL REVIEW OF THE DEBT-GROWTH RELATIONSHIP

The theoretical models exploring the debt-growth relationship can be grouped into three types. The first types of models claim that a reasonable level of debt stimulates growth; the second imply that a very large debt stock has detrimental effect on growth and the final type combine these two ideas stating that there is a nonlinear relationship between debt and growth (i.e. at earlier stage of borrowing the country experiences positive growth and once the debt level reaches a critical point the debt effect becomes negative). The reminder of this sub-section discusses each of the three types of the theoretical models postulating the debt-growth relationship.

Models Postulating a Positive Debt-Growth Relationship

According to numerous theoretical models, reasonable levels of current debt inflows are positively related with growth. In traditional neo-classical models, for example, capital mobility or the country's ability to borrow and lend enhances transitional growth. There is an incentive for capital scarce countries to borrow and invest since the marginal product of capital is greater than the World interest rate. Some endogenous growth models have similar implications. Usually, Ramsey (1928) model is used to study the debt dynamics. Several attempts have been made to modify Ramsey model by allowing international borrowing and lending. Barro and Sala-i-Martin (2003) and Barro, Mankiw and Sala-i-Martin (1995) propose such models based on rather unrealistic assumption of perfect international capital mobility that leads to some counterfactual empirical implication such as the instantaneous convergence of capital and output to the steady state at an infinite rate. Consequently, efforts have been made to incorporate the more realistic assumption of imperfect international capital market into the model as a country may not be able to borrow freely due to debt repudiation risk (Cohen and Sachs 1986 and Barro and Sala-i-Martin 2003). In these models low levels of debt are still associated with high growth.

Eaton (1993) looks at the relationship between debt and growth of two particular models, one by Uzawa (1965) (which is elaborated on by Lucas (1988) and hence is known as Uzawa-Lucas model) and the other by Cohen (1991). He finds that in both of these models growth falls as the cost of foreign capital (interest rate) increases because higher world interest rate makes savings more attractive than current consumption. Also higher world interest rate makes foreign capital more expensive and thus foreign borrowing falls. The ultimate result is a positive relationship between debt and growth.

Recent theoretical studies on debt and growth have been heavily dominated by attempts to extend the Romer (1986), Lucas (1988) and Barro and Sala-i-Martin (2003) methodology in order to incorporate borrowing into the picture of long-term steady state growth. A typical example is Ziesemer (1995) who finds changes in both TOT and foreign debts to affect long-term rates of growth. Forslid (1998) argues that a country will borrow from abroad when the interest rate is below its growth rate. This will raise the welfare of all future generations whilst leaving the welfare of the current generation unaffected. Milbourn (1997) argues that, in the steady state, faster population growth leads to a higher foreign debt per capita. He investigates the relationship between economic growth, population growth, capital accumulation and foreign debt using an open economy neoclassical growth model. He looks at the macroeconomic forces which explain the different experiences of a number of countries that had large debt stocks in the 1980s. During the 1980s many developing countries fell into a debt trap due to a combination of various factors, e.g. higher World interest rates, lower commodity (export) prices. However, some countries such as Indonesia and Korea, which were in similar circumstances as heavily indebted countries, did not fall into a debt trap; and Turkey which initially did, recovered unlike these nations. Other economies including New Zealand, Finland, Australia, Sweden, Canada and Spain also accumulated debt rapidly during the 1980s, and yet did not face the same problems as the HIPCs. Milbourn explains these differences by arguing that when the rate of growth falls below the real interest rate less the marginal propensity to consume out of wealth, the country enters a debt trap. The chapter concludes that only interest rate changes have the potential to cause debt spirals whilst an increase in the rate of population growth does increase foreign debt per head, it does not affect output per head or capital per head.

Models Postulating a Negative Debt-Growth Relationship

After the 1982 debt crisis, the experience of heavily indebted DCs changed the above view of both academics and policymakers regarding the debt-growth relationship. As an attempt to explain how and why large accumulated debt stocks led to lower growth of indebted DCs several models including the DOH by Krugman (1988) and Sachs (1989), and enhanced DOH by Corden (1988) amongst others have been proposed. Krugman and Sachs argue that if there is some likelihood that debt-service will exceed debtor's repayment ability in the future then the expected debt-service becomes an increasing function of the debtor's output level, i.e. the higher the GDP the higher the debt-service payment. Therefore, private agents, including investors, will perceive a very high debt level as a future tax on their returns to capital, which reduces the incentives for investment. Although, the model does not explicitly analyse growth, the implication is that a large stock of debt would reduce growth via lowered investment. As it is explained above that in the neo-classical growth model the driving force of growth is capital and lower investment leads to lower level of capital which in turn results in slower or negative growth.

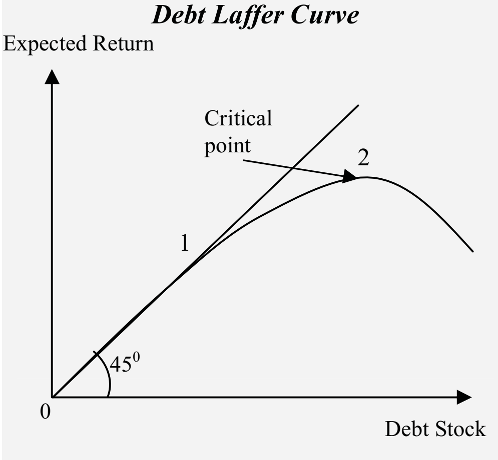
Corden (1989) argues that debt overhang not only reduces incentives for investment but discourages any action requiring upfront cost because parts of the proceeds will be taxed away by creditors. Correspondingly, the government will have less incentive to undertake difficult but necessary reforms such as trade liberalisation or fiscal adjustments to encourage investment. Furthermore, future high debt-servicing costs associated with high debt stocks increase the odds of government engaging in inflationary financing, devaluing the currency (due to excess demand for foreign currency created by debt-servicing needs) and/or cutting productive public investment/infrastructure (Agenor and Montiel 1999). Moreover high debt levels not only reduce growth by lowering the volume of investment but also the efficiency of investment, which is likely to be affected by poor macroeconomic policies and highly uncertain environment. This uncertainty in itself discourages investments and hinders growth. Serven (1997) and Dijkstra and Hermes (2001) have studied the impact of uncertainty on growth of indebted DCs. They found that the overall atmosphere contributes to investment projects that are poorly designed and implemented as well as badly allocated lowering the contribution of capital accumulation to growth.

Cohen (1995) opposes the debt overhang argument of Krugman and Sachs stating that a discount observed on the debt alone is not enough to conclude that high debt will act as a tax on the economy reducing investment and growth rate. He asserts that if lenders are more patient than borrowers and thus value the growth of the debtor more than the debtor itself (i.e. *lenders are efficient*) then they encourage investment instead of deterring it despite the discount on the debt. In other words, a high debt situation is likely to crowd-in instead of crowd-out investments as long as lenders are efficient. In such a situation creditors will try to encourage investment and growth by making them contingent on debt rescheduling. In other words, creditors will not force debtors to repay in full but only the market value of the debt stock. If lenders are unable to commit to this optimal rescheduling policy for the entire period of lending, a debt overhang scenario will occur whereby investment and growth will be even lower than what it would have been under debt overhang from the start which Cohen calls the financial autarky level in the later stages.

Models Postulating a Nonlinear Debt-Growth Relationship

A historical assessment reveals that both of the above views are consistent with the actual experience of the highly indebted countries. External borrowing originally had a positive impact on growth but continued borrowing during unfavourable economic conditions led to unsustainable debt levels that contributed negatively to growth. A number of models have been developed combining both of these ideas implying that debt may have a nonlinear effect on growth. There are various reasons to believe that large nominal debt stock may impair debtor's ability to repay and that reducing the debt stock may increase the probability of creditors being repaid. In other words, the size of the debt has an effect on country's repayment ability via three avenues. Firstly large debts stock may act as a high marginal tax rate on a country's efforts to expand because the creditors may gain most of the benefits instead of the debtors. Secondly, debt burden may appear as tax on capital and thus act as a disincentive for new investment. Thirdly, a large debt stock is likely to lead to default in which case the creditor may make bigger losses than if it reduces the debt stock in advance and prevents the default.

FIGURE 2.1:
Debt Laffer Curve



The debt overhang argument of Krugman and Sachs can be further extended to analyse what happens to the market value of debt (i.e. the amount creditors expect to get back) as the nominal stock of debt increases. It turns out that at low levels of debt the expected return which is measured by the secondary market price of debt is 1, but as debt increases its secondary market value falls and there comes a point at which any further *increase* in debt actually *reduces* the market value of debt because the debt rises beyond debtors' repayment ability. At this level, reducing the debt stock can increase creditors expected repayments (Figure 2.1). The horizontal axis measures the (present) value of a country's debt stock and the vertical axis measures the expected present value of its future debt-service, which is, what the creditors expect to get back, in other words it is the secondary market value of debt. At the low level of debt creditors expect to be repaid in full, so the expected value of debt lies along the 45-degree line (point 0 to 1 in Figure 2.1).

Nonetheless, as debt levels increase so does the probability of debtor defaulting. Hence the expected repayments become increasingly less. After a certain ‘critical level’, debt becomes so large that any further increase in debt stock actually reduces its value. As the curve is very similar to Laffer curve in tax analysis, it is called *Debt Laffer Curve*. When debtor is on the ‘wrong’ side (i.e. to the right of critical level) of the Laffer curve, it is in everyone’s interest to reduce the debt stock as doing so will increase the probability of creditors being repaid.

Although the Laffer curve does not explicitly examine growth, one can draw its implications for the growth rate of the debtor’s economy: as long as the debt stock is less than the critical level i.e. it is towards the left or the *good* side of the curve, it stimulates growth as it fills the savings-gap, that is it finances the investment projects for which there is no money available domestically. Up to this level of debt debtor has no problem servicing the debt and hence investors continue to invest without fearing higher future taxes. However, when the debt stock exceeds the critical level, it deters growth as a debt overhang situation arises. This has been investigated empirically by Elbadawi et al (1997), Pattillo et al (2001, 2004), Were (2001) and Claessens (1990) amongst others. See 2.2.2 for more details.

Cohen and Sachs (1986) and Cohen (1995) propose an endogenous growth type model with capital accumulation as the only factor of growth. Due to the debt repudiation risk, the borrowing country has limited access to international financial markets. They argue that the lenders will only lend the amount that will keep the cost of servicing the debt lower the than cost of default, which are assumed to be lost access to international financial markets (financial autarky) and lower productivity following Eaton and Gersovitz (1981). That is the maximum amount available to debtors is constrained to the amount such that the cost of default is always higher than the cost of servicing the debt making default an inferior option to servicing the debt, although it may not be serviced in full when debt becomes very large. The equilibrium lending strategy makes the growth of debt contingent on the growth rate of the debtor country and the equilibrium path of the debtor has two stages. During the first stage of borrowing, the debt constraint is not binding and the debt stock is growing at a faster rate than its GDP. Growth rate is high initially but falls successively as debt rises. In the second stage, the credit constraint becomes binding and the growth rate falls to a lower level where both the debt and the economy are growing at the same rate. Although the growth rate falls in the second stage, the authors stress that it is still higher than the financial autarky level. Cohen (1993) calculates the investment rate in financial autarky condition and compares it to the actual investment rate in the 1980s (when debt crisis emerged). He finds strong evidence for debt overhang hypothesis whereupon investment was crowed out by approximately 1/3.

Cohen and Sachs argue that the critical threshold is such that below it the debtor can service its debt fully but above it, it cannot. Semmler and Sieveking (2000) also argue that as long as debt level is less than the critical level, debtor has no debt-repayment problem, but as debt level exceeds critical threshold, debt reaches beyond debtor's repayment ability and further borrowing and debt rescheduling causes the debt to increase forever. This is consistent with the actual experience of DCs. Since the crisis, the main strategy adopted by the Fund-Bank has been further borrowing and debt rescheduling which is causing the debt to increase forever.

Other researchers arguing a nonlinear relationship between debt and growth of an economy are Forslid (1998) who argues that a country will borrow from abroad when the interest rate is below its growth rate. This will raise the welfare of all future generations whilst leaving the welfare of the current generation unaffected. Brito (2000) also concludes that the effect of government debt on the growth rate of output per capita is nonmonotonic. Debt will enhance the growth rate of output per capita if the growth rate is greater than real interest rate, but it will compress the growth rate of output per capita if the growth rate is less than the real interest rate.

Milbourne (1997) argues that when the rate of growth falls below the real interest rate less the marginal propensity to consume out of wealth, the country enters a debt trap. The chapter concludes that only interest rate changes have the potential to cause debt spirals whilst an increase in the rate of population growth does increase foreign debt per head, it does not affect output per head or capital per head.

Furthermore, Calvo (1998) presents a model where debt and growth are linked to capital flight. His argument is analogous to Krugman (1988) and Sachs (1989) regarding the high debt causing low incentives for investment which results in low growth. Nevertheless, he argues that for the intermediate level of debt the effect on growth is indeterminate giving rise to multiple equilibria. This implies that empirically a nonlinear type of relationship between debt and growth possibly with multiple thresholds should be observed.

2.2.2 EMPIRICAL LITERATURE

The empirical literature assessing the debt-growth link has grown extensively since the debt crisis in the early 1980s. However, majority of these studies use a standard set of domestic, debt, policy and other exogenous explanatory variables in Barro-type growth regressions and determine the threshold level of debt somewhat arbitrarily. Generally researchers find one or more debt variables to be significantly and negatively correlated with investment and/or growth, depending on the focus of the study. Borensztein (1990) for instance, confirms that debt overhang has an adverse effect on private investment in the Phillipines. The effect was strongest when private debt rather than total debt was used as a measure of the debt overhang. More recently Schclarek (2004) and Presbitero (2005) find a negative linear relationship between debt and growth. Schclarek concludes that the main channel through which debt affects growth is the capital accumulation channel. Also he finds that it is public rather than private debt that effects growth negatively.

According to Cohen (1993), however, the level of debt stock is not a sufficient factor to explain the slowdown in investment during the 1980s for DCs. He finds the actual flows of net transfers matter and the actual service of debt to 'crowd out' investment. Were (2001) also finds that although debt-servicing crowds out private investment, it does not have a direct effect on growth using time-series data for Kenya over the period 1970-1995. Mbanga and Sikod (2001) and Degefe (1992) find debt overhang and crowding out effect on private and public investment respectively using data for Cameroon. Some studies, such as Ajayi (1991), Osei (1995) and Mbire and Atingi (1997) used simulation analysis to show the impact of the debt burden on economic growth under different scenarios. Although most studies have found debt overhang effect and crowding out effect, there are few that confirm a favourable effect of external debt on growth. For example, Chowdhurry (1994) finds a favourable impact of debt on growth for Bangladesh, Indonesia and South Korea.

Elbadawi et al (1997) also confirm a debt overhang effect on economic performance using cross-section regression for 99 DCs. They confirm a nonlinear debt-growth relationship with a debt threshold occurring at a debt-to-GDP ratio of 97% using quadratic specification. They indicate that a high debt-service has serious implications for public expenditure - as economic conditions deteriorate governments find themselves with fewer resources and they cut public expenditure to meet external debt obligations once all the other resources have been used up. Thus their results not only confirm debt overhang and crowding out effects but also indicate that the debt burden has led to fiscal distress as manifested by severely compressed budgets.

Pattillo et al (2001, 2004) assess the nonlinear impact of external debt on growth using a large panel dataset for 93 DCs over 1969-98. They find an inverted u-shaped relationship between debt and growth such that the average impact of debt becomes negative at about 160% to 170% of exports and 35% to 54% of GDP. The marginal impact of debt becomes negative at about half these values. For a country with an average indebtedness, doubling the debt ratio would reduce per capita growth by 1% to 0.5% point. They notice that the differential in per capita growth between countries with external debt (in net present values) below 100% of exports and above 300% of exports seem to be in excess of 2% per annum. For countries that are to benefit from debt relief under the HIPC initiative, per capita growth might raise by 1% point. Their results also imply that high debt reduces growth mainly by decreasing the efficiency rather than the volume of investment. Clements et al (2003) also find that debt relief can raise growth of debtors by similar amount. Their findings suggest that debt deters public investment more than the private investment through debt-service instead of debt stock enforcing the crowding out argument. Their debt thresholds are at 50% and 20-25% for nominal and NPV of debt-to-GDP ratios. Cordella et al (2005) find countries face debt overhang when their debt-to-GDP-ratio reaches 15-30% and the marginal effect of debt becomes irrelevant at debt-to-GDP ratio of 70-80%. Imbs and Ranciere (2005) show that high debt hinders growth, particularly when debt-to-GDP ratio reaches 30-35%.

Presbitero (2007) observes debt relief would increase the growth of recipient – a reduction in debt-to-export ratio from 300% to 150% would raise growth by 1% point per annum. Furthermore, cuts in debt-service are more than twice as effective as equal increase in aid. Nonetheless, Depetris and Kraay (2005) find no evidence that debt relief would contribute to increased growth for debtors.

Other papers investigating the debt-growth relationship consider the role of uncertainty created by extensive debt levels for investment and growth. The literature acknowledges how debt may affect growth negatively due to the uncertainty surrounding the debt related issues such as how the debt-servicing obligations will be financed, whether and how much of it will be using countries' own resources and so on. Also the debt rescheduling terms may not be clear - whether there will be any additional lending and/or whether they will be any changes in government polices because of the rescheduling, whether government will participate in currency devaluation. Dijkstra and Hermes (2001) find supportive evidence for the negative impact of uncertainty on economic growth for HIPCs. Based on their results, they conclude that debt relief can contribute to regaining growth by reducing uncertainty with respect to debt servicing. This in turn may increase the effectiveness of government policies and consequently provide the private sector with positive signals about the future profitability of their investment.

2.3 DEBT-GROWTH MODEL & ITS SPECIFICATIONS

This section firstly presents the model used to estimate the debt-growth relationship and then discusses the various specifications that are employed to model the nonlinearity of the debt-growth relationship.

2.3.1 THE DEBT-GROWTH MODEL

Growth is inevitability related to a country's indebtedness. For example, one can think of a country as an individual who has to borrow in the early stage of his life in order to gain the necessary 'know how' i.e. human capital that will enable him to earn his living in the later stage of his life and to repay the debt he incurred in earlier. Like the individual, a country needs resources in order to develop and grow. It may be able to generate some domestically but often it needs to look outside its borders and borrow from the international capital market. History shows that many advanced countries borrowed during their development phase. The four Asian Dragons (Hong Kong, Singapore, South Korea, Taiwan) also known as the Newly Industrialised Countries (NICs) are an example of this borrowing phenomenon. These nations had huge foreign net inflows after the WWII, first in the form of grants which was largely from bilateral official creditors of developed countries and then in the form of foreign direct investment. In the 1970s, the composition of foreign net inflows into these countries was primarily in the form of loans from commercial banks of developed nations to the governments of these countries or at least these loans were publicly guaranteed. Taiwan and South Korea had a foreign debt-to-GDP ratio of around 9% during the 1970s. South Korea's indebtedness arose from $301 million in 1965 to $2.57 billion in 1970s. During this period, the country experienced high growth rate of its output. It is estimated that without this massive influx of foreign credit in the 1960s, Korea's output would have been two-third of what it was in 1971 (Barrett and Chin, 1987).

In contrast, many DCs that had similar patterns of international capital flow have been facing very severe debt servicing problems for nearly three decades. Foreign debt has become a huge barrier to the growth and the development of these nations. During the 1980s many DCs particularly in Latin American and SSA found it difficult to service their foreign debt as their high growth during the 1970s (due to low world interest rates and access to world capital markets) came to a sudden end due to rising world interest rates and worsening of TOT. The massive debt stocks that the DCs had accumulated by the early 1980s led to slower/negative growth of these nations. See the previous section for detailed arguments on why and how a large debt stock acts as a strong disincentive not only to capital investment but also to partake in any activity aimed at enhancing output as a (large) part of the proceeds will be paid to creditors in servicing the debt.

The above discussion leads to the question of how and why debt helped the Asian Dragons whilst it failed in DCs. The answer is a combination of factors including an open political process and export-oriented economic policy. NICs usually benefit from comparatively low labor costs, which translate into lower input prices for suppliers. As a result, it is often easier for producers in NICs to outperform and outproduce factories in developed countries, where the cost of living is higher, and labor unions and other organizations have more power to keep wages high.

The original explanation for why debt is deterring growth in heavily indebted developing countries comes from Krugman (1988) and Sachs (1989) as a DOH. DOH and the associated debt Laffer curve are discussed in section 2.2. Recall that a debt overhang situation arises when a country has accumulated so much debt relative to its income/repayment ability that it cannot fully meet the debt obligations without borrowing further and/or increasing taxes. Since the government has already over borrowed, any further borrowing is unlikely or at least very limited. So, the only viable option the government has is to increase taxes. Therefore, high debt induces investors to cut back on their investments because they perceive a large debt stock as higher future taxes on their investment. The implication is that lower investment results in lower growth of output.

In addition to the debt overhang effect there is also the crowing-out effect for public and publically-guaranteed debt as the debtor government has to spend more of its limited revenues for servicing the debt instead of spending it on public investment/infrastructure, health and education. Crowding-out of direct public investment may reduce private investments, as some public investments are complementary to private investments (Diaz-Alejandro, 1981; Taylor, 1993; Solimano, 1993). Furthermore, there may be lost externalities from certain types of public investment such as physical infrastructure, giving rise to a fall in productivity of investment.

High debt-service will also reduce social spending on education and health which has serious implications for human capital that is an important determinant of long-run growth (Lucas, 1988; Mankiw Romer and Weil, 1992). Moreover, many highly indebted countries frequently divert resources, including foreign aid and other foreign exchange resources, to take care of pressing debt-service obligations, particularly debt owed to the multilateral institutions (The Fund-Bank), which is deemed "nonreschedulable".

The following sub-section presents the model one can draw from the above discussion.

Basic Model Formation

The empirical specification of the debt-growth model is a reduced form growth regression based on the studies by Elbadawi etc al (1997), Pattilo et al (2001, 2004), Hansen (2004) and Imbs and Ranciere (2005). We follow this strand of literature on debt-growth by estimating the conditional correlation between debt and growth in panel growth regressions. However, we depart from the existing literature by paying a significantly more emphasis on the nonlinearity of the debt-growth relationship, in particular the estimation techniques employed to estimate the debt threshold.

The model consists of three types of variables. The first are the standard variables in a growth regression such as population growth $(\Delta \ln(L))$, physical and human capital represented by investment-to-GDP ratio (I/Y) and schooling rate (H). The second set of variables are the policy or controlling variables like the openness (E/Y), real exchange rate $(E(P^*/P))$ and the fiscal position of debtor government represented by budget-deficit-to-GDP ratio (BD/Y). Lastly, the model incorporates debt variables to capture the DOH and the crowding out effects by adding debt-to-GDP ratio (D/Y) and debt-service-to-GDP ratio (DS/Y) respectively. The basic model estimated in this study is of the following form:

$$\begin{aligned}\Delta \ln(y_{it}) = \alpha_i + \beta_1 \Delta \ln(L_{it}) + \beta_2 \Delta \ln(H_{it}) + \beta_3 \ln\left(\frac{I_{it}}{Y_{it}}\right) + \beta_4 \Delta \ln\left(\frac{E_{it}}{Y_{it}}\right) \\ + \beta_5 \Delta \ln\left(\frac{BD_{it}}{Y_{it}}\right) + \beta_6 \Delta \ln\left(R_{it} \frac{P_{it}^*}{P}\right) + \beta_7 \ln\left(\frac{DS_{it}}{Y_{it}}\right) + \ln \beta_8 \left(\frac{D_{it}}{Y_{it}}\right) + \varepsilon_{it}\end{aligned} \quad [2.1]$$

where i and t are country and time index respectively Δ is first differenced operator and *ln* is the natural log. Before explaining the relationship between growth of output and each of the explanatory variables it is worth noting that although, the above model and the specifications used in the literature by the above mentioned studies all contain similar variables on investment, policy and debt, there are some differences. For example, our model differs from Elbadawi et al's model as they use debt-service-to-export rather than debt-service-to-GDP ratio. Also, they use public rather than total investment. Hansen uses FDI-to-GDP ratio with aid and debt variables. These differences enable a test of robustness of the results to different variables in the model.

On the one hand, an increase in the growth rate of population can lead to an increase in the labour force increasing the growth rate of output per capita. On the other hand, higher population means lower capital per capita and lower output per capita, as the total output has to be shared by a greater number of people. Thus, the growth rate of population can have either a positive or a negative effect on the growth rate of output per capita depending upon the productivity of the increased population.

The elasticity of human capital is expected to be positive as greater human capital results in higher growth rate of output because people become better educated and have higher levels of skills and understanding becoming more productive. In other words, since human capital is the 'know how' of the labour force it increases the productivity of each worker. The analyses of the role of human capital go back to Adam Smith (1776/1937) who considered human capital as other types of capital giving returns of the investors. Schultz (1961) has emphasised the role of human capital in economic growth and improving the living standards. Lucas (1988) pointed out the positive externalities associated with human capital and argued that it is essential in determining the rate of per capita GDP growth. The higher the rate of human capital the higher the growth rate of output as work force becomes more efficient. Mankiw, Romer and Weil (1992) also emphasised the importance of human capital for sustained growth rate of output. Historical observation shows that investment in human capital has been one of the major sources of growth in all-modern economies during this century. The empirical literature on economic growth and human capital has found a close correlation between human capital variables and economic growth.

The marginal product of physical capital should be positive because investment-to-GDP ratio causes an increase in growth due to the accelerator principle. The Harrod-Domar model argues that growth rate of output is a function of savings or investment to output ratio. The Solow growth model suggests that higher savings increase the growth rate of GDP temporarily and lead to a higher level of output per capita permanently.

Openness, measured by the total external trade as a ratio of GDP reflects how quickly and easily a country is able to import and adopt foreign technology. An economy with a more open trade policy is expected to have higher imports and quicker adoption of the newly developed ideas and equipments from the rest of the world than an economy with a restrictive trade policy. This is particularly important for DCs, as they are not innovators but imitators of the technologies of developed nations. Thus, the rate at which they can import and implement the new technologies is central to their economic growth rate. However, this is based on the assumption that new technologies will increase the efficiency of output (productivity level), which requires not only an open trade policy but also the provision of necessary skills and trainings to labour force. Gallup et al. (1998) showed that open economies are generally in a better position to import new technologies and new ideas from the rest of the world. They are also more likely to have a greater division of the labour force and production processes consistent with their comparative advantages.

Another important policy variable is the relative competitiveness of a country measured by its real exchange rate (RER). RER is calculated as nominal exchange rate deflated by country's average export price to its import price. Changes in RER affect private consumption decisions, induce the creation and extinction of entire industries and play a key role in adjustments to economic shocks. These changes also affect a country's welfare as a fall in its RER means that it receives less in return for each unit it exports, and an improvement in a country's RER means that it receives more for each unit it exports assuming constant nominal exchange rate. RER also reflects the extent of vulnerability of the economy to external factors and consequently the reliance of the economy on foreign resources for financing.

Fiscal position of the government is another factor influencing the productivity level of a country. Studies such as Fischer (1993) and Easterly and Rebelo (1993) examine the role of the government's fiscal policy in determining the growth rate. They found that large and consist budget deficits are negatively correlated with the economy's growth rate. Thus, a balanced budget should have a positive effect reflecting macroeconomic stability.

The debt-service-to-GDP is expected to have negative effect on the growth rate of output because higher debt-service is likely to crowd-out public investment and social spending given limited government revenues. This crowding-out of public spending on infrastructure, health and education becomes particularly acute once all the other government sources, such as foreign reserves have been used up in servicing the debt. The impact of debt-service on growth rate should be negative and significant if the crowding out effect has a direct effect on the growth rate of GDP per capita.

The effect of debt on the growth rate of output is expected to be such that at low levels of debt, the impact is positive but at high levels of debt, the effect is negative. See the following sections for further details about this issue.

Nonlinearity of the Debt-Growth Relationship

So far, the model has not taken into account the nonlinearity of the debt-growth relationship. That is, it assumes that the debt-growth relationship is linear whereas in the literature there is much argument that the relationship is nonlinear whereby there is a critical level of debt beyond which debt becomes detrimental to growth but below this level debt enhances growth. Section 2.2 presents the formal argument known as the DOH or the debt Laffer curve which shows that there is a limit (critical debt level) at which accumulated debt stimulates investment and growth. The possible empirical implications of this type of model are nonlinear effects of debt on growth. Accordingly, the model attempts to capture the nonlinearity of the debt-growth relationship. In fact, the key aim of this study is to empirically estimate the critical level of debt using a number of different specifications detailed in the following sub-section. Here only a general functional form taking into account the nonlinearity of the debt-growth relationship is expressed below.

$$\begin{aligned}\Delta \ln(y_{it}) = \alpha_i + \beta_1 \Delta \ln(L_{it}) + \beta_2 \Delta \ln(H_{it}) + \beta_3 \ln\left(\frac{I_{it}}{Y_{it}}\right) + \beta_4 \Delta \ln\left(\frac{E_{it}}{Y_{it}}\right) + \beta_5 \Delta \ln\left(\frac{BD_{it}}{Y_{it}}\right) \\ + \beta_6 \Delta \ln\left(R_{it} \frac{P_{it}^*}{P}\right) + \beta_7 \ln\left(\frac{DS_{it}}{Y_{it}}\right) + \ln\left[J\left[\left(\frac{D_{it}}{Y_{it}}\right), \left(\frac{D_{it}}{Y_{it}}\right)^*\right]\right] + \varepsilon_{it}\end{aligned} \qquad [2.2]$$

This is the most general form of the model that is estimated in this study.

2.3.2 MODEL SPECIFICATIONS

Although a nonlinear debt-growth relationship has been widely discussed in the literature, the form of the relationship has not been studied in as much detail. Most researchers include a "high" and "low" debt dummy variable or consider a quadratic specification to capture the nonlinearity of debt in Barro-type growth regressions. No one, to our knowledge, has studied the threshold level of debt systematically determining the optimal level (or range) of debt using an endogenously determining technique, such as Hansen's (1996, 2000), which is exactly what this study attempts to do.

The study considers a number of exogenously and endogenously determined threshold estimation techniques to check the robustness of the results and to compare the results with the findings in the existing literature as well as giving a benchmark against which to compare the results from the preferred technique - Hansen's threshold model. His model is preferred as it is the most flexible technique from a theoretical point of view. In order to explain these specifications the debt-growth model [2.2] is rewritten as:

$$\Delta ln\, y_{it} = \beta' \mathbf{x}_{it} + J\left(d_{it}, \tilde{d}_{it}\right) + \varepsilon_{it} \qquad [2.3]$$

where $\mathbf{x}$ is the vector of all the variables explained above except the actual debt-to-GDP ratio (d) and the optimal or threshold level of debt $(\tilde{d})$ variables. The chapter attempts to determine whether the function $J(.)$ is nonlinear in d using various methods of modelling a nonlinear relationship including 'interaction debt dummy model', 'linear spline model', 'quadratic model' and 'endogenous threshold model', each of which is discuss below.

Interaction Debt Dummy Model

The simplest way to model any nonlinearities in the debt-growth relationship is to create interaction "high" and "low" debt dummy variables and use them in the growth regression. The interaction terms capture the possibility that the debt-to-GDP ratio has a different effect above and below a particular threshold. To create such a variable, define z_{it} as a simple dummy variable for country *i* at time *t*, that takes on a value of 1 if debt is below the threshold and zero otherwise. Two different ways of determining the value of threshold in this model are considered. In the first case the median[6] debt of each country $\overline{d}_i$ is computed and then the average of the $\overline{d}_i s$ across the countries is taken to obtain the threshold level of debt $\widetilde{d}$. If $\overline{d}_i > \widetilde{d}$, then country *i* is classed as a "highly" indebted country, otherwise it is a "low" indebted country. The value of z is as follows:

$$z_{it} = \begin{cases} 1 \text{ if } \overline{d}_i < \widetilde{d} \\ 0 \text{ otherwise} \end{cases}$$

The second threshold measure uses the debt-to-export ratio considered unsustainable by the Fund-Bank. According to the HIPC initiative, a country with a debt-to-export ratio of 150% or greater is "highly" indebted country. Thus, now the threshold debt level is 150% of debt-to-export ratio $\widetilde{d} = 150\%$, which is compared with the actual debt-to-export ratio of each country in each year. Note that debt-to-export ratio is used to classify each country as either a highly indebted or otherwise and then the model is estimated using debt-to-GDP ratio to capture the debt overhang effect.

$$z_{it} = \begin{cases} 1 \text{ if } d_{it} < 150\% \\ 0 \text{ if } dit \geq 150\% \end{cases}$$

Once the value of z is known it is straightforward to create the interaction debt dummy variables. The debt term from equation [2.3] can be expressed as follows:

[6] Median instead of mean average is used due to many outliers that distort the value of mean.

$$
\begin{aligned}
J\left(d_{it}, \widetilde{d}\right) &= \gamma_1 d_{it} I\left(d_{it} \le \widetilde{d}\right) + \gamma_2 d_{it} I\left(d_{it} > \widetilde{d}\right) \\
&= \gamma_1 d_{it} I(z_{it} > 0) + \gamma_2 d_{it} I(z_{it} \le 0) \\
&= \gamma_1 d_{it}^{l} + \gamma_2 d_{it}^{h}
\end{aligned}
\qquad [2.4]
$$

where $I(.)$ is an indicator function, d^{l} is "low" debt-to-GDP ratio while d^{h} is the "high" debt ratio. Since $z = 1$ if d_i or d_{it} is less than the threshold debt $\widetilde{d}$, the term γ_1 is capturing the effect of debt when debt level is "low" and γ_2 reflects the debt effect when debt level is "high". If $\gamma_1 = \gamma_2$ then the debt-growth relationship takes linear form and [2.4] reduces to γd . However, if $\gamma_1 \ne \gamma_2$ and $\gamma_1 > 0$ while $\gamma_2 < 0$, then the debt-growth relation is an inverted v-shaped relationship where debt stimulates growth if it is below the threshold but detracts growth if it is above the threshold value.

Linear Spline Model

The linear spline specification is an alternative method of estimating a nonlinear relationship. The method involves dividing the value of debt into *'n'* different intervals or segments and then estimating *'n'* parameters corresponding to each of these intervals. For *'n'* segments one places '$(n-1)$' knots at certain values of debt. Note that the researcher has to determine arbitrarily both the location and the number of knots. One can divide the dataset into equal number of observations, i.e. have each knot placed at a certain percentile of the data. Alternatively, one could divide the value of the variable into *'n'* equal segments and estimate a parameter for each of these equal-width portions of the function. That is the knots are equally spaced over the range of debt.

In this study, both of these methods are used to determine the values of each knot. The former method, known as the '*percentile spline*' (because one essentially divides the data into *'n'* percentiles) involves sorting the data according to the variable of interest, debt-to-GDP ratio in this case. Then taking the value of debt-to-GDP ratio corresponding to the $\left(\frac{k}{n}\right)^{th}$ observation as the k^{th} knot value, where $k = 1,\ldots,n-1$ is number of knots for n piecewise linear functions. For the latter approach knots are set at $d_{min} + (d_{max} - d_{min}) * \left(\frac{k}{n}\right)$, where d_{min} and d_{max} are minimum and maximum values of debt-to-GDP ratios respectively. The debt term in equation [2.3] equals the following for the spline model

$$
J\left(d, \widetilde{d}\right) = \sum_{k=1}^{n} \gamma_k d_{k,it} \qquad [2.5]
$$

where d_k is the value of debt-to-GDP ratio at k^{th} knot In this study, $n = 3$ so $k = 2$.

Quadratic Specification

The quadratic specification is also considered to model the nonlinearity of the debt-growth relationship in the literature (see for example, Elbadawi et al, Pattillo et al). With the quadratic model, the debt term in the general model [2.3] equals

$$J\left(d_{it},\widetilde{d}\right)=\gamma_1 d_{it}+\gamma_2 d_{it}^2 \qquad [2.6]$$

This specification differs from the above specification in that the critical turning point is estimated rather then being pre-specified. To estimate the threshold debt level $\widetilde{d}$, [2.6] is substituted into [2.3] and the resultant equation is partially differentiated and set equal to zero, i.e. $\partial y_{it}/\partial d_{it}=\gamma_1+2\gamma_2 d=0$. Solving this yields $-(\gamma_1/2\gamma_2)\equiv\widetilde{d}$. As long as consistent estimates of γs can be obtained one can approximate, for large samples, the variance of this critical point, $\widetilde{d}$ using the 'delta' method (Green (2003) p. 70) as:

$$Var\left(\hat{\tilde{d}}\right)=\frac{1}{\hat{\gamma}_2^2}\left[\tfrac{1}{4}Var(\hat{\gamma}_1)+\hat{\tilde{d}}Cov(\hat{\gamma}_1,\hat{\gamma}_2)+\hat{\tilde{d}}^2 Var(\hat{\gamma}_2)\right] \qquad [2.7]$$

This allows the computation of the confidence intervals, which enables us to check the accuracy of the point estimate.

Hansen’s Threshold Model

One of the most advanced techniques used in the chapter to determine the threshold level(s) of debt is that proposed by Hansen (1996). Hansen's approach enables one to endogenously determine and test the significance of threshold levels of debt in the debt-growth model whilst allowing us to estimate other coefficients at the same time. Given that both, the threshold level(s) and the parameter coefficients are being estimated simultaneously one cannot rely on the standard econometric theory for valid inferences and thus needs a non-standard econometric framework. Hansen (2000) provides such framework.

The previously described methods of modelling and estimating the nonlinearity of the debt-growth relationship are very restrictive as they either impose the threshold(s) rather than estimating them or impose a specific functional form for the debt-growth relationship. Hansen’s methodology is more flexible as it systematically determines the threshold level(s) of debt without assuming any particular functional form for the debt-growth relationship.

To explain Hansen’s estimation techniques the debt-growth relationship is written as

$$\Delta ln\, y_{it} = \beta' \mathbf{x}_{it} + \gamma_1 d_{it} I\left(d_{it} \leq \tilde{d}\right) + \gamma_2 d_{it} I\left(d_{it} > \tilde{d}\right) + \varepsilon_{it} \qquad [2.8]$$

where all the terms are as defined previously except the debt term, which is $J\left(d_{it}, \tilde{d}\right) = \gamma_1 d_{it} I\left(d_{it} \leq \tilde{d}\right) + \gamma_2 d_{it} I\left(d_{it} > \tilde{d}\right)$.

The impact of debt is divided into two regimes depending on whether debt is less than the threshold level $\tilde{d}$ or otherwise. Note that the threshold is common across countries. Before estimating this model a number of issues need to be explained including i) how the threshold level of debt and the coefficient estimates β, γ_1 and γ_2 can be estimated simultaneously; ii) how $\gamma_1 = \gamma_2$ can be tested; iii) how the confidence intervals for the threshold value can be constructed and lastly; iv) how the asymptotic distribution of the slope of the parameter estimates can be obtained to make appropriate inferences. In order to explain these issues, denote the sum of squared residuals by *S(.)*, i.e.

$$\sum_{t=1}^{T} \sum_{i=1}^{N} \varepsilon_{it}^2 \equiv S\left(\beta\left(\tilde{d}\right), \gamma\left(\tilde{d}\right)\right) \qquad [2.9]$$

It is clear that *S(.)* is not a linear function in parameters *βs* and *γs* because they depend on the threshold level of debt $\tilde{d}$. Accordingly, it is a step function where the steps occur at some distinct values of the threshold variable (debt). Nonetheless, when $\tilde{d}$ is conditional on a particular threshold value like $\tilde{d}_0$, *S(.)* becomes linear in *βs* and *γs*. Thus one can obtain the conditional OLS estimators $\hat{\beta}\left(\tilde{d}_0\right)$ and $\hat{\gamma}\left(\tilde{d}_0\right)$ by minimising *S(.)*. By experimenting with all the possible values of debt as conditional threshold values one finds that the value of threshold $\tilde{d}_0$ is such that it minimises the *S(.)*. That is

$$\hat{\tilde{d}} = \arg_{\tilde{d}_0} \min S\left(\tilde{d}_0\right) \qquad [2.10]$$

The study uses a grid search on 99 debt quantiles ranging from 1% to 99% with each quantile changing by 1%; that is, the debt quantile considered are (1%, 2%, … 99%). After knowing the threshold value $\tilde{d}$ it is simply a mater of running OLS on [2.8] to obtain the estimates of *βs* and *γs*.

Next, the statistical significance of the nonlinearity is tested by testing the null that there is no nonlinearity, i.e. $\gamma_1 = \gamma_2$ against the alternative that there is nonlinearity, i.e. $\gamma_1 \neq \gamma_2$. According to Hansen (1996), as the threshold value $\tilde{d}$ does not enter the regression under the null, the asymptotic distribution of the test statistic depends on the sample moments and thus the critical value cannot be tabulated. However, Hansen also states that bootstrapped p-values are asymptotically valid. Hansen proposes an approach that can be used to obtain these p-values. The procedure consists of six steps:

1. Estimate [2.8] to obtain the residuals $\hat{\varepsilon}_{it}$ and group them by country as $\hat{\varepsilon}_i = (\hat{\varepsilon}_{i1}, \hat{\varepsilon}_{i2}, ..., \hat{\varepsilon}_{iT})$
2. Calculate the standard LM test statistics under the null of linearity and denote it by LM*
3. Draw with replacement a sample size *n* of residuals from the empirical distribution function $\hat{\varepsilon}_1, \hat{\varepsilon}_2, \hat{\varepsilon}_3, ..., \varepsilon_n$
4. Generate the bootstrapped dependent variable under the null that $\gamma_1 = \gamma_2$ as $\Delta ln\, y_{it}^b = \hat{\beta}' \mathbf{x}_{it} + \hat{\gamma} d_{it} + \varepsilon_{it}^b$. The errors are generated from the normal distribution $\hat{\varepsilon}_{it}^b \sim N\left(0, \hat{\varepsilon}_{it}^2\right)$, where $\hat{\varepsilon}'s$ are those obtained from step 3.
5. Using the bootstrapped sample estimate equation [2.8] under the null and the alternative to calculate the bootstrapped LM statistic denoting it as LM^b.
6. Repeat steps 3-5 a large number of times and compute the bootstrapped p-value as the percentage of bootstraps for which $LM^b > LM^*$.

Finding simply the point estimates of threshold level is not enough without testing its significance. Testing the significance of the threshold entails testing the null that $\tilde{d} = \tilde{d}_0$. In order to do this the Likelihood Ratio (LR) test statistics is calculated as

$$LR_n\left(\tilde{d}\right) = n\left[S_n\left(\tilde{d}\right) - S_n\left(\hat{\tilde{d}}\right)\right] \Big/ S_n\left(\hat{\tilde{d}}\right) \qquad [2.11]$$

However, Hansen (2000) shows that the LR test statistic does not have the usual χ^2 distribution in the threshold model. Hence, he tabulated the appropriate critical value in Table 1 on page 582 of his paper.

Lastly, the asymptotic distribution of the slope coefficients needs to be determined. Hansen (2000) confirms that even though the parameter estimates are conditional on the threshold level of debt, the normal asymptotic theory holds because the dependence is not of first-order importance.

2.4 DATA DESCRIPTION

This section details the construction of the data used and its sources. It also studies the time series properties of the dataset by performing various unit root tests.

2.4.1 CONSTRUCTION OF DATASET

The data set consists of annual observations for 56 countries observed from 1969 to 2000, giving 32 years of data. The aim of this study was to include all the countries that are heavily indebted i.e. having been facing debt-servicing problems since late 1970s and early 1980s. However, lack of data meant that only 56 countries could be included in the sample. The countries chosen for the study are all the countries falling in category of heavily indebted countries with low to medium income according to the Bank World criterion and had data available. The main sources of data are *Penn World Table*s (PWT), *Bosworth and Collins* (2003) (BC) and *World Development Indicators* (WDI) by the World Bank (WB). Real GDP per capita, real exchange rates and openness indicators measured in constant prices are taken from PWT. Data on human capital and real gross domestic fixed investment and real GDP both measured in local currency units are obtained from BC. The latter two variables are used to calculate the investment-to-GDP ratio. Variables acquired from WDI include total external debt and its ratio to exports and GDP, total debt-service and its ratios to export and GDP, total export, population, Secondary School Enrolment (SSE) rate, budget deficit and TOT. Data on both the ratios and the total of a variable is collected because a number of observations on ratio variables were missing due to data on one of the variable being unavailable.

As there are a large number of observations missing, especially for variables from WDI, various other sources including *IMF Government Finance*, *International Financial Statistics by IMF, Global Development Finance* and *African Development Indicators* are used to complement these variables. A number of techniques are used to deal with missing observations including the use of mean-values, fitting a line through the data and exponential growth rate. The main advantage is that these methods are conceptually simple and result in a full dataset. However, there are several disadvantages, such as it may give biased estimators especially for mean method unless the data are missing completely at random. Extent of the bias depends on the mechanism and the proportion of the missing data as well as the information available in the data set. Furthermore, all imputation methods give smaller standard errors because the estimated values are treated as the actual values and the extra source of error is ignored, giving smaller variances.

2.4.2 PRELIMINARY ANALYSES

Preliminary analysis involves studying the properties of the data used. In particular, it entails studying the simple descriptive statistics of variables and looking at the simple correlation between these variables. As the data set consists of a long time dimension (32 years for each country), it is inevitable that the time-dimensional properties of the data, i.e. the stationarity of the variables are investigated. The following subsection discusses these issues in more details.

Descriptive Statistics

Table 2.1 gives the summary statistics of the variables used in the chapter. Two measures of the central tendency or the averages of the variables are used: mean and median. The spread of the variables is measured by the standard deviation, coefficient of variation which is defined as the standard deviation divided by mean and the standard error of the mean that is standard deviation divided by square root of the number of observations. Also interquartile range is calculated to find if there are any unusual observations.

Where *y, i, s, h, o, b, tot, r, n, d, e, ds* are GDP per capita, gross fixed domestic investment, SSE rate, human capital index, openness, fiscal balance, TOT, real exchange rate, population, debt, export and debt-service respectively. 'Δ' denotes the first difference and '*ln*' denotes the natural log of the variable, so Δlny is the growth rate of GDP per capita. The division operator indicates ratio of two variables, i.e. the investment-to-GDP ratio is i/y.

The average GDP per capita is about $3,400 that varies considerably from as low as $424 to nearly $14,000. The growth rate of GDP per capita is 1% that has a standard deviation of only 6% but considerably larger range of 90%. On average the countries under investigation have had an annual growth rate of 2% over the period 1969 to 2000. They have also experienced population growth rate of 2%. The SSE rate is very low - less than 40% of the secondary school aged children actually attend the school and the growth rate of enrolment rate is only 3%. It seem that some countries have had good growth in enrolment rates while others have had a fall of up to 80% from 1969 to 2000. An alternative measure of human capital complied by Bosworth and Collins (2004) is also used. This is virtually constant with an average growth rate of 1%. Nonetheless, the average level of investment-to-GDP ratio is good as countries on average have been investing about 20% of their GDP over the 32 years.

Over the sample period there seems to be large fluctuations in currency value indicated by an average depreciation rate of 16%, which may be due to greater openness of these economies. Openness indicator, which looks at a country's export as ratio of GDP, shows that export has been a significant proportion of the GDP counting as much as 60%.

TABLE 2.1
Data Description

Variable	Median	Mean	Std. Dev.	Std. Err. mean	Min.	Max.	Cof. Var.	Int. Rng.
y	2,869	3,397	2,452	57.42	424	13,927	0.72	3,454
Δlny	0.02	0.01	0.06	0.00	-0.54	0.36	4.90	0.06
gln(i/y)	18.88	20.02	8.28	0.19	3.90	68.27	0.41	9.45
s	34.86	37.23	22.49	0.53	2.67	108.49	0.60	36.04
Δlns	0.03	0.03	0.08	0.00	-0.80	0.63	2.98	0.05
h	1.12	1.13	0.09	0.00	0.97	1.51	0.08	0.12
Δlnh	0.00	0.01	0.00	0.00	-0.01	0.03	0.65	0.00
o	50.46	59.15	37.87	0.89	2.64	315.72	0.64	41.55
Δlno	0.01	0.01	0.13	0.00	-0.83	1.06	12.87	0.12
b/y	-3.11	-4.20	5.87	0.14	18.27	-61.14	-1.40	5.42
tot	101.07	111.77	38.14	0.89	25.23	431.60	0.34	27.36
Δlntot	-0.01	-0.01	0.17	0.00	-1.03	1.38	-22.57	0.13
r	7.75	1,149	19,131	447.95	0.00	625,218	16.65	73.83
Δlnrer	0.04	0.16	0.44	0.01	-0.37	7.87	2.69	0.16
n^*	11.7	56.1	170	3.98	0.70	1260	3.03	29.4
Δlnn	0.02	0.02	0.01	0.00	-0.37	0.22	0.58	0.01
d/e	214.46	305.10	369.86	8.66	2.01	4,266.44	1.21	228.34
Δln(d/e)	0.00	0.02	0.36	0.01	-4.74	4.49	14.99	0.26
ds/e	21.22	24.53	20.01	0.47	0.23	398.87	0.82	20.61
Δln(ds/e)	0.00	0.01	0.47	0.01	-3.80	3.26	41.54	0.38
d/y	43.84	61.69	71.45	1.67	0.10	1,064.41	1.16	47.10
Δln(d/y)	0.02	0.04	0.34	0.01	-4.67	4.65	8.38	0.20
ds/y	4.46	5.52	4.83	0.11	0.01	75.28	0.88	5.24
Δlnds/y	0.02	0.03	0.46	0.01	-3.90	3.41	16.56	0.36

Population is in millions except the coefficient of variation, which is in units.
Abbreviation of the terms is: Std. is standard, Dev. is deviation, Err is Error, min is for minimum, max is for maximum, Coff.: Var. is for coefficients of variation and Int. rng means interquartile range

The external debt-to-export ratio is 305%, more than twice that declared unsustainable by the Fund-Bank (150%). The highest debt-to-export ratio reached a staggering level of 4266%. However, this is only observed once for Nicaragua in 1990. As only one-third of the sample has debt ratio above the mean, median is perhaps a better average indicator of debt. The debt-to-export ratio has on average grown at 2% across all countries, although some countries have had growth in their debt many times this figure – the maximum growth rate experienced by a country was 449% and maximum fall in debt has been 474%. Given this large increase in debt for some countries and equally large decrease in debt for other countries, it is not surprising that the median debt-to-export ratio is zero. The mean debt-to-GDP ratio is 70% while the median is 44%. As with others statistics this average should be taken with care given massive spread across countries and overtime. The maximum debt-to-GDP ratio is 1064% while the minimum is only 0.1%. Debt, according to debt-to-GDP ratio, has grown on average between 2% and 4%, but some countries have experienced much bigger growth - as much as 465%, while others have had equal decline.

The debt-service burden of these countries counts for nearly ¼ of their exports and more than ½ of their GDP. While debt-service-to-export has grown at 1% the debt-service-to-GDP has grown by 3% suggesting that countries' export has increased more than their GDP over the sampled period.

Simple and Partial Correlation

As a preliminary investigation of the relationship between the variables of interest it is useful to study how these variables are correlated and how strong is the relationship between them. Table 2.2 presents the bivariate correlation between the variables used. An asterisk (*) indicates that the correlation is significant at 5% level.

TABLE 2.2
Simple Correlation between the Variables

	Δlny	ln(i/y)	Δlnh	Δlns	Δlno	b/y	Δlnrer	Δlntot	Δlnn	d/e	d/y	ds/e
Δlny	1.00											
ln(i/y)	0.18*	1.00										
	0.00											
Δlnh	0.05*	0.17*	1.00									
	0.05	0.00										
Δlns	0.03	0.04	0.04	1.00								
	0.14	0.14	0.08									
Δlno	-0.19*	0.06*	0.01	-0.02	1.00							
	0.00	0.01	0.64	0.38								
b/y	0.11*	-0.08*	-0.07*	0.03	0.11*	1.00						
	0.00	0.00	0.01	0.17	0.00							
Δlnrer	-0.18*	-0.10*	0.03	-0.01	0.05*	-0.17*	1.00					
	0.00	0.00	0.26	0.74	0.05	0.00						
Δlntot	-0.02	-0.03	0.00	-0.04	0.06*	0.06*	-0.07*	1.00				
	0.52	0.27	0.93	0.10	0.01	0.01	0.00					
Δlnn	0.10*	-0.05*	0.03	0.00	-0.12*	0.04	-0.08*	0.00	1.00			
	0.00	0.03	0.18	0.99	0.00	0.12	0.00	0.99				
d/e	-0.15*	-0.16*	-0.10*	-0.02	-0.02	-0.19*	0.31*	-0.15*	-0.16*	1.00		
	0.00	0.00	0.00	0.50	0.43	0.00	0.00	0.00	0.00			
d/y	-0.14*	-0.03	-0.03	-0.04	0.02	-0.30*	0.32*	-0.14*	-0.03	0.69*	1.00	
	0.00	0.16	0.15	0.13	0.39	0.00	0.00	0.00	0.16	0.00		
ds/e	-0.10*	-0.04	0.09*	0.00	-0.04	-0.12*	0.19*	-0.10*	-0.04	0.35*	0.21*	1.00
	0.00	0.10	0.00	0.94	0.10	0.00	0.00	0.00	0.10	0.00	0.00	
ds/y	-0.09*	0.12*	0.11*	-0.04	0.01	-0.21*	0.10*	-0.09*	0.12*	0.08*	0.46*	0.59*
	0.00	0.00	0.00	0.08	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00

An asterisk, *, indicates that the correlation between the two variables is significant at 5%
Second line gives the significance level.

The correlation between GDP and the other variable is as expected. Growth is significantly affected by all the variables except the growth rate of SSE and TOT growth. However, the growth rate of GDP is significantly correlated with human capital index, (which is an alternative variable for human capital) and real exchange rate (which is similar to TOT). Real exchange rate and TOT both are a measure of a country's aggregate external price competitiveness. TOT can be defined as the amount a country can buy with what it sells abroad. In other words, it is a ratio of an index of export prices to an index of import prices. Deteriorating of TOT means that the price of exports has decreased relative to the price of imports. Hence the price of imports is rising faster than the price of exports. TOT is said to be improving if the price of exports is rising faster than the price of imports. The regression analysis experiments with these variables generally show that human capital index and real exchange rate are significant while TOT and SSE rates are not.

Table 2.3 illustrates the partial correlation coefficient of growth rate is GDP per capita with each variable in the table, holding the other variables in constant. The growth rate is positively and significantly correlated with investment to GDP ratio, fiscal budget to GDP ratio and population growth rate. However, the correlation between growth rate of output and both measures of human capital is although positive is highly insignificant suggesting that human capital contributes little to the growth rate of GDP per capita. The debt-to-GDP ratio is negatively and significantly correlated with the growth rate of output supporting the debt overhang hypothesis, but the there is little support for the crowding out hypothesis indicated by positive and insignificant correlation between growth rate and debt-service-to-GDP ratio.

TABLE 2.3
Partial Correlation between the Variables

Variables	Partial correlation	p-value
Investment to GDP	0.19	0.00**
School enrolment rate	0.02	0.46
Human capital index	0.02	0.31
Openness	-0.21	0.00**
Fiscal budget-to-GDP ratio	0.11	0.00**
Growth rate of TOT	-0.01	0.55
Growth rate of exchange rate	-0.11	0.00**
Population growth rate	0.07	0.00**
Debt-to-GDP ratio	-0.05	0.03*
Debt-service to GDP	0.01	0.69

** and * indicates that the partial correlation of this variable with the growth rate of GDP is significant at 1% and 5% respectively.

2.4.3 PANEL UNIT ROOT TESTS

Since the dataset has a reasonably long time-dimension (32 years), it is important to examine the time-series properties of the data and specifically test whether the variables are stationary or non-stationary. It is well known that the classical tests are invalid for non-stationary variables. The correlation observed between two non-stationary variables is generally meaningless, i.e. spurious except under some special circumstance of cointegration. A number of univariate unit root tests including ADF, Phillip and Perron (1988) and DF-GLS by Elliott et al (1996) are conducted to study the properties of each variable used. The results (omitted due to space constraint) show that all variables are non-stationary.

However, these tests have low power and are extremely sensitive to deterministic chosen such as the lag structure, whether the data generating process has a constant, time trend etc. As an attempt to overcome the low power of the univariate stationarity tests[7], panel unit root tests[8] have been developed, which require panel dataset like the one used in this chapter. Here two tests including Im Pesaran and Shin (1997, 2004) and Maddala and Wu (1999) are employed. Both of these tests conduct a unit root test such as ADF test for each cross-sectional unit and then combine this result in a unique way[9]. The IPS test computes the simple average of the individual ADF test statistics and argues that it follows a normal distribution asymptomatically due to the Central Limit Theorem. Maddala and Wu test, on the other hand, combines the probability values *(p)* of the unit root test statistics to compute the panel test. It is based on the argument that combining a uniformly distributed variable such as p as $-2lnp$ results in a chi-squared distributed variable with 2 degrees of freedom, i.e. $-2\log p \sim \chi_2^2$ (Fisher 1930). Further using the additive property of chi-squared distribution, the panel test statistics can be computed as $-2\sum_{i=1}^{N} \log p_i \sim \chi_{2N}^2$ where N is the number of cross-sectional units.

The deterministic components of the unit root tests are chosen somewhat arbitrarily as usual for these kinds of tests. Each test is performed using two lags and a constant but no trend unless specified otherwise for each country.

The null hypothesis of a unit root is rejected for nine variables by both tests but five variables including GDP per capita, SSE rate, human capital index, exchange rate and openness are non-stationary. SSE rate should also be a nonstationary variable especially for

[7] A description of univariate unit root tests such as ADF, Philip and Perron and DF-GLS is provided in chapter 3 section 3.3.1. The results for the variables used are provided in the appendix.

[8] See chapter 3 section 3.3.1 for more details.

[9] IPS test is only valid for ADF test, while the Maddala and Wu test can be used for any unit root test.

DCs as they are likely to experience an upward trend in the proportion of population being educated as the country develops over time. Although it is a rather stable variable, it is unlikely that it decreases as often as it increases. That is, its mean/variance should be increasing over time making it a nonstationary variable. Similarly, exchange rate and openness are non-stationary, i.e. have time dependent first or second moments.

TABLE 2.4
Panel Unit Root Test

Variables	Im Pesaran and Shin	Maddala and Wu	
		ADF	Phillips-Perron
GDP per capita[1]	-2.163 (0.348)	130.673 (0.136)	136.119* (0.077)
Investment to GDP	-1.878*** (0.000)	163.633*** (0.002)	198.190*** (0.000)
School enrolment rate	-1.584 (0.186)	105.418 (0.705)	46.882 (1.000)
Human capital index	-1.572 (0.213)	55.209 (1.000)	82.142 (0.989[2])
Openness	-1.360 (0.832)	94.976 (0.902)	97.599 (0.864)
Fiscal budget to GDP	-2.096*** (0.000)	199.415*** (0.000)	347.704*** (0.000)
Growth rate of TOT	-3.443*** (0.000)	561.397*** (0.000)	1704.680*** (0.000)
Real Exchange rate	-0.873 (1.000)	41.147 (1.000)	13.281 (1.000)
Population growth rate	-2.225*** (0.000)	306.392*** (0.000)	140.590** (0.046)
Debt-to-export ratio	-1.934*** (0.000)	135.264* (0.085)	207.792*** (0.000)
Debt-service to export ratio	-2.106*** (0.000)	150.082** (0.013)	250.422*** (0.000)
Debt-to-GDP ratio	-1.826** (0.002)	139.658* (0.052)	236.015*** (0.000)
Debt-service to GDP	-1.992*** (0.000)	159.752*** (0.003)	194.807*** (0.000)

- Critical values for model with only constant are: 10% = –1.64, 5% = –1.67 and 1% = –1.73
- Critical values for model with a constant and a trend are: 10% = -2.28, 5% = -2.31 and 1% = -2.36
- Number of observations for each of 56 countries are 32
- Critical values (χ^2) are: 10% = 133.73, 5% = 139.92 and 1% = 152.04
- The level at which null is rejected is indicated by asterisks: *** implies null is rejected at or less than 1%, ** indicates it is rejected at or less than 5% and * means that it is rejected at or below 10%.
- Figures in the parentheses are the probability values.
- [1] Trend as well as a constant is used for these variable(s).

Both debt-to-export and debt-to-GDP ratios are stationary as expected because debt, export and GDP are nonstationary variables in levels, thus their ratios are likely to be stationary series. The results for the debt variables are not equally supported by both tests. While IPS test strongly rejects the null of non-stationarity for all four debt variables, the

Maddala and Wu test can only reject the null at 10% for debt-to-export and GDP ratios. Nonetheless Maddala and Wu test is able to reject the null for debt-service to export and debt-service-to-GDP ratios at 1% like IPS test.

TABLE 2.5
Panel Unit Root Tests on Differenced Data

Variables	Im Pesaran & Shin	Maddala & Wu	
		ADF	Phillip-Perron
GDP per capita	-2.963	426.539	1225.141
	(0.000)	(0.000)	(0.000)
SSE rate	-2.212	208.073	1701.887
	(0.000)	(0.000)	(0.000)
Human capital index	-1.983	159.487	413.877
	(0.000)	(0.003)	(0.000)
Exchange rate	-2.184	251.819	699.296
	(0.000)	(0.000)	(0.000)
Openness	-3.233	451.474	1587.705
	(0.000)	(0.000)	(0.000)

Table 2.5 above gives the results for the differenced variables that were nonstationary. All the variables are stationary after taking the first differences. Thus, the logarithmic difference, which is interpreted as the growth rate of the differenced variable, is used for the estimation purpose.

2.4.4 DATA PROPERTIES AND ESTIMATORS

While the data used in this study is collected from respectable sources like the WDI of the WB, it is nonetheless of not a very high quality, as the governments of DCs who gather the data and pass it on to the WB have very limited resources for this task. Therefore a number of tests are performed to identify any influential observations such as outliers, and leverages, so that appropriate estimation techniques can be used to estimate the parameters of the model. The techniques used to identify the problematic observations include the graphical methods, i.e. scatter plots of the data, computations of statistics such as predicted standardised residuals, Cook's D statistics, dfits and dfbeta. All of the methods are explained in the appendix.

The results reveal that the data does indeed possess unusual and influential observations, which can lead to biases in the OLS estimators. Consequently, alternative estimators that can deal with outliers and leverages should be used. There are two such estimators employed in this chapter: robust-weighted estimator and the quantile, or the median estimator along with the OLS with robust (Huber-White) standard errors. Both exogenous models and one of the endogenous threshold model (quadratic) are estimated using these three estimators with and without country-dummies.

The OLS minimises the squared sum of residuals whereas the robust-weighted regression seeks to minimise the weighted squared sum of residuals taking into account the outliers. The weights of each observation depend on the value of the residuals. When the residual value is near zero the weights are near one and as the residuals increase the weights decrease. Observations with unusual value - i.e. very large residuals will not be used for the actual estimation. The median estimator minimises the absolute value of residuals instead of the squared residuals. This boils down to estimating how the median, instead of the mean of the dependent variable changes due to the changes in one of the explanatory variables. It is also resistant to the influence of outliers and gives more accurate estimates than OLS but not as accurate as the robust-weighted estimators. The quantile and the robust-weighted estimators are also appropriate when dataset contains leverage[10]. In this case, the robust-weighted estimator is preferred as it not only downsizes the large residual observations but also ignores the values with Cook's D statistics greater than unity.

Monte Carlo experiments establish that robust wighted and quantile estimators provide unbiased estimates with better efficiency than OLS for heavy-tailed but symmetrical errors. For asymmetrical disturbance, however, these estimators, like OLS cannot, at least theoretically, provide an unbiased intercept, but all the other regression coefficients remain unbiased and relatively precise estimates. Thus with the robust-weighted estimators there is a risk of getting biased estimate of the constant for the sake of getting unbiased and more efficient estimates of other coefficients which are often more interesting than the constant.

Further to using three estimators detailed above, two types of models, FE and pooled regression are estimated for each specification detailed in section 2.3.2. A FE model allows country-specific effects through the constant term in the equation and assumes that beta parameters are the same for all countries in the sample, more explicitly it sets $\tilde{g}_i = \hat{\tilde{g}}_i$ but $\tilde{\beta} = \hat{\tilde{\beta}}$ for all betas in the general empirical model [2.2]. The pooled regression simply pools the data and estimates one single model for all the countries, i.e. $\tilde{g}_i = \hat{\tilde{g}}$ and $\tilde{\beta} = \hat{\tilde{\beta}}$. So the main difference between the two models is that the FE model allows country-specific dummies whilst pooled model assumes that there is no difference between the countries and estimates a single model for all countries in the sample. Therefore, under FE model a separate equation is estimated for each country constraining the coefficients (except the

[10] Note that all observations have some leverage, which is neither good nor bad. The problem, however, arises when an observation is very influential, i.e. an outlier - not a member of the intended population.

constant) to be the same across all countries, whereas under pooled regression it is assumed that there is no difference between the countries.

2.5 EMPIRICAL ESTIMATES OF THE DEBT-GROWTH RELATIONSHIP

This section presents a discussion of the empirical results estimated for the debt-growth model derived in section 2.3.1. The model has been estimated using numerous estimation techniques and model specifications. The section firstly reports the findings from exogenously determined threshold models, and then it proceeds to examine the results from endogenously determined threshold models.

2.5.1 EXOGENOUS THRESHOLD MODELS

Two exogenously determined threshold models namely; the interaction debt dummy model and the linear spline model are estimated. The reason these model are used in this study is that they are simple and have been used in the literature and thus enable direct comparison between the results of this study and the findings of the existing literature. Furthermore, the results from these models can also be used as a benchmark to make comparisons between the exogenous and the endogenous threshold models.

Interaction Dummy Models

The empirical results from the interaction dummy models are presented in Table 2.6. In the first three columns, the results are from the FE model and in the last three columns the results relate to the pooled model. Both models are estimated using OLS estimator with robust standard errors, the robust-weighted regression and the median estimators.

The Table also reports the results from two different measures of the “high” and “low” debt dummies. These have been defined in subsection 3.2.2 under interaction debt dummy models. The main difference between the two approaches is that under one a country is either “highly” indebted or otherwise for all the 32 years, whereas under two a country may be highly indebted in some periods but not necessarily in all of periods.

If there is a nonlinear debt-growth relationship then the “high” debt estimates should be negative and significant while the “low” debt estimate should be positive and significant. This will indicate that the debt-growth relationship is an inverted v-shaped. The results show that debt has a positive effect for both “low” and “high” debt regimes under FE model. However, under the pooled regression the relationship is either inverted v-type or linear and

TABLE 2.6
Debt-Growth Interaction Dummy Model

	With Country Dummies						Without Country Dummies					
	OLS	**Robust**	**Median**	**OLS**	**Robust**	**Median**	**OLS**	**Robust**	**Median**	**OLS**	**Robust**	**Median**
Log of investment to GDP ratio	0.046 (0.019)**	0.026 (0.007)***	0.027 (0.007)***	0.046 (0.015)***	0.026 (0.007)***	0.020 (0.008)***	0.052 (0.019)***	0.030 (0.007)***	0.029 (0.008)***	0.052 (0.015)***	0.031 (0.007)***	0.038 (0.007)***
Lagged log of investment to GDP ratio	-0.029 (0.018)	-0.007 (0.007)	-0.007 (0.006)	-0.028 (0.014)**	-0.005 (0.007)	-0.000 (0.008)	-0.026 (0.018)	-0.007 (0.007)	-0.007 (0.008)	-0.026 (0.014)*	-0.008 (0.007)	-0.011 (0.007)
Growth rate of human capital index	0.251 (0.420)	0.406 (0.319)	0.592 (0.285)**	0.255 (0.357)	0.402 (0.318)	0.466 (0.347)	0.354 (0.416)	0.459 (0.296)	0.521 (0.335)	0.420 (0.374)	0.493 (0.299)*	0.291 (0.296)
Growth rate of openness	-0.106 (0.024)***	-0.054 (0.008)***	-0.054 (0.008)***	-0.108 (0.019)***	-0.054 (0.009)***	-0.051 (0.009)***	-0.104 (0.023)***	-0.058 (0.009)***	-0.051 (0.010)***	-0.105 (0.019)***	-0.056 (0.009)***	-0.052 (0.009)***
Fiscal deficit to GDP ratio	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***
Growth rate of real exchange rate	-0.017 (0.005)***	-0.020 (0.003)***	-0.022 (0.002)***	-0.018 (0.005)***	-0.021 (0.003)***	-0.022 (0.003)***	-0.017 (0.005)***	-0.020 (0.002)***	-0.022 (0.003)***	-0.014 (0.004)***	-0.018 (0.002)***	-0.019 (0.002)***
Growth rate of population	0.659 (0.226)***	-0.457 (0.153)***	-0.037 (0.081)	0.651 (0.374)*	-0.461 (0.153)***	-0.054 (0.097)	0.356 (0.359)	-0.494 (0.112)***	-0.365 (0.083)***	0.278 (0.431)	-0.583 (0.112)***	-0.344 (0.079)***
Log of debt service to GDP ratio	-0.002 (0.003)	-0.002 (0.002)	-0.002 (0.002)	-0.001 (0.003)	-0.002 (0.002)	-0.002 (0.002)	-0.001 (0.002)	-0.004 (0.002)**	-0.003 (0.002)*	0.001 (0.003)	-0.003 (0.002)*	-0.003 (0.002)*
Log of "low" debt to GDP ratio (Median)	0.002 (0.003)	0.001 (0.002)	0.004 (0.002)				0.002 (0.003)	0.001 (0.002)	0.002 (0.002)			
Log of "high" debt to GDP ratio (Median)	0.002 (0.004)	-0.000 (0.002)	0.001 (0.002)				-0.002 (0.003)	-0.001 (0.002)	-0.001 (0.002)			
Log of 'low' debt to GDP ratio (HIPCs)				0.003 (0.003)	0.001 (0.002)	0.003 (0.002)				-0.004 (0.003)	-0.003 (0.002)*	-0.004 (0.002)***
Log of "high" debt to GDP ratio (HIPCs)				0.000 (0.003)	-0.001 (0.002)	0.001 (0.002)				-0.005 (0.003)*	-0.002 (0.002)	-0.002 (0.002)
Observations	1767	1766	1767	1767	1766	1767	1767	1766	1767	1767	1766	1767
Adjusted R squared	0.15	0.17		0.15	0.18		0.13	0.15		0.12	0.15	

Figures in the parentheses are the robust SEs. Significance level is indicated by "*", "**" and "***" for 10%, 5% and 1%. Dependent Var.: Growth rate of GDP per capita negative. Although, there is some evidence that the relationship is not linear, surprisingly, the effect does not seem to be significant except for the HIPC threshold estimates without country-dummies. Thus, the linearity of the relationship is examined by testing the null that $\gamma_1 = \gamma_2$ using Wald's test. The null can be rejected in nearly half of the cases as shown in Table 2.7 but not in all cases. The nonlinear relationship is supported strongly when the average of the country's median debt-to-GDP ratio is used as the threshold and the country-dummies are omitted. Overall, the results from this model are not conclusive about the form of the debt-growth relationship.

TABLE 2.7
Wald's test statistics for the null that $\gamma_1 = \gamma_2$

Null: $\gamma_1 = \gamma_2$	With Country-dummies			Without Country-dummies		
	OLS	Robust	Median	OLS	Robust	Median
$\tilde{d} = 56.69\%$[1]	0.01 (0.92)	0.09 (0.76)	1.38 (0.24)	17.67 (0.00)***	16.07 (0.00)***	21.95 (0.00)***
$\tilde{d} = 150\%$[2]	1.96 (0.16)	3.13 (0.08)*	1.88 (0.17)	0.22 (0.64)	0.61 (0.44)	6.06 (0.01)**

1. $\tilde{d}$ is the average of the median debt-to-GDP ratio for each country *i*, $\overline{d}_i$.
2. According to the Fund-Bank's HIPC initiative a country is highly indebted if its debt-to-export ratio is greater than 150% otherwise it is a low indebted country. (Note that here the debt-to-export ratio rather than the debt-to-GDP ratio is used to classifies each country as highly indebted or low indebted.)

Further to studying the effect of debt on the growth, i.e. the DOH, the crowding out effect is also analysed. The results show that the crowding out effect captured by debt-service-to-GDP ratio is insignificant for most of the estimators. Since the debt-service and the debt stock of a country are likely to be correlated and neither has a significant effect on growth individually, it is interesting to test if the joint effect is significant or not. Table 2.8 reports the Wald's test statistics for the null that the debt overhang and the crowding out effect are zero jointly, i.e. $ds = d^l = d^h = 0$.

TABLE 2.8
Wald's test statistics for the null $\gamma_1 = \gamma_2 = \beta_{ds}$

Null: $\gamma_1 = \gamma_2 = \beta_{ds}$	With Country-dummies			Without Country-dummies		
	OLS	Robust	Median	OLS	Robust	Median
$\tilde{d} = 56.69\%$[1]	0.21 (0.89)	0.64 (0.59)	1.06 (0.36)	8.50 (0.00)***	11.65 (0.00)***	11.97 (0.00)***
$\tilde{d} = 150\%$[1]	0.75 (0.52)	1.62 (0.18)	1.06 (0.37)	1.80 (0.15)	6.41 (0.00)***	9.99 (0.00)***

See TABLE 2.7 for the definition of $\tilde{d}$'s.

The results generally fail to reject the zero effect when country-dummies are included but not when the country-dummies are excluded. Again, the result is ambiguous which does not necessarily indicate that the crowding out effect due to large debt-service payments has insignificant effect on the growth rate of GDP per capita. Instead, this is likely to be because the model is miss-specified, which leads us to a more general specification – the linear spline model considered below.

Linear Spline Specification

The linear spline specification estimates the nonlinear relationship between debt and growth as a piecewise linear function. The analyst has to decide on the number and the location of each knot. This study uses two methods for selecting the values of each knot: the first method sorts the data according to the debt ratio and splits the sample into 3 equal intervals placing 2 knots – first at the debt ratio of 354.87% and the second at the debt ratio of 709.64%. The second method places knots at the 33rd percentile and at the 66th percentile of debt-to-GDP ratio. The corresponding debt ratios are 32.35% and 60% respectively. See section 3.2.2 for a detailed explanation on how these knots are decided upon.

Table 2.9 reports the results estimated under the linear spline regressions using both of the above mentioned know selection methods under FE and pooled regression. The spline specification using the equal width splines indicates that debt has positive effect on growth when debt-to-GDP ratio is less than 355% but negative when debt ratio is above 710%. In between the debt effect is positive for most of the estimator. However, the debt overhang effect seems to be insignificant for the debt range spline except when debt ratio is above 710% for the pooled regression.

However, the percentile-spline gives a slightly different picture. It illustrates that when debt is below 33rd percentile (i.e. debt-to-GDP ratio is less than 32%) the debt impact is positive and significant for both FE and the pooled regression models. Between the 33rd and the 66th percentile, which correspond to the debt-to-GDP ratio of 32% and 60% respectively, the debt effect becomes negative and highly significant across all estimators with and without country-dummies. Although the effect remains negative after the 66th percentile for models without country-dummies, it becomes positive for models with country-dummies. Thus, the FE models indicate that there is likely to be multiple thresholds so fitting a dummy model with only one threshold is not appropriate.

TABLE 2.9
Debt-Growth Linear Spline Specifications

	With Country Dummies						Without Country Dummies					
	Debt Range			Debt Percentile			Debt Range			Debt Percentile		
	OLS	Robust	Median	OLS	Robust	Median	OLS	Robust	Median	OLS	Robust	Median
Log of investment-to-GDP ratio	0.045 (0.015)***	0.025 (0.007)***	0.025 (0.012)**	0.042 (0.015)***	0.023 (0.007)***	0.019 (0.008)**	0.051 (0.015)***	0.031 (0.007)***	0.034 (0.009)***	0.049 (0.015)***	0.029 (0.007)***	0.034 (0.009)***
Lagged log of investment-to-GDP ratio	-0.029 (0.014)**	-0.006 (0.007)	-0.008 (0.012)	-0.026 (0.014)*	-0.004 (0.007)	-0.002 (0.008)	-0.026 (0.014)*	-0.008 (0.007)	-0.010 (0.009)	-0.024 (0.014)*	-0.007 (0.007)	-0.009 (0.009)
Growth rate of human capital index	0.251 (0.359)	0.413 (0.318)	0.553 (0.522)	0.163 (0.359)	0.335 (0.315)	0.538 (0.357)	0.371 (0.374)	0.474 (0.298)	0.217 (0.373)	0.287 (0.373)	0.444 (0.298)	0.418 (0.365)
Growth rate of openness	-0.105 (0.019)***	-0.052 (0.008)***	-0.051 (0.014)***	-0.105 (0.019)***	-0.049 (0.008)***	-0.049 (0.010)***	-0.102 (0.019)***	-0.055 (0.009)***	-0.050 (0.011)***	-0.102 (0.019)***	-0.054 (0.009)***	-0.054 (0.011)***
Fiscal deficit-to-GDP ratio	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)**	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***
Growth rate of real exchange rate	-0.017 (0.005)***	-0.020 (0.003)***	-0.022 (0.004)***	-0.017 (0.005)***	-0.021 (0.003)***	-0.022 (0.003)***	-0.013 (0.004)***	-0.018 (0.002)***	-0.019 (0.003)***	-0.014 (0.004)***	-0.018 (0.002)***	-0.019 (0.003)***
Growth rate of population	0.659 (0.376)*	-0.445 (0.153)***	0.042 (0.148)	0.653 (0.378)*	-0.474 (0.152)***	-0.112 (0.101)	0.279 (0.434)	-0.564 (0.111)***	-0.346 (0.093)***	0.296 (0.425)	-0.559 (0.111)***	-0.379 (0.097)***
Log of debt-service-to-GDP ratio	-0.002 (0.003)	-0.002 (0.002)	-0.003 (0.003)	-0.001 (0.003)	-0.002 (0.002)	-0.001 (0.002)	-0.001 (0.003)	-0.004 (0.002)**	-0.004 (0.002)*	0.000 (0.003)	-0.004 (0.002)**	-0.004 (0.002)*
$Log(d < d_1)$	0.013 (0.008)*	0.011 (0.007)	0.014 (0.011)	0.008 (0.004)**	0.005 (0.003)**	0.006 (0.003)**	0.003 (0.006)	0.007 (0.007)	0.008 (0.008)	0.007 (0.004)*	0.005 (0.002)**	0.006 (0.003)**
$Log(d_1 \leq d < d_2)$	0.002 (0.004)	-0.001 (0.003)	0.003 (0.004)	-0.026 (0.008)***	-0.020 (0.006)***	-0.020 (0.007)***	0.001 (0.004)	0.001 (0.002)	0.002 (0.003)	-0.030 (0.007)***	-0.016 (0.005)***	-0.014 (0.006)**
$Log(d \geq d_2)$	-0.001 (0.006)	-0.001 (0.004)	-0.002 (0.006)	0.008 (0.007)	0.007 (0.004)*	0.005 (0.005)	-0.013 (0.004)***	-0.008 (0.003)***	-0.011 (0.003)***	-0.003 (0.005)	-0.004 (0.003)	-0.008 (0.004)**
Observations	1767	1766	1767	1767	1766	1767	1767	1766	1767	1767	1766	1767
Adjusted R-squared	0.15	0.18		0.16	0.18		0.12	0.15		0.13	0.15	

Figures in the parentheses are robust SEs. Significance level is indicated by "*", "**" and "***" for 10%, 5% and 1%, *d* represents the debt to GDP ratio see Table 2.5.4 for the value of d_1 & d_2. Dependent var.: Growth rate of GDP per capita

It is interesting to examine if the debt effect is the same under all 3 regimes, that is to test whether $\gamma_1 = \gamma_2 = \gamma_3$ or not and to see if the joint debt effect is significant or not, i.e. whether $\gamma_1 = \gamma_2 = \gamma_3 = 0$. To do this Wald's test is conducted. Table 2.10 present the test statistics for the equally width debt-spline and the percentile spline. For the debt-spline model, the null that $\gamma_1 = \gamma_2 = \gamma_3$ cannot be rejected when country-dummies are included but can be rejected when country-dummies are omitted. Also, for the FE models the null that the joint debt effect is insignificant cannot be rejected but for the pooled regression it can be. Therefore, the FE model predicts a linear but insignificant relationship while the pooled regression suggests a nonlinear and significant relationship. The debt percentile spline suggests that the relationship is nonlinear and jointly significant at 1% significance level for the pooled and the FE model. Overall, the results from linear spline specification indicate a nonlinear debt-growth relationship.

TABLE 2.10
Wald's Test-Statistics For the Joint Debt Effect

	With Country-dummies			Without Country-dummies		
Debt-spline	**OLS**	**Robust**	**Median**	**OLS**	**Robust**	**Median**
$\gamma_1 = \gamma_2 = \gamma_3$	1.77 (0.17)	1.40 (0.25)	1.85 (0.16)	4.44 (0.01)	4.70 (0.00)	5.06 (0.01)
$\gamma_1 = \gamma_2 = \gamma_3 = 0$	1.35 (0.26)	0.94 (0.42)	1.54 (0.20)	3.70 (0.01)	3.95 (0.01)	4.01 (0.01)
Debt percentile						
$\gamma_1 = \gamma_2 = \gamma_3$	9.16 (0.00)	7.46 (0.00)	5.65 (0.00)	12.94 (0.00)	9.49 (0.00)	8.26 (0.00)
$\gamma_1 = \gamma_2 = \gamma_3 = 0$	6.15 (0.00)	5.06 (0.00)	3.83 (0.00)	9.67 (0.00)	6.92 (0.00)	6.29 (0.00)

Figures in the parentheses are the probability values

2.5.2 ENDOGENOUS THRESHOLD MODEL

The findings from the above models support the proposition of a nonlinear relation between debt and growth. However, so far in the analysis, the threshold level of debt has been chosen using relatively arbitrary methods and then the debt-growth relationship is estimated using either a single threshold or a multiple thresholds. Although these methods are useful for modelling a nonlinear relationship, they are very restrictive, as the researcher has to decide upon the threshold(s) before estimating the model rather than determining it systematically. Thus, we now turn to endogenously determined threshold models: quadratic and Hansen.

Quadratic Model

The results from the quadratic specification are presented in Table 2.11. This specification reveals that most variables are statistically significant, the exception are human capital index and the debt-service-to-GDP ratio capturing the crowding out effect. It is surprising to find that the human capital and the crowding out effects are insignificant since the literature has generally found both of these effects to be significant. The crowding out effect is sometime more predominant than the debt overhang effect. Based on previous findings, it was expected that the large amounts of debt-service payments faced by highly indebted DCs is taking away the limited resources from these countries that could have been used for health and education purposes. Governments of these nations are servicing the debt with very limited revenues instead of investing the funds in public services like health and education or building sound public infrastructure to support the growth of their countries.

TABLE 2.11
Growth Regression Quadratic in Debt

	With country-dummies			Without country-dummies		
	OLS	Robust	Median	OLS	Robust	Median
Log of investment to GDP ratio	0.045 (0.019)**	0.026 (0.007)***	0.023 (0.009)***	0.051 (0.019)***	0.031 (0.007)***	0.036 (0.008)***
Lagged log of investment to GDP ratio	-0.029 (0.018)	-0.008 (0.007)	-0.006 (0.009)	-0.026 (0.018)	-0.007 (0.007)	-0.009 (0.008)
Growth rate of human capital index	0.249 (0.416)	0.414 (0.317)	0.566 (0.389)	0.388 (0.409)	0.492 (0.297)*	0.437 (0.339)
Growth rate of openness	-0.105 (0.024)***	-0.051 (0.008)***	-0.050 (0.011)***	-0.102 (0.024)***	-0.053 (0.009)***	-0.053 (0.010)***
Fiscal deficit to GDP ratio	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)**	0.001 (0.000)***	0.001 (0.000)***	0.001 (0.000)***
Growth rate of RER	-0.016 (0.005)***	-0.020 (0.003)***	-0.022 (0.003)***	-0.013 (0.005)***	-0.017 (0.002)***	-0.019 (0.003)***
Growth rate of population	0.658 (0.225)***	-0.449 (0.153)***	0.038 (0.110)	0.277 (0.395)	-0.564 (0.111)***	-0.358 (0.090)***
Log of debt-service to GDP ratio	-0.002 (0.003)	-0.002 (0.002)	-0.002 (0.002)	-0.000 (0.002)	-0.004 (0.002)**	-0.003 (0.002)*
Log of debt-to-GDP ratio	0.009 (0.004)**	0.007 (0.004)*	0.010 (0.005)**	0.008 (0.007)	0.008 (0.004)**	0.007 (0.004)*
Squared of log of debt-to-GDP ratio	-0.001 (0.001)*	-0.001 (0.001)**	-0.001 (0.001)**	-0.002 (0.001)**	-0.002 (0.000)***	-0.002 (0.001)***
Constant	-0.067 (0.027)**	-0.044 (0.017)***	-0.056 (0.020)***	-0.066 (0.020)***	-0.037 (0.011)***	-0.046 (0.012)***
Observations	1767	1766	1767	1767	1766	1767
Adjusted R-squared	0.15	0.18		0.12	0.15	

Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

The coefficient on the debt-to-GDP ratio is positive and significant while the coefficient for the debt-to-GDP ratio squared is negative and significant as expected. Accordingly, the results from the quadratic model suggest that there is an inverted u-shaped relationship between debt and growth as postulated by the debt Laffer curve due to Krugman (1988) and Sachs (1989). Furthermore, the debt effect has a statistically significant impact on the growth rate of GDP per capita (Table 2.11).

Estimates of Debt Thresholds and Confidence Interval

The point estimates and the 95% asymptotic confidence intervals for the turning points are reported in Table 2.12 for both types of models: FE and pooled regression. The implied growth maximising debt-to-GDP ratio estimates from the pooled regression seem rather low ranging from 8.63% to 12.40%. However, the estimates from the FE model appear more reasonable and closer to some of the estimates provided in the literature. The OLS gives us the highest turning point of 46% suggesting that debt begins to have negative effect on growth when debt-to-GDP ratio reaches approximately 46%.

TABLE 2.12
Threshold Estimates and 95% Confidence Intervals

	With Country-dummies			**Without Country-dummies**		
	OLS	**Robust**	**Median**	**OLS**	**Robust**	**Median**
Point estimate (%)	45.66	24.40	36.06	8.63	12.40	9.58
Upper confidence interval (%)	853.32	135.88	202.59	57.92	36.10	35.46
Lower confidence interval (%)	2.44	4.38	6.42	1.29	4.26	2.59

In the literature, Elbadawi et al (1997) find that the turning point is 97% of debt-to-GDP ratio for similar growth model specification using 99 DCs, which is considerably high compared with the estimates suggested by this and other studies. Pattillo et al (2001), for example, find debt-to-GDP ratio ranges from 35%-40%, while Cohen (1997) finds that debt becomes excessive when it reaches a debt-to-GDP ratio of 50%. Our estimates from the FE are in line with these estimates of the turning point. The pooled regression estimates also coincide with the findings of others such as Reinhart, Rogoff, and Savastano (2003) who suggest that the probability of a debt crisis (that has expected negative consequences for growth) increases significantly at debt levels as low as 15% of GNP, for countries with a high inflation and a history of defaults.

Proportion of Sample Within, Above and Below the 95% Interval

The FE model estimated by OLS gives the 95% asymptotic confidence interval of 2.44% and 835%. All countries have had debt that lies within this range for almost all of the years under investigation, seven countries have had debt less than the lower bound for less than 5 years and only one country (Nicaragua) has had debt level above the upper limit for two years during 1989 and 1990. The upper bound is distorted by few high debt observations – only 1 percentile of the sample has debt above 333%, which is only 1/3 of the upper bound. The robust-weighted regression, which takes into account the outliers, predicts the upper bound to be 135% and lower bound to be about 5%. The proportion of sample within the 95% confidence intervals is about 8% less than that for the OLS estimator. The median estimator illustrates similar story (Table 2.13).

TABLE 2.13
Proportion of Sample Within, Above and Below the 95% Intervals

	With Country-dummies			**Without Country-dummies**		
Proportion within the 95% intervals	**OLS**	**Robust**	**Median**	**OLS**	**Robust**	**Median**
Number of countries	57	57	57	57	53	52
Average number of years	31.37	28.70	29.82	20.21	12.60	12.69
Total sample (%)	98.03	89.69	93.20	63.16	36.62	36.18
Proportion above the upper limit						
Number of countries	1	20	8	46	57	57
Average number of years	2	6.75	6.75	14.30	19.37	19.80
Total sample (%)	0.11	7.40	2.96	36.07	60.53	61.84
Proportion below the lower limit						
Number of countries	7	12	15	4	12	8
Average number of years	4.86	4.42	4.67	3.50	4.33	4.5
Total sample (%)	1.86	2.91	3.84	0.77	2.85	1.97

The 95% confidence intervals estimated by all six models are very wide indicating lack of precision of the turning point estimates. Often this is due to inadequate sample size. Thus, the bootstrapped confidence intervals are calculated, which are also very wide and similar to the actual estimates (not report here).

The pooled regression also gives wide confidence intervals lacking the accuracy of the point estimates. However, as the point estimates are very low compared with the FE estimates (less than 13% of debt-to-GDP ratio) most of sample (up to 61%) falls above the upper limit of 35% of debt-to-GDP ratio compared with only 7% for the FE.

In summary, the turning point of the debt-to-GDP varies considerably depending on whether the model estimated is FE model or the pooled regression model. The FE model predicts a more realistic turning point that coincides with the current literature. The results also indicate that most of the countries have had debt within the 95% confidence interval from 1969 to 1980. However, form 1980s an increasing number of them have had debt above this level. Since the onset of the debt crisis in 1982, almost all of the countries have had debt ratios greater than what is considered optimal. This shows that after two and half decades of debt-management attempts, the situation of many indebted countries is no better than it was at the beginning of the crisis.

Hansen's Threshold Model

Thus far, numerous techniques have been employed to find the threshold effect, the level of debt below which debt enhances growth while above it debt deters growth. The dummy and the spline specification presuppose the threshold level via some arbitrarily manner rather than determining it systematically. Although, the quadratic specification is more flexible than these two, it too suffers from an important drawback of imposing a rather restrictive functional form, which may or may not be an adequate approximation of the true relationship. Therefore, Hansen's (1996, 2000) model is preferred as it determines the threshold endogenously and allows an unrestricted functional form.

Thresholds Estimates

The first step of Hansen's (1996) threshold model is to determine the number of thresholds by estimating [2.4] over ninety-nine quantiles (1%, 2%…99%) of debt-to-GDP. Using this it is found that there are two thresholds occurring at the 51st and 93rd percentile of debt-to-GDP ratio for model with the country-dummies. This corresponds to a debt-to-GDP ratio of 44.94% and 139%. That is, for this dataset, the critical level of debt-to-GDP ratio is about 45%, below which a country experiences positive growth of output but above it its growth rate slows down leading to negative growth in some circumstances. The model without country-dummies predicts the first threshold at a slightly higher debt ratio of about 53% , which occurs at the 60th percentile of the debt ratio.

The second threshold for this model is at 81st percentile, which corresponds to the debt ratio of 88%. The first threshold predicted by the pooled model is close to the estimate of Cohen (1990) who using quadratic specification found that debt affects growth negatively when debt-to-GDP ratio exceeds 50%, while Pattillo et al (2001) also using quadratic specification found that debt starts to have negative impact on growth when it approaches a debt-to-GDP ratio of 35%-40%. Our estimate is somewhat lower than Cohen's and closer to Pattillo et al (2001).

TABLE 2.14
Threshold Point Estimate, their Associated Bootstrapped P-values for the LM test and the 95% Confidence Intervals

	With Country-dummies	Without Country-dummies
Single threshold		
Point estimate	44.94	52.94
P-value	0.001***	0.001***
Lower bound of 95% confidence interval	31.14	34.87
Upper bound of the 95% confidence interval	61.50	64.78
Double threshold		
Point estimate	139.84	88.26
P-value	0.00***	0.00***
Lower bound of 95% confidence interval	The entire range of LR test statistics falls below the 95% critical values.	
Upper bound of the 95% confidence interval		

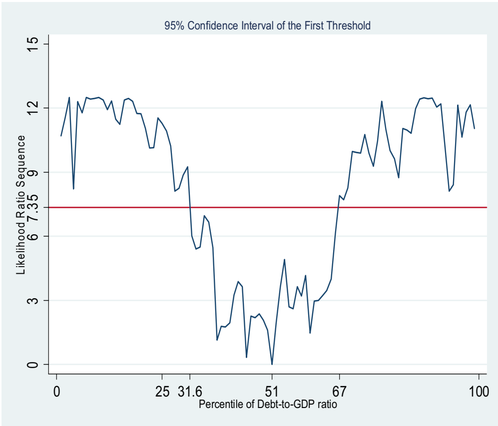
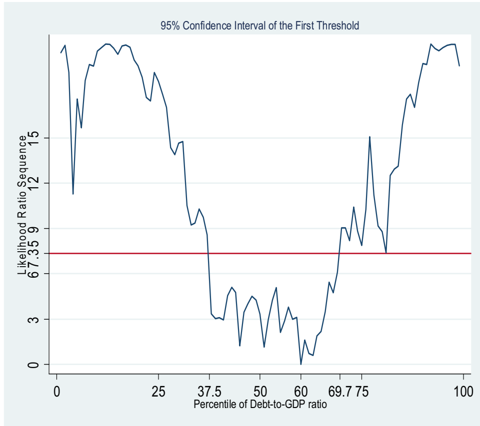
Testing the Significance of the Threshold(s)

After identifying the thresholds one sequentially tests the null hypothesis that there is no threshold using LM test statistics given by [2.99]. The results, summarised in Table 2.14 confirm that all four thresholds found are statistically significant at 1%. This result does support the argument that the debt-growth relationship is nonlinear and the evidences found against this by the interaction debt dummy model are misleading.

It is not adequate to simply report the point estimates without attaching some certainty to them. That is, without knowing how precise the estimates are. Hence, the 95% confidence intervals are also computed and reported in Table 2.14. For the FE the lower confidence interval occurs at 32nd percentile, which corresponds to the debt-to-GDP ratio of about 32%. The upper confidence interval occurs at 67th percentile of the debt corresponding to the debt-to-GDP ratio of 62%. The lower and the upper limits for the model without country-dummies are 35% and 65% of debt-to-GDP. The confidence intervals are slightly higher when the cross-country differences are not controlled for, but the difference between the two bounds is the same for both models. This suggests that although the threshold estimate under FE model is different from the pooled regression, the precision is the same regardless of whether the cross-country differences are controlled for or not. The confidence intervals are reasonably narrow to the point estimate falling within the thirteen and seventeen percentage points of the lower and the upper bound respectively for the FE model. For the pooled model the difference is the same except the upper bound is closer to the threshold. It is not possible to compute the intervals for the second thresholds as the critical values lie above the calculated LR statistics.

Threshold and Confidence Intervals Graphically

The confidence intervals for the threshold estimate can also be found graphically by plotting the LR sequence in *d, LR(d)* against *d* and drawing a horizontal line at the desired level of asymptotic critical values provided by Hansen (2000).[11] The portion of the graph lying below the horizontal line is the 'no rejection' region, i.e. the confidence intervals of the point estimate. Figure 2.2 and Figure 2.3 plot the LR sequence against the percentile of the debt. The threshold is where the LR is minimum and the 95% confidence intervals for the thresholds are where the horizontal line crosses the curve.

FIGURE 2.2 **95% Confidence Intervals for the First Threshold With Country-dummies**	**FIGURE 2.3** **95% Confidence Intervals for the First Threshold Without Country-dummies**
	

Proportion of Sample in Each Debt Regime

Table 2.15 summarises the proportion of sample in each regime. Fifty-five countries are below the first threshold for nearly half of the time-period under investigation, slightly smaller number for a smaller time-period within the two thresholds and 19 above the second threshold (for less than seven years on average). Overall, 51% of the sample falls with a debt-to-GDP ratio of less than 45%, 42% of the sample has debt ratio greater than 45% but less than 139% and only 7% has with debt ratio above 139%.

The proportion of sample below the first threshold estimated by pooled model is 60% and the remaining 40% is roughly divided equally between the other two regimes. Although, the number of countries within each regime changed from year to year, generally speaking there were more countries with debt below the 45% ratio in 1970s and early 1980s and more

[11] The critical values for the for the 95% and the 99% are 7.35 and 10.59

countries with debt above the second threshold of 139% in the mid-1980s to 2000. Countries had particularly high debt during the early 1990s. Similarly, there were more countries with debt below the first threshold prior to mid 1970s, but this changed during the early 1980s, when more and more countries started to have debt above this threshold. Since the debt crisis, the number of countries with debt above the 45% ratio remains high despite decades of efforts by institutions like the Fund-Bank and bettors and creditors to resolve the crises.

TABLE 2.15
Proportion of Sample in Each Debt Regime

Regime	With Country-dummies	Without Country-dummies
$d \le \tilde{d}_1$		
Number of countries	55	57
Average number of years	16.93	19.21
Total sample (%)	51.04	60.03
$\tilde{d}_1 < d < \tilde{d}_2$		
Number of countries	54	46
Average number of years	14.17	8.30
Total sample (%)	41.94	20.94
$d \ge \tilde{d}_2$		
Number of countries	19	32
Average number of years	6.74	10.89
Total sample (%)	7.02	19.02

Parameter Estimates and Associated Standard Errors

The coefficient estimates and their standards errors are reported in Table 2.16. The findings support the hypothesis that physical capital has positive and significant impact on growth; however, human capital appears insignificant for most of the estimators except for the median estimator with country-dummies. Openness, fiscal deficit and the RER are all significant at 1% across all models. However, openness indicator suggests that as a country becomes more "open" its growth rate of GDP per capita declines. To understand this recall that openness can increase because of rising export or a decreasing imports or GDP. If openness increases due to falling imports and/or GDP then the growth rate of output would be negatively affected. Population growth rate is also a significant determinant of growth rate of output. It appears that higher population results in lower growth rate suggesting that the labour force is less productive, which is expected for the DCs given their low level of physical and human capital and technology. Although, the debt-service-to-GDP ratio, reflecting the crowding out effect has the correct sign, it is statistically insignificant.

TABLE 2.16
Threshold Regression Estimates

	With Country-dummies			Without Country-dummies		
	OLS	**Robust**	**Median**	**OLS**	**Robust**	**Median**
Log of investment to GDP ratio	0.044	0.024	0.020	0.049	0.030	0.031
	(0.019)**	(0.007)***	(0.004)***	(0.019)**	(0.007)***	(0.009)***
Lagged log of Investment to GDP ratio	-0.027	-0.005	-0.001	-0.025	-0.008	-0.007
	(0.018)	(0.007)	(0.004)	(0.018)	(0.007)	(0.009)
Growth rate of human capital index	0.180	0.345	0.548	0.289	0.436	0.511
	(0.416)	(0.316)	(0.200)***	(0.412)	(0.298)	(0.388)
Growth rate of openness	-0.107	-0.052	-0.045	-0.101	-0.056	-0.047
	(0.024)***	(0.008)***	(0.005)***	(0.024)***	(0.009)***	(0.011)***
Fiscal deficit to GDP ratio	0.001	0.001	0.001	0.001	0.001	0.001
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Growth rate of real exchange rate	-0.018	-0.021	-0.023	-0.014	-0.019	-0.020
	(0.005)***	(0.003)***	(0.002)***	(0.005)***	(0.002)***	(0.003)***
Growth rate of population	0.646	-0.474	-0.192	0.298	-0.547	-0.329
	(0.233)***	(0.152)***	(0.056)***	(0.379)	(0.111)***	(0.103)***
Log of debt-service to GDP ratio	-0.001	-0.002	-0.001	-0.001	-0.004	-0.003
	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)**	(0.002)
Log of debt-to-GDP ratio						
$J\left(d \le \tilde{d}_1\right)$	0.005	0.004	0.005	0.005	0.003	0.004
	(0.003)*	(0.002)*	(0.001)***	(0.004)	(0.002)	(0.003)
$J\left(\tilde{d}_1 < d < \tilde{d}_2\right)$	0.002	0.001	0.002	0.001	0.001	0.002
	(0.003)	(0.002)	(0.001)	(0.003)	(0.002)	(0.002)
$J\left(d \ge \tilde{d}_2\right)$	0.004	0.003	0.004	-0.001	-0.000	0.000
	(0.003)	(0.002)	(0.001)***	(0.003)	(0.002)	(0.002)
Constant	-0.071	-0.028	-0.043	-0.068	-0.035	-0.049
	(0.018)***	(0.013)**	(0.008)***	(0.019)***	(0.010)***	(0.013)***
Observations	1767	1766	1767	1767	1766	1767
Adjusted R-squared	0.16	0.18		0.13	0.15	
$\tilde{d}_1$		44.94%			52.94%	
$\tilde{d}_2$		139.83%			88.26%	

Dependent variable: Growth rate of GDP per capita
Robust standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

Countries in the lower end of the debt quantiles (i.e. with debt less than 45%) appear to benefit from external debt. A one percentage point increase in debt-to-GDP ratio leads to half a percentage point increase in the growth rate of output per capita. The magnitude of the debt effect on growth rate of output becomes small and statistically insignificant when debt is above 45% but below 139%[12]. The impact of debt in the upper end of the debt quantiles is also positive and significant for the median estimator. The results do not confirm the

[12] However, when only the first threshold is included the overall debt effect is positive and significant, while the effect over and above the threshold level is negative and significant confirming the debt overhang effect.

existence of the debt overhang and the crowding out effects, which might be due to multicolinearity problem as the debt stock and the debt-service are likely to be correlated. This gives rise to an interesting test, testing the joint significance of the debt and debt-service ratios. Results strongly reject that there is no debt effect for all the models. In addition, the null of no debt and crowding out effect for all the models is rejected. Thus, the debt and debt-service has significant impact on the growth rate of the indebted countries (Table 2.16).

Significance of DOH and Crowding-Out Effect

Table 2.17 presents the Wald's test statistics for the significance of the debt overhang and the crowding out effects. The results overwhelmingly reject the null hypothesis in both cases indicating that the debt overhang and the crowding-out effects are statistically significant.

TABLE 2.17
Significance of the DOH & Crowding Out Effect

	With Country-dummies			Without Country-dummies		
Null:	OLS	Robust	Median	OLS	Robust	Median
$\gamma_1 = \gamma_2 = \gamma_3 = 0$	4.71 (0.01)	5.86 (0.00)	8.42 (0.00)	7.66 (0.00)	5.88 (0.00)	8.32 (0.00)
$\gamma_1 = \gamma_2 = \gamma_3 = \beta_{ds} = 0$	3.7 (0.01)	4.84 (0.00)	6.57 (0.00)	6.24 (0.00)	8.40 (0.00)	9.41 (0.00)

2.5.3 Summary of the Results

The dummy interaction model indicates that the relationship between debt and growth could be linear or nonlinear (inverted v-shaped) relationship as is expected. The linear spline specification does not provide robust evidence as to whether the relationship is linear or otherwise. However, one may deduce the existence of a nonlinear relationship between debt and growth and multiple thresholds. As the results from these exogenous threshold models are different for different estimators one can neither support the theories predicting a nonlinear relationship nor refute them. This may be because these specifications are inaccurate way of modelling the nonlinearity of debt-growth relationship. The main criticism of these approaches is that the critical or the threshold level of debt is chosen rather than determined using a statistical estimation method. That is the researcher has to split the sample in some arbitrarily manner instead of determining the threshold endogenously. Thus, the quadratic specification is used, which suggests that the debt-growth relationship is inverted u-shaped relationship as predicted by Cohen and Sachs (1986), Cohen (1990), Calvo (1998), Krugman (1988) and Sachs (1989). However, different estimators give different point estimates of the debt-to-GDP ratio when the impact of debt becomes detrimental to growth – it ranges from as low as 9% to as high as 46%. The OLS estimator, for example gives the highest turning point of the debt-to-GDP ratio of about 46%, while the median estimator suggests that the optimal debt ratio is about 24%, the robust-weighted regression, however, predicts a debt-to-GDP ratio of 36%. Without country-dummies, the point estimates are very low – less than 13%.

This lead us to our preferred model – Hansen (1996, 2000)'s threshold model which not only determines the threshold endogenously it also allows for multiple threshold and does not impose any specific functional form. The results indicate that there are two thresholds, both of which are highly significant. The first threshold identified using FE model is at about 45% and the second[13] is at 139% of debt-to-GDP ratio. The results from the pooled regression suggest that the first threshold is at 53% and the second is at 88%. The results also indicate that most of the countries have had debt within 95% confidence interval from 1969 to 1980. Since 1980, the outset of the debt crisis, almost all of the countries have had debt ratio greater than the threshold level estimated. This shows that after nearly three decades of debt-management attempts, the situation of many indebted countries is as bad as it was at the start of the crisis if not worse.

Our findings that the impact of debt becomes negative at about 45% to 53% of debt-to-GDP ratio are in line with the findings of Pattillo et al (2001) who found that debt starts to have negative effect on growth when it reaches the range 35%-40%. These results are also consistent with Cohen (1997)'s results that a ratio of 50% and above is detrimental for growth. However, the threshold estimate of Elbadawi et al (1997), which are directly comparable with the OLS quadratic specification with country-dummies, is far greater than our estimates. Their threshold value of 97% is closer to our second threshold of 88% via Hansen's methodology. Furthermore, the estimate of Reinhart et al (2003) (15%) is far less than our estimates from Hansen's model but are closer to our estimates from the pooled regression under quadratic specification.

2.6 CONCLUSION AND POLICY IMPLICATIONS

The chapter attempts to answer the question that affects the lives of millions of world's poor people. More specifically, it attempts to find the sustainable level of debt i.e. debt level that is desirable for growth? The current debt levels of DCs are perceived as unsustainable preventing millions from decent standards of living. The ongoing campaign by

[13] Searching in above the 51st quantile as the first threshold occurred at 51st quantile

coalitions like JDC and WDM have certainly brought the debt issue to everyone's attention especially the world leaders.

These campaigns are based on the general consensus that too much debt is preventing poor countries from developing and eradicating poverty. This perception is supported academically by the work of Krugman, Sachs, and Cohen amongst others who have demonstrated that the debt-growth relationship is nonlinear such that there is a critical or a threshold level of debt beyond which the effect is negative but below it the effect is positive. Furthermore, debt relief schemes such as HIPCs initiative by the Fund-Bank is based on this argument. However, the actual thresholds used to carry out the debt sustainability analysis of a country in order to decide the debt relief it can receive are arbitrarily determined.

The chapter addresses this need by employing an advance methodology that not only determines the threshold endogenously but also allows for multiple thresholds whose statistical significance can be tested. For this the study uses a panel dataset consisting of 32 years from 1969 to 2000 for 56 highly indebted low/medium income countries that have been suffering from the debt crisis since the 1980s.

Two thresholds above which growth would suffer have been identified. The first threshold is at a debt-to-GDP ratio of 45% suggesting that debt becomes detrimental to growth once the debt ratio reaches this threshold. In other words, debt is sustainable as long as the debt-to-GDP ratio remains below 45%. This finding is in line with the findings of others such as Pattillo et al and Cohen.

However, what is the growth maximising level of debt, which debtors should aim for? This question is addressed by searching for the threshold values of debt within the lower range of the growth distribution and the findings suggest that a debt-to-GDP ratio of 7% is the growth maximising level of debt. Nearly 96% of the sample countries have had debt above this growth maximising level. The debt level has been particularly high since the late 1970s in SSA countries but in LAC countries, the problems became severe in the early 1980s. All these countries will benefit from debt reduction. The question of how much will they gain in terms of higher growth rate of output per capita is left for future research.

3 ASSESSING INTERTEMPORAL DEBT SUSTAINABILITY; PANEL INTEGRATION & COINTEGRATION METHODS

3.1 INTRODUCTION

Debt levels are important indicators of a country's performance to both policymakers and investors. Short-term debt levels are not a major concern, as the imbalance is the natural outcome of reallocating capital to the country which has the highest possible returns (Hakkio 1995). However, large and persistent debt levels tend to result in serious problems for the country and may require policy reforms or structural changes to the economy in order to reduce the debt to sustainable levels. Large debt levels not only impose a burden on the future generations by increasing interest payments but also deter investments as they indicate high future taxes on investment returns (Krugman 1988). High debt levels may also result in devaluation and/or tighter macroeconomic policy. All of these factors can lead to lower standards of living as they reduce the future output of the country. Indeed the call for the debt cancellation by DCs and non-government organisations like JDC is based on the understanding that DCs debt is damaging the growth and development of these countries and preventing millions from decent standards of living. It is argued that a country's DS is very important for its stability that promotes economic growth.

The persistently high external debt experienced by many DCs since the early 1980s has motivated considerable interest in a number of issues related to the stock of debt and the growth and the development of these countries. The sustainability of these countries' debt is one of the prominent issues. Numerous efforts have been made by the debtor governments, non-government coalitions such as JDC and the Fund-Bank to reduce the debt stocks to sustainable levels. The Fund-Bank define debt to be sustainable if the current debt stock can be serviced without resorting to exceptional financing or major correction in the balance of income and expenditure, i.e. rolling-over or restructuring of debt and/or interest payments.

Academically, DS has been assessed in one of two ways: threshold indicators or the satisfaction of IBC. The previous chapter estimated threshold levels of debt below which debt promotes growth but above which, debt hinders growth, i.e., it investigated the *threshold sustainability* and found that a debt-to-GDP ratio above 45% is growth-damaging.

In this chapter the second sustainability concept (IBC) is employed to assess the debt situation of 56 DCs over the 32 years from 1969. According to the IBC, a country's debt is sustainable as long as it satisfies the No Ponzi Game (NPG) condition which requires the actual external debt of a country to equal the present discounted value of its future trade balances surpluses.

The empirical implications derived from the IBC are expressed in terms of the time-series properties of a country's debt, output and their ratio. It is argued that for a sustainable level of debt, the debt-to-GDP ratio must be I(0) or the debt stock and the GDP should be cointegrated. The empirical analyses are carried out using two different approaches: the unit root approach suggested by Hamilton and Flavin (1986) and the cointegration method proposed by Trehan and Walsh (1988 1991) and Hakkio and Rush (1991). The main difference between the two is that whilst the unit root method restricts the Cointegrating Vector (CV) for the debt-to-GDP relationship to be $(1,-1)$ the cointegration approach allows it to be $(1,\beta)$, where $\beta \neq 1$.

The overall empirical results from the unit root tests suggest that debt is *unsustainable* for most of countries in the sample but not for all of them. The cointegration approach gives different result depending on the test used. Kao (1998) and Johansen (1995) tests indicate that debt is sustainable as debt and GDP are cointegrated whilst MK's LM test suggests that debt is not sustainable as debt and output are not cointegrated. Since the LM test has smaller size distortion its results are more reliable. Therefore, the general conclusion is that the debt levels of DCs are indeed *unsustainable* in the sense that their debt-to-GDP ratio is nonstationary or debt and output are not cointegrated. This finding provides a relatively formal statistical analysis that supports the widely held view that these countries have been facing debt servicing problems since the early 1980s. Their debt levels have been accumulating as they have been unable to service their outstanding debt without further borrowing and/or rolling-over. Creditors continue lending just enough to prevent debtors from defaulting, as doing so keeps creditors' option of being repaid alive whereas defaulting means that creditors would not be repaid even if in the future debtor experiences high growth.

This chapter is organised as follows: section 3.2 discusses the theoretical criteria for DS, while section 3.3 presents the testable hypotheses and the methodologies used to examine the DS. The data and some preliminary analyses are discussed in section 3.4. The main empirical findings of the chapter are discussed in section 3.5 and the conclusion is presented in section 3.6.

3.2 DS IN POLICY, THEORY & EMPIRICS

It is argued that DS has significant implication for the economic stability of a country which in turn is an essential requirement for economic growth. This section looks at the DS issue from three different perspectives: firstly the practical or the policy views, secondly the theoretical standpoints and lastly the empirical aspects.

The practical viewpoint consists of a brief review of how DS is assessed in practice focusing on the framework the Fund-Bank use to manage the TWD crisis in subsection 3.2.1. The theoretical framework used in the literature to study the DS is introduced and outlined in the subsequent subsection 3.2.2. The empirical subsection surveys the numerous testing procedures related to this theoretical framework, which have been proposed since the seminal paper of Hamilton and Flavin (1987) in 3.2.3.

3.2.1 DEFINING DS IN POLICY

Economic theory is used to propose models that enable the identification of the so called "threshold of solvency" which refers to the ratios of debt-to-GDP, revenue or export under which debt is considered sustainable but above which debt is unsustainable or excessive. From chapter 2 we know that Krugman (1988) and Sachs (1989) proposed the DOH to explain the excessive debt levels of DCs coupled with high levels of capital outflow during 1980s. The authors suggest that there is an optimal debt level below which the debtor does not have any problem servicing the debt so that its debt is considered to be sustainable. However, above this level the debtor finds it difficult to fully meet the debt obligations without resorting to debt rescheduling so its debt is said to be unsustainable.

The Fund-Bank's definition of DS coincides with this idea. They argue that DS is the "ability and the willingness of debtor to meet the current and future external debt service obligation in full without recourse to debt rescheduling or accumulation of arrears and without compromising growth" (The Fund-Bank 2001).[14]

Solving the TWD Crisis – Multi-Lateral Efforts

Since the debt crisis in the 1980s, various efforts have been made by the debtors, creditors, multilateral organisations such as the Fund-Bank to resolve the crisis and bring the debt levels of most highly indebted countries to "sustainable" level. One of the latest schemes to reduce the external debt burden of the most severely indebted low income

[14] World Bank (1998) provides the same definition but without reference to growth

countries to "sustainable level" is the HIPCs initiative promoted by 1996 G8 summit and enhanced in 1999. The aim of the scheme is to reduce the debt level by coordinating the actions of debtors and creditors through multilateral institutions such as the Fund-Bank.

The initiative defines sustainability using debt threshold indicators which are arbitrarily determined. Due to failure of the original HIPC to reduce the debts to sustainable level and the increased pressure from coalitions like JDC, the Fund-Bank "enhanced" the HIPCs initiative. The actual ratios used under each initiative to assess a country's DS are presented in Table 1.1 in the introductory chapter. Countries meeting these requirements, i.e. having debt ratios above these limits, are considered as having "unsustainable" levels of debt and qualify to receive debt relief if they meet certain conditions set by the Fund-Bank.

3.2.2 DS IN THEORY

It is widely asserted that the Fund-Bank have proposed these targets without any analytical reasoning (Hjertholm, 2000). However, there is a large body of literature that originally focused on analysing the sustainability or the solvency of government's debt that has been subsequently extended to study the dynamics of a country's Current Account (CA) or debt. This body of literature has mainly studied the developed countries and has not been applied to DCs' 1980s debt crisis. The literature derives the empirically testable restrictions for DS using the IBC or NPG condition. The NPG condition also known as the PVC states that a country's debt is sustainable as long as the transversality condition or the IBC is satisfied in infinite horizon. For *public* (domestic) debt to be sustainable, it must equal the present discounted value of the future *primary* surpluses. However, for a country's *foreign* debt the necessary sustainability condition is that the current debt stock must equal the present discounted value of future *trade* balances. The criteria for sustainability in terms of the growth rate of output and interest rate on debt is such that for public debt to be sustainable, the primary surplus must be growing at a rate higher than the interest rate on debt so the government has sufficient funds to meet its debt obligations fully. For foreign debt the growth rate of trade balance surplus must exceed the interest rate on debt, so the debtor country has sufficient earnings from its export to meet the debt obligations fully. See below for more detail derivations of sustainability criteria. However, please note that as this study is primarily concerned with foreign debt and because the analysis for government debt is similar to foreign debt the following discussion is limited to current account only.

After deriving empirically testable conditions for debt sustainability an empirical test of DS is performed either in a unit root or in a cointegration framework. Hamilton and Falvin (1987) and Wilcox (1989) argue that in order for the IBC to be satisfied, debt should be a stationary process. Hakkio and Rush (1991), Smith and Zin (1991) and Trehan and Walsh (1988) alternatively, argue that debt should be cointegrated with fiscal or CA deficit/surplus for the IBC to be satisfied. A brief description of these tests is given in 3.2.3.

Intertemporal Budget Constraint

In order to derive the debt dynamic equation a number of identities are used, including the national accounting identity that states that a country's GDP, (Y_t) consists of three elements: consumption (C_t), investment (I_t) and net export or trade balance (X_t) which is export (E_t) less imports (M_t). The national accounting identity in algebraic form is

$$Y_t = C_t + I_t + (E_t - M_t) = C_t + I_t + X_t \qquad [3.1]$$

The GDP measures the value of the total output produced within a country regardless of the producers' nationality and the value of the total output produced by country's nationals regardless of their location is measured by GNP. GNP equals the GDP plus net factor payment (rD_{t-1}), i.e. $GNP_t = Y_t - rD_{t-1}$. Substituting [3.1] into this GNP identity yields:

$$GNP_t = C_t + I_t + X_t - rD_{t-1} \qquad [3.2]$$

where the last two terms together make up the CA. More explicitly, CA equals the trade balance plus the net factor payment, i.e. $CA_t = X_t + rD_{t-1}$. CA deficit equals the excess of absorption over production more precisely a country's CA deficit implies that the country is consuming more than it is producing thus it must be importing more than it is exporting. Note that if a country has only negative foreign assets (debt) and does not have any domestic assets held by foreigners then the (net) factor payment equals the debt service payment.

Since a country's savings (S_t) equals GNP less consumption equation [3.2] can be expressed in terms of change in debt using the fact that the difference between savings and investment equals the change in the foreign assets (debt)

$$\Delta D_t = rD_{t-1} - X_t = I_t - S_t \qquad [3.3]$$

where D_t is the debt in period *t* and ΔD_t is change in debt. The second equality expresses the CA deficit and the final equality refers to the capital account surplus. If a country has a

CA balanced $(X_t = 0)$, the growth rate of debt equals the interest rate but if it has CA deficit $(X_t < 0)$, the growth rate of debt is above the interest rate whilst if it has CA surpluses $(X_t > 0)$, the growth rate of debt is below the interest rate. Equation [3.3] shows that a country's CA deficit is simply the change in its debt. Re-writing [3.3] in terms of D_t yields the following debt accumulation equation.

$$D_t = (1+r)D_{t-1} - X_t \qquad [3.4]$$

According to [3.4] debt in period *t*, D_t is equal to the debt in period $t-1$, D_{t-1} plus net factor payment or debt service due on last period's debt less trade balance deficit/surplus.

In order to study the debt dynamics and the long-run restrictions required for DS one needs to derive the IBC. Since [3.4] holds for every period one can combine these period by period budget constraints to derive the IBC. That is, by taking expectations of [3.2] and recursively eliminating future values of the stock of debt one can derive the IBC as [15]

$$(1+r)D_t = \sum_{j=1}^{\infty}\left(\frac{1}{1+r}\right)^j X_{t+1+j} + {}_j \underset{\longrightarrow\infty}{lim}\left(\frac{1}{1+r}\right)^j D_{t+1+j} \qquad [3.5]$$

The most important term of the above equation is the last term. If it is positive then the country is considered to be "bubble financing"[16] its debt. If it is negative then the country is making Pareto inferior decisions because creditors can raise their welfare by consuming more and lending less. Husted 1992 explains this scenario. Thus, it must be zero if both lenders and borrowers are making optimal decisions. McCallum (1984) argues that for a dynamically efficient economy[17] in steady-state equilibrium with constant interest rate the transversality condition of the lender's utility maximisation problem directly implies the NPG condition. That is, the imposition of NPG condition or satisfaction of PVC is the optimal behaviour of lenders in a deterministic model with no population growth. The NPG condition requires that the last term in equation [3.5] equals zero.

---

[15] In deriving the above IBC it has been assumed, for expositional simplicity, that the (expected) interest rate is constant over time rather than time varying. A generalisation of a time varying interest rate does not add to the problem being considered here. See Cuddington (1997) for details of PVC with non-constant interest rate.

[16] Bubble refers to either an economic cycle characterized by rapid expansion followed by a contraction, or a surge in equity prices, often more than warranted by the fundamentals and usually in a particular sector, followed by a drastic drop in prices as a massive sell off occurs, i.e. security prices rise above their true value and will continue to do so until prices go into freefall and the bubble bursts.

[17] An economy that appropriately balances short-run concerns (static efficiency) with long-run concerns

$$\lim_{j\to\infty}\left(\frac{1}{1+r}\right)^{j} D_{t+1+j} = 0 \qquad [3.6]$$

This condition states that the present value of net foreign assets in the indefinite future converges to zero implying that debt cannot grow faster than the average interest rate on it.

The NPG condition in [3.6] is justified by the argument that lenders would not allow the borrowers to perpetually pay their entire current interest obligations by further borrowing as doing so would lead to debt growing at a rate equal to interest rate and thus the discounted value of debt in [3.6] would not converge to zero. If $lim_{j\to\infty}(1+r)^{-j} D_{t+T+1} > 0$, the present value of what the country is consuming and investing exceeds the present value of its output by an amount that is always nonzero. The economy is continually borrowing to meet the interest payments on its debt rather than reducing its consumption $(C+I+G)$ below its output (Y) to pay off its existing debt. Consequently, debt is growing at a rate greater than interest rate and the limit in [3.6] is always positive. However, creditors would never allow such a Ponzi scheme at their expense as it amounts to providing free resources to debtors which they could consume themselves in order to maximise their own utility. Likewise the limit in [3.6] can never be strictly negative as the domestic residents are now providing free resources to foreigners which they can consume themselves and increase their own utility level. Only when $lim_{j\to\infty}(1+r)^{-j} D_{t+T+1} = 0$ is the economy asymptotically consuming the resources its budget constraint permits. Thus, condition [3.6] is a necessary and a sufficient condition for optimality.

IBC together with the NPG condition implies that debt is subject to present value borrowing constraint. That is debt at any point in time must equal the present value of expected future CA surpluses:

$$D_t = \sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^{j} X_{t+j} \qquad [3.7]$$

Equation [3.7] states that the present value of an economy's resource transfers to foreigners (i.e. trade balance) must equal the value of the economy's initial debt. Hence, the IBC is satisfied if and only if the country pays off its initial (current) debt through sufficiently large future trade balance surpluses. However, the IBC approach has been criticised as it does not impose any limits on the growth rate of debt, it merely requires that country's debt level must equal the present discounted value of future trade balance surpluses.

Drawbacks of IBC criterion

The IBC approach has been criticised for being too loose and impractical. McCallum (1984) illustrated that a permanent deficit inclusive of interest payment could be consistent with optimising behaviour satisfying NPG condition, but not permanent deficit exclusive of interest. In other words, IBC imposes only a mild restriction on the evolution of a country's CA and debt. It only requires that the country's discounted value of the net foreign assets is zero in the infinite horizon. Alternatively, the condition states that as long as there is an expectation that the country will run CA surpluses in the future, it can have a very large CA deficit for a long period of time or it can have a permanent deficit as long as it can pay the interest payments. That is, provided that the CA inclusive of interest payments is stationary a country can run an indefinite deficit. However, it is unrealistic and infeasible to run large trade surpluses in the long-run to finance persistently excessive trade deficits in the short run. The exchange rate and domestic income adjustment to contract imports and expand exports (or rise savings and cut investments) may be excessive and inefficient if a country runs a trade deficit for too long; and markets may not allow it to borrow for that long period.

Under the IBC criterion for DS, stock of debt of a country can increase without limits as long as it does not increase faster than the real interest rate the DS condition is satisfied. The criterion however does impose some limits on the behaviour of trade balances. It implies that the discounted value of trade balances should be at least equal to the initial debt of the country; if a country is initially running trade deficits and has a stock of debt; it needs to run trade surpluses over time to satisfy its IBC.

Given the looseness of the IBC criterion for DS and the inefficiency or the infeasibility to run trade deficits for a long time in expectation of running trade surpluses in an uncertain future, it may be more reasonable to consider some other criterion for DS. If the country's growth rate is less than the real interest rate the debt-to-GDP ratio is growing at an increasing rate over time but according to the IBC country's debt is sustainable even under such circumstances. In fact, the dynamics of the CA those lead to an increase of the debt-to-GDP ratio without bounds can be seen as being effectively unsustainable: the financial markets will eventually get concerned about the country's ability and willingness to repay its debt and will limit its borrowing leading to a debt crisis.

Feve and Henin (2000) also argue that whilst the PVC is a plausible measure of sustainability theoretically, it is not consistent with the practical concept of sustainability.

That is, in a dynamically efficient economy, which has an interest rate higher than the growth rate of its GDP, debt-to-GDP and interest-to-GDP can grow without limits while satisfying the PVC. They argue that a more practical criterion that takes into account the country's ability to repay in terms of its growth rate is required and they propose examining the boundness of debt-to-GDP ratio for assessing the DS.

Therefore, a non-increasing debt-to-GDP ratio is seen as a practical condition for sustainability - a country is likely to remain sustainable as long as the ratio is not growing. This criterion is related to the "resource balance gap". In a country where the debt-to-GDP ratio is growing, the gap (which is the difference between the current trade balance and the trade surplus required to stabilise the debt-to-GDP ratio) becomes wider. Such a required trade surplus is larger the higher the debt-to-GDP ratio is and the greater the differential between the real interest rate and the growth rate of the economy is. The following subsection discusses an alternative criterion for sustainability.

Alternative criterion for DS

Following the drawbacks of the IBC criterion for DS, Feve and Henin (2000) propose "effective sustainability" criterion where debt-to-GDP ratio is bounded such that the probability of debt-to-GDP ratio, d_t, exceeding some upper limit of debt ratio, d_u, is always less than one.

$$0 < \left[\Pr\left(\lim_{t \to \infty} d_t > d_u \right) \right] < 1 \qquad [3.8]$$

One can think of the upper limit of debt as corresponding to the Maastricht criterion of debt-to-GDP ratio of 60% for European countries, or the Fund-Bank criterion of debt-to-GDP ratio of 50% used to assess the DS for the DCs. It can also be seen as a threshold used under the HIPC initiative whereby a country with debt-to-export ratio above 150% is considered unsustainable.

Under this sustainability criterion a country that has growing GDP can run perpetual CA deficits and still maintain a constant debt-to-GDP ratio. In order to express the relationship between the sustainability condition based on IBC and the sustainability condition based on the debt-to-GDP ratio the debt dynamic equation, [3.2] can be rewritten in terms of the debt-to-GDP ratio.

$$\frac{D_t}{Y_t} = \frac{(1+r)D_{t-1}}{(1+g)Y_{t-1}} - \frac{X_t}{Y_t} \qquad [3.9]$$

where $Y_t = (1+g)Y_{t-1}$ and $g > 0$ is the growth rate of GDP between period *t-1* and *t*. Now the debt dynamics depend on the ratio of interest factor to growth factor. Thus, debt is increasing when $r > g$ and $X_t = 0$ as the growth rate is not sufficient to fully service the debt. The debtor country is required to borrow further in order to pay the interest charges on its existing debt, or simply reschedule the payments. Both of these lead to a higher level of debt, which may result in debt crisis. However, debt is growing at a smaller rate than the GDP when $r < g$ so that there is no threat of a default or debt crisis. In fact, if the country were to maintain the same level of borrowing then its debt would shrink over time and the country could become a net creditor.

The change in debt-to-GDP ratio can be written as:

$$\Delta d_t = \frac{(r-g)}{(1+g)} d_{t-1} - x_t \qquad [3.10]$$

where $d_t \equiv D_t / Y_t$ and $x_t \equiv X_t / Y_t$. From [3.10] it is apparent that if $x_t = 0$, the debt-to-GDP ratio will increase or decrease at the interest rate in excess of the growth rate of GDP.[18] If however, the trade balance to GDP is positive (i.e. in surpluses) then debt-to-GDP ratio will grow at a rate less than $(r-g)$, but if the trade balance is in deficit then debt ratio will grow at a rate higher than $(r-g)$. In order to keep the debt-to-GDP ratio constant, i.e. have a sustainable level of debt according to this definition of sustainability, the country has to run a trade surplus as a fraction of GDP that is equal to the interest payment in excess of growth rate:

$$x_t = \frac{(r-g)}{(1+g)} d_{t-1} \qquad [3.11]$$

The right hand side of the equation [3.11] measures the debt burden on the economy. The higher this burden is the greater the likelihood that the debt is or will become unsustainable in the sense that the cost of servicing the debt will become too large inducing the debtor country to default. Cohen and Sachs (1986) developed a model where they

[18] Feve and Henin (2000) call this excess interest rate as the growth corrected real interest rate and the right hand side term of equation [3.10] the growth corrected surplus/deficit ratio.

consider when a default becomes a profitable option for the debtor. Thus, to maintain a constant debt to output ratio the country only needs to be able to pay the excess of interest over growth rate and the necessary amount of trade balance surplus to GDP equals the interest payment in excess of growth rate.

3.2.3 DS IN ECONOMETRICS; A SURVEY

Numerous tests have been put forward to test the NPG condition in order to determine whether a country's budget deficit is sustainable or not. The first was a unit root test proposed by Hamilton and Flavin (1984) which was further developed by Trehan and Walsh (1991) for non-stationary cases leading to cointegration tests of debt and deficits. These tests have been extended to study the sustainability of CA or the external debt of a country which is mainly applied to developed countries datasets. The following subsection outlines various tests that have been proposed for testing the DS. Firstly it reviews Hamilton and Flavin's test, then Trehan and Walsh's and finally Hakkio and Rush's.

Hamilton and Flavin Test

Section 3.2.2 shows that debt is sustainable if the NPG condition holds. Using this argument Hamilton and Flavin derived the empirically testable restrictions for assessing the DS. They showed that the NPG, condition holds if debt and the present discounted value of future surpluses are stationary. They derived this restriction using the average real interest rate to evaluate the debt evolution equation such that the difference between actual and the average real rate is expressed as the error term. i.e. $D_t = (1+r)D_{t-1} - X_t + \varepsilon_t$, where ε is the error term defined as $\varepsilon = (r_t - r)D_{t-1}$. Here r_t denotes the ex post real interest rate on debt in period t and r is the average interest rate. Iterating forward and imposing the NPG condition [3.6] yields

$$D_{t-1} = \sum_{j=0}^{\infty}(1+r)^{-(j+1)}X_{t+j} + \eta_t \qquad [3.12]$$

where $\eta_t \equiv \sum_{j=0}^{\infty}(1+r)^{-(j+1)}\varepsilon_{t+j}$ is assumed to be a mean zero stationary process. Therefore debt is stable only if $\sum_{j=0}^{\infty}(1+r)^{-(j+1)}X_{t+j}$ is a stationary process. Otherwise debt becomes explosive and the NPG condition is violated. In empirical analysis stationarity of debt is tested to examine the DS in this framework.

Trehan and Walsh Test

Trehan and Walsh (1991) prove that Hamilton and Flavin test is appropriate as long as debt series can be characterised as a general Autoregressive Moving Average (ARMA) process. When debt is an ARMA/ARIMA process PVC holds if and only if both debt and deficit/surpluses are integrated of the same order. Furthermore they demonstrate that in the case where deficit is a non-stationary process the PVC holds if there is a linear combination of X_t and D_{t-1} that is stationary. That is NPG condition implies that debt and deficit should be cointegrated. They propose that if a variable such as debt evolves according to equation [3.4] with constant interest rate and $(1-\delta L)X_t$ is a mean zero stationary process with $0 \le \delta < (1+r)$, then the PVC holds if there is a linear combination of D_t and X_{t-1} that is stationary. They also showed that if debt is a difference stationary process (i.e. $\delta = 1$) then PVC holds only if the interest inclusive of trade deficit $(X_t + rD_{t-1})$, that is the CA, is stationary. For debt to be sustainable it should be cointegrated with the trade deficit with the CV$(1, r)$.

Hakkio and Rush Test

Hakkio and Rush (1991) proposed an alternative method of testing the PVC, which consists of testing for cointegration between export and import. The validity of their test depends on two key assumptions: firstly r_t is assumed to be stationary with unconditional mean r and secondly export and import are unit root, i.e. $I(1)$ processes.

They showed that country's debt is stable if import and export are cointegrated with vector $(1,-1)$ but argued that this is not a necessary condition unless export and import are expressed as a ratio of GDP or population. The test for the stability of debt in this framework boils down to testing whether export and import are cointegrated or not, or alternatively testing whether the error term of the estimation equation is stationary or not. Testing whether the CV is $(1,-1)$, which is testing whether β equals unity or not is only necessary when debt is expressed as a ratio of GDP or export.

The above three procedures showed that empirically DS can be tested under the IBC by examining the time series properties of debt and related variables such as trade balance, CA, import and export. The following section uses this idea of studying the time series properties of debt and output for assessing the DS.

3.2.4 SECTION SUMMARY

This section has discussed the topic of DS from policy, theory and empirical perspectives. In policy the threshold concept of DS is applied by multilateral organisations like the Fund-Bank to reduce the debt levels of DCs to sustainable levels. The Fund-Bank have proposed under the HIPC initiative that a NPV of debt-to-export ratio above 150% is unsustainable. However, this threshold is neither based on any theoretical justification nor is it derived from any econometric model despite the fact that there is an extensive set of literature arguing that in the absences of any restrictions on borrowing, a country continue (over-) borrowing. Furthermore, it will be able to meet its debt service charges by simply further borrowing and thus it can continually rollover its debt without ever having to re-pay it, at least in full, leading to an ever increasing debt. However, it is unlikely that the lender will be willing to lend such an amount. Accordingly, the PVC or a NPG condition is imposed to prevent a country from following such an explosive debt path whilst allowing for short-term indebtedness. The IBC requires that the initial debt equals discounted value of future trade surpluses. That is a country running a trade deficit now must run trade surpluses in the future equal to the initial debt in order to keep its debt at sustainable level.

Although, the IBC imposes limits on the behaviour of the trade balances, it does not impose any restrictions on the growth rate of debt. When interest rate is higher than the growth rate of GDP, the debt-to-GDP ratio is growing at an increasing rate, but under the IBC criterion debt is still sustainable as long as the initial debt equals the discounted future surpluses. Therefore, an alternative criterion based on the debt-to-GDP ratio is considered to be more practical and realistic measure of DS.

Finally, the econometric tests that have been proposed in the literature for assessing the DS are briefly outlined.

3.3 TESTABLE HYPOTHESES & METHODOLOGIES

Section 3.2.2 presents the IBC argument that debt is sustainable if NPG condition is satisfied. It goes on to claim that, this condition is not sufficient as it does not limit the growth of debt. A more realistic and practical measure is to study the relationship between debt and output. As long as debt is growing in line with the GDP, i.e. if there is a long-run equilibrium relationship between debt and output then debtor would not have any problem servicing the debt so the debt level would be sustainable. This essentially means that as long as growth rate of output exceeds the interest rate, debt (in theory) is serviceable. However, for public debt there is an additional condition that the primary surplus grows at a higher rate than the interest rate. For foreign debt, the trade surplus growth must exceed the interest rate. In this study, we only consider the first condition and leave the second condition for future research on this topic. The underlying assumption here is that if growth is sufficient then there will be surpluses to meet the debt obligations. Hence, for public debt we are assuming that an efficient tax system is in place so that changes in output lead to changes in tax revenues. Similarly, it is assumed that changes in output are strongly correlated with changes in trade balance.

The requirement of a long-run relationship between debt and output has an interesting implication that is empirically testable. The debt sustainability requirement in terms of the time series properties of debt and output is that while these two variables are nonstatioanry a combination of them should be stationary. Otherwise, debt can grow without any limits and drift away from output leading to explosive debt situations where a debtor can no longer meet the debt obligations from its income, as the amount of money required to service the debt exceeds the income it receives in terms of its GDP.

In econometric terms, the sustainability criterion requires that the mean and variance of the error (ε_{it}) in following equation is independent of time.

$$D_{it} = \alpha_i Y_{it}^{\beta_i} \exp(\varepsilon_{it}) \qquad [3.13]$$

where α_i is a constant, β_i is the CV, D_{it} and Y_{it} are debt stock and output in period *t* for country *i* respectively.

The most advanced techniques available in the empirical literature to study the long-run equilibrium relationship between variables are integration and cointegration tests. In this chapter, numerous univariate and panel data integration and cointegration techniques are used to test the DS of DCs. These can be categorised into three types. The first is the unit root tests, while the second is the single equation panel cointegration tests and the final is the systems likelihood-based approach developed by Johansen (1995) and its extension to panel data by Larsson, Lyhagen and Lothgren (2001) (henceforth LLL). Furthermore Fisher (1932)'s idea is applied to develop a new test for testing restrictions on the long-run CV in panel data. The remainder of this section is divided into two parts: the first outlines the unit root approaches in subsection 3.3.1 and the second discusses the cointegration approaches in subsection 3.3.2.

3.3.1 UNIT ROOT APPROACHES

As stated above debt is sustainable as long as debt and output have a long-run equilibrium relationship which in terms of integration and cointegration methods entails a combination of debt and output that is stationary. A special combination of debt and output is the debt-to-GDP ratio where the CV β_i is restricted to 1. Assessing DS in this special case simply involves testing for the stationarity of debt-to-GDP ratio. Transforming [3.13] into a debt-to-GDP ratio relationship involves setting β_i to unity and dividing the equation by Y_{it}, resulting in $\left(D/Y\right)_{it} = \alpha_i \exp\left(\varepsilon_{it}\right)$.

In order to explain how unit root test can be used to test the DS suppose that the log of debt-to-GDP ratio is generated by AR(1) process

$$d_{it} = \alpha_i + \rho_i d_{it-1} + \varepsilon_{it} \qquad [3.14]$$

where $d_{it} \equiv \ln\left(D/Y\right)_{it}$, ε_{it} is iid with zero mean and α_i is the constant term reflecting the cross-country variations. The necessary condition for stable debt ratio is that $\rho_i < 1$ which ensures that the debt and/or the interest rate charges do not grow out of line with the GDP. In other words, testing for the sustainability of debt boils down to simply testing whether debt-to-GDP ratio is stationary or not i.e. whether $\rho_i < 1$ or not. The empirical analyses of this chapter use two different unit root methods to assess the DS of DCs. The first is the univariate unit root tests that are conducted for each country individually and the second is the panel unit root tests that combine the individual country test statistics to compute the panel versions. The reminder of this section firstly outlines the univariate tests and then the panel tests employed in this study.

Univariate Unit Root Methods

Three univariate unit root tests are performed to assess the DS and to ensure that the results are robust. The first is the Augmented Dickey Fuller (ADF) test proposed by Dickey and Fuller (1979). The second is the Phillips and Perron (PP) (1988) test and the final is the DF-GLS test proposed by Elliot, Rothenberg and Stock (ERS) (1996).

For the ADF test an augmented version of [3.14] such as

$$\Delta d_t = \delta' w_t + \tilde{\rho} d_{t-1} + \sum_{j=1}^{J} \gamma \Delta d_{t-j} + \varepsilon_t \qquad [3.15]$$

is estimated for each country individually. Where $\tilde{\rho} \equiv (\rho - 1)$, δ is a vector of parameters of the deterministic such as constant and trend while w which is either (1) or $(1, t)$ is the vector of deterministic included in the model. Finally J is the maximum number of lags of the dependent variable included to ensure that error is white noise. The null is that the debt ratio is a unit root process $(\tilde{\rho} = 0)$ against the alternative that it is a stationary process, i.e. has no unit root $(\tilde{\rho} < 0)$.

PP developed a number of unit root tests as a generalization of the ADF test that allow for a weaker set of assumptions concerning the error process. Their tests differ from the ADF tests mainly in how they deal with potential serial correlation and heteroskedasticity in the errors. While the ADF tests use a parametric autoregression to approximate the ARMA structure of the errors in the test regression, the PP test corrects for any serial correlation and heteroskedasticity in the errors of the test regression by directly modifying the test statistics. PP test estimates [3.15] without the lag terms and under the null hypothesis that $\tilde{\rho} = 0$, the test statistics have the same asymptotic distributions as the ADF statistics.

In general, the ADF and PP tests have very low power against I(0) alternatives that are close to being I(1). That is, these tests cannot distinguish highly persistent stationary processes from nonstationary processes very well. In addition, their power diminishes as deterministic terms are added to the test regressions. Hence, tests that include a constant and a trend in the test regression have less power than the tests that include only a constant.

To increase the power of the test particularly against very persistent alternatives, ERS (1996) proposed a new test known as the DF-GLS. ERS derived a class of test statistics referred to as *efficient unit root tests* that have substantially higher power than the ADF and PP unit root tests especially when $\tilde{\rho}$ is close to zero. ERS's efficient test for an autoregressive unit root is similar to an (augmented) DF unit root statistics, but has the best overall performance in terms of small-sample size and power, dominating the ordinary DF test. The generalised least square unit root test, otherwise know as DF-GLS "has substantially improved power when an unknown mean or trend is present" (ERS, p.813).

ERS assume that the DGP is $d_t = \delta' w_t + u_t$ where $u_t = \rho u_{t-1} + v_t$. The null is that d_t is $I(1)$, so that $\rho = 1$ and the alternative is that d_t is $I(0)$ so that $|\rho| < 1$. The procedure involves detrending or demeaning the data set and then testing for a unit root using the usual ADF test regression without any deterministic components at the second stage. For detrending (demeaning) the data, ERS use the trend parameters $\hat{\delta}$ estimated under the alternative that $\rho < 1$ and define the detrended (demeaned) series as $\tilde{d}_t = d_t - \hat{\delta} w_t$. The authors call this detrending procedure GLS de-trending and then use the GLS de-trended data to estimate the ADF test regression by least square and compute the t-statistics for $\rho = 0$.

When only a constant is included, ERS show that the asymptotic distribution of the DF-GLS test is the same as the ADF t-test, but has higher asymptotic power (against local alternatives) than the DF t-test. When both a constant and a trend are included the asymptotic distribution of the DF-GLS test, however, is different from the ADF t-test. ERS and Ng and Perron (2001) provide critical values for the DF-GLS test in this case.

Panel Unit Root Methods

Since the univariate unit root tests suffer from low power, more powerful tests known as panel unit root tests have been proposed. The literature on panel techniques has grown extensively over the last decade in search of finding more powerful unit root and/or cointegration tests by adding cross-section dimension to the analyses. The logic behind the argument is that since these tests require long time-series, which are unavailable in practice, one can perhaps use the cross-sectional dimension to increase the dataset and thus the power of these tests. However, adding a cross-sectional dimension to the time-series results in a whole set of new challenges. A number of surveys, including Banerjee (1999), Phillips and Moon (2000), Baltagi and Kao (2000) and Smith (2000) have been conducted on this fast growing literature reviewing the new tests and techniques that have been developed. Here only a brief outline of the various tests employed to investigate the sustainability of DCs' debt is presented.

The analysis of unit roots and cointegration for panel data started with the work of Levin and Lin (1992, 1993) (LL) and Quah (1994). Quah studied the null of unit root in panels with homogenous dynamics while Levin and Lin proposed a test that allowed heterogeneous dynamics, fixed effects and individual-specific deterministic trends. However, these tests were rather restrictive as they tested under the null and the alternative that each cross-section unit has a common autoregressive root. That is $\rho_i = \rho$ for all i under the null and the alternative. While the hypothesis is acceptable under the null, it is implausible under the alternative as it implies not only that each cross-section has no unit root but also that they have the same value of ρ. This would mean in growth literature, for example, that all countries converge at the same rate. Consequently a number of more general tests have been proposed in the literature. In this study, three such panel unit root tests including Im Pesaran and Shin (IPS) (1997, 2003), Maddala and Wu (MW) (1999) and Hadri (2000) are considered.

Im Pesaran and Shin (1997, 2003) test

IPS (1997) proposed a test to allow heterogeneous ρ_i under the alternative. Another important difference of IPS test from the LL test is that a separate unit root test is performed for each cross sectional unit, such as a country instead of pooling the data. IPS proposed two panel data unit-root tests, the so-called $\overline{LM}_{bar}$ and $\bar{t}_{bar}$ tests. Both of them are based on the estimation of individual ADF regressions and then combining the individual test statistics by taking an average over the cross-section.

The $\bar{t}_{bar}$ test statistic use the individual t-statistic computed from the ADF test under the null of a unit root. Denoting the i[th] country's t-statistic as $t_{i,T}$, the $\bar{t}_{bar}$ statistic is calculated as:

$$\bar{t}_{bar} = \frac{\sqrt{N}\left[\left(\frac{1}{N}\sum_{i=1}^{N} t_{i,T}\right) - E(t_T)\right]}{\sqrt{Var(t_T)}} \qquad [3.16]$$

where the mean $E(t_T)$ and variance $Var(t_T)$ are the adjustment terms used to standardise the test statistic. These are computed by Monte Carlo simulation and are given in IPS (1997, *Table 2*).

The $\overline{LM}_{bar}$ test is similar to the $\bar{t}_{bar}$ test, but it uses the group-mean Lagrange Multiplier (*LM*) statistic computed from the individual *LM*-statistics for testing the null of a unit root rather than the *t*-statistics. The appropriate mean $E(LM_T)$ and variance $Var(LM_T)$ adjustment terms for $\overline{LM}_{bar}$ statistics are provided in IPS (1997, *Table 1*).

Using the Central Limit Theorem IPS showed that under the null, as both T and N become sufficiently large the test statistics have the standard normal distribution in the limit. Hence the critical values can be obtained from the upper and the lower tail of the $N(0,1)$ distribution for $\overline{LM}_{bar}$ and $\bar{t}_{bar}$ statistics respectively. However, for small samples IPS have provided the appropriate value in IPS (2003, Table 2)

Monte Carlo simulations of IPS (1997) show that in finite samples the $\overline{LM}_{bar}$ and the $\bar{t}_{bar}$ tests perform reasonably well, granted that the orders of the individual augmented DF regressions are not underestimated. The $\bar{t}_{bar}$ test marginally outperforms the $\overline{LM}_{bar}$ test, and both are far better than the LL test.

Although IPS test was proposed as a generalisation of LL test, it too has some restrictions such as the requirement of a balanced panel, same lag structure for all cross-section units. The test is asymptotic and requires large T and N to be normally distributed, i.e. there is a large small bias requiring simulation method to generate critical values for small samples. Some of these issues have been addressed in the later version of the paper, IPS (2003), where they proposed a modified $\bar{t}_{bar}$ statistics that allows for unbalanced panel and provided the critical value for small samples in Table 2 of their paper. The test statistics for unbalance panel uses the average of adjustment terms across cross sections.

Maddala and Wu (1999)

Although the latter version of IPS test does not require balanced panels, the procedure is parametric and one still needs the means and the variances adjustment terms that can only be obtainable by simulation in order to calculate the test statistics. Unlike the IPS tests, the procedure advocated by MW (1999) is nonparametric and does not require any extra information. Furthermore, the WM test can be adapted to any unit root test, not just the ADF. If the ADF test is used then the null and the alternative hypotheses are the same as under the IPS tests making them directly comparable.

Like the IPS tests, the MW test is based on *N* independent tests on the *N* individuals. However, while the IPS test combines the test statistics, the MW test, following Fisher (1932), combines the observed significance levels. Fisher showed that combining a uniformly distributed variable p, $p \sim U(0,1)$ as $-2\ln p$ yields a chi-square distributed variable x with 2 degrees of freedom (df), i.e. $-2\ln p \equiv x \sim \chi_2^2$. If p_i is the p-value from the unit root test statistics for the i^{th} cross sectional unit then using the additive property of chi-square distribution $-2\sum_{i=1}^{N} \ln p_i$ is chi-squared distributed with *2N* df assuming cross section independence. That is the panel unit root tests statistics for the MW tests is:

$$x = -2\sum_{i=1}^{N} \ln p_i \sim \chi_{2N}^2 \qquad [3.17]$$

According to the Monte Carlo simulations MW test dominates the LL and IPS $\bar{t}_{bar}$ tests in terms of size distortion and relative power. When some of the individual series are stationary and the others are non-stationary, the MW test is the most powerful. The higher the fraction of stationary series in the panel is, the bigger this power advantage.

Hadri (2000)

Hadri (2000) proposed a residual-based LM test that has a null of stationarity for all the panels against the alternative of a unit root in the panel. It is based on the OLS residuals of d_{it} on a constant or a constant and a trend. In particular Hadri considers the regression $d_{it} = \delta w_{it} + \eta_{it} + \varepsilon_{it}$, where $\eta_{it} = \eta_{it-1} + v_{it}$ is a random walk process, and ε_{it} and v_{it} both are generated from N(0,1).

The null hypothesis is that the debt ratio is stationary, i.e. $H_0 : \sigma_{vi}^2 = 0$ and the alternative is that it is non-stationary, i.e. $H_a : \sigma_{vi}^2 > 0$ for country i. The test statistic is based on the partial sum of residuals and can be computed when the cross-section errors are homoskedastic, hetroskedastic or serially independent.

The test statistic is asymptotically normally distributed. Their simulations show good size and power of this test, especially when *T* is above 50. Monte Carlo simulations show that the Hadri test is less prone to size distortions that are caused by contemporaneous correlation.

3.3.2 COINTEGRATION APPROACHES

Alternatively, one can assess the DS by testing for cointegration between debt and GDP. The key difference between cointegration and stationarity tests is that the former allows an unrestricted CV $(1, \beta)$ whilst the latter restricts it to $(1, -1)$. The cointegration framework has a clear advantage over the stationarity tests as it estimates rather than pre-supposes the CV and moreover allows restrictions to be tested on the CV.

Time series cointegration tests, like the unit root tests, have low power particularly when *T* is small, which is often the case as data is limited to post-war periods for developed countries and is even less for the DCs. Thus, several panel cointegration tests have been developed to increase the power by adding cross-sectional dimension.

These panel cointegration tests can be divided into types. The first is the residual-based and the second is the likelihood-based. The following section outlines these two respectively.

Residual-Based Cointegration Approach

The residual-based cointegration tests involve conducting a unit root test on the estimated residuals from the long-run relationship of [3.13], which can be log-linearised as follows:

$$\ln(D_{it}) = \ln(\alpha_i) + \beta_i \ln(Y_{it}) + \varepsilon_{it} \qquad [3.18]$$

The debt level is considered sustainable if the errors term ε_{it} in the above relationship is stationary. Thus testing for the sustainability of debt requires testing for the stationarity of error terms, which in this framework requires a unit root test on the residual ε_{it}.

In this chapter, two types of residual-based tests are used. The first performs a unit root test such as DF/ADF on the residuals from a cointegrating long run equation, like [3.18]. The second one is an LM test where there is a unit root in the MA component of the DGP.

Residual-Based DF/ADF Tests

Kao (1999) proposed a number of residual-based DF and ADF-type panel cointegration tests which involve two stages. In the first stage, a long-run relationship of type [3.18] is estimated to obtain the estimated residuals. In the second stage a unit root test is conducted to test the stationarity of these residuals. For the first stage Kao suggests using a FE model with common CV $(\beta_i = \beta)$ across all countries and country-specific constant α_i.

The null hypothesis of the test is that there is *no cointegration* between debt and output which in this framework simply involves testing whether the residuals from the long-run equation [3.18] are stationary or not, i.e. whether $\rho = 1$ or $\rho < 1$ in equation such as $\hat{\varepsilon}_{it} = \rho\hat{\varepsilon}_{it-1} + \omega_{it}$. If $\rho = 1$ then there is no cointegration as the linear combination of debt and output is not stationary. On the other hand if $\rho < 1$ then debt and output are cointegrated as their linear combination is stationary.

Kao derived four DF tests and one ADF test. Two of the DF tests, known as DF_ρ and DF_t are based on the assumption that regressors and errors are strictly exogenous. The other two tests referred to as DF_ρ^* and DF_t^*, are based on the assumption that regressors and errors are endogenous. For the ADF test the DF regression is augmented with lag values of error to overcome the serially correlated disturbance $\omega_{it\rho}$. He showed that the asymptotic distribution of the DF and ADF tests converges to standard normal $N(0,1)$ by sequential limit theory.

The above panel cointegration tests are essentially univariate extensions of the original time series two-step procedure of Engle and Granger (1987) where a panel unit root test is conducted on the estimated residuals from the long run cointegrating regression. However, no extensions have been proposed in the literature for the use of panel unit root tests such as IPS and MW for the estimated residuals from the cointegrating regression to test for the cointegration between variables.

Residual-Based LM test

McCoskey and Kao (1998) (henceforth MK) derived a residual-based LM test for panel cointegration with the null of *cointegration*. It is a panel data version of the LM test proposed by Harris and Inder (1994) for time series. The test allows for heterogeneous slopes and intercepts across countries and requires an efficient estimator such as the Fully Modified (FM) OLS estimator by Phillips and Hansen (1990) and the Dynamic Least Square (DOLS) estimator by Saikkonen (1999) and Stock and Watson (1993). Kao and Chiang (2000) showed that for panel data FM and dynamic OLS are asymptotically normally distributed with zero mean.

The precise form of the model consists of a long-run relationship like [3.18], where Y_{it} is assumed to be $Y_{it} = Y_{i,t-1} + e_{it}$ with $e_{it} = \pi_{it} + u_{it}$ and $\pi_{it} = \pi_{i,t-1} + \varphi u_{it}$. The null of cointegration involves testing if $\varphi = 0$ or not.

The test statistics are based on averaging the individual LM statistics of each country, which are computed using the partial sums of the estimated residuals from the long-run regression of nonstationary debt and output. The specific form of the test statistics is

$$\overline{LM} = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{1}{T^2}\sum_{t=1}^{T} S_{it}^2 \Big/ \hat{\sigma}_e^2\right) \qquad [3.19]$$

where S_{it} is the partial sums of the estimated residuals from FMOLS or DOLS estimators, such that $S_{it} = \sum_{j=1}^{t} \varepsilon_{ij}$ and $\hat{\sigma}_\varepsilon^2$ is consistent estimator of σ_ε^2 under the null.

Likelihood-Based Cointegration Approach

The second types of cointegration tests are the likelihood-based system approach of Johansen (1995) for pure time series and its extension to panel data by LLL (2001). Engle and Granger (1987) argue that as long as relation [3.18] holds a VECM of the following form can be constructed:

$$\mathbf{\Delta z_t} = \boldsymbol{\alpha} + \mathbf{A_1 \Delta z_{t-1}} + \mathbf{A_2 \Delta z_{t-2}} + \ldots + \mathbf{A}_k \mathbf{\Delta z_{t-k}} + \mathbf{B z_{t-2}} + \boldsymbol{\varepsilon}_\mathbf{t} \qquad [3.20]$$

where $\mathbf{z_t}$ is a 2*1 vector of variables under investigation, i.e. $\mathbf{z_t} = [\ln(D_t) \;\; \ln(Y_t)]$ and $\mathbf{\Delta z_t} = [\Delta(\ln(D_t)) \;\; \Delta(\ln(Y_t))]$. $\boldsymbol{\varepsilon}_\mathbf{t}$ is a 2*1 vector of error terms. $\mathbf{A}_k$ for $k = 1 \ldots k$ and $\mathbf{B}$ are the 2*2 matrices of coefficients. $\mathbf{A}_k$ matrices contain the short-run dynamics reflecting the immediate response of $\Delta \mathbf{z_t}$ to changes in lagged values of $\Delta \mathbf{z}$ while $\mathbf{B}$ contains the long-run effects of debt on GDP and vice versa.

In system [3.20] $\mathbf{B}$ is the key matrix, in particular its rank or linearly independent rows are the focus of our attention. There are three different possibilities regarding the rank of matrix $\mathbf{B}$: Firstly, all elements of $\mathbf{B}$ are zero, i.e. $\mathbf{B}$ is a null matrix. This implies that the rank of $\mathbf{B}$ is zero. Thus, Δz_t would only depend on the first differences of its lagged values. That is there is no error correction mechanism operating and thus there is no long-run effect or cointegration between debt and output. Thus, one obtains a model of VAR is in first differences in this case. Secondly, the matrix $\mathbf{B}$ is a full matrix, i.e. its rank equals the number of variables in the system, as all its rows are linearly independent of each other. This suggests that there is no cointegration in fact both variables are I(0) which contradicts our earlier assumptions that both of these variables are I(1) processes. The final possibility is that the rank of matrix $\mathbf{B}$ is greater than zero but less than two (the number of variables in the system). In this case, there is one row of $\mathbf{B}$ which is linearly dependent on the other, i.e. rank is one. This indicates that debt and output are cointegrated, in which case the matrix $\mathbf{B}$ can be decomposed into two matrices such that $\mathbf{B} = \boldsymbol{\psi}\boldsymbol{\beta}'$, where $\boldsymbol{\psi}$ is 2*1 and $\boldsymbol{\beta}'$ is 1*2. The vector $\boldsymbol{\psi}$ contains the speed of adjustment parameters while the vector $\boldsymbol{\beta}'$ consists of long-run parameters. The vector $\boldsymbol{\psi}$ contains the adjustment parameter that correct for any deviations between debt and GDP from the equilibrium relationship. It takes a value between zero and one; when the elements of $\boldsymbol{\psi}$ are close to one the adjustment process is very quick and when they are near zero it is relatively slow.

Johansen (1995) Test

Johansen (1995) proposed multivariate cointegration test based on maximum likelihood method. It essentially involves testing the rank of $\mathbf{B}$ matrix using the trace or maximal eigenvalue test statistics computed as follows:

$$\lambda_{trace}(\kappa) = -T \sum_{i=r+1}^{n} \ln\left(1 - \hat{\lambda}_i\right) \qquad [3.21]$$

$$\lambda_{\max}(\kappa, \kappa + 1) = -T \ln\left(1 - \hat{\lambda}_{r+1}\right) \qquad [3.22]$$

where T is the number of observations and $\hat{\lambda}_i$ is the estimated value of the characteristic root (eigenvalue) obtained from the estimated $\mathbf{B}$ matrix.

Under the trace statistics the null hypothesis is that there are κ CVs against the alternative that there are $n-1$ CVs. Under the maximal eigenvalue statistics the null is that there are κ CVs against the alternative that there are $\kappa+1$ CVs. Both tests are sequential requiring one to begin with testing the null that the rank equals zero and if the null is rejected then move to the null that the rank equals one otherwise concludes that rank equals zero. That is the sequential testing continues until the null hypothesis cannot be rejected.

In order to determine a structural model Johansen proposed a likelihood ratio test for testing identifying and overidentifying restrictions implied by economics theory on the CV(s) and the speed of adjustment coefficients. The test statistics has chi-square distribution with df equal to the number of restriction imposed.

Furthermore one can perform the postestimation or the diagnostic testing such as calculating the impulse response functions to study the effects of shocks or forecasting the levels and the first differenced of variables using the estimated VECM.

Larsson, Lyhagen and Lothgren (2001) Test

LLL extend the likelihood-based cointegration rank test of Johansen to panel data models following the ideology of IPS unit root test where the individual country test statistics is averaged. That is the proposed panel rank test statistic called $\overline{LR}_{bar}$, is similar to IPS's $\bar{t}_{bar}$ statistic. It consists of obtaining Johansen's trace test statistics for each country in the sample assuming that each country is heterogeneous and then averages these using [3.23] across all countries.

$$\overline{LR}^{*}_{bar} = \left[\sqrt{N}\left(\overline{LR}_{bar} - E(Z_k)\right)\right] / \sqrt{Var(Z_k)} \qquad [3.23]$$

where $\overline{LR}_{bar} = \frac{1}{N}\sum_{i=1}^{N} LR_{i,trace}$ and $LR_{i,tracee} = -T\sum_{j=r+1}^{p} ln\left(1-\hat{\lambda}_{i,j}\right)$ and $\lambda_{i,j}$ is the j^{th} eigenvalue corresponding to i^{th} country. $\overline{LR}_{bar}$ is then standardised using the mean $E(Z_k)$ and the variance $Var(Z_k)$ of the asymptotic trace statistics.

The Monte Carlo simulation by LLL found that their test requires large time series dimension without which the size of the test is distorted even if the cross-sectional dimension is large. Thus trying to increase the power of Johansen's rank test by using cross-sectional dimension does not seem work.

Although LLL's test is preferred to the single equation residual-based tests of Kao and MK as it has a number of advantages over them. Firstly, it enables the feedback between the two variables in the system, while the single equation approach assumes that all the Xs are exogenous. Secondly, the system's approach looks at the ECMs for both variables whereas the single equation method only looks at one possible ECM, while in general there may exist ECMs for each variable in the system. Finally and most importantly, the single equation approach assumes that there is only one cointegrating relation between the variables, which is not necessarily true especially for multivariate case. However, LLL's test does not allow for cross-sectional dependence, which may exist between countries.

Panel Tests for Identification Restrictions

LLL also propose **panel chi-square test** for testing restrictions on the CV again using Johansen's parameter restriction tests. As Johansen's test is chi-square distributed they apply the additive property of chi-square distribution to obtain the panel chi-square test. The panel test is simply the total sum of the N individual country's chi-square statistics. The panel test statistics is chi-square distributed with NR df where N is number of countries and R is number of restrictions.

An alternative to LLL's the paper also uses **Fisher's test** for testing the identifying and over-identifying restrictions on the CV for panel dataset. This is analogue to the Fisher's panel unit root test developed by Maddala and Wu (1999). See section 3.3 for details.

Fisher showed that combining any uniformly distributed variable p as $-2\ln p$ yields a chi-square distributed variable x with 2 df. Since the observed significance level (p-values) is a uniformly distributed variable, Fisher's test essentially involves combining the p-values of the test statistics as $-2\ln p$ for each country and then adding these over all the countries again using the additive property of the chi-squared distribution to compute the panel test statistics. Fisher's test also chi-square distributed with 2N df.

3.4 DATASET AND THE TIME SERIES PROPERTIES

This section performs some preliminary analyses on the data in 2 subsections. The first subsection 3.4.1, describes the dataset used and the various sources it is collected from. Then it gives some key descriptive statistics and bivariate correlation between debt and output. The second subsection 3.4.2 details the derivation of the parsimonious model used in the later analyses and conducts some univariate and panel unit root tests on debt stock and GDP of 56 countries under investigation.

3.4.1 DESCRIPTION OF DATASET AND SOURCES

This section is divided into three parts. The first details the dataset used in the paper and sources it is gathered from. The second specifies some descriptive statistics to gain an understanding of how indebted the countries under investigation are and what their growth rate of GDP is. Whilst the third examines the bivariate correlation between debt stock and GDP to see how debt affects output.

Dataset and Sources

The dataset consists of annual observations from 1969 to 2000 for 56 DCs including HIPCs, non-HIPCs low and medium income. Both HIPCs and non-HIPCs as well as low and medium income countries are consider to avoid any possible bias due to sample selection with respect to debt or economic performance. The main source of the data is the World Development Indicators (WDI) by the World Bank. Chapter 2 section 2.4.1 provides details on the sources and the construction of the dataset.

Debt refers to the country's total external debt stock, which is debt owed to non-residents repayable in foreign currency, goods, or services. Total external debt is the sum of public, publicly guaranteed, and private non-guaranteed long-term debt, use of IMF credit, and short-term debt. Short-term debt includes all debt having an original maturity of one year or less and interest in arrears on long-term debt. Data are in current U.S. dollars.

GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars.

Descriptive Statistics

The preliminary analyses of the data start by looking at some key descriptive statistics and the bivariate correlation between debt and output. Table 3.1 gives the summary statistics related to growth in debt, GDP and debt-to-GDP ratio. Two measures of the central tendency or the average of the variables are computed: mean and median. The spread of the variables is measured by the standard deviation, coefficient of variation (which is defined as the standard deviation (SD) divided by mean) and the standard error of the mean (that is SD divided by square root of the number of observations). The statistical dispersion is also computed by interquartile range, which measures the distance between the 75^{th} percentile and the 25^{th} percentile. It is essentially the range of the middle 50% of the data. As it uses the middle 50% of the data, it is not affected by outliers or extreme values.

Debt has grown at a considerable rate of nearly 11% on average which is almost twice the growth rate in GDP of 6.7%. Thus, debt-to-GDP ratio has grown at nearly 4% on average. However, the median indicates that growth rate of debt is only slightly greater than the growth rate of GDP and that debt-to-GDP ratio has grown at a moderate rate of less than 1.5%. Nonetheless, one must bear in mind that there is large cross-country differences as some countries have had a growth in their debt ratio of nearly 500% whilst others have had only 8.6%.

TABLE 3.1
Data Description

	Debt-to-GDP ratio	Growth Rate in		
		Debt	GDP	Debt-to-GDP ratio
Mean	61.79	10.63	6.73	3.90
Median	43.64	8.48	8.23	1.45
Standard Deviation	72.02	29.08	18.60	33.39
Standard Error of mean	0.10	-483.04	-289.22	-467.34
Maximum	1064	468.51	181.89	464.58
Minimum	1.17	2.74	2.76	8.56
Coefficient of Variation	1.70	0.70	0.45	0.80
Interquartile Range	47.91	15.83	13.89	20.03

The mean debt-to-GDP ratio is 70% while the median is 44%. As with other statistics this average should be taken with care given substantial cross-country difference. The maximum debt-to-GDP ratio is 1064% while the minimum is only 0.1%. The debt-to-GDP ratio, has grown on average by 2% suggested by mean and 4% indicated by median, but some countries have experienced much bigger growth – as much as 465%, while others have had equal percentage of fall – 467%.

Simple and Partial Correlation

As a preliminary investigation of the relationship between the variables of interest it is useful to study how these variables are correlated. Table 3.2 presents the bivariate correlation between the variables under investigation and their significance level. An asterisk (*) indicates that the correlation is significant at the 5% level.

The correlation between debt stock and output level is positive and highly significant whilst the relationship between output level and debt-to-GDP ratio is negative and significant. The results indicate that when debt-to-GDP ratio increases by 1%, output levels fall by $0.2 millions. In addition, the relationship between growth rate of output and debt stock is negative, confirming that large debt stocks do hinder the growth rate of output – a

$100 million increase in debt stock will result in a 9% fall in growth rate of output. Furthermore, a 1% increase in debt-to-GDP ratio will lead to 0.22% decrease in output growth rate.

TABLE 3.2
Simple Correlation Between the Variables

	Debt stock (Millions)	GDP (Millions)	Debt-to-GDP ratio	Growth rate of debt	Growth rate of GDP	Growth rate of debt ratio
Debt stock (Millions)	1.00					
GDP (millions)	0.84* (0.00)	1.00				
External Debt to GDP ratio	0.36* (0.00)	-0.21* (0.00)	1.00			
Growth rate of debt	-0.07* (0.00)	-0.05 (0.06)	-0.05* (0.04)	1.00		
Growth rate of GDP	-0.09* (0.00)	0.03 (0.17)	-0.22* (0.00)	0.07* (0.00)	1.00	
Growth rate of debt ratio	-0.01 (0.66)	-0.06* (0.02)	0.08* (0.00)	0.83* (0.00)	-0.50 (0.00)	1.00

* Indicates that the correlation between the two variables is significant at 5%. Figures in the parentheses are the significance level.

The growth rate of debt and debt stock are negatively correlated, indicating that as debt stock becomes larger debtor countries find it more difficult to borrow further as creditors ration their credit to these countries and instead loan to other borrowers. This is what happened to countries when they declared themselves insolvent the in early 1980s. The growth rate of the external debt of Mexico, for example, was 17% on average five years prior to the default in August 1982 and only 9.8% for the five years after the default.[1]

3.4.2 Investigating the Time Series Properties of Debt and GDP

This section examines the time series properties of debt stock and GDP. Two types of unit root tests are employed for this purpose. Firstly a number of univariate tests are used to conduct the individual country analyses and then the panel unit root tests are used to investigate the time series properties of debt and GDP. Section 3.3.1 discusses the relative merits of these two types of tests.

However before conducting the unit root analysis one needs to derive the most parsimonious model that can be used to calculate the test statistics. This requires carrying out a specification search in order to determine the appropriate lag length for the ADF and the PP tests for each country under the analyses. The reminder of this section firstly details the various model building steps that are used to determine the appropriate lag length for each country. Then it presents and discusses the results from the three univariate unit root tests including ADF, PP and DFGLS. Finally it illustrates the results from three panel unit root tests including IPS, MW and Hadri.

Searching for a Parsimonious Model

In order to find the parsimonious ARIMA model for debt, output and debt-to-GDP ratio for each of the 56 countries the following iterative model-building steps are employed:

1. tentative identification
2. estimation by maximum likelihood
3. diagnostic checking – residual analysis.

The first stage involved reviewing the time series plots, the autocorrelation function (ACF) and the partial autocorrelation functions (PACF) of external debt, GDP and debt-to-GDP ratio of each country. As an initial analysis of the likely Data Generating Process (DGP) the paper tests whether debt is a Trend Stationary (TS) process or a Differenced Stationary (DS) process using the ACF and the PACF of level and differenced data. Finding high autocorrelation in raw data series but low autocorrelation in the first difference of the series indicates that the series might be a DS process rather than a TS process. That is, to make the series stationary one needs to difference it rather than detrend it, as detrending will not remove the stationarity. This also implies that the ACF and PACF of detrended series will also be high and identical to the raw data. If this is the case then it can be argued that the series is more likely to be a stochastic process instead of a deterministic process. Furthermore, one can test if the MA component of the differenced series has a unit root because differencing a TS process yields a non-invertible MA process, i.e. wrongly differencing the TS series enforces unit root or perfect serial correlation in the errors.

Across all the countries, one finds high autocorrelation passing through zero going to negative figures for the raw data series but relatively lower autocorrelation in the differenced series suggesting that debt is a DS process for all countries. Furthermore, the results show that the detrended series has almost identical autocorrelation as the raw series implying that the external debt is a stochastic variable rather than deterministic variable as detrending does not eliminate the non-stationarity but differencing does. Like the ACF of raw data the ACF of detrended data display a slow decay while PACF for both series cut-off after a certain lag length except for a DS process.

In the second stage, the maximum number of parameters $(k = p + q)^2$ suggested by ACF and PACF (which is 5) is taken and the models are estimated for $k - j$ (where $j = 0,1,2,...k - 1$) parameters to calculate the information criterions proposed by Schwarz (1987) and Akaike (1974). The model with the highest likelihood for a given number of parameters is selected since the aim is to maximise the likelihood function. Both of these criterions involve selecting the model with the maximum likelihood after imposing a penalty for the number of parameters, but they differ with respect to the size of the penalty. More specifically Akaike Information Criterion (AIC) maximises $AIC = -2 \ln L - 2k$; where L is the likelihood, so $\ln L$ is the log likelihood and $k = p + q$ is the number of parameters. Schwarz Criterion (SIC) maximises $SIC = -2 \ln L - k \ln T$, where T is the number of observations. Since $\ln T$ is greater than 2 as long as T is greater than 7 Schwarz criterion penalises more heavily than Akaike criterion and thus is likely to selects a smaller lag model than AIC.

After selecting a model according to these criteria, it is estimated and some diagnostic checks on the residuals of the model are carried out. If the model had white noise residuals then it was considered adequate and was used in subsequent analyses of the univariate and panel unit root tests. If however, the model did not have white noise residuals then it was re-specified using the above procedure but this time taking the model with not the highest AIC/SIC but with second highest AIC/SIC. In other words, the model with the highest AIC/SIC that had white noise residuals was selected.

Time Series Properties via Univariate Methods

A number of univariate methods are utilized to investigate the time series properties of external debt and GDP series in order to ensure the robustness of the results. This is particularly important given the low power of these tests. The first test is the ADF test proposed by Dickey and Fuller (1979), the second test is the PP test proposed by Philips and Perron (1988) and the third test used is the DFGLS test developed by Elliott, Rothenberg and Stock (1996). For a description of these tests see subsection 3.3.1.1.

Table 3.3 and 3.4.4 illustrate the univariate unit root test for debt and GDP for the levels and the difference data series. The first column of the Tables show the country name, the second indicates the lag length used to estimates the test statistics for each of the test. The lag length is determined by the procedure detailed above. The lag length shown in Table 3.3 and 3.4 are those suggested by SIC which in most of the cases is one. Only for two countries a lag length of 4 is indicated by SIC.

TABLE 3.3
Univariate Unit Root Tests For External Debt Stock

		Levels Data					Differenced Data				
		ADF		Phillip & Perron		DFGLS	ADF		Phillip & Perron		DFGLS
Country	Lag	t-test	p-value	t-test	p-value	t-test	t-test	p-value	t-test	p-value	t-test
Algeria	1	-4.75	(0.00)	-2.73	(0.07)	-0.92	-1.67	(0.45)	-3.56	(0.01)	-2.19
Argentina	2	-1.56	(0.50)	-0.75	(0.83)	-0.79	-1.83	(0.36)	-3.38	(0.01)	-1.38
Bangladesh	4	-2.86	(0.05)	-2.47	(0.12)	1.80	-5.29	(0.00)	-6.79	(0.00)	-1.10
Bolivia	2	-2.48	(0.12)	-1.81	(0.37)	-0.66	-1.91	(0.33)	-3.51	(0.01)	-1.72
Brazil	1	-7.28	(0.00)	-2.23	(0.19)	0.71	-2.33	(0.16)	-4.81	(0.00)	-1.91
Cameroon	2	-2.70	(0.07)	-2.03	(0.27)	-0.76	-1.59	(0.49)	-3.48	(0.01)	-1.65
Chile	1	-1.77	(0.40)	-1.14	(0.70)	0.56	-2.65	(0.08)	-3.71	(0.00)	-2.08
China	1	-2.29	(0.18)	-2.16	(0.22)	-0.49	-3.90	(0.00)	-5.65	(0.00)	-4.67
Colombia	1	-2.07	(0.26)	-0.88	(0.79)	-0.07	-2.36	(0.15)	-4.90	(0.00)	-1.33
Costa Rica	3	-3.27	(0.02)	-6.16	(0.00)	-0.50	-1.14	(0.70)	-9.41	(0.00)	0.53
Cote d'Ivoire	1	-4.57	(0.00)	-2.76	(0.06)	-0.55	-1.16	(0.69)	-3.77	(0.00)	-1.67
Dom. Republic	1	-3.17	(0.02)	-2.29	(0.18)	-0.11	-2.41	(0.14)	-4.80	(0.00)	-2.01
Ecuador	4	-3.24	(0.02)	-1.96	(0.31)	-1.00	-1.29	(0.64)	-3.08	(0.03)	-1.41
Egypt	1	-2.48	(0.12)	-2.13	(0.23)	-0.85	-1.85	(0.36)	-3.52	(0.01)	-2.94
El Salvador	1	-2.47	(0.12)	-4.21	(0.00)	0.87	-3.35	(0.01)	-6.56	(0.00)	-0.99
Ethiopia	2	-1.86	(0.35)	-1.61	(0.48)	-0.96	-1.42	(0.57)	-3.68	(0.00)	-1.34
Ghana	1	-0.97	(0.77)	-0.69	(0.85)	0.16	-5.50	(0.00)	-4.76	(0.00)	-3.52
Guatemala	1	-2.82	(0.06)	-2.04	(0.27)	-0.29	-1.84	(0.36)	-3.31	(0.01)	-1.73
Guyana	1	-6.10	(0.00)	-2.47	(0.12)	-0.41	-2.14	(0.23)	-6.75	(0.00)	-2.09
Haiti	1	-2.32	(0.16)	-2.06	(0.26)	1.02	-3.02	(0.03)	-5.04	(0.00)	-3.18
Honduras	1	-4.16	(0.00)	-5.87	(0.00)	0.66	-3.21	(0.02)	-6.04	(0.00)	-0.58
India	2	-1.74	(0.41)	-1.09	(0.72)	-0.39	-1.19	(0.68)	-4.27	(0.00)	-1.05
Indonesia	1	-3.21	(0.02)	-1.47	(0.55)	0.14	-2.76	(0.06)	-4.25	(0.00)	-2.16
Iran	1	-1.64	(0.46)	-1.62	(0.48)	-1.21	-3.90	(0.00)	-4.62	(0.00)	-3.65
Jamaica	1	-1.96	(0.31)	-1.66	(0.45)	0.05	-2.15	(0.22)	-4.63	(0.00)	-2.25
Jordan	1	-3.17	(0.02)	-3.30	(0.01)	-0.37	-1.56	(0.50)	-2.63	(0.09)	-1.65
Kenya	1	-3.46	(0.01)	-2.66	(0.08)	0.19	-2.60	(0.09)	-3.36	(0.01)	-2.23
Madagascar	2	-0.96	(0.77)	-1.10	(0.71)	-0.12	-2.98	(0.04)	-10.60	(0.00)	-2.79
Malawi	1	-2.98	(0.04)	-1.66	(0.45)	0.02	-2.95	(0.04)	-4.34	(0.00)	-1.88
Malaysia	2	-2.26	(0.19)	-4.10	(0.00)	-0.18	-2.27	(0.18)	-3.68	(0.00)	-0.49
Mali	1	-1.94	(0.31)	-1.40	(0.58)	-0.08	-2.78	(0.06)	-4.20	(0.00)	-1.95
Mauritius	2	-2.06	(0.26)	-1.50	(0.54)	-0.66	-2.19	(0.21)	-2.68	(0.08)	-1.81
Mexico	1	-4.27	(0.00)	-5.55	(0.00)	0.23	-2.28	(0.18)	-13.80	(0.00)	0.41
Morocco	3	-3.63	(0.01)	-3.75	(0.00)	-1.05	-1.20	(0.67)	-3.38	(0.01)	-0.58
Mozambique	3	-0.66	(0.86)	-2.16	(0.22)	-0.13	-2.99	(0.04)	-8.22	(0.00)	-2.04
Nicaragua	1	-3.46	(0.01)	-2.37	(0.15)	-0.16	-2.32	(0.17)	-3.83	(0.00)	-2.22
Nigeria	1	-2.20	(0.21)	-3.80	(0.00)	0.24	-3.85	(0.00)	-6.35	(0.00)	-1.32
Pakistan	1	-3.20	(0.02)	-1.44	(0.56)	0.00	-3.11	(0.03)	-5.26	(0.00)	-1.93
Panama	1	-5.47	(0.00)	-10.33	(0.00)	0.01	-2.01	(0.28)	-5.13	(0.00)	0.07
Paraguay	2	-2.35	(0.16)	-1.70	(0.43)	-0.52	-2.04	(0.27)	-3.19	(0.02)	-1.77
Peru	1	-2.07	(0.26)	-1.58	(0.49)	0.42	-2.74	(0.07)	-3.93	(0.00)	-2.74
Rwanda	1	-1.92	(0.32)	-2.19	(0.21)	-0.63	-3.83	(0.00)	-4.12	(0.00)	-2.36
Senegal	2	-3.10	(0.03)	-2.31	(0.17)	-0.71	-1.27	(0.64)	-2.40	(0.14)	-1.55
Sierra Leone	1	-5.84	(0.00)	-2.13	(0.23)	0.09	-2.70	(0.07)	-7.28	(0.00)	-1.29
South Africa	1	-1.63	(0.47)	-1.71	(0.43)	-1.50	-4.15	(0.00)	-5.51	(0.00)	-3.87
Sri Lanka	1	-2.88	(0.05)	-4.37	(0.00)	0.28	-3.61	(0.01)	-6.49	(0.00)	-0.47
Tanzania	1	-8.92	(0.00)	-1.97	(0.30)	0.21	-5.12	(0.00)	-10.51	(0.00)	-0.89
Thailand	2	-1.87	(0.35)	-3.37	(0.01)	-0.98	-1.40	(0.58)	-9.51	(0.00)	0.47
Trin. & Tobago	1	-1.74	(0.41)	-1.48	(0.54)	-0.30	-3.66	(0.00)	-5.57	(0.00)	-3.09
Tunisia	1	-2.72	(0.07)	-1.80	(0.38)	-0.43	-2.73	(0.07)	-3.58	(0.01)	-2.09
Turkey	1	-1.68	(0.44)	-0.88	(0.79)	0.33	-3.53	(0.01)	-4.90	(0.00)	-2.34
Uganda	2	-1.65	(0.46)	-1.18	(0.68)	-0.67	-1.60	(0.48)	-3.90	(0.00)	-1.21
Uruguay	1	-2.19	(0.21)	-1.41	(0.58)	1.16	-3.06	(0.03)	-5.71	(0.00)	-2.59
Venezuela	2	-1.99	(0.29)	-1.80	(0.38)	-0.90	-2.23	(0.19)	-3.60	(0.01)	-1.49
Zambia	1	-3.00	(0.04)	-2.37	(0.15)	-0.47	-1.75	(0.40)	-3.11	(0.03)	-2.62
Zimbabwe	2	-1.25	(0.65)	-1.00	(0.75)	-0.77	-1.74	(0.41)	-2.80	(0.06)	-1.67

Critical values for:

- ADF are PP tests, which are roughly the same, are -3.72, -2.99 & -2.62 at 1%, 5% & 10% significance level.
- DFGLS test depends on the lag length for 5% and 10% but not for 1% sig. level. 1% critical value is -2.65; 5% are -2.44, -2.39, -2.34, & -2.29 and 10% are -2.13, -2.08 -2.03 &-1.98 for lags 1-4 respectively.

Only a constant is included in all three tests and
Null for all tests is that the process, i.e. debt is nonstationary.

TABLE 3.4
Univariate Unit Root Tests For GDP

		Levels Data					Differenced Data				
		ADF		Phillip & Perron		DFGLS	ADF		Phillip & Perron		DFGLS
Country	Lag	t-test	p-value	t-test	p-value	t-test	t-test	p-value	t-test	p-value	t-test
Algeria	1	-3.30	(0.01)	-3.79	(0.00)	0.80	-2.16	(0.22)	-3.30	(0.02)	-2.36
Argentina	2	-0.95	(0.77)	-0.90	(0.79)	0.53	-4.17	(0.00)	-6.75	(0.00)	-3.74
Bangladesh	4	-1.57	(0.50)	-0.54	(0.88)	0.17	-5.82	(0.00)	-7.08	(0.00)	-10.62
Bolivia	2	-0.97	(0.77)	-0.99	(0.76)	0.19	-3.69	(0.00)	-5.35	(0.00)	-3.37
Brazil	1	-2.29	(0.18)	-2.46	(0.13)	-0.30	-3.07	(0.03)	-3.77	(0.00)	-3.11
Cameroon	2	-3.12	(0.03)	-2.58	(0.10)	0.30	-2.24	(0.19)	-3.65	(0.00)	-2.50
Chile	1	-0.95	(0.77)	-0.89	(0.79)	1.83	-4.38	(0.00)	-4.65	(0.00)	-5.62
China	1	0.37	(0.98)	0.11	(0.97)	-0.14	-3.41	(0.01)	-5.60	(0.00)	-2.87
Colombia	1	-1.77	(0.40)	-1.99	(0.29)	0.62	-1.99	(0.29)	-2.70	(0.07)	-1.80
Costa Rica	3	-0.96	(0.77)	-1.10	(0.72)	-0.68	-2.89	(0.05)	-4.80	(0.00)	-2.77
Cote d'Ivoire	1	-2.92	(0.04)	-2.79	(0.06)	1.17	-2.60	(0.09)	-3.29	(0.02)	-2.95
Dom. Republic	1	-1.54	(0.51)	-1.67	(0.45)	-0.23	-3.44	(0.01)	-6.31	(0.00)	-3.10
Ecuador	4	-3.07	(0.03)	-2.30	(0.17)	-0.41	-1.56	(0.50)	-3.54	(0.01)	-1.83
Egypt	1	-0.46	(0.90)	-0.54	(0.88)	0.28	-4.54	(0.00)	-6.34	(0.00)	-4.20
El Salvador	1	-0.91	(0.79)	-0.64	(0.86)	-0.03	-2.20	(0.21)	-2.38	(0.15)	-2.03
Ethiopia	2	-2.49	(0.12)	-2.60	(0.09)	-0.44	-2.14	(0.23)	-5.19	(0.00)	-1.95
Ghana	1	-1.86	(0.35)	-2.08	(0.25)	0.51	-3.95	(0.00)	-4.18	(0.00)	-3.11
Guatemala	1	-1.64	(0.46)	-1.78	(0.39)	-0.22	-2.89	(0.05)	-3.81	(0.00)	-2.75
Guyana	1	-1.66	(0.45)	-1.68	(0.44)	0.38	-3.35	(0.01)	-5.17	(0.00)	-3.46
Haiti	1	-1.66	(0.45)	-1.49	(0.54)	0.17	-5.09	(0.00)	-4.90	(0.00)	-4.82
Honduras	1	-1.57	(0.50)	-1.83	(0.36)	0.70	-2.39	(0.14)	-2.86	(0.05)	-2.17
India	2	-1.89	(0.34)	-1.63	(0.47)	0.15	-2.82	(0.06)	-4.16	(0.00)	-2.59
Indonesia	1	-2.52	(0.11)	-2.41	(0.14)	-1.30	-3.42	(0.01)	-4.93	(0.00)	-3.62
Iran	1	-2.83	(0.05)	-2.61	(0.09)	0.17	-5.85	(0.00)	-5.40	(0.00)	-5.77
Jamaica	1	-1.19	(0.68)	-1.35	(0.60)	-0.09	-4.11	(0.00)	-4.49	(0.00)	-3.81
Jordan	1	-2.60	(0.09)	-1.81	(0.38)	0.12	-2.67	(0.08)	-3.24	(0.02)	-2.28
Kenya	1	-2.45	(0.13)	-2.41	(0.14)	-0.04	-3.39	(0.01)	-4.96	(0.00)	-3.36
Madagascar	2	-2.90	(0.05)	-2.54	(0.11)	-0.09	-2.34	(0.16)	-5.26	(0.00)	-2.79
Malawi	1	-2.50	(0.12)	-2.41	(0.14)	0.74	-4.58	(0.00)	-5.33	(0.00)	-4.43
Malaysia	2	-2.78	(0.06)	-2.02	(0.28)	-0.25	-2.21	(0.20)	-3.83	(0.00)	-2.17
Mali	1	-2.49	(0.12)	-2.31	(0.17)	1.34	-4.04	(0.00)	-5.30	(0.00)	-4.25
Mauritius	2	-2.40	(0.14)	-2.00	(0.28)	0.73	-2.54	(0.10)	-3.82	(0.00)	-2.18
Mexico	1	-1.32	(0.62)	-1.26	(0.65)	0.25	-4.72	(0.00)	-4.28	(0.00)	-4.63
Morocco	3	-2.28	(0.18)	-2.33	(0.16)	-1.22	-2.09	(0.25)	-3.78	(0.00)	-2.33
Mozambique	3	-1.39	(0.58)	-1.38	(0.59)	-1.01	-2.70	(0.07)	-5.42	(0.00)	-2.45
Nicaragua	1	-2.84	(0.05)	-2.36	(0.15)	-0.50	-5.51	(0.00)	-4.29	(0.00)	-5.32
Nigeria	1	-1.92	(0.32)	-3.05	(0.03)	0.18	-2.61	(0.09)	-5.88	(0.00)	-1.40
Pakistan	1	-0.93	(0.78)	-1.12	(0.71)	0.25	-4.12	(0.00)	-4.55	(0.00)	-2.98
Panama	1	-2.00	(0.29)	-2.20	(0.20)	-0.27	-2.41	(0.14)	-2.95	(0.04)	-2.39
Paraguay	2	-2.39	(0.15)	-2.23	(0.20)	0.36	-2.04	(0.27)	-2.66	(0.08)	-2.05
Peru	1	-1.23	(0.66)	-1.38	(0.59)	-0.44	-4.23	(0.00)	-6.89	(0.00)	-4.06
Rwanda	1	-2.25	(0.19)	-2.25	(0.19)	-0.32	-3.50	(0.01)	-6.21	(0.00)	-3.58
Senegal	2	-2.55	(0.10)	-2.14	(0.23)	-1.06	-2.57	(0.10)	-4.71	(0.00)	-3.03
Sierra Leone	1	-2.67	(0.08)	-2.54	(0.11)	0.05	-5.14	(0.00)	-5.17	(0.00)	-4.96
South Africa	1	-2.15	(0.23)	-2.23	(0.20)	1.46	-3.99	(0.00)	-3.95	(0.00)	-3.80
Sri Lanka	1	-0.35	(0.92)	-0.46	(0.90)	0.43	-4.22	(0.00)	-6.72	(0.00)	-4.13
Tanzania	1	-1.97	(0.30)	-2.03	(0.27)	0.02	-2.77	(0.06)	-4.56	(0.00)	-2.79
Thailand	2	-2.35	(0.16)	-1.86	(0.35)	-0.03	-1.39	(0.59)	-2.77	(0.06)	-1.49
Trin. & Tobago	1	-2.56	(0.10)	-2.46	(0.13)	0.68	-2.14	(0.23)	-3.49	(0.01)	-2.45
Tunisia	1	-3.44	(0.01)	-3.80	(0.00)	0.58	-2.23	(0.19)	-3.12	(0.03)	-3.22
Turkey	1	-1.88	(0.34)	-1.29	(0.63)	-1.73	-3.36	(0.01)	-5.10	(0.00)	-3.23
Uganda	2	-2.66	(0.08)	-2.57	(0.10)	-0.39	-3.75	(0.00)	-5.77	(0.00)	-3.66
Uruguay	1	-1.33	(0.62)	-1.21	(0.67)	0.99	-3.13	(0.02)	-4.50	(0.00)	-3.30
Venezuela	2	-2.06	(0.26)	-1.91	(0.33)	-1.53	-1.58	(0.49)	-5.70	(0.00)	-1.87
Zambia	1	-3.22	(0.02)	-2.34	(0.16)	-0.53	-4.35	(0.00)	-4.16	(0.00)	-3.74
Zimbabwe	2	-3.14	(0.02)	-2.81	(0.06)	0.00	-3.24	(0.02)	-3.14	(0.02)	-3.00

- See under Table 3.3 for notes

The next 3 columns of the Table 3.3 and 3.4 show the test statistics for ADF, PP and DFGLS tests for the level series respectively. The stationarity test results for the debt stock series are neither conclusive nor consistent as they are for the output series. One can confidently say that the GDP series of all the countries under investigation is a nonstationary process integrated of order one. Although, there are some difference across the three tests where one test may indicate that GDP is stationary series whilst the other suggest that it is I(1) process. However, there is not a single country for which all three tests indicate that GDP is integrated of order other than one. That is PP test for example shows that Tunisia's GDP is I(0) while the DFGLS fails to reject the null of non-stationarity in the levels series at 1% significance level but does reject the null that differenced series is non-stationary.

Although the picture is a bit more complicated for the debt stock series there is again not a single country for which all three tests find that debt is integrated for order other than one. Hence, one can argue that test results from all the three tests considered here indicate that debt and output are both I(1) processes.

Time Series Properties via Multi-Country Methods

This section presents and discusses the results from a number of panel unit root tests for the external debt stock and GDP of 56 DCs. Given the low power of the standard unit roots tests such as ADF and PP for distinguishing the null of a unit root from the alternative of stationarity, especially for near unit root processes, various efforts have been made to increase the power of unit root tests. One such contribution is in the area of panel unit root tests. A brief outline of these tests is presented in subsection 3.3.1.

The results from each of three tests for debt and output are presented in Table 3.5. The upper part of the table illustrates the results from the tests testing the null of a unit root such as IPS and MW whilst the lower part shows that results from the test testing the null of no unit root. For IPS and MW tests the results from up to three lags are presented for the level and differenced series. For Hadri's tests the results corresponding to three different assumption regarding the across country disturbance are given. These assumption are homoskedastic, hetroskedastic and serially independent across country errors.

The IPS test shows that debt stock and GDP are integrated of order one as the null hypothesis of a unit root in the levels series cannot be rejected whilst the null can be rejected for the differenced series. However, the results are sensitive to the lag length.

For MW both the ADF and PP tests are performed on the individual country dataset. The ADF, which can be compared directly with the IPS test, indicates that debt stock and GDP are both I(1) processes as IPS test showed. The PP version of MW test also suggests that debt stock and output are I(1) series.

TABLE 3.5
Panel Unit Root Tests for External Debt and GDP

	Level data			1st difference		
Null: unit root	1	2	3	1	2	3
Im Pesaran and Shin						
t_{bar} statistics						
Debt stock	-2.19	-2.27	-2.32	-3.54	-2.90	-2.67
	(0.46)	(0.09)	(0.04)	(0.00)	(0.00)	(0.00)
GDP	-2.38	-2.20	-2.35	-4.050	-3.02	-2.85
	(0.03)	(0.24)	(0.02)	(0.00)	(0.00)	(0.00)
Maddala and Wu						
ADF-Fisher χ^2						
Debt stock	124.32	80.22	84.26	339.72	205.00	182.04
	(0.20)	(0.99)	(0.98)	(0.00)	(0.00)	(0.00)
GDP	131.65	125.93	155.35	621.55	362.38	313.26
	(0.10)	(0.17)	(0.00)	(0.00)	(0.00)	(0.00)
PP-Fisher χ^2						
Debt stock	101.02	99.07	100.128	813.04	827.34	829.65
	(0.76)	(0.80)	(0.78)	(0.00)	(0.00)	(0.00)
GDP	75.66	73.69	71.24	987.05	985.64	1000.36
	(0.98)	(0.99)	(0.99)	(0.00)	(0.00)	(0.00)
Null: No unit root						
Hadri	Homo	Hetero	Ser. Dep	Homo	Hetero	Ser. Dep
Debt stock	83.79	90.56	23.06	-1.95	8.00	1.39
	(0.00)	(0.00)	(0.00)	(0.97)	(0.00)	(0.08)
GDP	69.41	60.69	18.80	-1.82	2.66	1.77
	(0.00)	(0.00)	(0.00)	(0.97)	(0.03)	(0.04)

- Figure in the parentheses are p-values.
- Homo, Hetero and SerDep indicates the test statistics when the across-country disturbances are assumed to homoskedastic, heteroskedastic or serially independent.
- Deterministic include a constant and a trend for IPS and MW test and for Hadri's test demeaned dataset is used.
- indicates that null is rejected at 1%
- Critical values:
- IPS test: -2.36, -2.31 and -2.28 at 1% 5% and 10% significance level respectively
- MW test: 80.15, 88.57 and 93.30 at 1% 5% and 10% significance level respectively (χ^2 with 2N(112) df.
- Hadri test: the test statistics are asymptomatically standard normal.

The bottom part of Table 3.5 illustrates the results from Hadri's panel unit root test when errors are assumed homoskedastic, heteroskedastic and serially independent across countries. The null that all countries have stationary debt and GDP is rejected even at 1% significance level under the three assumptions regarding the disturbance across countries. Consequently the first differenced series for each variable is tested. This time the null of no unit root in the series cannot be rejected even at 10% significance level when errors are assumed to be homoskedastic. However, when errors are assumed to be hetroskedastic the debt stock seem to be integrated of order higher than one at 1% level and so does GDP at 5% significance level. Since there are strong consistent evidence not just from this chapter but also from the existing literature that GDP is a unit root process integrated of order one, it can be argued that the assumption of hetroskedasticity in across-country errors is perhaps incorrect.

Overall, one can with reasonable confidence argue that the debt stock and the GDP series are I(1) processes as suggested by the univariate and the panel unit root tests. However, before concluding the discussion on the panel unit root tests it is worth noting that although panel unit root test have more power than the ordinary unit root tests, they too have some problems which are discussed below in subsection 3.5.1.

3.5 EMPIRICAL ANALYSES OF THE DS OF 56 DCS

In this section a number of univariate and panel data unit root and cointegration tests are applied to investigate the DS of DCs. In what follows firstly the results from various unit root tests on debt-to-GDP ratio are presented in subsection 3.5.1. Subsequently, in subsection 3.5.2, the findings from the residual-based cointegration tests are discussed and finally results from the likelihood based cointegration tests are presented in subsection 3.5.3. At the end of the section, a brief summary reviewing the key findings of the paper is presented.

3.5.1 TESTING DS USING UNIT ROOT TESTS

Two types of unit root tests are used to assess the DS for 56 DCs. The first are the univariate tests which are performed on each country's debt-to-GDP ratio independently whilst the second are the panel tests which combine the individual test statistics in a hope to increase the power of these tests. The reminder of this section firstly presents and discusses the results from the univariate tests and then illustrates the findings from the panel tests.

Univariate Unit Root Tests

Three univariate unit root tests including ADF, PP and DFGLS are employed to test if the debt of DCs is sustainable or not. A brief description of these tests is given in subsection 3.3.1.

The specification search strategy used to find the parsimonious models used to estimate the test statistics under the ADF and the PP tests is outlined in subsection 3.4.2. It essentially consists of firstly checking the time plots and calculating the ACF and PACF of the levels and the differenced data and secondly computing the BIC for each country for $p-k$ number of lags, where p is maximum lag suggested by autocorrelation functions, and $k=1,2,...,p-1$. The lag length shown in columns 2 of Table 3.6 refer to the lag suggested by BIC. The most common lag length indicated by BIC is 1 and the largest is 4 which is for only two countries.

TABLE 3.6
Assessing DS via Univariate Unit Root Tests

		ADF		Phillip Perron		DF-GLS			ADF		Phillip Perron		DF-GLS
	Lags	t-test	p-value	t-test	p-value	t-test		lags	t-test	p-value	t-test	p-value	t-test
Algeria	1	-2.22	(0.20)	-1.62	(0.47)	-1.78	Malawi	1	-1.09	(0.72)	-0.92	(0.78)	-1.14
Argentina	2	-1.42	(0.57)	-1.34	(0.61)	-1.84	Malaysia	2	-1.96	(0.30)	-3.12	(0.02)	-0.23
Bangladesh	4	-3.21	(0.02)	-2.60	(0.09)	0.25	Mali	1	-0.84	(0.81)	-0.86	(0.80)	-0.83
Bolivia	2	-2.13	(0.23)	-1.35	(0.60)	-1.40	Mauritius	2	-2.01	(0.28)	-1.30	(0.63)	-2.74
Brazil	1	-2.78	(0.06)	-1.59	(0.49)	-1.96	Mexico	1	-1.72	(0.42)	-5.83	(0.00)	-0.58
Cameroon	2	-0.94	(0.77)	-0.62	(0.87)	-0.47	Morocco	3	-2.26	(0.19)	-2.15	(0.22)	-1.04
Chile	1	-2.09	(0.25)	-1.74	(0.41)	-1.94	Mozambique	3	-0.86	(0.80)	-1.84	(0.36)	-0.46
China	1	-2.74	(0.07)	-2.54	(0.11)	-1.16	Nicaragua	1	-1.79	(0.38)	-1.33	(0.62)	-0.89
Colombia	1	-1.52	(0.53)	-1.53	(0.52)	-1.69	Nigeria	1	-1.32	(0.62)	-1.77	(0.40)	-0.51
Costa Rica	3	-1.41	(0.58)	-3.56	(0.01)	-0.80	Pakistan	1	-3.69	(0.00)	-2.73	(0.07)	-2.29
Cote d`Ivoire	1	-2.25	(0.19)	-1.27	(0.64)	-0.90	Panama	1	-2.39	(0.15)	-5.70	(0.00)	-0.57
Dom. Republic	1	-1.06	(0.73)	-1.11	(0.71)	-1.28	Paraguay	2	-2.00	(0.29)	-1.42	(0.57)	-2.22
Ecuador	4	-1.70	(0.43)	-1.10	(0.71)	-1.10	Peru	1	-2.00	(0.29)	-2.18	(0.21)	-2.15
Egypt	1	-1.49	(0.54)	-1.07	(0.73)	-1.08	Rwanda	1	-1.29	(0.64)	-1.35	(0.61)	0.26
El Salvador	1	-1.67	(0.45)	-3.71	(0.00)	-0.57	Senegal	2	-1.76	(0.40)	-1.38	(0.59)	-0.75
Ethiopia	2	-1.47	(0.55)	-1.15	(0.70)	-0.99	Sierra Leone	1	-1.66	(0.45)	-0.98	(0.76)	-0.32
Ghana	1	0.33	(0.98)	0.57	(0.99)	0.75	South Africa	1	-1.05	(0.73)	-1.11	(0.71)	-0.90
Guatemala	1	-1.62	(0.47)	-1.14	(0.70)	-1.13	Sri Lanka	1	-2.07	(0.26)	-3.42	(0.01)	-0.24
Guyana	1	-2.84	(0.05)	-1.51	(0.53)	-1.10	Tanzania	1	-7.01	(0.00)	-3.43	(0.01)	-1.36
Haiti	1	-1.84	(0.36)	-1.78	(0.39)	-0.80	Thailand	2	-1.08	(0.72)	-3.80	(0.00)	-0.16
Honduras	1	-3.23	(0.02)	-4.92	(0.00)	0.49	Trin. & Tob.	1	-1.13	(0.70)	-1.09	(0.72)	-1.27
India	2	-1.31	(0.63)	-0.98	(0.76)	-1.38	Tunisia	1	-1.73	(0.42)	-1.39	(0.59)	-2.64
Indonesia	1	-0.89	(0.79)	-1.11	(0.71)	-1.13	Turkey	1	-0.90	(0.79)	-0.79	(0.82)	-0.76
Iran	1	-2.95	(0.04)	-2.75	(0.07)	-1.93	Uganda	2	-1.43	(0.57)	-1.41	(0.58)	-1.36
Jamaica	1	-1.49	(0.54)	-1.20	(0.68)	-1.53	Uruguay	1	-1.82	(0.37)	-1.65	(0.46)	-1.63
Jordan	1	-1.69	(0.44)	-1.88	(0.34)	-0.67	Venezuela	2	-1.54	(0.51)	-1.41	(0.58)	-1.78
Kenya	1	-1.58	(0.49)	-1.32	(0.62)	-0.82	Zambia	1	-1.69	(0.44)	-1.55	(0.51)	-1.12
Madagascar	2	-0.70	(0.85)	-1.22	(0.66)	-0.70	Zimbabwe	2	-0.94	(0.77)	-0.74	(0.84)	-1.18

See notes under Table 3.4 for critical values and deterministic included in these tests.

Table 3.6 presents the results from a number of univariate tests assessing the DS of 56 DCs. Recall the argument from section 3.2 of this chapter that a unit root in the debt-to-GDP ratio suggests that the debt is at an unsustainable level. Therefore, finding a nonstationary debt ratio or not being able to reject the null of a unit root implies that the debt is *unsustainable*. The results presented in Table 3.6 illustrate that the debt ratios are indeed *nonstationary* for most of the countries as the null of a unit root in the debt ratios cannot be rejected except for a handful of countries. The PP test indicates that 12 out of 56 nations have sustainable level of debt, whilst the ADF test suggests that only 8 countries have sustainable debt whereas the DFGLS test indicates that just 5 countries have sustainable debt level. Furthermore, according to both ADF and PP tests only 5 countries (namely Bangladesh, Honduras, Iran, Pakistan and Tanzania) have sustainable debt. Pakistan is the only country for which all three tests show that the debt is at sustainable level.

It has been argued by many academics (Krugman 1988, Sachs 1989, Elbadawi et al 1997, Pattillo et al 2004), policymakers and others such as the non-governmental organisations like the JDC that unsustainable debt levels lead to slow or negative growth rate of debtor country. Consequently, the finding of unsustainable debt suggests that the debts ratios of DCs should be reduced to encourage the growth and the development of these nations. (See chapter 2 of the thesis for more details about the relationship between debt and output.)

Although these tests provide useful insight about the individual country's debt levels, they should not be relied upon solely due to their very low power as explained earlier. This leads us to the analysis of DS using the second set of unit root tests.

Panel Unit Root Tests

In this section three panel unit root tests including IPS, MW and LM test by Hadri (2000) are employed to assess the DS of 56 DCs. These tests are considered more powerful than the univariate versions as they utilise not only the time dimension of the dataset but also the cross-sectional dimension. Section 3.3.1 gives a detailed description of the three tests applied here.

TABLE 3. 5.2
Assessing DS Using Panel Unit Root Tests

	Lags			
Null: Unit Root	**1**	**2**	**3**	**4**
Im Pesaran and Shin				
t_{bar} statistics	-1.97 (0.00)	-1.82 (0.00)	-1.79 (0.01)	-1.82 (0.00)
Maddala and Wu				
ADF	259.58 (0.00)	137.58 (0.05)	149.74 (0.01)	177.05 (0.00)
PP	203.27 (0.00)	199.67 (0.00)	198.76 (0.00)	199.21 (0.00)
Null: No Unit Root				
Hadri	Z_{mu}		Z_{tau}	
Homoskedastic	100.56 (0.00)		59.45 (0.00)	
Heteroskedastic	86.84 (0.00)		60.42 (0.00)	
Serially independent	26.01 (0.00)		17.07 (0.00)	

- Figures in the parentheses are the p-values
- Panel unit root tests are performed with 32 time observations on 56 cross-sectional units
- A constant is assumed for IPS and MW test
- For critical values see Table 3.5.

Table 3.7 presents the results for the IPS and the MW tests on the log of the debt-to-GDP ratios for up to 4 lags. It also reports the results from Hadri's panel unit root test when errors are assumed homoskedastic, heteroskedastic and serially independent across countries. The results from the IPS and both versions of MW tests (ADF and PP) reject the null hypothesis that there is a unit root across all countries against the alternative that at least one country's debt-to-GDP ratio is stationary. Since a unit root in debt-to-GDP ratios implies that the debt ratios are at unsustainable level, the findings from these two tests indicate that not all the countries in the sample have unsustainable debt and that there is at least one country in the sample that has sustainable debt ratio. This is consistent with the findings from the univariate unit root tests that showed that there are few countries with stationary or sustainable debt-to-GDP ratios.

However, according to Hadri test the debt ratios of all DCs are nonstationary, as the null of a no unit root for all the countries can be rejected under all three assumptions (homoskedastic, heteroskedastic and serially independent) regarding the cross-country errors. The key difference between IPS and MW and Hadri tests is the treatment of cross-country disturbance. Whilst the IPS and the MW tests ignore the cross-country correlation by assuming that observations are generated independently across countries, Hadri's test assumes dependence between countries and computes the test statistics under the assumption that the cross-country disturbances may be correlated, heteroskedastic or homoskedastic. When the assumption of independence is violated the test statistics follow unknown distributions. Moreover, this assumption is unrealistic as countries cannot be independent of each other especially in today's global economic environment. Therefore, one should place more weight on the finding from Hadri test than on the IPS and the MW tests.

In addition to this problem, panel unit root tests suffer from other drawbacks, so their results should be interpreted with caution. One problem that all three tests have in common is that the rejection of the null hypothesis suggests that there is at least one country in the panel that has (non)stationary debt ratio, but the tests do not indicate how many and which particular panel members are (non)stationary. In fact, Karlsson and Lothgren (2000) warn that for large T, panel unit root tests have high power and there is a possible risk in concluding that *all* the panels are stationary when in fact *only a small proportion* of them are stationary. For small T, these tests have low power and thus there is a risk of concluding that all the panels are nonstationary while only a small proportion of them are. Since in practice mixed panels are likely to be very common, this feature renders these tests of limited use. Nevertheless, there is some hope for Hadri's test as it not only takes into account the across country serial correlation but the simulations studies also show that it has good size and power, especially when T is above 50. Monte Carlo simulations confirm that the Hadri's test is less prone to size distortions that are caused by contemporaneous correlation.

3.5.2 TESTING DS BY RESIDUAL-BASED PANEL COINTEGRATION TESTS

This subsection presents materials on three related topics. The first concentrates on testing whether a long run equilibrium relationship exists between debt and GDP. The second illustrates the potential CV estimated by a number of estimators included OLS, BC-OLS, FMOLS and DOLS and tests the long-run restriction implied by the theory.

Cointegration between Debt and GDP

The residual-based tests are of two types – one where a DF/ADF test is conducted on the residuals and the other is a LM test where there is a unit root in the MA component of the DGP. The first type is developed by Kao (1999) whilst the second is proposed by McCoskey and Kao (1998). In this chapter both these types are used to assess the sustainability of debt of DCs. The following section discusses the results from these two types of tests and the subsequent section presents the findings from the likelihood-based tests by Johansen (1995) and Larsson Lyhagen and Lothgren (2001).

Since cointegration is an equilibrium relationship between two or more non-stationary variable it is a prerequisite to test for the stationarity of the variable under investigation before one can test for cointegration. In the previous section on preliminary analysis of the data unit root tests were performed on debt stock and GDP. The results on the natural log of external debt stock and output of DCs from the univariate and panel unit roots tests are illustrated in Table 3.3, 3.4.4 and 3.4.5. Overall, the tests concluded that both series are nonstationary and thus one can proceed to test for cointegration among them.

Residual-Based DF/ADF Tests

Table 3.8 reports the test results from the residual-based cointegration tests of Kao and MK described in 3.3.2. Kao's test investigates the null hypothesis that there is no cointegration between stock of debt and GDP. In all cases, the null of no cointegration for the three different estimators: OLS, FMOLS and DOLS can be rejected. Therefore, Kao's residual-based tests conclude that debt and GDP of DCs are *cointegrated*. This implies that the debt of countries under investigation is *sustainable* as cointegration means that debt is growing in line with the GDP. So that countries' are able to service the debt without facing any difficulty. These results conflict with the earlier findings from the unit root approach that the debt ratios are unsustainable. The main difference between the two approaches is that the unit root procedures imposed a pre-supposed restriction that the CV is $(1,-1)$ whilst the cointegration tests allow the vector to be $(1,\beta)$ where β can take any value. So the unit root tests are a special case of cointegration tests, where $\beta \equiv -1$. Consequently the conflicting results may be because the restriction imposed by the unit root tests is not valid yielding misleading results. On the other hand, the residual-based cointegration tests of Kao are not very powerful especially when the time-dimension (T) is relatively smaller than cross-sectional dimension (N) which is the case here as in this study T = 32 whilst N = 56.

Kao (1999) showed that all his tests have large size distortion when *T* is small but *N* is very large and that the power becomes even smaller when both *T* and *N* are small. Holding *T* fixed and increasing *N* does increase the power of the test but not as much as increasing T and holding N fixed. In general, the *T* dimension has bigger impact on increasing the power of the tests than the *N* dimension.

TABLE 3.8
Residual-Based Panel Cointegration Tests

Null: No Cointegration	**Estimators**		
Kao (1999)	**OLS**	**FMOLS**	**DOLS**
DF_ρ	-5.366 (0.00)	-3.070 (0.001)	-2.325 (0.010)
DF_t	-4.970 (0.00)	-2.127 (0.017)	-1.198 (0.115)
DF_ρ^*	-18.561 (0.00)	-14.718 (0.00)	-13.451 (0.00)
DF_t^*	-6.198 (0.00)	-4.457 (0.00)	-3.899 (0.00)
ADF	-6.324 (0.00)	-6.112 (0.00)	-6.108 (0.00)
Null: Cointegration			
McCoskey & Kao (1998)			
LM^*	28.315 (0.00)	41.709 (0.00)	49.003 (0.00)

Figure in the parenthesis are the probability value of null being true.

Residual-Based LM Test

Further to the size distortion problem mentioned above, the null of Kao's test is *no cointegration.* Tests of null of no cointegration have been criticized in the time series literature for having lower power than the tests of null of cointegration. Also the former are seen as less attractive in applications where economic theory implies cointegration between some variables rather than no cointegration. That is, in order to increase the power of the test, tests of the null of cointegration instead of the null of no cointegration have been proposed. These tests are particularly appealing in economic applications where the theory predicts cointegration a priori or it is more logical to have the null of cointegration rather than the null of no cointegration. In the pure time series literature Harris and Inder (1994) and Shin (1994) have proposed tests for the null of cointegration. In the panel data MK have developed a test for the null of cointegration.

In the context of this chapter MK test is more appropriate as debt-to-GDP criterion for DS requires that the debt should be cointegrated with the output. This is because if debt accumulates at a faster rate than GDP the debt-to-GDP ratio will eventually explode and the debtor country will not be able to service its debt. In order to apply MK's LM test an efficient estimator such as FMOLS and DOLS is required. In this chapter both these estimators are used to test the hypothesis of cointegration. Each test has its own advantages: the LM_DOLS uses the asymptotic moments for all value of T and does not depend on nonparametric correlation. The LM_FMOLS test is less dependent on the order and the proper specification of the lag and lead structure. The bottom part of Table 3.8 reports the LM^* statistics for FMOLS and DOLS estimators. In both cases, the null that there is a cointegrating relationship between debt and output is rejected. Hence, debt of DCs is *not sustainable* as Kao's tests of cointegration concluded above.

MK demonstrate that the T dimension is more influential in increasing the power of the test than the N dimension as is the case with Kao's test. However, their LM residual-based cointegration test has very small size distortion even for small T and small N unlike Kao's test. Therefore, the LM test of MK is preferred to DF/ADF tests of Kao so whenever there is a conflicting result from these tests, MK's test should be given the preference.

Estimating and Testing Restrictions on the CV

The unit root approach imposes the restriction that $\hat{\beta} = -1$ and then tests for the stationarity or the sustainability of debt, the cointegration approach, on the other hand, allows $\hat{\beta}$ to take any value and then tests for cointegration between debt and output, i.e. test the sustainability of debt. Hence, it is interesting to obtain the empirical estimates of the potential CV $\hat{\beta}$ and to statistically test if $\hat{\beta}$ is indeed equal to (minus) unity or not. It is worth noting that it is not necessary for $\hat{\beta} = -1$ for the debt levels to be sustainable, it is nonetheless interesting to estimate $\hat{\beta}$ and to test whether these estimates are statistically significantly different from -1 or not. Although, this test can be carried out in pooled regression, the results are not reliable, so they should be seen only as an indication rather than confirmative evidence.

The upper part of Table 3.9 reports the parameter estimates of $\hat{\beta}$ in equation [3.17]. Although the estimated coefficient has the expected sign and the t-statistics is significantly large, the OLS estimate is generally biased due to endogeneity in variables. Hence, the t-statistics do not have the usual t-distribution. Therefore, one should not place too much confidence on the estimates of $\hat{\beta}$ and its significance under the OLS estimator. Given this a number of alternative estimators including the bias corrected OLS, FMOLS and DOLS are used to estimate $\hat{\beta}$. The $\hat{\beta}$ coefficient estimated by FMOLS is similar to DOLS, which is not surprising given that both these estimators have the same limiting distribution derived by Kao and Chiang (2000). FMOLS gives the estimate of $\hat{\beta}$ closest to unity – 0.97 while DOLS seems to under estimate it and the conventional and the biased corrected OLS tends to over estimate it. Kao and Chiang study the finite sample properties of the OLS, FMOLS and DOLS estimators. They found that OLS has a significant bias in finite samples and the best estimator is DOLS as it outperforms both FM estimator and OLS.

The lower part of Table 3.9 presents the Wald's test statistics which show that $\hat{\beta}$ is -1 for only FMOLS estimator and rejects the null that $\hat{\beta} = -1$ for the other three estimators. That is the null hypothesis that $\hat{\beta}$ equals minus unity can be rejected for all estimators.

TABLE 3.9
Potential CV - Estimates and Restriction Test

	Estimators			
	OLS	**BC OLS***	**FMOLS**	**DOLS**
Estimates of $\hat{\beta}$	1.37	1.54	0.97	0.84
	(55.86)	(26.18)	(15.94)	(12.52)
R^2	0.64	0.64	0.58	0.33
Wald's statistics for null: $\hat{\beta} = -1$	96.63	43.18	32.37	27.42

- Estimates are based on pooled data from 1969-2000 for 56 countries giving 1792 observations.
- All regressions include unreported country-specific constants.
- Figures in the parentheses are conventional t-ratios.
- The dependent variable is the log of external debt stock.
- * BC is the bias corrected OLS estimate

3.5.3 TESTING DS BY LIKELIHOOD-BASED COINTEGRATION TESTS

This subsection consists of three parts. The first focuses on testing the existence of a cointegrating relationship between debt stock and output for the 56 DCs using Johansen (1995) and Larsson et al (2001) rank tests. Johansen's rank test is performed separately for each country whilst Larsson et al's test combines the individual country test statistics to compute the panel rank test similar to IPS test. The second part is concerned with estimating the potential CV using Johansen's maximum likelihood framework. The final segment tests the restriction on the long-run CV implied by economic theory.

Cointegration between Debt and Output

The previous cointegrating analyses based on a single equation approach did not provide conclusive results as one test suggested that the debt levels are sustainable whilst the other indicated otherwise. Moreover, these tests suffer from several drawbacks such as the assumption that all regressors are exogenous and there is no feedback between the two variables in the system, i.e. they only consider one possible ECM rather than all ECMs that may exist. Therefore, in this section the system approach is employed to test the DS of DCs. In particular, Johansen (1995) system based likelihood framework is used to test for number of cointegrating relations for each country individually. Johansen's procedure treats all the variables in the system as endogenous and studies all the possible ECMs simultaneously. Then the panel version of Johansen's rank tests developed by Larsson et al (2001) is used to test for the existence of a common largest cointegrating rank across all countries assuming a heterogeneous panel model. This test is based on the likelihood-based trace statistics for cointegration rank computed by Johansen's procedure. Larsson et al's test statistics, $\overline{LR}^{*}_{bar}$, given in [3.22], consists of averaging the individual trace test statistics proposed by Johansen over all the countries and then standardising them using mean and variance of asymptotic trace statistics.

Table 3.10 presents the individual country-by-country Johansen's trace statistics and Larsson et al (2001) panel $\overline{LR}_{bar}$ and $\overline{LR}^{*}_{bar}$ test statistics. The Johansen's statistics show that rank equals 1 for 38 (34) countries and zero for 11 (21) countries at 5% (1%) significance levels. This means that for 38 (34) countries debt and output are cointegrated but for 11 (21) countries there is no long-run relationship between debt and output. Recall the argument of section 2 that a cointegration between debt and output implies that debt is growing inline with the debtor country's output so the debtor has no problem in servicing the debt from its income therefore the debt level is considered sustainable. In short according to Johansen's test debt is sustainable for 38 (34) countries but is unsustainable for 11 (21) countries at 5% (1%) significance level. For 7 countries in the sample, rank equals the maximum number of variables in the system (2), which indicates that the debt of these countries is not cointegrated since the rows/columns of the cointegrating matrix are independent of each other. That is debt and GDP are two random variables that are determined independently of each other in the long-run. However, when 1% significance level is chosen, only one country, Bangladesh has debt independent of GDP.

TABLE 3.10
Johansen Trace Statistics and Larsson et al's Panel Rank Statistics

	Rank under the null		Rank (r_i)			Rank under the null		Rank (r_i)	
	r = 0	r = 1	5%	1%		r = 0	r =1	5%	1%
Algeria (1)	32.41	5.03	1	1	Malawi (1)	37.74	12.32	2	1
Argentina (1)	27.17	4.65	1	1	Malaysia (2)	17.86	6.55	0	0
Bangladesh (4)	34.87	14.75	2	2	Mali (2)	21.82	7.89	1	0
Bolivia (1)	23.47	2.29	1	0	Mauritius (2)	19.39	4.58	0	0
Brazil (1)	33.51	5.38	1	1	Mexico (1)	55.50	7.30	1	1
Cameroon (2)	28.73	5.13	1	1	Morocco (1)	37.90	1.80	1	1
Chile (1)	24.45	2.39	1	0	Moz'bique (3)	14.41	3.09	0	0
China (1)	30.14	6.28	1	1	Nicaragua (1)	24.38	5.66	1	0
Colombia (1)	52.78	6.97	1	1	Nigeria (3)	30.37	10.01	2	1
Costa Rica (3)	17.94	2.56	0	0	Pakistan (4)	32.09	5.27	1	1
C. d`Ivoire (3)	22.39	8.87	1	0	Panama (2)	33.72	3.28	1	1
Dom. Rep. (1)	27.36	2.53	1	1	Paraguay (2)	22.48	8.34	1	0
Ecuador (1)	29.92	5.71	1	1	Peru (1)	26.31	6.27	1	1
Egypt (1)	28.92	5.37	1	1	Rwanda (1)	23.80	6.95	1	0
El Salvador (2)	16.73	1.96	0	0	Senegal (1)	25.51	4.73	1	1
Ethiopia (1)	26.39	8.07	1	1	Sierra Leone (1)	17.15	5.95	0	0
Ghana (1)	25.97	9.63	2	1	South Africa (1)	17.20	4.04	0	0
Guatemala (1)	39.27	2.55	1	1	Sri Lanka (3)	39.04	3.56	1	1
Guyana (4)	22.63	5.45	1	0	Tanzania (2)	59.38	5.54	1	1
Haiti (1)	25.61	7.38	1	1	Thailand (3)	21.68	8.11	1	0
Honduras (2)	28.97	5.11	1	1	Trin. & Tob. (3)	31.01	10.70	2	1
India (2)	26.33	4.32	1	1	Tunisia (2)	31.24	9.71	2	1
Indonesia (3)	25.62	8.35	1	1	Turkey (1)	28.15	4.80	1	1
Iran (1)	14.02	5.60	0	0	Uganda (1)	37.63	7.49	1	1
Jamaica (1)	14.77	1.07	0	0	Uruguay (4)	39.71	5.84	1	1
Jordan (4)	19.57	3.41	0	0	Venezuela (2)	27.57	2.73	1	1
Kenya (1)	29.20	6.81	1	1	Zambia (2)	30.88	9.61	2	1
Madagascar (2)	18.36	8.15	0	0	Zimbabwe (2)	22.86	5.48	1	0

Panel Rank Tests

Full sample	Rank under the null = 0	Rank under the null = 1	5%	1%
$\overline{LR}_{bar}$	28.11	5.95	-	-
$\overline{LR}^{*}_{bar}$	50.78	24.23	2	2
Sub-sample				
$\overline{LR}_{bar}$	27.60	5.24	-	-
$\overline{LR}^{*}_{bar}$	46.39	19.30	2	2

- The critical values, assuming a constant in the cointegrating equation, for the Johansen's test are 19.96 and 9.24 for r = 0 and r =1 at 5%, whilst the appropriate critical values at 1% are 24.69 and 12.97 for r = 0 and r = 1 respectively.
- It is assumed that the level data have no linear trend and the cointegrating equations have intercepts
- Figures inside the parenthesise given next to each country are the VAR order suggested by BIC for a series of vector autoregressions of order 1 to 4.
- Critical values for the panel cointegration tests presented at the bottom of the Table are 1.71 and 2.46 at 5% and 1% significance level.
- Sub-sample excludes all the countries with rank 2 found under Johansen's test.

The results for the panel test of Larsson et al (2001) are presented in the lower segment of Table 3.10 for the full sample of countries and a sub-sample of countries with rank 1 and 0. The Table also reports both the $\overline{LR}_{bar}$ and the $\overline{LR}^{*}_{bar}$ statistics corresponding to equation [3.21] and [3.22] respectively, to show the difference between the simple averages and standardised trace statistics.

The null hypothesis are rejected in both sequential tests as the $\overline{LR}^{*}_{bar}$ statistics are greater than the critical values in both cases leading to the conclusion that the common *largest* cointegration rank in the panel is 2. This implies that the debt and the GDP of DCs are both I(0) processes, which is highly unlikely as these variables are found to be I(1) processes by not only this chapter but also in the literature on time series. In order to understand why there is such a strong rejection of the null hypothesis whilst the Johansen's test indicates that the most common rank is 1, the table also shows the simple averages of the trace statistics across 56 countries for rank 0 and 1 under the null. Although the averages are much smaller than the panel statistics, they are still greater than the critical values.

For rank 0 the average is 28.11, which is almost half the value of Larsson et al rank statistic and for rank 1 the average is 5.95 which is more than 4 times less than the panel rank statistic suggesting that the rank statistics are inflated by the standardisation process. The inflation of the statistics is particularly high when cross-sectional dimension of the dataset is greater than the time dimension. Indeed, as already mentioned, Larsson et al did show that their panel rank test has a large size distortion particularly for small T despite having large N. In fact they illustrated that the size distortion is particularly worse when T is smaller than N which is the case with the current sample ($T=32 < N=56$). Other studies have also concluded that Larsson et al test has large size distortion. Gutierrez (2003), for example, studied the size and the power of cointegration tests by Kao (1999), Pedroni (2000) and Larsson et al (2001). He showed that Larsson et al test does the worst and both Kao and Pedroni tests outperform Larsson et al test. Therefore, one should not place much confidence in Larsson et al test which contradicts the findings from other relatively more reliable tests like Kao's.

Furthermore, excluding all 7 countries with rank 2 (suggested by Johansen's test conducting at 5% significance level) does not make much difference to either the simple averages or the standardised statistics shown in the last two rows of Table 3.10. This confirms that the panel rank statistics are not inflated by the presence of a few extreme results but by some other factor, like the cross sectional dimension (N) discussed above.

Estimates of the CV

The previous analysis of Johansen's rank test showed that for 38 out of 56 countries debt and output are cointegrated. Naturally, the next step of the analysis is to obtain the estimates of the long-run parameter, beta. Table 3.11 presents Johansen's normalized beta estimates for countries with rank 1, 0 and 2. The overall result disregarding the rank test shows that beta is statistically significant for 42 countries and is negative for 34 of them. Specifically, for approximately 61% of the countries, beta estimate is negative and statistically significant indicating a positive relationship debt and output.

The estimated coefficients are statistically significant for 32 out of 38 countries suggesting that GDP has a statistically significant effect on debt for most of the countries. Also, for 24 of these 32 countries the beta estimate is negative indicating a positive relationship between debt and output. So an increase in GDP leads to an increase in the level of debt. The reasons for this is that high GDP means that the country has increased level of income and can thus finance its own activities without resorting to borrowing at least to the level it previously did when its GDP was lower. However, the magnitude of the impact for these countries with negative beta is somewhat mixed – for nearly one half of them (13) beta is greater than unity whilst for the second half (11) of them beta is less than or equal to unity.

For nearly one-quarter of the countries with statistically significant beta the results show that high GDP leads to further borrowing. This may be because the country is credit rationed and thus higher GDP increases its borrowing capacity resulting in creditors increasing their credit to the country. For these countries with positive and statistically significant beta the magnitude effect is greater than unity indicating that 1% increase in GDP leads to more than 1% increase in the credit limit and thus borrowing.

Since the focus of the paper is on the use of panel data techniques, it is necessary to obtain some panel estimate of beta. Two different methods are used to combine country's individual betas estimates to compute the "panel" beta. Pesaran and Smith (1995) propose these two methods of consistently estimating the long run average effects assuming cointegration. The first method involves simply averaging the individual parameter estimates for each cross-section, such that panel beta equals $\overline{\beta} = \frac{1}{N}\sum_{i=1}^{N}\beta_i$, where N is number of cross sections.

The second method involves estimating a cross-section relationship between the averages across-time. More specifically its entails estimating $\overline{d}_i = \alpha + \beta\overline{y}_i + \varepsilon$, where $\overline{d}_i = \frac{1}{T}\sum_{t=1}^{T}\ln D_{it}$ and $\overline{y}_i = \frac{1}{T}\sum_{t=1}^{T}\ln Y_{it}$. Although this provides consistent estimates of beta, the usual standard errors are not valid. Instead Pesaran and Smith suggest White's hetroskedasticity consistent standard errors. Both methods rely on the assumption of independence across the cross-sections for the asymptotic to hold. The second approach also makes the assumption of strong exogeneity of regressors.

TABLE 3.11
Normalised Beta Estimates

Countries with rank 1	Beta	SE(Beta)		Beta	SE(Beta)
Algeria (1)	8.69	(2.25)***	Kenya (1)	-0.67	(0.29)**
Argentina (1)	-0.20	(1.57)	Mali (2)	-0.42	(0.45)
Bolivia (1)	-2.37	(0.62)***	Mexico (1)	-1.00	(0.09)***
Brazil (1)	-0.83	(0.14)***	Morocco (1)	4.34	(1.16)***
Cameroon (2)	-0.27	(0.30)	Nicaragua (1)	-1.91	(0.77)***
Chile (1)	-0.95	(0.24)***	Pakistan (4)	1.72	(0.67)***
China (1)	-2.74	(0.88)***	Panama (2)	4.99	(1.00)***
Colombia (1)	-0.99	(0.06)***	Paraguay (2)	-0.91	(0.16)***
Cote d`Ivoire (3)	6.09	(2.15)***	Peru (1)	-0.54	(0.38)*
Dominican Republic (1)	-0.63	(0.26)**	Rwanda (1)	-0.41	(0.84)
Ecuador (1)	-1.35	(0.13)***	Senegal (1)	2.35	(1.48)*
Egypt (1)	11.18	(9.79)	Sri Lanka (3)	-4.61	(0.54)***
Ethiopia (1)	-2.56	(0.36)***	Tanzania (2)	-0.72	(0.08)***
Guatemala (1)	-1.25	(0.15)***	Thailand (3)	-1.41	(0.05)***
Guyana (4)	1.04	(0.74)*	Turkey (1)	-1.43	(0.19)***
Haiti (1)	-0.21	(0.66)	Uganda (1)	-2.22	(0.45)***
Honduras (2)	6.67	(1.85)***	Uruguay (4)	-0.47	(0.17)***
India (2)	-0.95	(0.18)***	Venezuela (2)	-1.21	(0.20)***
Indonesia (3)	-4.26	(0.97)***	Zimbabwe (2)	-3.96	(0.52)***
Countries with rank 0					
Costa Rica (3)	0.15	(0.33)	Malaysia (2)	-0.95	(0.18)***
El Salvador (2)	-0.66	(0.22)***	Mauritius (2)	-0.84	(0.21)***
Iran (1)	-0.95	(0.28)***	Mozambique (3)	2.68	(0.38)***
Jamaica (1)	11.82	(6.32)***	Sierra Leone (1)	0.36	(1.48)
Jordan (4)	0.10	(0.46)	South Africa (1)	-3.89	(1.73)***
Madagascar (2)	3.50	(2.15)			
Countries with rank 2					
Bangladesh (4)	-1.16	(0.18)***	Trinidad & Tobago (3)	-1.62	(0.21)***
Ghana (1)	-2.06	(0.43)***	Tunisia (2)	0.77	(0.46)
Malawi (1)	-0.87	(0.34)***	Zambia (2)	-19.82	(3.57)***
Nigeria (3)	-1.22	(0.54)***			

	Panel beta(s)	
	Average beta	Cross-sectional beta
All countries	-0.16	0.78
Countries with rank 0	1.03	0.67
Countries with rank 1	0.15	0.80
Countries with rank 2	-3.71	0.63

- Number of stars (*) next to the standard errors indicate the precision of beta estimates

The bottom part of Table 3.11 illustrates the average and the cross sectional beta estimates for all the countries in the sample despite the rank and for countries with rank 0, 1, and 2. For the cointegrated group of countries (with rank = 1) the average beta is 0.15 suggesting that on average an increase in GDP of 1% results in a fall in debt stock of 0.15%. For the full sample of countries the average beta is -0.16 indicating that debt-output relationship is positive. The cross-sectional estimates of beta are all positive and less than unit for all four groups of countries, signifying that debt-output relationship is negative but less than one-for-one, so that a 1% increase in GDP leads to less than 1% fall in debt stock.

Thus far two approaches have been applied to test the DS of DCs: unit root approach and cointegration approach. The key difference between the two approaches is the assumption regarding the CV beta. The unit root approach assumes it to be unit whilst the cointegration approach allows it to take any value and furthermore, enables one to test whether it is unit or not. In order for the unit root tests on the debt-to-GDP ratio and the cointegration tests between debt and GDP to reconcile the beta estimates has should be unit. However, note that it is not necessary for beta to be unity in order for the debt levels to be sustainable. The next subsection tests whether beta is indeed unity or not for individual and panel of countries under investigation.

Testing Restrictions on the CV

Table 3.12 displays the chi-square test statistics for the over identifying restriction that the CV is $(1,-1)$ for the cointegrated set of countries, i.e. countries with rank 1. The null hypothesis that the vector $\boldsymbol{\beta}$ is $(1,-1)$ can be rejected for 12 out of 38 countries for which debt and output are cointegrated. This means that debt and output are cointegrated for 26 countries with vector $(1,-1)$ and 12 countries with vector $(1,-\beta)$, where $\beta \neq -1$. In asymptotic, countries with cointegrated debt and output with vector $(1,-1)$ should have stationary or sustainable debt-to-GDP ratio. However, this is not what the data suggests – there are only 7 countries that have stationary debt (according to one of the unit root tests employed) and cointegrated debt and output with vector $(1,-1)$. For the remaining 19 countries with CV $(1,-1)$, the unit root tests find debt-to-GDP ratio to be non-stationary. This may be due to small sample and the technical variations in unit root and cointegration tests.

On the other hand countries with CV $(1,-\beta)$ where $\beta \neq -1$, the unit root tests should not necessarily find the debt-to-GDP ratio to be stationary as the restriction imposed by unit root tests is not satisfied. The actual results show that the debt ratio is indeed non-stationary for majority of these countries.

TABLE 3.12
Chi-squared Statistics for Overidentifying Restrictions on Beta

Countries with rank 1	**Chi-squared**	**p-value**		**Chi-squared**	**p-value**
Algeria (1)	8.35	0.00	Kenya (1)	0.40	0.53
Argentina (1)	0.17	0.68	Mali (2)	0.48	0.49
Bolivia (1)	4.44	0.04	Mexico (1)	0.00	0.99
Brazil (1)	0.92	0.34	Morocco (1)	9.00	0.00
Cameroon (2)	1.96	0.16	Nicaragua (1)	0.85	0.36
Chile (1)	0.05	0.83	Pakistan (4)	12.42	0.00
China (1)	2.06	0.15	Panama (2)	23.38	0.00
Colombia (1)	0.05	0.82	Paraguay (2)	0.12	0.72
Cote d`Ivoire (3)	1.39	0.24	Peru (1)	1.32	0.25
Dom. Republic (1)	1.72	0.19	Rwanda (1)	0.08	0.78
Ecuador (1)	1.66	0.20	Senegal (1)	1.17	0.28
Egypt (1)	0.97	0.32	Sri Lanka (3)	24.22	0.00
Ethiopia (1)	2.24	0.13	Tanzania (2)	7.06	0.01
Guatemala (1)	1.18	0.28	Thailand (3)	2.57	0.11
Guyana (4)	5.79	0.02	Turkey (1)	1.60	0.21
Haiti (1)	0.29	0.59	Uganda (1)	4.92	0.03
Honduras (2)	2.38	0.12	Uruguay (4)	9.62	0.00
India (2)	0.04	0.85	Venezuela (2)	0.52	0.47
Indonesia (3)	6.05	0.01	Zimbabwe (2)	11.81	0.00
Countries with rank 0					
Costa Rica (3)	9.37	0.00	Malaysia (2)	0.02	0.89
El Salvador (2)	2.33	0.13	Mauritius (2)	0.25	0.62
Iran (1)	0.00	0.96	Mozambique (3)	5.27	0.02
Jamaica (1)	4.07	0.04	Sierra Leone (1)	0.36	0.55
Jordan (4)	2.13	0.14	South Africa (1)	1.24	0.26
Madagascar (2)	0.80	0.37			
Countries with rank 2					
Bangladesh (4)	0.53	0.47	Trinidad & Tobago (3)	3.24	0.07
Ghana (1)	0.43	0.51	Tunisia (2)	4.58	0.03
Malawi (1)	0.03	0.86	Zambia (2)	11.01	0.00
Nigeria (3)	0.09	0.76			

	Panel Test Statistics for Overidentifying Restrictions	
	Panel Chi-square	*Fisher's statistics*
Full Sample	199.00 (0.000)	287.75 (0.000)
Countries with rank 0	25.84 (0.007)	41.27 (0.008)
Countries with rank 1	153.25 (0.000)	216.65 (0.000)
Countries with rank 2	19.91 (0.006)	29.84 (0.008)

Critical values

	Country test	Panel test				Fisher's test			
df (rank)	1	11 (0)	38 (1)	7 (2)	56 (all)	22 (0)	76 (1)	14 (2)	112 (all)
1%	6.63	24.72	61.16	18.48	83.51	40.29	107.58	29.14	149.73
5%	3.84	19.68	53.38	14.07	74.47	33.92	97.35	23.68	137.70

Overall the individual country test shows that that overidentifying restriction that the CV $\boldsymbol{\beta}$ is $(1,-1)$ is satisfied for most of the countries. Given that the focus of the paper is the use of panel data techniques two different panel tests are used to test this overidentifying restriction. The bottom part of Table 3.12 illustrates the results from the panel versions of the overidentifying restriction tests.

The first test is simply the chi-square test where the additive property of chi-square distribution is used to derive the panel test statistics. The results show that the null hypothesis that the CV $\boldsymbol{\beta}$ is $(1,-1)$ can be rejected even at 1% significance level.

The second test is the Fisher's χ^2 test suggested in this chapter. It combines a country's individual p-values to compute the panel test statistics. The test is χ^2 distributed with 2N df, where N is the number of cross sectional units, such as countries. The chi-square test statistics of 216.65 is greater than the critical value of 107 at 1% level. Hence the null can be rejected as with the first test suggesting that the CV is not $(1,-1)$ for all the countries. This provides the reconciliation between the unit root tests that find debt-to-GDP ratio to be non-stationary/unsustainable and the cointegration tests that show debt and output to be cointegrated and hence sustainable. It appears that the prior restriction, imposed by the unit root tests, is not satisfied which may have caused the discrepancies between unit root test and the cointegration test.

3.5.4 SUMMARY OF THE KEY EMPIRICAL RESULTS

In this section the DS of 56 DCs has been assessed using two different approaches. The first imposes a prior restriction on the beta so that debt and GDP are cointegrated with vector $(1,-1)$ whilst the second allows the CV to be unrestricted. The latter technique is further divided into single equation analysis and systems analysis.

TABLE 3.13
Countries With Unsustainable Debt According to Multi-County Methods

Results	Unit Root tests	Cointegration tests	Overall
Not unsustainable for all countries	IPS and MW	Kao	
Unsustainable for all countries	Hadri	MK	Ambiguous
Undetermined		LLL	

It is difficult to classify each country's debt into a sustainable or unsustainable category, as the results across different tests are not consistent. Table 3.13 summarises the findings from each of the 6 multi-country test used. Only 2 out of 6 tests show that debt of all countries is unsustainable, while 3 of them find that debt is not unsustainable for all countries – there is at least one country in the sample that has sustainable debt. However, multi-country methods do not show which country has sustainable debt and which has unsustainable debt.

TABLE 3.14
Countries' Debt Classification According to Univariate Methods

Sustainable (3)	Ambiguous (7)	Unsustainable (46)		
Honduras (1)	Bangladesh (2)	Algeria (3)	Iran (3)	Jamaica (4)
Pakistan (1)	Guyana (2)	Argentina (3)	Kenya (3)	Jordan (4)
Tanzania (1)	Mexico (2)	Bolivia (3)	Malawi (3)	Madagascar (4)
	Panama (2)	Brazil (3)	Malaysia (3)	Mozambique (4)
	Sri Lanka (2)	Cameroon (3)	Mali (3)	Sierra Leone (4)
	Thailand (2)	Chile (3)	Mauritius (3)	South Africa (4)
	Tunisia (2)	China (3)	Morocco (3)	
		Colombia (3)	Nicaragua (3)	
		Costa Rica (3)	Nigeria (3)	
		Cote d'Ivoire (3)	Paraguay (3)	
		Dom. Republic (3)	Peru (3)	
		Ecuador (3)	Rwanda (3)	
		Egypt (3)	Senegal (3)	
		El Salvador (3)	Trin. & Tobago (3)	
		Ethiopia (3)	Turkey (3)	
		Ghana (3)	Uganda (3)	
		Guatemala (3)	Uruguay (3)	
		Haiti (3)	Venezuela (3)	
		India (3)	Zambia (3)	
		Indonesia (3)	Zimbabwe (3)	

5% significance level is used to conduct the hypothesis testing
Figures in the parentheses are the number of tests that indicated debt levels of to unsustainable

Therefore, the results from the individual country are summarised in Table 3.14. The Table lists the countries under "sustainable", "ambiguous" or "unsustainable" category. A country's debt is classified as "sustainable" if 3 out of 4 tests conclude as such. If half of the tests show that debt is sustainable and half find that it is unsustainable, then countries are listed under the "ambiguous" category. If 3 or 4 tests conclude that a country's debt is unsustainable then it is classified as such. The Table also reports the number of tests finding debt of a country as unsustainable in the brackets next to country name.

For majority of the countries (46) debt is at sustainable level and only for 3 countries can we say that debt might be "sustainable". There is not a single country for which all univariates tests conclude that its debt is sustainable.

3.6 SUMMARY AND CONCLUDING REMARKS

The IBC states that a country's debt is sustainable as long as its current debt equals the present value of future trade balance surpluses. However, IBC has been criticised for being unrealistic and impractical as a country can run CA deficit (i.e. accumulate debt) over a long-term without violating the IBC. This behaviour is unrealistic in practice as creditors will not lend for such a long period and investors will became very caution in investing in highly indebted country due to debt overhang prospect. The more appropriate criterion for assessing the DS has been argued to be the debt-to-GDP ratio criterion, which states that debt is sustainable as long as debt and output of the debtor do not drift too far apart, i.e. the equilibrium relationship between the two variables does not breakdown in the long-run.

The empirical implications derived in terms of the time series properties of debt and GDP relationship is that the debt-to-GDP ratio should be stationary overtime and that the debt and the output should be cointegrated. This chapter has examined the intertemporal DS of 56 DCs from 1969 to 2000 using numerous different methodologies including unit root tests, residual-based and likelihood-based cointegration techniques. Since the unit root approach imposes a prior restriction on the relationship between debt and output such that the CV is $(1,-1)$, the cointegration approaches is also used which not only allows unrestricted CV also enables test restriction on the CV.

Although the empirical results appear sensitive to the methodology used, the overall results can be said to confirm that the debt levels of DCs under investigation are indeed *unsustainable*. The results from the univariate and the panel unit root tests show that debt of most countries is unsustainable as the debt-to-GDP ratios are nonstationary. This is supported by the findings from MK test for which cannot reject the null of no cointegration and the Larsson et al test that finds debt and output to be two independent variables without any long-run relationship. Only Kao test shows that all countries have sustainable debt levels and Johansen test suggests that majority of countries have sustainable debt as their debt and GDP are cointegrated in the long-run. The latter two tests are weaker than the unit root test of Hadri and the cointegration test of MK both of which show that debt is unsustainable.

Since the tests concluding that debt is sustainable have larger size distortion and lower power than the tests concluding that the debt is unsustainable, more weight is placed on these latter tests and the debt of DCs is more likely to be unsustainable, than to be sustainable. Therefore, creditors should write down these unsustainable debt levels to reduce the debt stock to sustainable levels. There is a large body of literature arguing that high debt stocks have detrimental effect on the growth and development of debtor country. See chapter 2 for details of the detrimental effect of high debt on the growth of debtor country.

4 ESTIMATING DEBT SUSTAINABILITY INDICATOR

4.1 INTRODUCTION

Following the results of the previous two chapters, all countries under the analyses are assumed to have "unsustainable" debt position. That is, all countries have debt-to-GDP ratio above the sustainable threshold of 45%. Furthermore, the debt ratios are non-stationary and no long-run relationship exists between debt and output of these nations. Given this, the aims of this chapter are twofold: firstly, to measure the extent to which these countries' debt is unsustainable and secondly to investigate the sources or factors of non-sustainability. The degree of unsustainability, called the DSI is measured by the persistence of shocks using univariate persistence techniques proposed by Campbell and Mankiw (1987) and multi-country measures suggested by PPL (1993). These persistence estimates are then decomposed according to the sources of shocks using the methodology advocated by LPP (1992) to investigate what factors cause debt to become unsustainable. In particular, the paper looks at three specific shocks to determine the extent to which these factors can explain unsustainability in debt.

The shocks considered are generally attributed to the emergence of the 1980s debt crisis. The exact factors leading to the crisis are several and interlinked, making it very hard to assign appropriate weights to them. Some researchers categorise the factors into various camps: the debtor nations, private lending institutions, creditor nations and structure of international financial system (Decoodt, 1986). Others take conditions of the 1970s as the causes of crisis and there are some who consider the inherited structure of DCs as the root of the crisis. Despite these different views of the causes of debt crisis, generally three shocks to DCs are widely believed to be the main cause of the debt crisis. These include interest rate shock, non-oil exporting commodity price shock and oil price shock, which are investigated in this chapter.

The key findings of the chapter indicate that the debt levels of LAC and SSA countries are indeed *unsustainable* and the degree of unsustainability is *high* for LAC countries as compared to SSA countries. This may be because LAC countries are relatively more open and hence are more vulnerable to external shocks than SSA countries. Also, as SSA are lower-income countries with higher debt-to-GDP ratios than LAC, any further increase in debt due to an external shock cannot be absorbed by SSA countries so the new increase in debt is written-off making the persistence of shocks temporary. Moreover, the findings support the perception that interest rate, non-oil commodity prices and oil price shocks had significant contribution to the 1980s debt crisis. However, the contribution of these shocks is less *significant* than other unidentified factors, suggesting that one must look beyond these shocks to understand fully the causes of the crisis.

The chapter proceeds from this introduction to section 4.2, which outlines the DSI. Section 4.3 provides some historical analysis of the economies under investigation particularly how they became debt crisis countries. The empirical tests of the DSI are presented and discussed in section 4.4. The sources of shocks to debt-to-GDP ratios are examined in section 4.5 and finally the concluding remarks are made in section 4.6.

4.2 DSI AND SOURCES OF SHOCKS

Chapter 2, subsection 2.2.1 briefly reviews how DS is assessed in practice, i.e. the framework the Fund-Bank use to manage the TWD crisis. It goes on to argue that their analysis is not based on any economic theory. Subsequently, it introduces the theoretical framework used in the literature to study the DS and outlines the numerous testing procedures which have been proposed. This section comments on the drawbacks of the current methodologies used to assess the DS and introduces an alternative empirical procedure that produces a *DSI.*

4.2.1 THE DEBT SUSTAINABILITY INDICATOR

Although in the literature various tests or methods have been proposed to test the sustainability of debt they all boil down to the same conclusion. Therefore, one can say that the literature on the DS classes a country either into a sustainable or unsustainable group by testing the time series properties of debt stock and debt ratio. A country with stationary debt-to-GDP ratio or cointegrated debt and output is considered sustainable while a country with non-stationary debt ratio or non-cointegrated debt and output is considered unsustainable.

However, such a dichotomy between sustainable and unsustainable countries is not useful or realistic particularly since unit root and cointegration tests have very low power and cannot distinguish a unit root process from a near unit root process. Consequently, a country's debt level may well be classed as unsustainable but the debt process is not necessarily a unit root, instead it is a near unit root process. That is a country close to debt crisis is very likely to be classed as a debt crisis country by unit root tests as these tests have very low power. The implications of wrongly classifying a country as debt crisis are many and detrimental, including creditors rationing their credits to this country, investors withdrawing their investments and currency depreciating suddenly raising the value of debt and the cost of servicing the debt as all debt is traded in the US dollars and so on. Furthermore the appropriate policy recommendation could be very different under each scenario. For a debt crisis country, the appropriate strategy might be to reduce the debt levels via debt forgiveness to sustainable level, whereas for a country close to debt crisis the appropriate strategy might be to eliminate any further borrowing.

Therefore, the concept of sustainability should not be seen such that a country's debt is either sustainable or unsustainable but instead as a continuum such that one can measure the degree of a country's DS. That is one should estimate how close or how far away a country is from having unsustainable level of debt rather than testing if its debt level is sustainable or not. By using a continuum, i.e. a *Sustainability Indicator*, researchers can advise governments/debtors about their borrowing capacity and warn them against any possible accumulation of debt to unsustainable levels. The indicator is more informative for policy makers, investors, debtors and creditors than the usual dichotomy of sustainability vs. unsustainability. The indicator is not only a more practical mean of assessing the DS, but is also more useful indicator for determining the appropriate debt management policy.

Keeping in line with the existing tests for DS, such as unit root and cointegration, the paper proposes a new empirical technique for assessing the DS using persistence measures. This is closely related to the unit root literature as it also analyses the time series properties of debt stock or debt ratio. The difference is that whilst unit root tests examine whether a variable is a unit root process or not (i.e. whether the characteristic root lies inside the unit root circle or not), the persistence measure computes the random walk component of the variable. The literature on persistence measure estimates "how close" a series is to a unit root process. The following subsection explain the computation of persistence measures using some models and shows the link between the persistence and the unit root techniques.

Univariate Persistence Measures

Generally speaking three different approaches have been developed to measure the persistence: firstly the rate of persistence can be estimated by a direct estimation of the parameters of the underlying model proposed by Campbell and Mankiw (1987). Secondly persistence can be estimated by using the variance or the autocorrelation ratios suggested by

Cochrane (1988). Finally, the persistence can be measured by estimating an unobserved components model suggested by Harvey and Todd (1983), Harvey (1985), Watson (1986), Clark (1987) and Beveridge and Nelson (1981). In this study only the first approach suggested by Campbell and Mankiw (1987) is utilised. Although these three approaches seem rather different from each other, they all boil down to the same thing as shown by PPL (1993). That is all three measures are alternative methods of scaling the spectral density function evaluated at zero frequency. PPL showed that Campbell and Mankiw method scales the spectral density function by conditional variances while Cochrane method scales the density function by unconditional variance.

In order to explain the measures of persistence suppose that y_t can be represented by a univariate ARIMA process such that

$$a(L)(1-L)y_t = b(L)\varepsilon_t \qquad [4.1]$$

where y_t is the level or the logarithm of variable of interest such as debt-to-GDP ratio, L is the lag operator such that $Ly_t = y_{t-1}$, ε_t is the white noise process with constant variance of σ_ε^2, $a(L)$ and $b(L)$ are the finite-order lag polynomials such that $a(L) = 1 - a_1L - a_2L^2 - ... - a_pL^p$ and $b(L) = 1 + b_1L + b_2L^2 + ... + b_qL^q$.

Equation [4.1] has a MA representation for the change in y_t as expressed below

$$(1-L)y_t = \Delta y_t = A(L)\varepsilon_t \qquad [4.2]$$

where the MA representation $A(L) = a(L)^{-1}b(L)$ is an infinite polynomial in the lag operator. Using ARIMA (p,q) or MA (∞) representations Campbell and Mankiw (1987a) showed that the measure of persistence is given by the infinite sum of the MA coefficients in the Δy_t process. Here the impact of a unit shock occurring in period t on Δy_t in s-period ahead (in period $t+s$) is A_S while the impact on y_t in period $t+s$ is $\sum_{j=0}^{s} A_j$. The total impact of a shock on the level of a series such as y_t is the infinite sum of these MA coefficients i.e. $\sum_{j=0}^{\infty} A_j = A(1)$. The value of $A(1)$ is known as the persistence measure and the following example illustrate how it is computed for simple AR and ARMA models.

Suppose that ARIMA [4.1] is approximated by an AR(1) process $\Delta y_t = \rho \Delta y_{t-1} + \varepsilon_t$, then the persistence measured by $A(1) = (1-\rho)^{-1}$. For an AR(2) the persistence is given by

$A(1) = (1 - \rho_1 - \rho_2)^{-1}$. For an ARIMA(1,1) process like $\Delta y_t = \rho \Delta y_{t-1} + \varepsilon_t + \theta \varepsilon_{t-1}$, the persistence equals $A(1) = (1 - \rho)^{-1}(1 + \theta)$. For ARIMA(2,2) $\Delta y_t = \rho_1 \Delta y_{t-1} + \rho_2 \Delta y_{t-2} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2}$, the persistence equals $A(1) = (1 - \rho_1 - \rho_2)^{-1}(1 + \theta_1 + \theta_2)$.

Multi-Country Persistence Measure

The persistence measure described in the above section is extended to the multi-country model by LPP and PPL. To explain these measures of persistence, let $\mathbf{y}_t$ be a $q \times 1$ vector of stochastic variable like debt-to-GDP ratio for *q* different countries such that it can be represented by a first-differenced stationary linear process as follows:

$$\Delta \mathbf{y}_t = \mu + C(L)\varepsilon_t \qquad [4.3]$$

where $\Delta \mathbf{y}_t$ is the $q \times 1$ vector of growth rates of $\mathbf{y}_t$, μ is the $q \times 1$ vector of constant representing country-specific mean growth rate and ε_t is the $q \times 1$ vector of white noise innovations with zero mean and the covariance matrix $\Theta = (\theta_{ij})$, $C(L)$ is the matrix of polynomial taking the following form:

$$C(L) = \sum_{i=1}^{\infty} C_i L^i = C_o + C_1 L + C_2 L^2 + \ldots \qquad [4.4]$$

where C_i 's are square matrices of dimension q representing the fixed parameter coefficients and $C_0 = I_q$, i.e. it is an identity matrix. The $(i,j)^{th}$ element of $C(L)$ is denoted by $C_{ij}(L)$.

PPL and LPP showed that various measures of persistence proposed in the literature for univariate models are all based on the spectral density function of $\Delta \mathbf{y}_t$ evaluated at frequency zero, $f_{\Delta \mathbf{y}}(0)$ and that these measures only differ with respect to the scaling factor. Using spectral density approach they derived persistence measures at the aggregate and the country level in multivariate framework. The un-scaled country measure of persistence given by the spectral density function of $\Delta \mathbf{y}_t$ evaluated at frequency zero is

$$\mathbf{2\pi\pi_{\Delta y}(0) = C(1)\Theta C(1)'} \qquad [4.5]$$

One can scale [4.5] by either the conditional variances of $\Delta \mathbf{y}_t$ to get the Campbell and Mankiw (1987a b) measure or the unconditional variances to obtain the Cochrane (1988) measures of persistence. The multivariate persistence approach allows us not only to calculate the country-specific persistence (p_i) but also the cross-country persistence (p_{ij}) as well as the aggregate effect of a shock. Country-specific measure p_i is analogue to $c(1)$ in the univariate case measuring the long-run effects of a shock on the level of y_t. The cross-country persistence, however, gives the infinite-horizon effect of a shock in country j on the level of y_{it} in country i.

Let P denote the matrix of persistence, then the $(i, j)^{th}$ element of the P matrix given by [4.6] is the long-run effect of a shock originating in country j on the level of y_{it} in country i. Thus, diagonal elements of the matrix are the country-specific measures of persistence while the off-diagonal elements are the cross-country measures of persistence.

$$p_{ij} = \frac{s_i' \mathbf{C}(1) \Theta \mathbf{C}(\mathbf{1})' s_j}{e_j' \Theta e_j} \qquad [4.6]$$

where $(i, j = 1,2...q)$ and s_i is the selection vector with unity on its i^{th} element and zero elsewhere.

The following subsection briefly describes LLP's procedure for measuring the persistence of a particular shock to $\mathbf{y_{it}}$ process.

4.2.2 IDENTIFYING SOURCES OF SHOCKS

If one is interested in the persistence effect of a particular shock such as interest rate on the level of $\mathbf{y_t}$ then the appropriate multivariate model of $\mathbf{y_t}$ is

$$\Delta \mathbf{y_t} = \mu + \mathbf{E}(\mathbf{L})\eta_\mathbf{t} + \mathbf{C}(\mathbf{L})\varepsilon_\mathbf{t} \qquad [4.7]$$

where $\mathbf{E}(\mathbf{L})$ is a matrix of lag polynomials $\mathbf{E}(\mathbf{L}) = \sum_{i=1}^{\infty} \mathbf{E_i L^i} = \mathbf{E_0} + \mathbf{E_1 L} + \mathbf{E_2 L^2} + \dots$, where $\mathbf{E}_i{}'s$ are $q \times r$ matrixes of coefficients measuring the effect of a shock on the growth rate of $\mathbf{y_t}$. $\eta_\mathbf{t}$ is a $r \times 1$ vector of shocks in global variable $\mathbf{z_t}$ defined by

$$\mathbf{z_t} - \mathbf{Q x_t} = \eta_\mathbf{t} \qquad [4.8]$$

where $\mathbf{x_t}$ is a $k \times 1$ vector of exogenous variables that determine $\mathbf{z_t}$ and $\mathbf{Q}$ is a $r \times k$ matrix of coefficients. The innovations $\eta_\mathbf{t}$ are white noise process with mean zero and constant variance given by $\Phi = (\phi_{ij})$. These innovations represent specific global shocks in variables such as interest rate, exchange rate, money supply and so on. The $\varepsilon_\mathbf{t}$ are country specific shocks that do not correspond to the identified shocks but represent the variations in disturbance due to other unidentified shocks specific to an economy. LPP assume that $\eta_\mathbf{t}$ and $\varepsilon_\mathbf{t}$ are not correlated in order to ensure the [4.7] and [4.8] are identified (see section 3.3. of PPL (1993) for further details.).

The multivariate measure of persistence analogue to [4.21] when *r* particular shocks have been identified is

$$p_{ij} = \frac{s'_i\,\mathbf{E(1)\Phi E(1)}' s_j + s'_i\,\mathbf{C(1)\Theta C(1)}' s_j}{\mathbf{V}(\Delta \mathbf{y_t} \mid \mathbf{\Omega_{t-1}})} \qquad [4.9]$$

where $\mathbf{V}(\Delta \mathbf{y_t} \mid \Omega_{\mathbf{t}-1})$ is the conditional variance of $\Delta \mathbf{y_t}$ given by the following expression:

$$\mathbf{V}(\mathbf{y_t} \mid \Omega_{\mathbf{t}-1}) = s'_j\,\mathbf{E(0)}\Phi\mathbf{E(0)}' s_j + s'_j\,\mathbf{\Theta} s_j \qquad [4.10]$$

As before the country specific persistence is the diagonal element of P matrix and the cross-country persistence is given by the off diagonal elements of the matrix.

The persistence measure given by [4.9] can be decomposed into components – one measuring the effect of some specific or known shocks (P^n) and the other measuring the persistence effects of non-specific or unknown innovations (P^u). This decomposition can be done for both the individual country persistence and for the aggregate level of persistence. The country persistence decomposition yield

$$p_{ij} = \delta_{ij} p_{ij}^n + (1 - \delta_{ij}) p_{ij}^u \qquad [4.11]$$

where

$$p_{ij}^n = \frac{\mathbf{s}'_i\,\mathbf{E(1)\Phi E(1)}'\mathbf{s}_j}{\mathbf{s}_j'\mathbf{\Phi}'\mathbf{s}_j} \qquad [4.12]$$

and

$$p_{ij}^{u} = \frac{\mathbf{s}_i'\mathbf{C}(\mathbf{1})\mathbf{\Theta}\mathbf{C}(\mathbf{1})'\mathbf{s}_j}{\mathbf{s}_j'\mathbf{\Theta}'\mathbf{s}_j} \qquad [4.13]$$

The scaling element δ_{ij} depends on the combination of variance covariance of $\boldsymbol{\varepsilon}_\mathbf{t}$ and $\eta_\mathbf{t}$ so that it is a weighted average of these variances: $\delta_{ij} = \frac{\mathbf{s}'_i\Phi'\mathbf{s}_j}{\mathbf{s}'_i\Phi'\mathbf{s}_j + \mathbf{s}'_i\Theta'\mathbf{s}_j}$

Using the multivariate framework one can also compute the aggregate level of persistence using disaggregated data where one takes a weighted average of the individual $\mathbf{y_t}$ such that $Y_t = \varpi'\mathbf{y_t}$, with ϖ denoting the weighting matrix consisting of fixed positive numbers. The multivariate model expressed by equation [4.6.14] becomes as follows for the aggregated $\mathbf{y_t}$.

$$\Delta Y_t = \varpi'\left[\mu + \mathbf{E}(\mathbf{L})\eta_\mathbf{t} + \mathbf{C}(\mathbf{L})\varepsilon_\mathbf{t}\right] \qquad [4.14]$$

The aggregate level of persistence denoted by P_Y^2 is then:

$$P_Y^2 = \frac{\varpi_i'\mathbf{E}(1)\Phi\mathbf{E}(1)'\varpi_j + \varpi'\mathbf{C}(\mathbf{1})\mathbf{\Theta}\mathbf{C}(\mathbf{1})'\varpi_j}{\varpi'\Phi\varpi + \varpi'\Theta\varpi} \qquad [4.15]$$

A comparison of country persistence given by [4.9] and the aggregate persistence given by [4.15] shows that s_i has been replaced with ϖ_i. As with the country persistence, the aggregated persistence can be decomposed into a component due to some identified shocks and a component due to some unidentified innovations; all that is required is replacing the selection vector s_i by the weight vector ϖ in the corresponding equations.

4.2.3 Section Summary

In summary, it is argued that the existing tests for the sustainability of debt are not practical means of assessing the DS as they classify a country into a dichotomy of sustainable against unsustainable. This categorisation of countries is neither realistic nor practically useful measure of DS. In practice DS should be continuous measure reflecting the continuous nature of debt variable. Consequently, a new measure, accommodating this continuum of debt is proposed in this section, which shows the degree of a country's DS, or its vulnerability to external shocks causing unsustainable debt levels.

The section then outlines a very useful tool for analysing the effect of some specific shocks, such as interest rates, to the DS of a country. More specifically, it describes the methodology of LPP that can be used to decompose these DS measures into identified and unidentified components. Such analysis can improve our understanding of how debt levels of DCs become unsustainable in the 1980s. The subsequent section provides a background to the emergence of 1980s debt crisis.

4.3 BACKGROUND OF THE 1980S DEBT CRISIS

This section considers the trends in foreign debt of DCs and discusses the factors leading to the massive accumulation of external debt, which the DCs have been struggling to service since early 1980s. The section is primarily concerned with the historical analysis of the external debt of selected LAC and SSA countries. (Section 4.4 provides the justification for selecting LAC and SSA countries). More specifically, the section studies the time path of external debt from 1969 to 2000 to see how debt has evolved overtime for LAC and SSA countries. Then it reviews some of the factors that are attributed to the causes of 1980s debt crisis. The section is split into three subsections. The first subsection, 4.3.1, provides an overview of LAC and SSA economics. The second subsection, 4.3.2, looks at the evolution of debt whilst the final subsection, 4.3.3, outlines the main causes of the crisis.

4.3.1 OVERVIEW OF LAC AND SSA ECONOMIES

Table 4.1 illustrates some key macro statistics for 10 selected LAC and SSA countries in each region from 1969 to 2000. The Table reports the average figures over the 32 years under the analysis for each country plus the average statistic for each region calculated as the average of the 10 selected countries in each region. The Table reports 9 different statistics related to various topics, including the *output* represented by average GDP per head in column (1) and the growth rate of GDP per capita over the 32 year period in column (2). Next it shows the *sources of output* including the physical investment-to-GDP ratio in column (3) human capital index complied by Bosworth and Collins (2003) in column (4) and SSE rates in column (5). The third topic the table shows relates to the country's *trade* with other countries reflected by export per head in column (6), terms of trade measured by export price to import prices in column (7) and openness calculated as export-to-GDP ratio in column (8). Finally column (9) shows country's *exchange rate* against US dollar.

Table 4.1 shows that GDP per capita is sufficiently higher for LAC countries than for SSA countries. The average for the 10 LAC countries is above \$5,500 whilst for SSA countries it is less than $2,000. Moreover, the growth rate over the 32 years has been respectable for all LAC countries except for Venezuela that has had a negative growth rate of 1.41%. However, for SSA countries the picture is rather different – nearly all the countries have had negative growth rate and Uganda is the only exception with a growth rate of above 1%. This is surprising, as the investment-to-GDP ratio is similar for both groups; indeed, SSA country, Nigeria, has had the highest investment ratio amongst both groups of counties. Each country from SSA region has had an investment ratio of at least 10% of its GDP which is only slightly lower than the lowest ratio by LAC countries. Nonetheless, the SSE rates indicate that the differences in the output level and rate of two regions may be due to the differences in human capital. The SSE rates shown in column (5) of Table 4.1 are considerably diverse for the two regions. The average SSE rate for LAC is about 47% whilst for SSA it is only 22%, indicating that nearly half of the secondary school age population is attending the school in LAC whereas less than one quarter are attending school in SSA.

TABLE 4.1
Key Macro Statistics for LAC and SSA Countries

	(1) GDP per Head (US$)	(2) Growth rate of GDP (%)	(3) Investment to GDP ratio (%)	(4) Human capital index	(5) School enrolment rate (%)	(6) Export per head (US$)	(7) Terms of trade (%)	(8) Openness (%)	(9) Exchange rate
Latin America & Caribbean									
Argentina	9641	0.60	20.3	1.13	65.20	359	98	13.47	0.33
Brazil	5860	2.46	24.2	1.11	42.12	198	131	11.71	0.26
Chile	6159	2.37	22.8	1.13	60.29	635	104	40.87	189
Colombia	4465	1.84	18.3	1.11	45.86	193	102	23.43	433
Dom. Republic	3178	3.47	20.9	1.12	41.35	287	106	66.42	5.86
Ecuador	3620	1.50	17.7	1.17	49.15	297	140	47.12	1908
Guatemala	3601	0.94	11.2	1.10	19.80	187	97	43.14	2.89
Mexico	7121	1.60	18.6	1.19	49.79	515	117	35.81	2.28
Peru	4588	0.13	17.5	1.19	58.92	188	107	24.17	0.74
Venezuela	7695	-1.41	18.4	1.19	34.85	825	105	57.63	108
Average	**5593**	**1.35**	**19.0**	**1.1**	**46.73**	**369**	**111**	**36.38**	**265**
Sub Saharan Africa									
Cameroon [H]	2122	0.79	15.1	1.10	19.99	15685	98	43.05	349
Ethiopia [H]	586	0.11	12	1.10	10.69	1083	99	40.07	3.28
Ghana [H]	1223	0.6	10.8	1.20	34.51	6337	133	68.13	591
Kenya	1190	0.96	18.4	1.20	20.40	8518	102	68.01	24.9
Madagascar [H]	1007	-1.18	10.6	1.10	15.54	4456	132	54.53	1625
Mozambique [H]	1183	-1.84	17.6	1.00	6.31	1855	172	56.69	2801
Nigeria	1034	-0.97	29.8	1.10	22.28	9760	165	83.54	12.19
South Africa	7495	0.44	18.1	1.10	78.31	63301	100	42.4	2.23
Tanzania [H]	548	-0.39	21.9	1.00	4.05	2871	130	51.73	190
Uganda [H]	681	1.38	16.0	1.10	8.87	3335	95	21.36	385
Average	**1707**	**-0.01**	**17.0**	**1.10**	**22.10**	**11720**	**123**	**52.95**	**598**

GDP per head and export per head figures are in US dollars.
[H] denotes an HIPC country.

Although the variations in SSE rates may explain some of the variations in the output and the growth rate of output, it does not solve the puzzle completely. The historical figures not only reveal that the growth rate for both sets of countries should be similar based on physical and other measures of human capital investment but the openness figures illustrate that SSA region should have higher growth than LAC region as former is more open than later. The average export per head of SSA countries is more than triple the LAC countries. Openness for LAC regions is also about 47% lower than for SSA region.

4.3.2 DEBT EVOLUTION OF LAC AND SSA

Table 4.2 below presents some key debt statistics for LAC and SSA countries from 1969 to 2000. The Table presents *external debt* per head, its ratio to GDP, export and capital. The next four columns of the Table show the *debt-service* per head, its ratio to GDP, export and capital.

TABLE 4.2
Key External Debt Indicators of LAC and SSA Countries

	(1) Debt per head (US$)	(2) Debt to GDP ratio (%)	(3) Debt to export ratio (%)	(4) Debt to capital ratio (%)	(5) Debt service per head (US$)	(6) Debt service to GDP ratio (%)	(7) Debt service to export ratio (%)	(8) Debt service to capital ratio (%)
Latin America & Caribbean								
Argentina	1609.10	36.77	433.42	8.58	206.00	4.79	57.49	1.10
Brazil	692.10	29.71	336.99	6.87	108.50	4.40	49.90	1.06
Chile	1230.52	56.03	232.23	0.14	191.55	8.22	33.87	0.02
Colombia	401.79	32.76	211.77	0.01	67.23	5.11	32.30	0.00
Dominican Republic	408.29	37.48	152.41	2.31	41.56	3.88	16.69	0.25
Ecuador	791.61	65.15	244.22	2.09	90.08	7.29	28.03	0.24
Guatemala	233.70	20.93	120.61	41.71	25.62	2.43	14.11	4.59
Mexico	1016.51	37.42	246.26	3.59	189.37	6.66	43.81	0.66
Peru	725.12	59.94	398.21	6.78	67.53	5.79	36.85	0.63
Venezuela	1365.58	40.96	159.53	1.90	192.02	5.55	21.55	0.27
Average	**847.43**	**41.71**	**253.57**	**7.40**	**117.95**	**5.41**	**33.46**	**0.88**
Sub Saharan Africa								
Cameroon H	359.93	50.39	214.82	0.12	29.68	3.95	16.75	0.00
Ethiopia H	91.99	78.71	859.39	25.87	2.34	1.97	21.31	0.01
Ghana H	196.87	55.45	352.31	27.15	16.19	4.51	28.53	0.02
Kenya	188.36	59.70	212.98	2.33	22.20	6.92	24.90	0.00
Madagascar H	209.56	81.12	474.85	0.08	11.08	4.39	27.28	0.00
Mozambique H	213.51	113.94	1239.78	0.01	6.79	2.96	39.58	0.00
Nigeria	182.91	61.75	213.96	3.74	16.88	5.24	21.59	0.00
South Africa	643.62	30.68	118.23	1.83	81.67	3.89	14.75	0.00
Tanzania H	223.53	107.83	835.30	0.17	5.64	2.65	21.22	0.00
Uganda H	95.49	40.12	401.41	0.04	5.76	2.45	23.91	0.00
Average	**240.58**	**67.97**	**492.30**	**6.13**	**19.82**	**3.89**	**23.98**	**0.00**

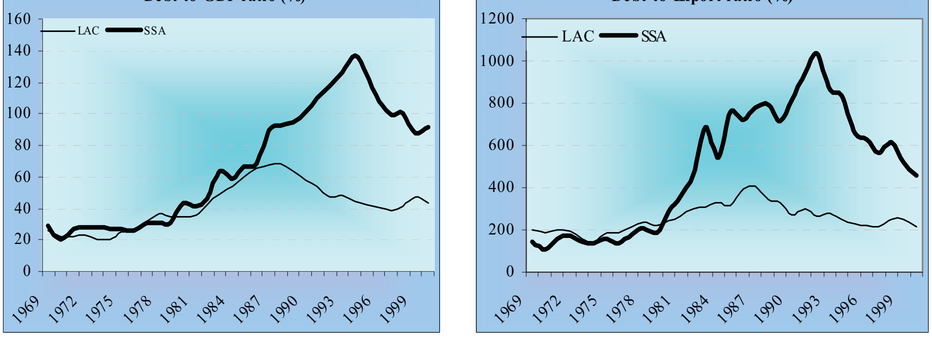
H denotes HIPC country.

From column (1) of Table 4.2 it is clear that debt stock of LAC countries is multiple times higher than the debt stock of SSA countries. On average a citizen in a LAC country owes $847 while a citizen in a SSA country owes only $240. However, the debt of the SSA countries in relation to their repayment ability measured by either country's GDP or its export earnings is greater than the LAC countries. The average debt-to-GDP ratio for SSA countries is about 68% whilst the average debt-to-GDP ratio for LAC countries is 42%. From the selected countries, the largest GDP ratio for SSA region is 114% whereas for LAC region it is 65%. Debt to export ratio display a similar picture. That is debt-to-export ratio for SSA countries is almost twice the debt-to-export ratio for LAC countries, but export per head for SSA countries is more than thrice the export per head for LAC countries. (See Table 4.1 column (3)).

However, debt to physical ratio indicates that LAC countries have slightly higher debt relative to their capital than SSA countries. From LAC region two countries, Chile and Columbia have debt to capital ratio less than 1% and nine have it less than 10%, illustrating that the debt is very small compare with the physical capital of these nations. For SSA region four nations have debt to capital ratio less than 1% and two have it greater than 10% compared with only one from LAC region. Overall, debt to capital ratio is very small illustrating that debt only a small fraction of the countries capital stock.

The last four columns of Table 4.2 present the debt burden of LAC and SSA countries from 1969 to 2000. Total debt-service per head is nearly six times greater for LAC region compared with SSA region. Correspondingly, the debt-service ratios shown in columns (6) to (8) are all greater for LAC countries on average than for SSA countries. On average almost 5.4% of GDP and 34% of export of LAC region is devoted to debt servicing. The corresponding ratios for SSA countries is relatively less – less than 4% of GDP and about 24% of export is devoted to meet the debt obligations of SSA countries.

FIGURE 4.1
Evolution of External Debt Ratios of LAC and SSA



In summary, Table 4.1 illustrates that debt stock of LAC is almost four times the debt stock of SSA countries. However, debt relative to the repayment ability measured by GDP or export is much greater for SSA nations compare with LAC nations. The debt burden is also greater for SSA countries than for LAC countries.

Next, the section looks at how debt and debt-service has evolved over the 32 year period. Figure 4.1 depicts the development of the average external debt of LAC and SSA countries from 1969 to 2000. The first panel shows how debt-to-GDP ratio is grown over time whilst the second country shows how debt-to-export ratio has advanced over the same period. For both groups of countries, debt-to-GDP ratio was stable from 1969 to 1980s, changing by a small percentage over this period. Nevertheless, from early 1980s to late 1980s debt-to-GDP rose sharply from 35% to 85% for LAC countries and from 38% to 59% for SSA countries. Throughout the 1970s and 1980s debt ratios of both groups of these countries remained roughly the same; there was hardly any gap between the debt-to-GDP ratios and debt-to-export ratios of LAC and SSA regions. However, from late 1980s this pattern changed and an increasing gap emerged as the debt of LAC region started to decrease, whilst the debt ratios of SSA countries stared to rise sharply between 1987 and 1995. Although, the debt ratios of SSA countries have fallen since 1995, they are still far greater than the debt ratios of LAC.

FIGURE 4.2
Evolution of Debt Service Ratios of LAC and SSA

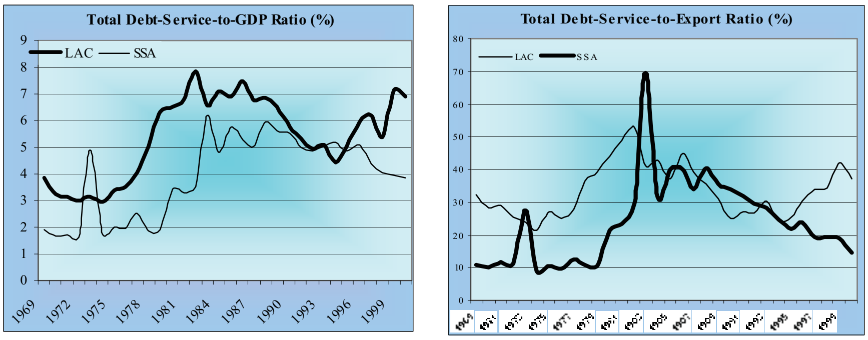


Figure 4.2 shows the debt burden of LAC and SSA from 1969 to 2000. The left panel shows the debt-service to GDP ratio and the right country shows the debt-service to export ratio. These debt-service ratios are unstable, particularly for SSA countries overtime unlike the debt ratios depicted in Figure 4.1. The instability is likely to have risen from the fact that the countries are often unable to service their debt at least fully and often this obligation is rolled over or rescheduled for future payment. From Figure 4.2, one may conclude that the debt problems of SSA region started earlier than the debt problem of LAC countries. During

the period of first oil price shock, 1973/4, the debt-service of SSA countries shot up considerably whilst the debt-service ratio of LAC countries remained unchanged, suggesting that SSA countries' debt problems started with the first oil price shock whilst the LAC countries' problem started almost a decade later when the second oil price shock coupled with numerous others occurred. In 1973 the debt-service of SSA countries exploded from 1.8% to 5% of GDP and from 10% to 28% of export. However, a year or so later the debt-service fell to its original level and remained stable for the next few years whereas LAC counties experienced a steady increase in their debt burden until early 1980s when one of its main country, Mexico defaulted on its foreign debt.

Early 1980s was when the real long lasting debt problems stared for DCs in LAC, SSA, South Asia, Middle East and other parts of the developing World. The next subsection reviews some of main events behind this noxious crisis, which has staved many to death.

4.3.3 Factors Leading to the 1980s Debt Crisis

The causes of 1980s debt crisis are the results of a complex interaction of many factors including the oil prices rises in 1973/74 and 1978/79, recycling of petro-dollar, recession resulting from second oil price shock, worsening of terms of trade of DCs and soaring World interest rates. The above section analysing the trends in external debt of DCs shows that from mid 1970s the debt of these countries started to rise very rapidly until the early 1980s when countries found themselves in difficulties servicing the debt and started to default on their foreign debt. This is the period when oil price shocks, interest rate shock and commodity price shock took place. Thus, the debt crisis of the 1980s has generally been attributed to these three shocks amongst other factors. The following section explains these three major shocks and illustrates how they led to the debt crisis of 1980s.

Rising Oil Prices

During the 1970s and the 1980s, rising oil prices led to escalating foreign debt of DCs. Oil importing countries, in particular, found themselves with substantially larger import expenditures than their export revenues resulting is large trade deficit. Unable to afford the high price of oil on World markets, developing nations were forced to secure billions of dollars in commercial and institutional loans to pay for more expensive oil imports and the increasing cost of all the other activities associated with their higher oil bills.

If oil-importing economies had reduced their oil-imports in order to avoid large trade deficits, then this would have had series consequence for their growth rate. These economies faced with export earnings falling short of the credit needed to finance the high priced oil imports were firstly forced to run down their foreign reserves and once these were exhausted they turned to external borrowing from the Western banks.

The initial OPEC price rise fulfilled the increased demand for borrowing by oil importing countries and absorbed the excess of oil funds from oil-exporters. In other words, whilst there was a higher demand for international credit by oil importers to pay for the import of oil, there was also an increase in supply of credit. As OPEC nations were not able to absorb the petroleum revenues as quickly as they were being generated many OPEC nations deposited their excess export earnings in the private international banks in developed nations creating whole new markets – the so-called Petro-dollar or Euro-currency markets. The Euro-currency markets started when non-US banks mainly European banks started to trade with US dollar by accepting the dollar deposits, paying interest on it and lending in US dollars directly without the involvement of US banks and outside the US banking regulatory framework. This solved the OPEC nations' problem of making productive use of their excess export funds whilst meeting the borrowing needs of oil-importing nations to finance high oil bills. The banks faced with the challenge of finding additional borrowers for the massive OPEC deposits in order to meet the interest payments promised to OPEC nations, were naturally too happy to lend.

Thus, the private banking system provided the means for Petro-dollar recycling where the oil revenues were circulated and re-circulated from oil-importers to OPEC nations to private international banks to back to the oil-importing countries.[19] In effect, the private banks were lending to oil-importers the additional funds that would enable them to continue the import of oil and other goods, with the funds that became available from the oil-importers in the first place. Later on additional loans were made not only to finance the imports of oil and other goods but also to facilitate the repayments of interest and principal coming due on the previously accumulated debt stock.

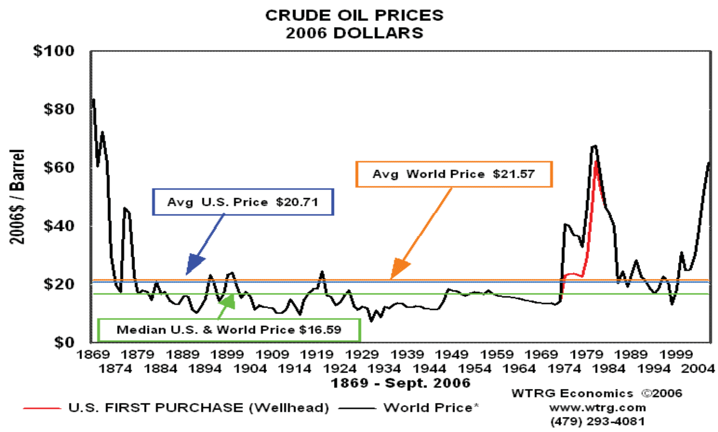
The 1973 oil shock also had effects of triggering inflation in the US and the rest of the industrialised nations and the second oil price rise in 1979 led to the most severe recession in industrialised countries in nearly half a century. The tragedy of this recession was that it should never have happened. This needless, recession was not the results of OPEC initiative but rather the results of a panic amongst oil buyers in countries highly dependent on oil imports. Germany and France (and other oil importers), fearing the security of their oil supply, started to buy oil in spot market despite the fact that inventories at the time were ample. Increased demand in the spot market for oil caused spot prices to rise and OPEC responded to this by adjusting the official oil prices correspondingly. If industrialised

[19] Devlin (1989) gives the full story of the petro-dollar recycling

countries had responded appropriately, resolving this panic then the second oil shock and the consequent deep recession would have been avoided.

The second oil shock pushed the World into a deep recession not because the oil prices had risen but because of the policy response by US and the rest of industrialised nations. Essentially, the US was in no position to choose between high inflation and low unemployment by 1979. Inflation, which had been increasing jumped into double figures following the second oil shock. Consequently, economic agents raised their expectations of future inflation putting upward pressure on the interest rates. Concurrently, the monetary authorities trying to control inflation tightened their monetary policy causing high interest rates, failing GDP and rising unemployment. Other developed nations followed similar policy ending in World's deepest recession in nearly half a century.

FIGURE 4.3



Source: *http://www.wtrg.com/oil_graphs/oilprice1869.gif*

Figure 4.3 shows the crude oil price in 2006 US Dollars from 1869 to 2004. From 1879 to late 1970s the oil price remained fairly stable but after the later 1970s they fluctuated drastically. The first major rise in crude oil price was in the early 1970s from about $10 to $40 per barrel. This was followed by another full-sized positive shock in the late 1970s which increased the crude oil price from about $35 to $65 per barrel.

Soaring Interest Rates

As mentioned above the oil shocks in particular the second one, increased the inflation rate putting upward pressure on interest rates and expected future inflation. As an attempt to control this soaring inflation, developed countries, starting with Federal Reserve of US, tightened their monetary policy leading to the highest interest rate ever recorded. This led to

World recession and triggered the overall crisis starting with Mexico. Mexican situation was the combination of high interest rates, which exacerbated debt-service costs for debtors and the sharp decline in oil prices in 1982. Falling revenues associated with lower oil prices and rising debt-service costs due to high interest rates made it difficult for oil-exporting countries to service their existing debt stock.

As most TWD was at variable interest rate tied to the LIBOR rate, the debt-service costs grew progressively greater as these rates approached record levels.[20] LIBOR rates averages 10.2% through 1980s; for 1981 and 1982, they increased to 15.8%. It was estimated that for every percentage point increase in LIBOR, debt-service costs for all DCs rose by $2 billion. For these countries interest payments almost tripled during the 1978-80, rising from $15.8 to $41.1 billion (Madrid, 1990)

Worsening of Terms of Trade

Many DCs rely on exports of a small number of agricultural commodities, even a single commodity, for a large share of their export revenues. This concentration leaves them exposed to unfavourable market or climate conditions. A drought or a drop in prices on the international markets can quickly drain their foreign exchange reserves, stifle their ability to pay for essential imports and plunge them into debt.

As many as 43 DCs depend on a single commodity for more than 20 percent of their total revenues from merchandise exports. Most of these countries are in sub-Saharan Africa or Latin America and the Caribbean and depend on exports of sugar, coffee, cotton and bananas. Most suffer from widespread poverty.

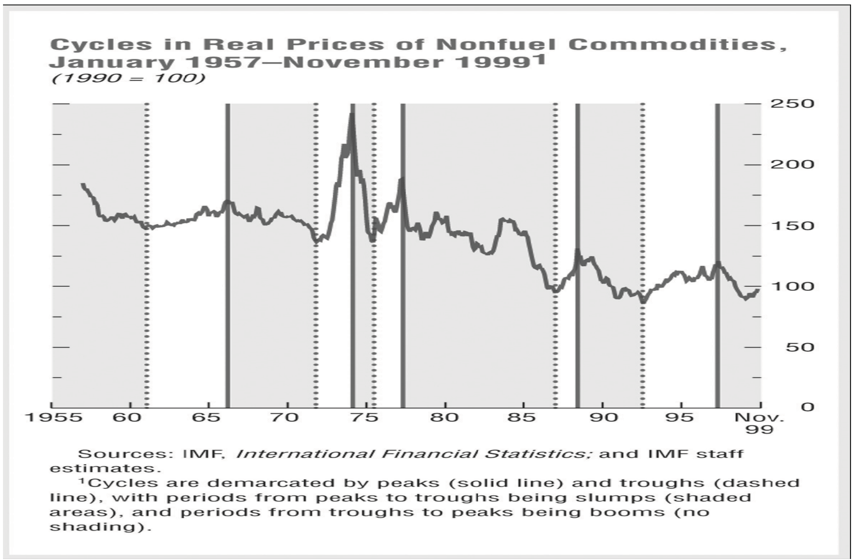
Figure 4.5 illustrates the trends in non-fuel commodity prices since mid 1950s. In the late 1950s and early 1960s, real prices of non-fuel commodities were relatively stable (with a peak in 1966). However, this changed in 1970s when non-oil prices started to raise – the highest prices observed in a half a century occurred in 1974. This led to OPEC rising the price of oil in 1973/4 which has had long lasting consequences for all countries but particularly severe for the developing nations.

There was an irregular decline in the second half of the 1970s and the early 1980s, and small peaks (each lower than the preceding) in 1988 and 1997. Most recently, there has been a slump accompanying the recession in Asia, a fall of more than 20% in dollar prices from 1997 to 1999. The prices of manufactures also fell by about 5% during this recession.

[20] LIBOR rates are sensitive to changes in short-term US interest rate as Euro-currency market is dollar denominated.

These falling prices were due to the most sever recession since the Great Depression of 1929 hitting industrialised nations hard. It meant that the demand for non-oil commodities exported from developing nations fell sharply, an average of 30% from 1981 to 1982. DCs faced with high import bills requiring foreign exchange continued to export the same quantity resulting in a sharp decrease in the price of exports of non-oil commodities at same time the domestic cost of production rose. Thus, DCs' export revenues declined as cost of production increased and the major importers reduced their purchase of goods due to recession in their own countries.

FIGURE 4.4



4.3.4 SECTION SUMMARY

In summary, the sharp oil price that began in 1973 and continued for almost a decade accelerated inflation in industrialised countries causing them to undertake contractionary monetary policy, both of which put pressure on interest rates leading it to rise to record levels. At the same the governments of DCs facing a worldwide collapse in commodity prices of their export goods and acceleration in their import goods, especially oil-importers, resorted to heave borrowing in order to pay for their imports of oil and other commodities. This expansion in lending was made possible via Euro-currency markets, where non-US banks were able to lend and deposit in US dollar without US involvement and outside their financial regulatory framework. Soaring interest rates meant that, what was already a large debt stock grew rapidly at an enormous rate as these loans were made at market variable rates. This combination of record level interest rates, low commodity prices including oil, as oil prices fell sharply in 1982, left export stagnant and debt-service commitments hard to be met. Many researchers argue that the debt-service problem was compounded by the new borrowings that took place during the 1979 to 1982 in order to cover the interest on the existing debt and/or to maintain the current level of consumption rather than to invest in productive investments.

4.4 ESTIMATING DSI

The previous section outlined the trends in external debt of 10 selected LAC and SSA countries and argued that the external debt plays a significant role in determining the economic polices and social conditions of these nations. Furthermore, the study of the time path of external debt from 1969 to 2000 showed that debt has grown drastically over the past three decades. This section examines whether the actual debt levels of LAC and SSA countries are sustainable or not. The section firstly carries out some preliminary analyses on the data used and assesses the DS using unit root approach for these selected countries. The prime objective of the section is to estimate the DSI for the chosen LAC and SSA countries using univariate and multi-country persistence measures discussed in section 4.2.

4.4.1 PRELIMINARY ANALYSIS OF DATA

This section firstly describes the dataset used and then illustrates how the most parsimonious model used for further analyses is derived. To gain an understanding of the likely Data Generating Process (DGP) for the debt-to-GDP ratio the autocorrelation and partial autocorrelation functions of raw and differenced data series of each of the country under analyses is studied. Furthermore, autocorrelation functions and information criterions like AIC and SIC are used to select the most parsimonious model for estimating the univariate persistence measures, which are the subject of the later part the section.

Dataset

The data used for this chapter consists of two groups of countries: LAC and SSA. Each group contains the ten largest countries of the region according to the population. Although, countries are divided by regions, there are important differences in the nature and the terms of their debt. All of the LAC countries are non-HIPCs, so their debt is on commercial terms, whilst most of the SSA countries are HIPCs so their debt is on non-commercial terms. These differences in debt make these two groups interesting to study, as it will reveal if these differences have different implications in terms of the vulnerability of shocks to debt sustainability.

The time dimension of the data is 32 years staring from 1969 to 2000. Although it would have been preferred to use 56 countries as in the previous two chapters without referring to the region, the technique employed in this chapter could not accommodate such a large number of countries. The technique requires a system of equations equal to the number of countries, i.e. 56, where each equation contains the contemporaneous and lagged value of all the countries in the system. If for example, two lag values are used, then each equation contains $113\left(1+\left(2*56\right)\right)$ parameters!

See subsection 2.4.1 of chapter 2 for further details about the data sources and variable definitions. Also see section 3.4.2 of chapter 3 for details about the derivation of the parsimonious ARIMA model used for each country in the subsequent analyses.

4.4.2 DS Using Unit Root Tests

In this subsection, two types of unit root tests are employed to assess the debt sustainability of LAC and SSA countries. The unit root tests can be seen as a preliminary investigation of the sustainability of debt. If the unit root tests conclude that debt-to-GDP ratio series is a stationary process then this indicates that these countries' debt level is at a sustainable level. If on the other hand debt-to-GDP ratio is non-stationary then it suggests that the debt levels are too high, i.e. unsustainable.

Univariate Unit Root Techniques

This subsection discusses the results from a number of univariate unit root tests conducted on the external debt of LAC and SSA countries under investigation. Firstly, it briefly outlines the test procedures for these tests and then discusses the empirical results from them.

Three univariate unit root tests are carried out to ensure the robustness of the results given that these tests have very low power. The first test is the ADF test proposed by Dickey and Fuller (1979), the second is the Phillips and Perron (1988) test and finally the DF-GLS test proposed by Elliott, Rothenberg and Stock (1996). A brief description of each of these tests is given in chapter 3 subsection 3.3.1.

For all three tests, ADF, PP and DF-LGS the model specification outlined above is used, where firstly the ACF and PACF of raw and differenced data is calculated to see the likely data generating process. Then the AIC and BIC for each country for $p-k$ number of lags is calculated. Where p is maximum lag suggested by autocorrelation functions, which in our case was *5* and $k = 1,2,..., p-1$. The table below reports the results for the lag length suggested by AIC. BIC also suggested the same lag length for all countries apart from Mexico with level data series. In most of the cases, lag one is used. However, whenever a higher lag order is used to estimate the ADF regression it is indicated by either a $ sign or £ sign, see below table notes for details.

TABLE 4.3
Univariate Unit Root Tests
1969-2000

	Raw Data			Differenced Data		
	ADF(1)[a]	PP(1)[a]	DF-GLS(1)[a]	ADF(1)[b]	PP(1)[b]	DF-GLS(1)[b]
Latin America & Caribbean						
Argentina	-1.35 (0.61)	-1.32 (0.62)	-1.09	-3.64 (0.01)	-5.71 (0.00)	-3.46
Brazil	-1.98 (0.29)	-1.56 (0.50)	-1.58	-4.34 (0.00)	-5.34 (0.00)	-1.83
Chile	-1.88 (0.34)	-1.74 (0.41)	-1.67	-4.11 (0.00)	-4.40 (0.00)	-3.77
Colombia	-2.42 (0.14)	-1.81 (0.38)	-2.31	-2.32 (0.17)	-4.49 (0.00)	-1.31
Dominican Republic	-1.06 (0.73)	-1.11 (0.71)	-1.14	-3.25 (0.02)	-6.29 (0.00)	-2.23
Ecuador	-1.43 (0.57)	-1.11 (0.71)	-0.73	-3.53 (0.01)	-4.87 (0.00)	-2.83
Guatemala	-1.62 (0.47)	-1.14 (0.70)	-1.02	-2.99 (0.04)	-4.72 (0.00)	-2.18
Mexico	-2.41 (0.14)	-5.68 (0.00)	-0.29	-3.72 (0.00)	-9.93 (0.00)	-0.66
Peru	-2.00 (0.29)	-2.18 (0.21)	-2.08	-3.90 (0.00)	-6.24 (0.00)	-3.34
Venezuela	-1.54 (0.51)	-1.41 (0.58)	-1.18	-3.61 (0.01)	-4.38 (0.00)	-2.53
Sub Saharan Africa						
Cameroon [H]	-1.17 (0.69)	-0.63 (0.86)	-0.21	-3.77 (0.00)	-5.52 (0.00)	-2.48
Ethiopia [H]	-1.61 (0.48)	-1.15 (0.70)	-0.76	-2.67 (0.08)	-4.48 (0.00)	-2.02
Ghana [H]	-0.33 (0.98)	-0.57 (0.99)	-0.77	-5.46 (0.00)	-5.89 (0.00)	-3.81
Kenya	-1.58 (0.49)	-1.32 (0.62)	-1.33	-3.70 (0.00)	-6.33 (0.00)	-2.77
Madagascar [H]	-0.70 (0.85)	-1.22 (0.66)	-0.69	-4.76 (0.00)	-9.73 (0.00)	-4.56
Mozambique [H]	-1.36 (0.60)	-1.85 (0.36)	0.12	-5.23 (0.00)	-7.59 (0.00)	-4.73
Nigeria	-1.32 (0.62)	-1.77 (0.40)	-0.44	-3.75 (0.00)	-4.99 (0.00)	-2.51
South Africa	-1.05 (0.73)	-1.11 (0.71)	-0.97	-4.22 (0.00)	-5.55 (0.00)	-4.09
Tanzania [H]	-7.01 (0.00)	-3.43 (0.01)	-1.41	-6.70 (0.00)	-11.30 (0.00)	-0.83
Uganda [H]	-1.37 (0.60)	-1.38 (0.59)	-1.24	-3.69 (0.00)	-5.72 (0.00)	-3.47

- [a] a higher lag is used for 7 countries – for Brazil Chile, Mexico, Venezuela, Madagascar and Mozambique a 2nd order lag is used. For Colombia a 3rd order lag is used.
- [b] a 2nd order lag is used for Mexico
- Critical values for ADF and PP test at 1%, 5% and 10% significance level are -3.72, -2.99 and -2.62 respectively. For DF-GLS test, however they are -2.65 -2.42 and -2.11 at 1%, 5% and 10% significance level respectively. The latter are interpolated critical values from tables presented by Elliott, Rothenberg, and Stock, which they obtained from simulations.
- A constant is included in all of the regression.
- For the DFGLS test only the results corresponding to the detrended data series rather than demeaned are report, but the result are identical.
- H denotes and HIPC country.

Table 4.3 presents the results from the univariate unit root tests including ADF, PP and DFGLS. The lag length for these tests was determined by the procedure outlined above in section 4.1. The results confirm that debt levels of most countries under investigation are indeed unsustainable as a non-stationarity cannot be rejected for most countries despite the regional variations. Chapter 3 explains that for a country to have a sustainable level of debt its debt-to-GDP ratio must be stationary.

The results are reasonably consistent across the three tests; all indicating that debt-to-GDP ratio is a non-stationary process for all countries. However, there is some variation in the results from one test to another as expected but the difference is not significant. The ADF test fails to reject the null of a unit root in all the countries in the level series but does reject the null for all countries except Colombia in the first difference series, indicating that the debt-to-GDP ratio is a first order differenced stationary process for all countries excluding Colombia. The PP test on the other hand does reject the null of a unit root in the differenced series for Colombia but not in the level series suggesting that its debt ratio is a differenced stationary process integrated of order one, unlike the ADF test. For Mexico and Tanzania, the PP test suggests that the debt ratio is a stationary process as it rejects the null of a unit root in the level and the differenced series. The DFGLS test does not reject the null of non-stationarity in the level series for all the countries but rejects the null in the differenced series for all countries except Brazil, Colombia, Mexico and Tanzania.

Given the unreliability of unit root tests these small difference are not unexpected but it is hard to make any conclusive inferences based solely on these findings. Nonetheless, it can be argue that univariate unit root tests suggest that the debt levels of LAC and SSA countries are unsustainable according to the debt-to-GDP ratio criterion.

Panel unit Root Techniques

Given the low power of standard unit roots tests such as ADF and PP of distinguishing the null of a unit root from the alternative of the stationarity, especially for near unit root processes, various efforts have been made to increase the power of unit root tests. One such contribution is in the area of panel unit root tests.

The analysis of unit roots and cointegration in country data started with the work of Levin and Lin (2002) and Quah (1994). Quah studied the null of unit root in countries with homogenous dynamics while Levin and Lin proposed a test that allowed heterogeneous dynamics, fixed effects and individual-specific deterministic trends. However, these tests were still rather restrictive in the sense that for both of these tests under the null and the alternative each cross-section unit has a common autoregressive root. That is $\rho_i = \rho$ for all i under both null and the alternative. While it maybe acceptable under the null, it is implausible under the alternative as it implies not only that each cross-section has no unit root but also that they have the same value of ρ. This would mean in growth literature, for example, that all countries converge at the same rate. Consequently a number of more general test have been proposed in the literature In this study three different panel unit root tests are considered including IPS (1997, 2003), MW (1999) and Hardi (2000). A brief description of these tests is presented in section 3.1 of the chapter 3.

The results from the all 3 panel unit root tests are presented in Table 4.4. The IPS and MW tests both test the null of a unit root in all countries against the alternative that at least one on these countries have stationary debt ratio. Hadri test, in contrast, tests the null that all countries' debt ratio is stationary against the alternative that at one of these countries debt ratio has unit root. For IPS and MW tests, the Table shows the results for up to 3 lags and for Hadri test it reports the results corresponding to the optimal lag chosen by AIC. The Table also shows the results when disturbance across countries is assumed to be homoskedastic, hetroskedastic and serially dependent for Hadri test.

TABLE 4.4
Panel unit Root Test
1969-2000

	Raw data			Differenced data		
Im Pesaran & Shin	**1**	**2**	**3**	**1**	**2**	**3**
Latin America & Caribbean	-1.90	-1.79	-1.74	-4.17	-3.38	-2.95
	(0.09)	(0.14)	(0.18)	(0.00)	(0.00)	(0.00)
Sub Saharan Africa	-1.64	-1.46	-1.36	-4.57	-3.43	-2.95
	(0.33)	(0.52)	(0.64)	(0.00)	(0.00)	(0.00)
Maddala & Wu ADF						
Latin America & Caribbean	20.91	20.61	23.69	98.76	51.78	54.86
	(0.40)	(0.42)	(0.26)	(0.00)	(0.00)	(0.00)
Sub Saharan Africa	50.53	8.59	10.39	135.53	75.67	48.76
	(0.00)	(0.99)	(0.96)	(0.00)	(0.00)	(0.00)
Maddala & Wu PP						
Latin America & Caribbean	41.14	40.38	40.21	191.60	190.28	189.93
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Sub Saharan Africa	17.57	17.77	17.96	415.30	419.57	423.47
	(0.62)	(0.60)	(0.59)	(0.00)	(0.00)	(0.00)
Hadri	**Hom**	**Het**	**Ser. Dep**	**Hom**	**Het**	**Ser. Dep**
Latin America & Caribbean	31.60	26.31	10.67	1.48	0.50	1.47
	(0.00)	(0.00)	(0.00)	(0.07)	(0.31)	(0.07)
Sub Saharan Africa	50.37	46.58	17.34	-1.42	-0.69	-0.29
	(0.00)	(0.00)	(0.00)	(0.92)	(0.75)	(0.62)

- Hadri test reports only the Z(mu) statistics, the Z(Tau) statistics not given here indicate the same conclusion as the Z(mu) statistics
- Figures reported inside the brackets are the p-values
- IPS and MW tests test the null that all countries are nonstationary processes, whilst Hadri test tests the null that all countries are stationary.
- Homo, Hetero and SerDep refer to statistics under the assumption of homoskedastic, heteroskedastic and serially dependent disturbances across units

Overall, all three tests including IPS MW and Hadri conclude that the debt-to-GDP ratio is a differenced stationary process integrated of order one. That is the null that debt-to-GDP ratio for all the countries in each group is non-stationary under IPS and MW tests cannot be rejected but the null in the first differenced series can be rejected. Under Hadri test the null is that all countries in both groups have stationary debt. This cannot be rejected in level series but is rejected when applied to the first differenced series. However, there are some variations in results from one test to another.

Since a unit root in the debt-to-GDP ratio indicates that the debt level is too high, i.e. unsustainable it is argued that the countries under the analyses are not satisfying the sustainability criterion of stationary debt ratio. The results from the panel unit root test not only coincide with the univariate unit root tests, but they are also in compliance with our expectation and the actual experience of the countries under investigation. It would be interesting to see what the persistence measure would suggest, i.e. are these countries in debt crisis or close to becoming debt crisis nations?

4.4.3 DS Using Persistence Approach

This leads us to the persistence approach for examining the DS. By using persistence measures one can see exactly how close a country is to a sustainable level of debt. It indicates whether further borrowing may lead to any debt servicing problems or not.

In the previous section a number of univariate and panel unit root tests are used to assess the DS of LAC and SSA countries. Overall the results conclude that the debt levels are indeed unsustainable for these countries as the unit root in the debt-to-GDP series cannot be rejected. These results must be treated with caution given the low power of these tests especially the univariate tests. However, they do suggest that an approach based on the difference stationarity of debt is empirically appropriate for evaluating the DS. Moreover, the unit root approach of assessing the DS simply classifies a country into either a sustainable or unsustainable group. Such dichotomy is rather unrealistic as in reality countries are more likely to go through a continuum running from stable to relatively stable to relatively unstable to unstable debt position. Hence a technique that can accommodate the continuous nature of DS that is based on the difference stationarity of debt is needed for assessing the DS. This is precisely what the persistence measure can provide us with. Persistence effectively means continuance of an effect after the cause is removed. Since persistence of a shock can be defined as "continuance or permanent change in a variable due to one period shock to that variable". A unit persistence measure in GDP, for example, means that an unexpected change in the GDP of one percent would change all future values of GDP by one percent.

Persistence is closely related with unit root processes. A unit root process has high persistence while a stationary process has low or zero persistence. That is the effect of a one period shock into the indefinite future to a difference stationary process is long-lived or permanent while to a trend stationary process is short-lived or temporary. In other words, shocks to stationary processes divert the economy from the long-run equilibrium for a short-term and eventually return to the original path. However, shocks to unit root processes result in permanent change in the long-run equilibrium. Therefore, we expect the persistence to be zero or close to zero for sustainable level of debt.

In this section univaraite and multi-country persistence measures are used to estimate the DSI. However, before estimating the sustainability indicator a persimmons model is derived using the same methodology as in section 4.4 when using the unit root tests. The remaining section is divided into two parts: the first subsection 4.3.1 details the results from univariate persistence techniques, which are estimated using Campbell and Mankiw approach (1987). The second subsection 4.3.2 outlines briefly the multi-county persistence techniques proposed by PPL and LPP and reports the results from them.

Univariate Persistence Techniques

Table 4.5 presents the univariate persistence measures for LAC and SSA countries which are estimated using the most parsimonious AR model selected by AIC. The figures inside the brackets next to each country correspond to the order of AR used to estimate the persistence measure given in the second column. Although the persistence measure can vary from zero to infinity for a general ARMA model, there is a lower bound for AR(p) models. For AR(1), for example, the persistence measure varies from ½ to infinity as the value of ρ is bounded between -1 and +1, in order to ensure that y_t is a stable process. For AR(2) the stability conditions imply that the persistence measure ranges from ¼ to infinity. As the order of AR increases the lower bound approaches zero.

In all cases, the findings suggest that shock have significant effect on debt-to-GDP ratio. Hence, the debt levels of all LAC and SSA countries under investigation are *unsustainable* which is in line with the previous findings from chapter 2 and chapter 3 as well as the above unit root tests. However, the results show different level of persistence of shocks to both groups of countries. Shocks are more persistent to the LAC countries than to SSA countries. On average a 1 percentage point (denoted here as 1%) shock to the LAC would change the debt ratio by 1.1 percentage point whereas for SSA countries the infinite horizon effect would be 0.9%. Also, a 1 percentage point shock would change the debt-to-GDP ratios by more than 1 percentage point for 6 out of 10 LAC countries but only for 3 out of 10 SSA countries. This suggests that the shocks have relatively bigger effect on the debt of LAC countries than they do on the debt of SSA countries. This may be explained by the differences in the market structure of these economies and the difference in the terms on the debt for these regions. The LAC countries are more open than SSA countries, so they are more vulnerable to shocks than SSA countries. LAC economies are also more free-market orientated whilst most of SSA countries are heavily controlled by their governments and creditors who are mainly the Fund-Bank.

Another possible explanation for higher persistent in LAC could be that as SSA countries are more heavily indebted than LAC countries, according to the debt-to-GDP ratios, the former are less able to absorb any further increase in debt due to some shock than the latter. Consequently, further increase in debt is written-off for SSA countries bringing the debt to pre-shock levels. This makes the empirical results on the persistence indicating that shocks have temporary effects on SSA countries' debt. Cohen (1995) argues that it is in creditors' interest to write-off parts of debt when debt goes beyond certain threshold in order to prevent the debtors from defaulting. The rationale behind this argument is that if debtor defaults then creditors would not be repaid. However, if debtor is prevented from defaulting then the creditors have the option of being repaid in the future if and when debtors experience positive growth.

This explanation is supported by the practical experience of LAC and SSA countries in terms of debt relief. Most of the SSA countries have had some debt relief whilst LAC countries have had very little if any. Nigeria has received debt relief of \$18m in 2005 although it is not classified as an HIPC country (JDC 2009).

TABLE 4.5
Univariate Measure of DSI
OLS, 1969 - 2000

Latin American & Caribbean	Persistence	Std Error	Sub Saharan Africa	Persistence	Std Error
Argentina (1)	0.93***	0.16	Cameroon (1) H	1.01***	0.18
Brazil (1)	1.15***	0.21	Ethiopia (1) H	1.26***	0.28
Chile (1)	1.24***	0.28	Ghana (1) H	0.83***	0.14
Colombia (1)	1.33***	0.30	Kenya (1)	0.87***	0.14
Dominican Republic (1)	0.87***	0.14	Madagascar (1) H	0.65***	0.07
Ecuador (1)	1.09***	0.22	Mozambique (1) H	0.75***	0.10
Guatemala (1)	1.19***	0.25	Nigeria (1)	1.10***	0.22
Mexico (2)	1.03***	0.10	South Africa (1)	0.95***	0.17
Peru (1)	0.87***	0.14	Tanzania (1) H	0.69***	0.05
Venezuela (1)	1.32***	0.30	Uganda (1) H	0.93***	0.16
Average	**1.10**	-	**Average**	**0.90**	-

- A specification search, detailed in 4.4.1, was carried out for the most parsimonious model.
- Figures in the parentheses next to each country report the order of AR used for each country.
- H denotes HIPC country
- Asterisk next to each persistence estimate indicate the precision of the estimate. "*", "**" and "***" indicate that point estimate is greater than one, two or three standard errors.

Multi-Country Persistence Techniques

Although the univariate persistence techniques provide a continuous measure of DS, they treat each country heterogeneously and consequently ignore all the cross-country correlation between shocks and their effects on debt. In reality shocks originating in one country do have significant effect on the debt ratios of another country particularly those closely related by geographical location; those having common economic characteristic such as high debt level and those trading with each other. Thus the multi-country persistence techniques are employed to examine the DS of LAC and SSA countries.

To estimate the multi-country measures of persistence a consistent estimate of the parameters of [4.3] $C(L)$ and Θ are required. For this purpose three versions of a model based on the second order vector autoregressive VAR (2) given in [4.16] are estimated. The first model called M1 is a fully unrestricted VAR (2) that explains the growth in debt for country i Δd_{it}, in terms of lagged growth in its debt and the debt of remaining countries.

$$\Delta d_{it} = \alpha_i + \sum_{h=1}^{H} C_{h,ii} \Delta d_{i,t-h} + \sum_{\substack{j=1 \\ j \neq h}}^{J} \sum_{h=1}^{H} C_{h,ij} \Delta d_{j,t-h} + \varepsilon_{it} \qquad [4.16]$$

where the first term gives the lagged growth rate of debt for country i and the second term represents the growth rate of debt of each of the remaining countries. In this study H is chosen to be 2; that is 2 lagged values of Δd_i and Δd_j, where $i \neq j$, are included in equation for country i.

With J countries, J equations each containing $1 + HJ$ parameters needs to be estimated under $M1$. For example with 10 countries ($J = 10$) and 2 lags ($H = 2$) 210 parameters excluding the parameters of variance and covariance matrix needs to be estimated under $M1$. Given there are only 32 time series observations for each country the df under $M1$ is 110. Clearly $M1$ is over-parameterised and cannot be estimated with any precision. However, there is a more parsimonious model which although allows for the feedback from country i to country j requires smaller number of parameters to be estimated. Thus, more precise estimates can be obtained with the second model called $M2$. $M2$ uses only an average of the growth in debt ratio in all the remaining countries instead of lagged growth in debt ratio for each of the j country, for country $i's$ equation.

$$\Delta d_{it} = \alpha_i + \sum_{h=1}^{H} C_{h,ii} \Delta d_{i,t-h} + \sum_{h=1}^{H} C_{h,j} \Delta d_{-i,t-h} + \varepsilon_{it} \qquad [4.17]$$

where $\Delta d_{-it} = \frac{1}{j}\sum_{j=1}^{J}\Delta d_{jt}$. The restricted model $M2$ imposes 160 parameter restrictions on $M1$ thus requiring only 50 parameter estimates instead of 210. $M2$ is further restricted to derive $M3$ by dropping the coefficients in $M2$ with t-ratio less than unity in absolute terms.

These three models were estimated for two groups of DCs each consisting of 10 countries using a maximum lag of 2. However, only the results from $M2$ and $M3$ are presented and discussed here as the results of $M1$ are not reliable given the df problem. The Seemingly Uncorrelated Regression Equation (SURE) estimator is employed to estimate the DS of each of 10 countries in LAC and SSA regions as well as the regional aggregate for both groups.

TABLE 4.6
Multi-Country and Aggregate DSI
Estimator SURE 1969-2000

	Unrestricted Model (M2)		**Restricted Model (M3)**	
Latin America & Caribbean	**Persistence**	**Std Error**	**Persistence**	**Std Error**
Argentina	0.919***	0.044	0.96***	0.03
Brazil	1.073***	0.049	1.086***	0.018
Chile	0.89***	0.026	0.937***	0.003
Colombia	1.991***	0.283	2.253***	0.42
Dominican Republic	1.046***	0.089	1.077***	0.047
Ecuador	1.416***	0.187	1.39***	0.103
Guatemala	1.686***	0.273	1.651***	0.071
Mexico	1.237***	0.068	1.195***	0.04
Peru	1.134***	0.096	1.12***	0.055
Venezuela	1.430***	0.185	1.565***	0.081
Aggregate	**1.830*****	**0.604**	**1.859*****	**0.307**
Sub Saharan Africa				
Cameroon H	0.981***	0.016	0.99***	0.015
Ethiopia H	1.373***	0.08	1.243***	0.019
Ghana H	0.602***	0.01	0.564***	0.005
Kenya	1.144***	0.051	1.113***	0.022
Madagascar H	0.631***	0.013	0.619***	0.008
Mozambique H	0.772***	0.032	0.736***	0.011
Nigeria	1.06***	0.053	1.063***	0.025
South Africa	0.942***	0.034	0.926***	0.011
Tanzania H	1.591***	0.126	1.582***	0.038
Uganda H	0.871***	0.034	0.865***	0.008
Aggregate	**1.183*****	**0.307**	**1.128*****	**0.140**

- Country's persistence is measured using equation (4.6)
- See notes under Table 4.5

The results from $M2$ and $M3$ are presented in the Table 4.6. The upper panel reports the findings for LAC countries and the bottom panel reports the results for SSA countries. The results are interpreted as follows: a point estimate of 0.92 for Argentina, for example, means that the debt-to-GDP ratio is 0.92% higher than it would have been in the absences of the 1% shock to Argentina. That is multi-country persistence measures the normalised infinite horizon effect of 1% typical or global shock in debt-to-GDP to country i. In all cases the estimates of DS are rather precisely estimated with relatively small standard errors.

The results show that debt is *unsustainable* for all countries in both regions as under the unit root methodology. However, the infinite horizon effect differs across countries, for some a 1% shock would change the debt ratio by less and than 1% whilst for others a 1% shock would change the debt ratio by more than 1%. The aggregate estimates illustrate that infinite horizon effect for LAC region is greater than the SSA region. Under the restricted model, a 1% shock would change the debt ratio of LAC region by 1.86% and SSA region by 1.13%. This is similar to the results from the univariate persistence measures. See above, under Univariate Persistence Techniques, for an explanation regarding higher persistence LAC than in SSA countries.

Countries with higher debt ratio are expected to have greater infinite horizon effect. Hence countries with debt ratio above the threshold found in chapter 2 should have higher persistence. The comparison with the critical threshold estimated in chapter 2 reveal that countries with debt ratio above the threshold of 45% do indeed have higher persistence.

4.4.4 SECTION SUMMARY

This section measures the DSI using a number of methodologies including the traditional approach so that the results from both approaches can be compared and the robustness of the results can be checked. The overall results indicate that the debt-to-GDP ratios of LAC and SSA are indeed *unsustainable*. However, the magnitude of a 1% shock is bigger for LAC countries under univariate and multi-country measures. This suggests that a 1% shock changes the debt levels of LAC by bigger amount than it the debt levels of SSA countries. This may be due to the differences in the nature and the terms of debt, economic and political structure of these economies. LAC countries are, for example, more open than SSA countries, so they are more vulnerable to shocks than SSA countries. This point is elaborated above under the Univariate Persistence Techniques subsection.

4.5 CAUSES OF THE 1980S DEBT CRISIS

Section 2.2 provided a brief discussion of the main causes of the 1980s debt crisis, particularly concerning various shocks that have been attributed to the crisis. This section turns to the second main aim of the paper, which is to identify and measure the contribution of the three widely believed shocks that led to the 1980s TWD crisis. This is done using the shock decomposition techniques proposed by LPP (1992). The following section outlines the procedure (for a more detailed description see the original paper).

From the previous discussion in section 4.4, it is clear that M1 is over-parameterised and cannot be estimated with any precision. Hence, only M2 and M3 were used to estimates the DSI. Likewise in this section only M2 and M3 versions, denoted by $\widetilde{M}2$ and $\widetilde{M}3$, are considered. M2 is augmented with the current and lagged values of the global shocks to give $\widetilde{M}2$ and $\widetilde{M}3$ is derived from $\widetilde{M}2$ in the same manner as M3 is derived from M2. The most general form of model M2 estimated in this section decomposes the errors into two components, one identified and the other unidentified as follows

$$\Delta d_{it} = \alpha_i + \sum_{h=1}^{H} C_{h,ii} \Delta d_{i,t-h} + \sum_{h=1}^{H} C_{h,i} \Delta \bar{d}_{-i,t-h} + \sum_{j=1}^{r} \sum_{h=1}^{H} \delta_{i,jh} \eta_{j,t-s} + \varepsilon_{it} \qquad [4.18]$$

The model $\widetilde{M}2$ specified in [4.18] above includes up to two lags of country and regional aggregate growth rate of debt-to-GDP ratio as in model *M2.* However, unlike *M2*, $\widetilde{M}2$ includes current and lagged values of global shocks. The complete version of $\widetilde{M}2$ not only consists of *J* country equation but also *r* different global shock equations. In this study three different global shocks η_{jt} $j = 1,\ldots,r$ are evaluated: i) oil price shocks, ii) interest rate shock and iii) commodity price shock. The first shock captures the unexpected changes in the World oil prices; the second reflects the unexpected fluctuations in the World interest rate whilst the third captures the unexpected variations in the non-oil exporting commodity prices of DCs. The aim is to measure the contribution of each of these three shocks to the changes in the debt ratios experienced by 1980s using the multivariate framework proposed by LPP and PPL. The following section details the specification of the three equations used to derive the shocks η_{jt}.

4.5.1 Specification of Global Shocks

This subsection briefly outlines the specification of the each of the shocks considered, namely, the oil price, interest rate and DCs' export (non-oil) commodity prices.

World Oil Price

Oil prices are determined by the balance between the supply of oil and its demand as for any other commodity, but as oil is a non-renewable resource its production and usage is influenced by complex set of factors that had undergone a major change over the last 25 years, which are perhaps not very important for other goods such as car. These changes in the production and the consumption of oil has had significant influence on the price of oil, which in turn has led to changes in the growth of output per workers of all countries, whether developing, or developed or they are importer or the exporters.

In its most unrestricted form it is assumed that price of oil P_t^0 is a function of previous year's price, demand for oil D_t^o, and supply of oil, S_t^o.

$$p_t^o = \alpha_{10} + \sum_{i=1}^{q} \beta_{1i} p_{t-i}^o + \sum_{i=1}^{q} \lambda_{1i} d_{t-i+1}^o + \sum_{i=1}^{q} \gamma_{1i} s_{t-i+1}^o + \eta_{pt} \qquad [4.19]$$

where α , β_i , λ_i and γ_i are the parameter estimates corresponding to the intercept, previous year's price influence and price elasticity of demand and supply respectively. The error term η_{pt} is the first element of the innovation matrix $\eta_{\mathbf{t}}$ in subsection 4.2.2. p_t^o , d_t^o and s_t^0 are the log of price, demand and supply of oil. Data for oil price is obtained from International Financial Statistics by IMF, while the data for demand[21] and supply[22] of oil data is from Key World Statistics published by International Energy Agency.

Though the demand for oil is rising due to higher income and population, the supply of oil is limited given the current reserve levels leading to an upward pressure on the price of oil. Following the oil price shocks of 1970s and 1980s, developed countries have substituted for other forms of energy for oil and have tried to become less dependent on oil for production. Furthermore, these countries have undergone a structural change moving away from manufacturing towards service production. Consequence, the demand by remaining oil-dependent industries in developed economics has become more inelastic. However, the supply of oil in the world market has fallen, at the same time resulting in proportionately greater price increase.

The oil price is also notably affected by the role of OPEC which has attempted now and again to restrict the world supply of oil in order to maximise the revenues. As OPEC members account for 40% of the world's oil production, the cartel has potential to exert significant influence over the world oil price as proven by the first oil price shock. The current trend in the production and the reserves of oil by OPEC and non-OPEC are rather

[21] Demand refers to net inland deliveries (including refinery fuel and international marine bunkers).
[22] Crude Oil and NGL Production, which consists of additives and other hydrocarbons (other than crude oil and NGL).

disproportionate such that the OPEC has much higher reserves but supply only 40% of the world's production while non-OPEC have much smaller reserves and yet supply 60% of the world's production. The reserves to production ratios at the end of 1999 was 14 years for non-OPEC and 77 years for OPEC members (BP 2000) for more details about the factors determining the price, demand and supply oil and recent trends, see Farrell et at (2001).

Interest Rate (LIBOR)

Interest rate is determined by the supply of money according to the liquidity preference theory. The argument is that holding money represents a trade-off between convenience and interest income. People keep money in their wallets or in low-interest accounts to have the convenience of being able to make payments without making special arrangements at the bank - that is, money saves "shoe leather costs." But the cost of this convenience is that they give up the interest income. If the cost goes up - the interest goes up- then people cut back on the assets they hold in cash and in their current accounts, shifting their assets into higher-yielding, non-monetary assets such as bonds. Thus the interest rate equation was specified as a function of past interest rates and money supply:

$$r_t = \alpha_{20} + \sum_{i=1}^{q} \beta_{2i} r_{t-i} + \sum_{i=1}^{q} \lambda_{2i} m_{t-i+1} + \eta_{rt} \qquad [4.20]$$

where r_t is the log of interest rates measured by UK clearing banks base rate from DataStream database and m_t is the log of money supply measured by the stock of M4 from Economic Trend Annual Supplement. UK base rate is used because most of TWD is tied to the six-month London Interbank Offered Rate (LIBOR), the interest rate banks offer each other in the unregulated London dollar market.

Commodity Price

The exporting commodity prices of DCs depend on various factors including the social and economic trends both in developing (exporting) and developed (importing) countries. Since DCs' exporting commodities are mainly agricultural products weather conditions and natural disasters have huge implications and this effect is further increased by the fact that DCs' exports are non-diversified. Changes in prices of these commodities have serious consequences for these counties, as they are heavily reliant on a single commodity. That is for most of the DCs a significant share (more than half) of their total export revenues comes from a single commodity which means that these countries' export is highly undiversified and extremely volatile.

The following specification for the commodity price equation is adopted

$$p_t^c = \alpha_{30} + \sum_{i=1}^{q} \beta_{3i} p_{t-1}^c + \sum_{i=0}^{q} \lambda_{3i} d_{t-i}^c + \sum_{i=0}^{q} \gamma_{3i} s_{t-i}^c + \eta_{ct} \qquad [4.21]$$

where α, β, λ and γ are parameters estimates. p^c, d^c and s^c are price, demand and supply of developing country's export commodities. The error term η_c represents the shocks or innovation in commodity market of DCs.

The dataset for the commodity prices index and the import and export indices was obtained from UNCTAD's Handbook of Statistic. These indices were in two different base years that were converted into a single base year.

Expectation Equations

Table 4.7 shows the exact equations used to derive the global shock examined in this chapter. The most general form of each equation included lagged values of the dependent and the independent variable up to 3 periods. These lagged values were subsequently eliminated if the t-value was less than unity in absolute terms and the model was re-estimated including only the variables with absolute t-statistics greater than unity.

The interest rate equation was originally specified in terms of lagged values of interest rate and contemporary and lagged values of money supply as expressed in [4.20] but surprisingly the estimated result showed that money supply has no predictive power for the interest rate. That is both contemporaneous and the lagged values of money growth were insignificant in the interest rate equation. Therefore, they were eliminated from the final interest rate equation used to derive interest rate shock. The estimates for the oil price equation showed that the contemporaneous effect of demand for oil and supply of oil on its price is insignificant. However, there is a significant lagged effect of demand and supply on the price of oil. Changes in demand for oil affect prices positively for up to two years whilst changes in supply affect prices negatively for the same period. The estimates for the non-oil exporting commodities price equation reveals that prices are determined by past three years' commodities prices, last year's demand and current and last year's supply.

After deriving the form of the global shock equations used to identify the shocks, the system of 10 individual country equations explaining the growth rate of debt-to-GDP together with the 3 global shock equations were jointly estimated by SURE estimator for

LAC and SSA countries. Before discussing the results for the contribution of these shocks to the 1980s debt crisis, the effect of these shocks is examined firstly. More precisely two hypotheses testing the long-run and the short-run effects of each of these shocks on every country in both groups is assessed.

TABLE 4.7
Equations Used To Derive The Global Shocks
OLS Estimator 1969-2000.

Oil Price Equation					
$\Delta p_t^o =$	0.024	$+ 0.043\ \Delta p_{t-1}^o$	$+ 9.119\ \Delta d_{t-1}^o$	$+ 10.475\ \Delta d_{t-2}^o$	$-6.056\ \Delta s_{t-1}^o$
	(0.066)	(0.196)	(4.915)	(5.620)	(4.749)
	$-1.203\ \Delta s_{t-2}^o$				
	(5.022)				
	R^2=0.278	SE=0.327	LLF=-5.376		
Interest Rate Equation					
$\Delta r_t =$	-0.289	$-0.022\ \Delta r_{t-1}$	$+2.559\ \Delta r_{t-2}$		
	(0.167)	(0.168)	(0.914)		
	R^2 = 0.307	SE = 0.230	LLF = 3.582		
Commodity Price Equation					
$\Delta p_t^c =$	0.115	$- 0.478\ \Delta p_{t-1}^c$	$- 0.361\ \Delta p_{t-2}^c$	$- 0.287\ \Delta p_{t-3}^c$	$+ 5.081\ \Delta d_{t-1}^c$
	(0.143)	(0.160)	(0.174)	(0.122)	(1.447)
	$- 1.294\ \Delta s_t^c$	$+ 2.171\ \Delta s_{t-1}^c$			
	(0.959)	(0.993)			
	R^2 = 0.578	SE = 0.382	LLF =-9.268		

- The estimates reported in the Table are computed using OLS estimator. However, for the persistence measures presented in the previous section in Table 4.6 and in the section Tables 4.5.2-4.5.4 are all computed using SURE estimator, where the country's debt-to-GDP growth equations were estimated jointly with the three global shocks.
- Δ refers to the difference of the variable. $(t-i)$ indicates that the variable is lagged i period. LLF is maximum likelihood. SE is standard error of regression.
- Figures in the parenthesis are standard errors.

4.5.2 Effects of Global Shocks: Transitory v Permanent

Having determined the expectations equations to be used to derive the global shocks, η_{it}, the following two hypotheses are tested using the Wald's test:

$$H_A \qquad \sum_{h=0}^{1} \delta_{i,jh} = 0 \qquad i = 1,...,10 \qquad , j = 1,...,3$$

$$H_B \qquad \delta_{i,j0} = \delta_{i,j1} \qquad i = 1,...,10 \qquad , j = 1,...,3$$

The first hypothesis, H_A, tests the null that global shocks have only temporary effect on the growth rate of debt-to-GDP ratio. The second hypothesis, H_B, tests the null that global shocks have neither temporary nor permanent effect on the debt-to-GDP ratio.

TABLE 4.8
Wald's Test Statistics

	Null: Global Shocks have short-run effect			Null: Global shock have no effect		
Latin America & Caribbean	**Oil Price**	**Interest rate**	**Commodity price**	**Oil Price**	**Interest rate**	**Commodity price**
Argentina	0.937	1.051	0.465	0.966	1.204	0.565
Brazil	0.224	0.030	0.251	0.255	3.910	0.732
Chile	0.005	0.064	0.025	0.807	0.094	0.766
Colombia	0.558	1.109	0.775	2.480	3.156	2.603
Dominican Republic	0.666	0.089	0.081	0.707	2.530	0.139
Ecuador	0.555	0.361	1.683	0.730	1.435	5.290
Guatemala	1.182	0.043	0.691	3.186	1.301	4.185
Mexico	1.711	0.001	1.643	1.719	2.231	1.979
Peru	0.410	0.891	0.251	3.981	3.155	1.532
Venezuela	1.258	0.013	0.764	2.655	5.264	2.777
Sub Saharan Africa						
Cameroon H	0.929	0.330	0.025	1.163	1.197	1.208
Ethiopia H	1.057	0.057	0.373	1.079	0.327	0.389
Ghana H	0.566	5.880*	0.458	0.566	7.280*	0.466
Kenya	0.981	0.106	0.012	2.712	4.626	4.827
Madagascar H	0.357	0.417	0.509	5.652	0.452	7.318*
Mozambique H	0.793	1.526	1.766	0.840	1.994	3.071
Nigeria	3.260	5.252*	0.642	3.288	5.268	0.974
South Africa	1.538	2.262	6.190*	7.795*	6.356*	8.168*
Tanzania H	0.000	1.124	0.250	0.005	1.165	0.517
Uganda H	1.055	0.595	1.828	1.070	0.597	2.359

- Results relate to $\widetilde{M}2$ derived in the text. For each country and each shock the Wald's test statistics are calculated for the following hypotheses:
  $H_A : \sum_{h=0}^{1} \delta_{i,j0} = 0$ and $H_B : \delta_{i,j0} = \delta_{i,j1}$, where $i = 1,...,10$, and $j = 1,...,3$.
- Critical values for the Wald's test statistics under H_A & H_B are $\chi^2(1)$ = 3.84 & $\chi^2(2)$ = 5.99.
- H denotes HIPC country

The Wald tests statistics for H_A and H_B are presented in the Table 4.8. The results relate to $\widetilde{M}2$ discussed in subsection 4.5.1. Neither of the hypotheses can be rejected at 5% significance level in most of the case suggesting that all the three global shocks considered no effect on the growth rate of debt-to-GDP ratio. The exceptions are Ghana and Nigeria, where interest rate shock has affected debt-to-GDP ratio. Madagascar has been affected by commodity price shock in the long-run whilst South Africa has been affected by all three shocks in the long-run.

However, the overall finding disagrees with the argument that debt crisis came about as a result of these shocks. This issue is examined in more details in the following, where the exact effect of theses shocks on the evolution of debt-to-GDP ratio is estimated using the decomposition techniques proposed by LPP. To this end a more restricted version of $\widetilde{M}_2$ was estimated where the coefficients with t-values less than unity in absolute terms were dropped yielding $\widetilde{M}_3$. The complete version of $\widetilde{M}_3$ consists of 13 equations: 10 country equations and 3 shock equations. The reminder of this section presents and discusses the results from this model. Subsection 4.5.3 explains the effect of identified global shocks relative to unidentified shocks on the crisis. This is followed by subsection 5.4.4 which illustrates the contribution of the identified shocks including oil price, commodity price and interest rate shocks on the crisis.

4.5.3 DEBT CAUSES: IDENTIFIED V UNIDENTIFIED SHOCKS

This section presents the results from, $\widetilde{M}_3$ which is the restricted version of model $\widetilde{M}_2$ given in [4.18]. $\widetilde{M}_3$ is estimated using SURE estimator and the results are presented in Table 4.9. The Table reports the results for each country and the two regions under investigation. The regional figures are presented as "aggregate" because they are simply the aggregate of ten individual countries in each region. The table gives the *total* effect of shocks and its decomposition into *identified* and *unidentified* component with standard errors. Total country and aggregate persistence are given in column (3) while the decomposition of these total into identified and unidentified are given in column (1) and (2) respectively. Note that the *identified* and the *unidentified* effects do not add up *total* effect due to the interaction between the two components.

In the Table the precision of each point estimate, which is calculated by dividing the point estimate by the standard error is indicated by one or more asterisks. (* indicates that the point estimate is greater than at least one standard error, ** indicate that the estimate is greater than at least two standard errors and so on.)

The results are interpreted as such: a 1% shock to a country say Argentina, would cause the growth rate of debt-to-GDP ratio 1.4% higher than it would have been in the absence of this shock. If this shock was one of the identified shocks then the growth rate of debt-to-GDP ratio would be 3.5% higher whilst if it was an unidentified shock then the effect would be 1.22%. Likewise, the aggregate statistics is interpreted as such that if there was a 1% shock to the region made up of the ten countries in the sample then infinite horizon effect on the growth rate of debt ratio would be 2.26% in the case of LAC and 1.02% in the case of SSA. If this shock was one of the identified shocks then the effect would be 1.50 (0.95) for LAC region and 0.80 (0.28) for SSA region. However, if it an unidentified shock then effect would be 2.98 (1.33) and 1.08 (0.20) for LAC and SSA regions respectively.

TABLE 4.9
Decomposition of Persistence of Shocks into Identified and Unidentified Component
Restricted Model – $\widetilde{M}3$, SURE Estimator 1969-2000

	(1) Identified		(2) Unidentified		(3) Total	
Latin America & Caribbean	**p**	**SE**	**P**	**SE**	**P**	**SE**
Argentina	3.50	3.80	1.22***	0.40	1.40**	0.53
Brazil	1.15*	0.95	1.00***	0.26	1.02***	0.32
Chile	11.62	141.97	0.99***	0.28	1.02***	0.28
Colombia	0.00	0.00	3.35*	2.14	3.35*	2.14
Dominican Republic	1.32*	0.85	1.33**	0.56	1.33**	0.59
Ecuador	1.19**	0.40	1.87**	0.64	1.49***	0.40
Guatemala	2.39*	1.77	2.02**	0.85	2.10**	0.93
Mexico	0.85**	0.37	1.12***	0.33	1.06***	0.33
Peru	1.49***	0.42	1.22***	0.24	1.32***	0.25
Venezuela	2.09*	1.10	1.56**	0.61	1.75**	0.72
Aggregate	**1.50***	**0.95**	**2.98****	**1.33**	**2.26****	**1.07**
Sub Saharan Africa						
Cameroon H	-		1.07***	0.09	1.07***	0.09
Ethiopia H	2.85*	2.59	1.43***	0.34	1.51***	0.37
Ghana H	2.50*	2.25	0.49***	0.06	0.74***	0.15
Kenya	0.48	0.56	1.15***	0.18	1.00***	0.20
Madagascar H	0.60*	0.48	0.77***	0.15	0.74***	0.15
Mozambique H	0.51***	0.06	0.52***	0.06	0.52***	0.06
Nigeria	1.44***	0.32	1.16***	0.19	1.29***	0.17
South Africa	1.28***	0.41	0.91***	0.21	1.03***	0.21
Tanzania H	1.37**	0.62	1.07***	0.12	1.12***	0.15
Uganda H	1.38***	0.38	0.85***	0.09	0.99***	0.08
Aggregate	**0.80****	**0.28**	**1.08*****	**0.20**	**1.02*****	**0.18**

*, ** & *** indicate that the persistence is greater than at least 1, 2, or 3 standard errors respectively.
H denotes HIPC country.

The *total* persistence is greater than one for all LAC countries indicating that the infinite horizon effect of a shock is progressive. That is a 1% shock to debt ratio in period t would change the growth rate of debt by more than 1% for all of LAC countries. However, for SS countries the infinite horizon effect seems to less. For 7 out of ten SSA countries the point estimate is less than or close to one indicating that 1% shock would change the debt ratio by 1% of less on permanent basis. The aggregate figure for LAC is 2.26(1.07) whereas for SSA it is only 1.02 (0.18). This pattern is not just for the *total* persistence effect, but also carries over to the identified and the unidentified components. Although the effect of an identified shock is greater than effect of an unidentified shock for 7 LAC countries it is only *significant* for 5 of these countries. In SSA 6 countries have a standard error smaller than the point estimate.

In more than half of the cases the persistence effect for global shocks is greater than the total effect reinforcing the conclusion that global shocks are more persistent, i.e. have long-term effect while other shocks are less important as their effect decays overtime. This reflects the fact that global shocks over the period of analysis are far more significant than other shocks.

Overall the results show that the identified shocks have contributed significantly to the accumulation of debt particularly for LAC countries. The infinite horizon effect of identified shocks is significant for both regions and is greater than one for LAC suggesting that a 1% shock from one of the identified shocks would cause the debt ratio to increase by more than 1%. However, the unidentified shocks are also important, often with smaller standard error and in a few cases with higher infinite horizon effect.

4.5.4 DEBT CAUSES: CONTRIBUTION OF IDENTIFIED GLOBAL SHOCKS

The previous subsection presented and discussed the results about the importance of shocks to the 1980s debt crisis of DCs. It decomposed the effect of shocks into identified and unidentified components and found that identified shocks together had significantly contributed to the crisis along with other unidentified factors. Thus the three shocks including interest rate, oil price and commodity price are not the only factors causing the crisis and one must look at beyond these to fully understand what caused the crisis. However, this is not the focus of this chapter since the aim is not to identify all the factors that caused the crisis but instead to investigate the role of some particular shocks, which are usually attributed to the crisis. Consequently, this subsection looks more closely at the role of individual shock for both groups of countries.

The Table 4.10 presents the identified estimates in column (1) and its decomposition into oil price in shock in column (2), interest rate in column (3) and commodity price column (4) for each of ten countries in LAC and SSA region plus the aggregate estimate for each region. The figures in this Table are interpreted in exactly the same way as in Table 4.9. So for example, the persistence measure for SSA region is 0.80 (0.28) which indicates that a 1% shock of either oil price, interest rate or commodity price to SSA region as whole would change the debt-to-GDP ratio by 0.8% forever; the corresponding effect for LAC region in almost twice this – 1.5% (0.95).

A 1% oil price shock would change the debt ratio by 1.71% (0.95) forever for LAC region but only by 0.82% (0.37) for SSA region. Nonetheless, a 1% interest rate shock would change the debt ratio of SSA by 0.41% but only by 0.06% (0.90) for LAC. The opposite is true for the commodity price shock: a 1% shock to commodity price would change the debt ratio by 1.42% (1.20) for LAC and 0.44% (0.67) for SSA. In other words, oil shock is the most important from the three identified shocks for LAC and SSA. The next important shock for LAC is commodity price shock whilst for SSA it is interest rate shock. The least important shock for LAC is interest rate whereas for SSA is commodity price. The identified shocks in total are more *significant* for SSA than for LAC but the magnitude is small.

TABLE 4.10
Decomposition of Global Shocks
Restricted Model – M3, SURE Estimator 1969-2000

Latin America & Caribbean	(1) Identified		(2) Oil Price		(3) Interest Rate		(4) Commodity Price		(5) Covariance
	P	SE	P	SE	P	SE	P	SE	STAT.
Argentina	3.50	3.80	3.35*	3.07	1.57	2.31	2.68	3.65	-8.61
Brazil	1.15*	0.95	0.25	0.78	0.27	1.03	1.12*	0.71	-0.08
Chile	11.62	141.97	2.77	37.26	0.35	6.83	9.71	119.84	33.00
Colombia	-		-		-		-		-
Dom. Republic	1.32*	0.85	1.55*	1.08	0.25	0.93	1.02	1.05	-1.78
Ecuador	1.19**	0.40	0.75*	0.55	0.52*	0.44	0.25	0.63	0.50
Guatemala	2.39*	1.77	2.55*	1.92	0.68	1.19	2.61*	2.18	-8.05
Mexico	0.85**	0.37	0.56	0.86	0.68	0.71	0.98*	0.78	-1.01
Peru	1.49***	0.42	0.62	0.71	0.78*	0.42	0.53	0.76	0.95
Venezuela	2.09*	1.10	2.23**	1.01	0.14	1.02	2.09*	1.13	-4.99
Aggregate	**1.50***	**0.95**	**1.71***	**0.95**	**0.06**	**0.90**	**1.42***	**1.20**	**-2.70**
Sub Saharan Africa									
Cameroon H	-	-	-	-	-	-	-	-	-
Ethiopia H	2.85*	2.59	3.01*	2.74	1.00	1.61	1.07	2.07	-3.06
Ghana H	2.50*	2.25	0.07	0.59	2.56*	2.24	0.12	0.25	-0.34
Kenya	0.48	0.56	0.18	0.31	0.48	0.59	0.03	0.75	-0.03
Madagascar H	0.60*	0.48	0.68*	0.38	0.10	0.11	0.60	0.80	-0.47
Mozambique H	0.51***	0.06	0.30*	0.23	0.45***	0.14	0.55***	0.14	-0.33
Nigeria	1.44***	0.32	1.01**	0.37	1.16**	0.49	0.53*	0.47	-0.57
South Africa	1.28***	0.41	0.14	0.28	0.65*	0.48	1.49**	0.54	-1.05
Tanzania H	1.37**	0.62	0.15	0.27	1.45*	0.90	1.14***	0.27	-1.54
Uganda H	1.38***	0.38	0.61*	0.45	0.67*	0.41	1.17***	0.15	-0.28
Aggregate	**0.80*****	**0.28**	**0.82****	**0.37**	**0.41***	**0.40**	**0.44**	**0.67**	**-0.39**

H denotes HIPC country.

4.5.5 Section Summary

In this section the contribution of three global shocks to the debt levels of LAC and SSA countries is analysed using the shock decomposition techniques proposed by LPP. The results support the view that oil price, interest rate and commodity price shocks have significantly contributed to rising the debt levels of LAC and SSA countries to unsustainable levels as their effect is statistically different from zero. However, the unidentified component, i.e. factor other than these three shocks, also have significant role in increasing the debt levels to unsustainable levels. Indeed, in come cases the unidentified component seems more prominent than the identified component.

From the three identified shocks, the results illustrate that the oil price shock is the most important for both groups of countries whilst the least important shock for LAC is interest rate and for SSA is the commodity price shock.

4.6 CONCLUSION

The paper introduces a more realistic measure for assessing the DS and opposes the traditional dichotomy between "sustainable" and "unsustainable" countries on the grounds that a country's DS is a continuum measure running from a stable to relatively stable to relatively unstable to unstable or debt crisis countries. Furthermore, the empirical techniques used to classify countries into stable and unstable groups are mainly unit root and cointegration tests which are well known for their low power especially against a unit root process. Thus, the paper suggests an alternative DS measures based on persistence measures and employs this to estimate the DSI of 10 LAC and 10 SSA countries. Under the traditional procedure one essentially tests whether the debt-to-GDP ratio is a stationary process or not and if debt ratio is found to be stationary then debt is considered to be at *sustainable* level. Since stationary processes have short-term memory, that is a one period shock has temporary effect, the persistence of a one period shock in infinite horizon is zero. Consequently, a persistence measure close to zero indicates that debt is at sustainable level and a measure far away from zero suggests that the debt is unsustainable.

The empirical results from the stationarity tests and the persistence measures suggest that debt of LAC and SSA countries under investigation is *unsustainable*. However, the persistence of shocks is greater for LAC than for SSA countries, suggesting that SSA countries are less vulnerable to shocks than LAC. This may be because, LAC are more open and thus are more vulnerable to shocks than SSA countries. Also, the debt of SSA is on concessional terms whilst the debt of LAC is on commercial terms so shocks have less effect on SSA's debt, especially the debt-service. Furthermore, SSA countries are heavily controlled by their governments and the creditors, at least more than LAC countries, so there are numerous political forces at work making it harder to justify the result in pure economic theory that assumes free-markets.

Since the debt-to-GDP ratios of SSA countries are greater than LAC countries, they are less able to absorb any external shock causing debt levels to rise further. In a further rising debt situation SSA countries' debt service obligations increase whilst their resources remain the same making default a superior option to servicing the debt. In such a situation creditors would write-off part of debt in order to prevent the debtors from defaulting as do so would keep creditors option of being repaid in the future (if and when the debtors experience good growth) alive, whereas, defaulting means that creditors would not be repaid at all. Therefore, whenever there is a shock rising the debt ratios of SSA countries, creditors write-off the further increase due to this shock making the empirical analysis indicating that shocks have temporary effect.

The second part of the empirical analysis concerning the contribution of certain factors to high debts levels of 1980s support the view that the oil price, the interest rate and the non-oil exporting commodity prices shocks that took place during the 1970s and early 1980s had a significant contribution to the debt problems of LAC and SSA countries in 1980s. The study of the individual effect of these shocks shows that oil price shock had the largest contribution for both groups but the magnitude of the effect is larger for LAC group. Commodity price is the second largest shock causing the debt crisis for LAC region whereas the second largest shock for SSA countries is the interest rate.

Nonetheless, these shocks are not the only factors leading to the crisis. Other factors unidentified in this chapter are just as important if not more. Hence one must research beyond these shocks to fully identify and understand the causes of the crisis.

5 CONCLUDING REMARKS

5.1 INTRODUCTION

The aim of this final chapter is to conclude the thesis by summarising and evaluating the major findings and detailing the key policy implications derivable from the empirical results. It is organised in four subsections, the first subsection, 5.2 reviews the key findings from the three substantive chapters and 5.3 makes comparisons between the results from them. Subsection, 5.3 outlines the policy implications that emerge from the analyses and lastly, subsection 5.4 suggests possible areas for further research on the TWD topic.

5.2 REVIEWING KEY FINDINGS OF THE STUDY

The thesis has examined some fundamentals questions concerning the TWD, growth and development of heavily indebted DCs and the sustainability of their debt levels. In particular the study investigated, the

- form of the relationship between debt and growth
- threshold level(s) of debt-to-GDP ratio below which debt is growth-enhancing but above it debt is growth-deterring
- growth-maximizing level of debt-to-GDP ratio.
- intertemporal sustainability of debt
- vulnerability to debt crises
- contribution of oil price shocks of 1970s, non-oil exporting commodity prices shock and the world interest rate shock to the emergence of 1980s crises.

These issues have been examined by formulating empirical models and deriving empirically testable restrictions using an extensive dataset consisting of 56 countries for 32 years from 1969 to 2000. The substantive empirical analyses are presented in chapters 2 to 4 of the thesis. ***Chapter 2*** investigated the non-linearity of the debt-growth relationship and determined the debt threshold(s) using Hansen (1996, 2000)'s econometric methodology and more conventional methods such as quadratic specification. Although there are some differences between the empirical results from different techniques the overall conclusion and the results from the most preferred model are as follows: the debt-growth relationship is indeed *non-linear* and the specific threshold at which debt becomes detrimental to growth is 45% of debt-to-GDP ratio.

This finding is in line with results of Elbadawi et al (1997), Pattillo et al (2001, 2004), Were (2001), Clements et al (2003), Cordella et al (2005) and Imbs and Ranciere (2005) who also find that the debt-growth relationship is non-linear. However the specific threshold estimates differ: Pattillo et al (35-40%), Clements et al (50%) and Imbs and Ranciere (30-35%) threshold estimates range from 30% to 50% of debt-to-GDP ratio. Others find a significantly different threshold estimates including Elbadawi et al who found a threshold of 97% and Cordella et al who find the threshold for the face value of debt-to-GDP ratio between 20-31%.

The threshold approach only looks at one point in time to decide if a country's debt is sustainable or not whereas economic theory suggest that persistently high debt is a problem not one period or short-term high debt. In fact a country can have high borrowing in the short-run as long as it can pay back in the long-term. Therefore, ***chapter 3*** uses an alternative concept of sustainability that encompasses a country's long-run debt situation. More specifically, it examines the DS in terms of a country's IBC. According to the IBC a country's debt is sustainable as long as it satisfies the NPG condition in infinite horizon. The empirical implications of this in terms of the time-series properties of debt and output are that debt-to-GDP ratio should be stationary or/and debt and GDP should be cointegrated for sustainable debt levels. Using univariate and the multi-country integration and cointegration techniques we find that the debt levels are at *unsustainable* level for at least most if not all of the countries in the sample.

The intertemporal DS is undoubtedly a more comprehensive concept than the threshold approach, but the use of unit root and cointegration tests are not the best techniques to assess the DS. Bohn (1998, 2007) amongst other propose alternative tests to assess the intertemporal sustainability. In his first paper Bohn advocates that IBC is satisfied if primary surpluses are positively and significantly correlated with debt-to-GDP ratio. In his recent study he argues that stationarity and cointegration tests are incapable of rejecting sustainability therefore error correction type functions should be used to asses DS.

In the ***final***, empirical chapter an alternative methodology is suggested for assessing the DS of a country. It is argued that the stationarity and cointegration method categorise each country into a dichotomy of sustainable vs. unsustainable whereas in reality the sustainability varies from very high level, where debt levels are very small, to very low level where debt situation is at crisis point as debt is a continues variable. In other words, a country's DS should be estimated as a continuous measure rather than be tested as sustainable vs. unsustainable. Chapter 4 addresses this issue and suggests a DS Indicator (DSI) which provides a more accurate and hence more informative measure of country's DS. In practice the DSI is computed by persistence measure. The lower (higher) the persistence measures the more (un)stable a country's debt is considered to be.

Using a subset sample of countries used in the previous two chapters, chapter 4 estimates a country's vulnerability to debt crisis via univariate and multi-country persistence measures suggested by Campbell and Mankiw (1988) and Lee Pesaran and Pierse (1992) respectively. Subset sample was necessary because the multi-country persistence measures involve estimating a global VAR model containing one equation for each country in the sample and allowing for interaction between all the countries. Evidence from the univariate and the multi-country measures show a similar picture illustrating the there is considerable variation between countries' DS. Some countries have measures as large as 2.25 (Colombia) whilst others have as small as 0.56 (Ghana). Hence classifying all the countries as unsustainable, which the unit root and cointegration approaches do is not accurate. The results also show that LAC countries are more vulnerable than the SSA countries.

The second half of the empirical analyses considered the contribution of three shocks to the 1980s debt crisis. Interest rate, commodity prices and oil price shocks are generally attributed to the debt crisis. The results show that these shocks did indeed have permanent effect on the growth rate of debt-to-GDP ratio. From the three identified shocks, oil shock is the most prominent for both regions, although the effect is bigger for LAC region. However, the least significant shock for LAC was interest rate whilst for SSA it was commodity prices.

Furthermore, the analysis of the exact effect of these shocks on the evolution of the debt ratio against the unidentified component reveal that although these shocks had significant effect on the emergence of the debt crisis other factors not identified here had even bigger contribution. Therefore, one must analyse factors beyond these shocks in order to understand the causes of the crisis.

5.3 EVALUATING KEY RESULTS OF THE STUDY

Table 5.1 summaries the main finds of all the empirical chapters in the thesis. Column (1) reports the results from chapter 2 under the threshold concept of debt sustainability. Here a country's debt is classified as unsustainable if its debt has been above the sustainable threshold of 45% of debt-to-GDP ratio for at least 5 years. Only 7 countries have had debt below 45% for less than 5 years. Column (2) gives the findings from chapter 3 under the intertemporal concept of debt sustainability using integration and cointegrating methods. Here if 3 or all the 4 tests indicated that debt is unsustainable then it is taken as unsustainable. However, if only 1 out of 4 tests indicated debt is unsustainable it is taken to be sustainable. If 2 tests showed debt is unsustainable whilst the other 2 showed it to sustainable then it is concluded to be ambiguous. Column (3) shows the results from chapter 4 under the IBC but using persistence techniques. Here debt is classified as unsustainable if persistence estimates is at least 0.5.

TABLE 5.1
Summary of the Key Findings from Each Chapter

	(1) Threshold (Years)	(2) IBC (Tests)	(3) DSI	(4) Overall		(5) Threshold (Years)	(6) IBC (Tests)	(7) DSI	(8) Overall
Algeria	U (17)	U (3)	-	2/2	Malawi	U (31)	U (3)	-	2/2
Argentina	U (14)	U (3)	U	3/3	Malaysia	U (12)	U (3)	-	2/2
Bangladesh	S (2)	A (2)	-	A	Mali	U (29)	U (3)	-	2/2
Bolivia	U (32)	U (3)	-	2/2	Mauritius	U (11)	U (3)	-	2/2
Brazil	U (5)	U (3)	U	3/3	Mexico	U (9)	A (2)	U	2/3
Cameroon	U (12)	U (3)	U	3/3	Morocco	U (24)	U (3)	-	2/2
Chile	U (21)	U (3)	U	3/3	Mozambique	U (19)	U (4)	U	3/3
China	S (2)	U (3)	-	1/2	Nicaragua	U (27)	U (3)	-	2/2
Colombia	S (1)	U (3)	U	2/3	Nigeria	U (19)	U (3)	U	3/3
Costa Rica	U (15)	U (3)	-	2/2	Pakistan	U (23)	S (1)	-	1/2
Cote d'Ivoire	U (23)	U (3)	-	2/2	Panama	U (27)	A (2)	-	1/2
Dom. Republic	U (10)	U (3)	U	3/3	Paraguay	U (6)	U (3)	-	2/2
Ecuador	U (23)	U (3)	U	3/3	Peru	U (25)	U (3)	U	3/3
Egypt	U (22)	U (3)	-	2/2	Rwanda	U (9)	U (3)	-	2/3
El Salvador	U (8)	U (3)	-	2/2	Senegal	U (22)	U (3)	-	2/2
Ethiopia	U (19)	U (3)	U	3/3	Sierra Leone	U (21)	U (4)	-	2/2
Ghana	U (18)	U (3)	U	3/3	South Africa	U (6)	U (4)	U	3/3
Guatemala	S (1)	U (3)	U	2/3	Sri Lanka	U (23)	A (2)	-	1/2
Guyana	U (31)	A (2)	-	1/2	Tanzania	U (32)	S (1)	U	2/3
Haiti	S (2)	U (3)	-	1/2	Thailand	U (9)	A (2)	-	1/2
Honduras	U (24)	S (1)	-	1/2	Trin. & Tobago	U (9)	U (3)	-	2/2
India	S (1)	U (3)	-	1/2	Tunisia	U (22)	A (2)	-	1/2
Indonesia	U (19)	U (3)	-	2/2	Turkey	U (8)	U (3)	-	2/2
Iran	S (1)	U (3)	-	1/2	Uganda	U (15)	U (3)	U	3/3
Jamaica	U (32)	U (4)	-	2/2	Uruguay	U (9)	U (3)	-	2/2
Jordan	U (22)	U (4)	-	2/2	Venezuela	U (14)	U (3)	U	3/3
Kenya	U (22)	U (3)	U	3/3	Zambia	U (30)	U (3)	-	2/2
Madagascar	U (22)	U (4)	U	3/3	Zimbabwe	U (10)	U (3)	-	2/2

Test refers to the number of unit root and cointegration tests that indicated debt levels to be unsustainable. Maximum number is 4.
Years refer to number of years a country's debt-to-GDP ratio was above the sustainable threshold of 45% from 1969-2000. So the maximum number of years is 32.
IBC refers to debt situation under the IBC approach.
Threshold refers to the debt situation under the threshold approach
U, S and A denote debt level is unsustainable, sustainable or results are ambiguous

Largely, countries with higher debt threshold do have nonstationary debt or noncointegrated debt and output as well as higher persistence estimates. For 43 countries the result of unsustainable debt are consistent through all 3 chapters and only for 13 countries this is not true.

5.4 POLICY IMPLICATIONS

The key objective of policymakers is to formulate an economic policy package that promotes growth and raises the welfare of the nation. Evidence from empirical studies can help policymakers to select an appropriate policy from alternative options. This section highlights some of the key policy implications that can be derived from the empirical results of the thesis. As with all empirical work one must be careful in generalising the findings as the results are based on a specific dataset which may change dramatically if a different dataset is used.

A clear conclusion of the analyses is that debt has significant implication for the growth and the developments of DCs. Debt effects growth non-monotonically whereby low levels of debt increased the growth rate of GDP by closing the savings-investment gap. However, high debt deters growth rate of output as it reduces investments due to the expectations of high future taxes accompanied by high debt service burden that crowds out public and social spending as well as creating greater uncertainty associated with debt roll-overs or rescheduling. The results also indicate that the debt levels of DCs are far higher than the desirable level for growth-enhancing. Thus, they ought to be reduced to sustainable level in order to allow the countries to growth and provide decent basic services to their citizens. The current debt relief measures are not adequate as countries after receiving full relief have not been set free from the debt problems.

However, simply cancelling the debt will not enhance growth and lift the countries from poverty enabling it to provide better standards of living. Debt cancellation need to be complimented with programmes that ensure that the relief provided will be utilised for profitable projects instead of ending up in corrupt leaders' pockets. Also appropriate policy reforms should be undertaken to restore investors' confidence. Relief funds should be used to improve the health and education of people as well as the quality of institutions and the development of financial/banking sector.

The current methodology used by the Fund-Bank to assess the sustainability of a country's debt is not very effective as it looks at a country's debt in one period in time rather than viewing it in infinite horizon as implicated by economic theory. Thus a country's intertemporal sustainability should be studied instead of the threshold sustainability. Empirically this can be tested by a number of econometric methodologies such as unit root tesst, cointegration tests, error correction models and persistence measures. It is argue in this study that persistence measures provide much more information to policymakers. It shows them the country's borrowing capacity over long-term horizon and thus indicates what the appropriate debt strategy is, i.e. should the country continue to borrow in the near future or should it reduce its debt level etc.

The results indicate that LAC countries' debt is less sustainable than SSA countries. This implies that more effort, by policymakers and non-government organisation like JDC should be made to, reduce LAC countries' debt. However, in practice more effort is directed towards the cancellation of SSA's debt as these countries have lower growth rate of output and higher levels of poverty than LAC countries. The second implication of this finding is that greater attention should be paid to other barriers to growth and development of SSA countries. These include improvements is health and education of people, i.e. increase in human capital, development of financial/banking sector, improvements in public infrastructure and quality of institutions. Enhancing rule of law, securing property rights, creaking down on corruption and reducing uncertainty in the economy should boost investors' confidence and lead to higher levels of investments reducing the need for loans to close the savings-investment gap. Higher investment should result in higher growth of output and better standards of living.

5.5 RECOMMENDATIONS FOR FUTURE RESEARCH

The analysis in the first empirical chapter use pooled dataset to estimate FE type models, it would be interesting and valuable contribution to the literature to carry out country-based analysis. Such studies would illustrate if there is a country-specific debt threshold or whether one threshold is applicable to all countries. Such analysis would also highlight if debt effects growth differently in different countries in terms of the magnitude of the effect and channels through which debt influence growth.

Another possible contribution to the topic under investigation could be the use of debt-to-export ratio rather than debt-to-GDP ratio. Also carrying out the analysis for the debt-service to GDP or debt-service-to-export ratio would provide useful insight into how debt-service rather than debt stock effects growth and whether there are any notable differences in terms of the growth maximising level of debt/debt service and sustainable level of debt/debt-service. Question such as how much a country's export earnings can be spent on servicing the debt before it represent a problem are left for future research.

Studies making comparisons between the use of persistence measures for assessing the sustainability and the Error Correction Model should also prove fruitful.

6 APPENDICES

6.1 STATUES OF HIPC COUNTRIES

HIPC countries can be classified into one of the three categories depending on what stage of the HIPC initiative they have reached. As of April 2009, ***twenty-four*** reached the ***completion point*** after successfully maintaining macroeconomic stability under a PRGF supported program, making key structural and social reforms and implementing PRSP for a minimum of one year. Upon reaching completion point, debt relief is provided irrevocably by debtor country's creditors and under MDRI. ***Eleven*** reached the ***decision point*** after accomplishing a record of macroeconomic stability, preparing a PRSP jointly with the Fund-Bank and having debt burden indicators above the HIPC initiative thresholds for data a year prior to the decision point. The amount of debt relief necessary to bring countries' debt indicators to HIPC thresholds is calculated, and countries begin receiving interim debt relief on a provisional basis. ***Five*** reached ***pre-decision point*** after meeting the income and indebtedness criteria at end-2004 and wish to benefit from the HIPC Initiative. Table A1 lists HIPC countries under each of these categories as of April 2009.

TABLE A1
Statues of HIPC Countries

Completion Point (24)		Decision Point (11)	Pre-Decision Point (5)
Benin	Mali	Afghanistan	Comoros
Bolivia	Mauritania	Central African Rep.	Eritrea
Burkina Faso	Mozambique	Chad	Kyrgyz Republic
Burundi	Nicaragua	Congo, Dem. Rep.	Somalia
Cameroon	Niger	Congo, Rep. of	Sudan
Ethiopia	Rwanda	Côte D' Ivoire	
Gambia	São Tomé & Príncipe	Guinea	
Ghana	Senegal	Guinea-Bissau	
Guyana	Sierra Leone	Haiti	
Honduras	Tanzania	Liberia	
Madagascar	Uganda	Togo	
Malawi	Zambia		

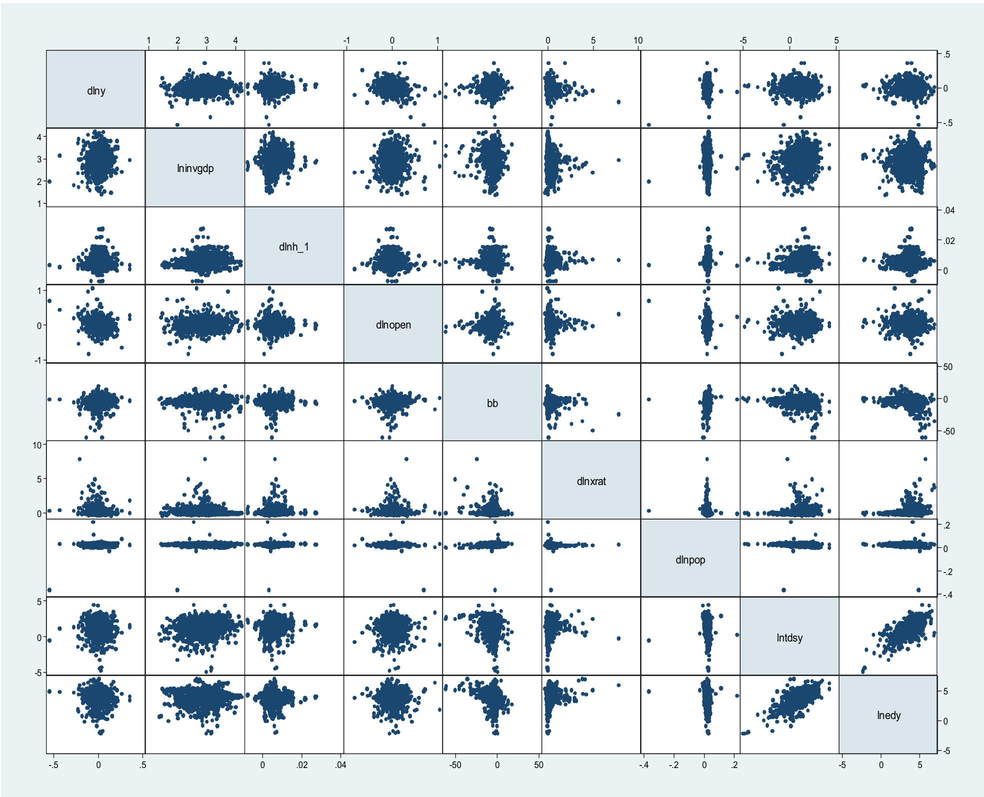
Figures in parentheses are the number of countries in each category
Information downloaded from the Word Bank website: http://go.worldbank.org/85B908KVE0

6.2 IDENTIFYING OUTLIERS, LEVERAGES AND INFLUENTIAL OBSERVATIONS

There are various methods for identifying unusual observations in the dataset due to some measurement or typing error. These are explained below.

6.1.1 GRAPHICAL METHOD

Graph each x variable with y to see if there is any observation(s) that lies far away from the main cluster of the observations.



6.1.2 PREDICT STANDARDIZED AND STUDENTIZED RESIDUALS

Standardized residuals are computed by dividing the residuals by its standard deviation. Standardized residuals in excess of 3.5 and –3.5 are considered as outliers. An alternative is studentized residuals that are defined as:

$$\varepsilon_t^s = \frac{\varepsilon_t}{\sqrt{\sigma_{(t)}^2(1-h)}}$$

where σ_t^2 is variance of residuals with t[th] observation deleted, h is leverage statistics. studentized residuals greater than +/- 2 is worrisome and requires further attention. Leverage is measured by the diagonal components of the hat matrix, which comes from the formula for the regression of y, $\hat{Y} = X\beta = X(X'X)^{-1}X'Y$. The hat matrix is $X'(X'X)^{-1}X$ which we denote by H, so that $\hat{Y} = HY$. The H matrix transforms Y into predicted Y and the diagonals of the matrix indicate the values that are outliers. Hence the diagonals measure the leverage. Leverage is bounded by two values: 1/n and 1. The closer the leverage is to one the more leverage the value has. Different rules of thumbs have been proposed for the cut off value of leverage. According to Belsley et al (1980)[1] leverage > 2k/n is high and Velleman and Welsch (1981)[2] suggest that 3k/n should be used for small samples and often researcher would use 2k+2/n as the cut off point.

The following table lists the countries and the period for which the absolute values of standardized residuals are greater than 3.5 cut off value.

TABLE A2
Standardized Residuals

Country	Period	Standardized Residuals
Haiti	1995	6.43
Jordan	1976	3.73
Sierra Leone	1999	3.84
Uganda	1981	7.05

[1] Belsley, D. A., Kuh, E. and Welsch R. E. (1998) Regression Diagnostics, New York: John Wiley
[2] Welleman, P. E. and Welsch, R. E. (1981) Efficient Computing of Regression Diagnostics, American Statistics, col. 35, pp 234-42.

The following table lists the countries and the period for which the absolute value of studentized residuals is greater than 2 cut off value.

TABLE A3
Studentized Residuals

Country	Period	Studentized Residuals	Country	Period	Studentized Residuals
Algeria	1972	3.31	Kenya	1971	2.86
Argentina	1993	2.23	Malawi	1971	2.66
Bangladesh	1974	2.38	Malawi	1995	3.51
Ecuador	1973	2.87	Mauritius	1976	2.68
Ethiopia	1993	3.00	Mozambique	1971	2.03
Ghana	1978	2.51	Mozambique	1987	2.14
Guyana	1976	2.16	Nicaragua	1990	2.06
Guyana	1991	3.30	Panama	1980	2.64
Guyana	1994	2.18	Rwanda	1976	2.69
Guyana	1997	2.97	Rwanda	1995	3.40
Haiti	1991	2.27	Rwanda	1996	2.03
Haiti	1994	3.11	Senegal	1982	2.60
Haiti	1995	6.51	Sierra Leone	1987	2.06
Haiti	1996	2.81	Sierra Leone	1999	3.85
Haiti	1997	2.09	Tanzania	1987	2.40
Haiti	1998	2.33	Trinidad &Tobago	1972	2.45
Iran	1982	2.44	Trinidad &Tobago	1991	2.60
Jamaica	1972	2.22	Uganda	1981	7.15
Jordan	1976	3.75	Uruguay	1986	2.11
Jordan	1978	2.80			

6.1.3 COOK'S D AND DFITS

Both of these measures look at the overall influence of outliers and are very similar except that they scale differently. Cook's D statistics can be measured as:

$$D_t = \left(\frac{1}{k}\right)\left(\frac{h_t}{1-h_t}\right)\left(\frac{\varepsilon_t^2}{s^2(1-h_t)}\right)$$

where k is number of parameters in the model, h is the leverage value, r is residuals and S is the standard deviation of residuals.

The lowest value that Cook's D can assume is zero and the higher the D statistics is the more influential the point. The cutoff point of Cook's D is $4/n$ or $4/(n-k-1)$ suggested by Belsley. We can graph the cook's d against standardized residuals to identify the outliers.

DFITS also uses information on residuals and leverage. The cut-off point for DFITs is $2(k/n)^{1/2}$. DFITS can take on positive and negative values - observations that have DFITS close to zero indicate that these observations are not influential.

The following table list the country and the period for which the Cook's D statistics detects an outlier, i.e. the observations for which the Cook's D statistics is greater than the cut-off point of 4/n. With n= 1792, 4/n = 0.0022.

TABLE A4
Cook's D Statistics

Country	Period	D stats	Country	Period	D stats	Country	Period	D stats
Algeria	1972	0.0037	Haiti	1996	0.0030	Panama	1988	0.0144
Argentina	1982	0.0042	Indonesia	1998	0.0041	Peru	1988	0.0036
Argentina	1989	0.0046	Iran	1975	0.0027	Peru	1989	0.0129
Argentina	1993	0.0026	Iran	1977	0.0031	Rwanda	1976	0.0050
Bangladesh	1971	0.0075	Iran	1980	0.0190	Rwanda	1994	9.2695
Bangladesh	1972	0.0070	Iran	1981	0.0033	Rwanda	1995	0.0331
Bangladesh	1973	0.0029	Iran	1982	0.0031	Rwanda	1996	0.0028
Bangladesh	1974	0.0050	Iran	1986	0.0060	Rwanda	1997	0.0607
Bolivia	1984	0.0067	Iran	1993	0.0068	Sierra Leone	1978	0.0050
Bolivia	1985	0.0257	Jordan	1976	0.0111	Sierra Leone	1986	0.0084
Brazil	1993	0.0058	Jordan	1978	0.0047	Sierra Leone	1987	0.0049
Brazil	1994	0.0053	Jordan	1989	0.0073	Sierra Leone	1990	0.0057
Chile	1975	0.0165	Jordan	1991	0.0118	Sierra Leone	1995	0.0031
Chile	1982	0.0028	Kenya	1971	0.0037	Sierra Leone	1998	0.0337
China	1978	0.0040	Malawi	1971	0.0073	Sierra Leone	1999	0.0275
China	1979	0.0038	Malawi	1994	0.0075	Tanzania	1987	0.0034
China	1984	0.0030	Malawi	1995	0.0121	Tanzania	1988	0.0605
Cote d`Ivoire	1980	0.0084	Mali	1975	0.0030	Tanzania	1992	0.0050
Ecuador	1973	0.0027	Mali	1976	0.0029	Tanzania	1997	0.0052
Ethiopia	1985	0.0035	Mauritius	1976	0.0035	Trin. & Tob.	1972	0.0035
Ethiopia	1992	0.0044	Mozambique	1971	0.0057	Trin. & Tob.	1985	0.0035
Ethiopia	1993	0.0148	Mozambique	1974	0.0084	Trin. & Tob.	1991	0.0076
Ghana	1971	0.0024	Mozambique	1975	0.0066	Trin. & Tob.	1992	0.0053
Ghana	1978	0.0032	Mozambique	1976	0.0126	Trin. & Tob.	1997	0.0103
Ghana	1983	0.0029	Mozambique	1983	0.0047	Trin. & Tob.	1999	0.0027
Guyana	1976	0.0062	Mozambique	1984	0.0041	Uganda	1979	0.0208
Guyana	1982	0.0184	Mozambique	1987	0.0063	Uganda	1981	0.0873
Guyana	1985	0.0046	Nicaragua	1979	0.0168	Uruguay	1986	0.0026
Guyana	1986	0.0177	Nicaragua	1983	0.0024	Venezuela	1971	0.0026
Guyana	1989	0.0062	Nicaragua	1988	0.0260	Venezuela	1980	0.0025
Guyana	1991	0.0140	Nicaragua	1990	0.0272	Venezuela	1989	0.0030
Guyana	1994	0.0038	Nigeria	1975	0.0229	Zambia	1973	0.0026
Guyana	1997	0.0042	Nigeria	1976	0.0039	Zambia	1975	0.0027
Haiti	1991	0.0026	Nigeria	1981	0.0122	Zambia	1991	0.0074
Haiti	1992	0.0355	Nigeria	1999	0.0066	Zimbabwe	1973	0.0028
Haiti	1994	0.0163	Nigeria	2000	0.0148	Zimbabwe	1977	0.0034
Haiti	1995	0.0146	Panama	1980	0.0038			

6.1.4 DFBETA

We can use DFBETAS to ascertain the magnitude of influence that an observation has on a particular parameter estimates if that observation is deleted. The formula for DFBETA is

$$dfbeta = \frac{b_j - b_{(i)j} e_j}{\sqrt{\sum e_j^2 \left(1 - h_j\right)}}$$

where b_j is the coefficient estimates of variable j and e is the residuals of regression of y on the remaining observations.

DFBETA measures the influence of how each coefficient is changed by deleting the observation. The cutoff point for dfbeta is $\frac{1}{2}\sqrt{n}$.

The following table lists the observations that are considered outliers according to dfbeta method.

TABLE A5
Potential Outliers detected by Dfbeta

Country	Period	dfbeta	Country	Period	dfbeta	Country	Period	dfbeta
Algeria	1972	0.19	Haiti	1996	0.17	Panama	1988	-0.38
Argentina	1982	-0.20	Indonesia	1998	-0.20	Peru	1983	-0.15
Argentina	1989	-0.21	Iran	1975	-0.17	Peru	1988	-0.19
Argentina	1992	0.15	Iran	1977	-0.18	Peru	1989	-0.36
Argentina	1993	0.16	Iran	1980	-0.44	Rwanda	1976	0.22
Bangladesh	1971	-0.27	Iran	1981	-0.18	Rwanda	1994	-9.87
Bangladesh	1972	-0.27	Iran	1982	0.18	Rwanda	1995	0.58
Bangladesh	1973	-0.17	Iran	1986	-0.24	Rwanda	1996	0.17
Bangladesh	1974	0.22	Iran	1993	0.26	Rwanda	1997	-0.78
Bolivia	1984	0.26	Jamaica	1972	0.15	Sierra Leone	1978	-0.23
Bolivia	1985	0.51	Jordan	1976	0.33	Sierra Leone	1986	0.29
Brazil	1993	0.24	Jordan	1978	0.22	Sierra Leone	1987	0.22
Brazil	1994	0.23	Jordan	1989	-0.27	Sierra Leone	1990	0.24
Chile	1975	-0.41	Jordan	1991	-0.34	Sierra Leone	1995	-0.18
Chile	1982	-0.17	Kenya	1971	0.19	Sierra Leone	1998	-0.58
China	1978	-0.20	Malawi	1971	0.27	Sierra Leone	1999	0.53
China	1979	0.20	Malawi	1994	-0.27	Tanzania	1987	0.18
China	1984	0.17	Malawi	1995	0.35	Tanzania	1988	-0.79
Cote d`Ivoire	1980	-0.29	Mali	1975	0.17	Tanzania	1992	-0.22
Ecuador	1973	0.16	Mali	1976	0.17	Tanzania	1997	-0.23
Egypt	1974	-0.14	Mauritius	1976	0.19	Trinidad &Tobago	1972	0.19
Egypt	1976	0.15	Mozambique	1971	0.24	Trinidad &Tobago	1985	-0.19
Ethiopia	1985	-0.19	Mozambique	1973	0.14	Trinidad &Tobago	1991	0.28
Ethiopia	1991	-0.14	Mozambique	1974	-0.29	Trinidad &Tobago	1992	-0.23
Ethiopia	1992	-0.21	Mozambique	1975	-0.26	Trinidad &Tobago	1997	-0.32
Ethiopia	1993	0.39	Mozambique	1976	-0.36	Trinidad &Tobago	1998	0.15
Ghana	1971	0.16	Mozambique	1983	-0.22	Trinidad &Tobago	1999	0.16
Ghana	1978	0.18	Mozambique	1984	-0.20	Uganda	1979	-0.46
Ghana	1983	-0.17	Mozambique	1987	0.25	Uganda	1981	0.95
Guyana	1976	0.25	Mozambique	1995	-0.14	Uruguay	1986	0.16
Guyana	1982	-0.43	Nicaragua	1979	-0.41	Venezuela	1971	-0.16
Guyana	1985	0.22	Nicaragua	1983	0.16	Venezuela	1980	-0.16
Guyana	1986	0.42	Nicaragua	1988	-0.51	Venezuela	1989	-0.17
Guyana	1989	-0.25	Nicaragua	1990	0.52	Zambia	1973	-0.16
Guyana	1991	0.37	Nigeria	1975	-0.48	Zambia	1975	-0.17
Guyana	1994	0.20	Nigeria	1976	-0.20	Zambia	1991	0.27
Guyana	1997	0.21	Nigeria	1980	-0.15	Zimbabwe	1973	-0.17
Haiti	1991	0.16	Nigeria	1981	-0.35	Zimbabwe	1974	-0.14
Haiti	1992	-0.60	Nigeria	1999	-0.26	Zimbabwe	1977	-0.18
Haiti	1994	0.40	Nigeria	2000	-0.39			
Haiti	1995	0.39	Panama	1980	0.20			

6.3 UNIVARIATE UNIT ROOT TESTS

TABLE A6
Univariate Unit Root Tests For GDP per capita

	Levels Data					Differenced Data				
	ADF		Phillip & Perron		DFGLS	ADF		Phillip & Perron		DFGLS
Country	t-test	p-value	t-test	p-value	t-test	t-test	p-value	t-test	p-value	t-test
Algeria	-1.96	0.30	-2.10	0.24	-0.70	-3.69	0.00	-7.02	0.00	-3.63
Argentina	-2.12	0.24	-1.59	0.49	-2.16	-4.03	0.00	-3.94	0.00	-4.11
Bangladesh	0.80	0.99	0.71	0.99	0.63	-4.07	0.00	-5.41	0.00	-3.86
Bolivia	-2.19	0.21	-1.25	0.65	-2.08	-1.82	0.37	-2.47	0.12	-1.83
Brazil	-3.37	0.01	-4.31	0.00	-0.38	-2.67	0.08	-3.51	0.01	-2.23
Cameroon	-1.78	0.39	-1.55	0.51	-1.33	-3.20	0.02	-3.92	0.00	-3.26
Chile	0.30	0.98	0.52	0.99	0.23	-3.16	0.02	-4.41	0.00	-3.23
China	1.57	1.00	1.90	1.00	0.89	-2.57	0.10	-4.28	0.00	-2.56
Colombia	-1.97	0.30	-2.87	0.05	-0.36	-2.83	0.05	-2.82	0.06	-2.65
Costa Rica	-2.22	0.20	-1.83	0.37	-1.36	-3.80	0.00	-3.31	0.01	-3.53
Cote d'Ivoire	-0.35	0.92	-0.34	0.92	-0.52	-4.10	0.00	-4.99	0.00	-3.67
Dom. Republic	0.76	0.99	-0.60	0.87	1.56	-2.38	0.15	-3.60	0.01	-1.53
Ecuador	-3.52	0.01	-3.67	0.00	-1.24	-1.99	0.29	-3.23	0.02	-1.96
Egypt	-0.10	0.95	0.06	0.96	0.16	-4.17	0.00	-3.74	0.00	-4.20
El Salvador	-2.43	0.13	-1.22	0.67	-2.45	-3.07	0.03	-2.56	0.10	-3.13
Ethiopia	-2.02	0.28	-1.99	0.29	-2.01	-5.73	0.00	-4.94	0.00	-5.80
Ghana	-2.51	0.11	-2.38	0.15	-2.44	-3.73	0.00	-4.59	0.00	-2.10
Guatemala	-2.64	0.08	-2.63	0.09	-1.11	-2.36	0.15	-2.79	0.06	-2.33
Guyana	-0.93	0.78	-1.10	0.72	-0.93	-4.04	0.00	-5.79	0.00	-4.12
Haiti	-0.57	0.88	0.10	0.97	-0.77	-2.86	0.05	-3.53	0.01	-2.86
Honduras	-2.92	0.04	-2.57	0.10	-1.70	-5.13	0.00	-5.12	0.00	-5.23
India	2.15	1.00	2.59	1.00	0.94	-2.93	0.04	-4.72	0.00	-2.54
Indonesia	-1.78	0.39	-2.07	0.26	0.04	-3.35	0.01	-4.04	0.00	-3.37
Iran	-1.02	0.75	-1.19	0.68	-1.05	-3.76	0.00	-5.95	0.00	-2.55
Jamaica	-1.99	0.29	-2.31	0.17	-1.87	-3.09	0.03	-5.40	0.00	-1.81
Jordan	-2.02	0.28	-1.20	0.67	-1.54	-3.10	0.03	-4.85	0.00	-1.76
Kenya	-6.60	0.00	-2.57	0.10	-2.38	-5.17	0.00	-6.36	0.00	-3.27
Madagascar	-1.35	0.61	-0.59	0.87	-0.42	-4.30	0.00	-6.73	0.00	-1.86
Malawi	-2.20	0.21	-1.74	0.41	-0.87	-3.66	0.00	-9.60	0.00	-2.44
Malaysia	-0.82	0.81	-0.75	0.83	0.17	-3.53	0.01	-3.53	0.01	-3.53
Mali	-1.66	0.45	-1.78	0.39	-1.44	-3.68	0.00	-5.15	0.00	-3.39
Mauritius	0.07	0.96	0.08	0.96	0.77	-3.36	0.01	-5.44	0.00	-3.44
Mexico	-1.38	0.59	-1.67	0.45	-0.01	-2.53	0.11	-3.61	0.01	-2.42
Morocco	-1.87	0.35	-1.54	0.51	-0.05	-4.87	0.00	-10.91	0.00	-4.21
Mozambique	-1.18	0.68	-1.58	0.50	-0.76	-2.57	0.10	-4.55	0.00	-2.29
Nicaragua	-0.55	0.88	-0.38	0.91	-0.32	-3.54	0.01	-4.22	0.00	-3.51
Nigeria	-1.65	0.46	-1.56	0.51	-1.90	-3.86	0.00	-4.21	0.00	-2.99
Pakistan	-0.75	0.83	-0.95	0.77	0.44	-3.13	0.02	-5.32	0.00	-3.06
Panama	-1.60	0.49	-1.74	0.41	-0.67	-3.14	0.02	-3.94	0.00	-3.01
Paraguay	-1.99	0.29	-2.30	0.17	-0.99	-1.45	0.56	-2.72	0.07	-1.50
Peru	-2.38	0.15	-1.85	0.36	-2.43	-4.31	0.00	-3.87	0.00	-3.79
Rwanda	-1.97	0.30	-2.25	0.19	-1.91	-5.08	0.00	-6.22	0.00	-5.07
Senegal	-3.36	0.01	-3.47	0.01	-3.10	-6.16	0.00	-6.75	0.00	-5.02
Sierra Leone	-0.62	0.87	-0.55	0.88	-0.48	-4.46	0.00	-6.43	0.00	-3.58
South Africa	-2.39	0.14	-2.96	0.04	-1.13	-3.40	0.01	-3.68	0.00	-2.66
Sri Lanka	0.46	0.98	0.62	0.99	0.73	-3.10	0.03	-5.48	0.00	-3.00
Tanzania	-1.32	0.62	-1.82	0.37	-1.37	-4.87	0.00	-7.65	0.00	-4.81
Thailand	-0.35	0.92	-0.59	0.87	0.36	-3.30	0.01	-3.60	0.01	-3.21
Trin. & Tobago	-1.58	0.49	-1.46	0.55	-0.90	-4.40	0.00	-6.42	0.00	-4.14
Tunisia	-2.27	0.18	-2.60	0.09	0.20	-3.51	0.01	-4.28	0.00	-3.29
Turkey	-0.93	0.78	-0.89	0.79	0.24	-4.16	0.00	-5.56	0.00	-4.23
Uganda	-1.14	0.70	-0.85	0.80	-1.22	-4.66	0.00	-4.45	0.00	-4.69
Uruguay	-1.32	0.62	-0.83	0.81	-1.11	-3.68	0.00	-3.31	0.01	-3.73
Venezuela	-2.75	0.07	-1.71	0.43	-0.94	-3.64	0.01	-5.33	0.00	-2.97
Zambia	-0.32	0.92	-0.48	0.90	-0.04	-3.40	0.01	-5.56	0.00	-3.36
Zimbabwe	-2.71	0.07	-4.09	0.00	-1.00	-4.16	0.00	-5.67	0.00	-2.15

TABLE A7
Univariate Unit Root Tests for Investment-to-GDP

	Levels Data					Differenced Data				
	ADF		Phillip & Perron		DFGLS	ADF		Phillip & Perron		DFGLS
Country	t-test	p-value	t-test	p-value	t-test	t-test	p-value	t-test	p-value	t-test
Algeria	-0.97	0.77	-1.37	0.60	-0.96	-3.22	0.02	-4.18	0.00	-2.02
Argentina	-2.13	0.23	-1.76	0.40	-1.93	-4.95	0.00	-3.93	0.00	-5.01
Bangladesh	-2.38	0.15	-3.01	0.03	-1.88	-4.54	0.00	-7.03	0.00	-4.11
Bolivia	-1.81	0.38	-1.38	0.59	-1.88	-3.56	0.01	-4.06	0.00	-3.47
Brazil	-0.90	0.79	-1.09	0.72	-0.76	-3.07	0.03	-4.55	0.00	-2.47
Cameroon	-1.54	0.51	-2.00	0.29	-1.19	-3.33	0.01	-4.14	0.00	-2.16
Chile	-1.99	0.29	-1.68	0.44	-1.90	-4.71	0.00	-4.43	0.00	-4.78
China	-1.38	0.59	-2.35	0.16	-0.33	-3.98	0.00	-5.54	0.00	-2.32
Colombia	-3.29	0.02	-2.07	0.25	-3.32	-2.99	0.04	-4.36	0.00	-2.70
Costa Rica	-2.88	0.05	-2.63	0.09	-2.42	-4.40	0.00	-4.52	0.00	-4.03
Cote d'Ivoire	-1.08	0.72	-0.75	0.83	-1.07	-2.68	0.08	-3.50	0.01	-2.52
Dom. Republic	-2.97	0.04	-3.16	0.02	-1.89	-5.24	0.00	-6.36	0.00	-5.17
Ecuador	-0.97	0.76	-1.21	0.67	-0.80	-4.68	0.00	-6.36	0.00	-4.71
Egypt	-1.78	0.39	-1.36	0.60	-1.53	-3.01	0.03	-4.16	0.00	-2.61
El Salvador	-1.73	0.42	-1.80	0.38	-1.10	-3.22	0.02	-4.79	0.00	-3.07
Ethiopia	-1.36	0.60	-1.60	0.48	-1.41	-3.03	0.03	-6.40	0.00	-2.77
Ghana	-1.68	0.44	-2.01	0.28	-1.71	-4.81	0.00	-6.53	0.00	-4.53
Guatemala	-2.14	0.23	-1.78	0.39	-2.07	-3.77	0.00	-4.08	0.00	-3.54
Guyana	-3.32	0.01	-3.60	0.01	-3.32	-5.47	0.00	-6.78	0.00	-5.55
Haiti	-2.22	0.20	-3.11	0.03	-1.15	-2.89	0.05	-5.78	0.00	-1.75
Honduras	-1.42	0.57	-1.06	0.73	-1.59	-4.85	0.00	-3.87	0.00	-4.87
India	-1.20	0.67	-0.99	0.76	-0.67	-6.42	0.00	-5.63	0.00	-5.75
Indonesia	-2.43	0.13	-3.54	0.01	-0.73	-4.29	0.00	-3.82	0.00	-3.02
Iran	-2.45	0.13	-1.91	0.33	-2.27	-3.43	0.01	-4.04	0.00	-3.43
Jamaica	-1.69	0.43	-1.64	0.46	-1.37	-3.59	0.01	-5.03	0.00	-3.66
Jordan	-2.57	0.10	-1.85	0.36	-2.37	-3.53	0.01	-4.84	0.00	-2.62
Kenya	-2.46	0.13	-1.39	0.59	-1.58	-6.30	0.00	-6.42	0.00	-2.91
Madagascar	-3.14	0.02	-3.86	0.00	-2.99	-4.80	0.00	-7.24	0.00	-4.60
Malawi	-0.30	0.93	-0.33	0.92	-0.20	-5.04	0.00	-9.73	0.00	-3.09
Malaysia	-2.10	0.24	-2.40	0.14	-1.32	-3.03	0.03	-4.08	0.00	-2.54
Mali	-2.48	0.12	-3.17	0.02	-1.76	-4.55	0.00	-6.51	0.00	-3.42
Mauritius	-2.58	0.10	-2.46	0.13	-2.44	-3.07	0.03	-7.10	0.00	-1.91
Mexico	-2.63	0.09	-2.32	0.16	-2.65	-4.31	0.00	-4.74	0.00	-4.39
Morocco	-2.47	0.12	-2.67	0.08	-2.34	-3.93	0.00	-5.67	0.00	-3.39
Mozambique	-1.29	0.63	-1.15	0.69	-1.35	-4.77	0.00	-5.13	0.00	-4.35
Nicaragua	-3.34	0.01	-2.98	0.04	-3.41	-6.63	0.00	-5.54	0.00	-6.68
Nigeria	-1.95	0.31	-2.02	0.28	-1.61	-3.13	0.02	-3.98	0.00	-2.29
Pakistan	-0.79	0.82	-0.37	0.92	-0.68	-4.03	0.00	-4.85	0.00	-3.77
Panama	-2.43	0.13	-1.76	0.40	-2.47	-4.42	0.00	-3.96	0.00	-4.36
Paraguay	-2.81	0.06	-2.05	0.27	-1.89	-3.49	0.01	-3.89	0.00	-3.35
Peru	-2.85	0.05	-2.07	0.26	-2.73	-3.29	0.02	-4.76	0.00	-2.50
Rwanda	-3.27	0.02	-3.03	0.03	-1.28	-3.50	0.01	-6.46	0.00	-3.59
Senegal	-1.94	0.32	-2.40	0.14	-1.23	-4.29	0.00	-4.81	0.00	-2.80
Sierra Leone	-3.37	0.01	-3.15	0.02	-1.98	-4.00	0.00	-7.26	0.00	-3.37
South Africa	-1.53	0.52	-1.25	0.65	-1.59	-3.78	0.00	-3.99	0.00	-3.35
Sri Lanka	-1.45	0.56	-1.40	0.58	-0.92	-2.64	0.08	-5.47	0.00	-2.64
Tanzania	-3.24	0.02	-4.00	0.00	-2.64	-7.50	0.00	-7.23	0.00	-3.61
Thailand	-2.56	0.10	-1.25	0.65	-2.61	-3.58	0.01	-3.39	0.01	-3.54
Trin. & Tobago	-2.10	0.24	-2.64	0.08	-1.40	-4.38	0.00	-5.69	0.00	-2.87
Tunisia	-2.42	0.14	-1.65	0.46	-2.44	-3.44	0.01	-3.38	0.01	-3.44
Turkey	-1.61	0.48	-1.92	0.32	-1.39	-3.28	0.02	-6.20	0.00	-3.14
Uganda	-2.17	0.22	-3.50	0.01	-2.03	-5.36	0.00	-8.55	0.00	-4.05
Uruguay	-3.16	0.02	-1.92	0.32	-3.21	-3.59	0.01	-3.08	0.03	-3.61
Venezuela	-1.84	0.36	-1.64	0.46	-1.90	-4.85	0.00	-4.86	0.00	-4.71
Zambia	-1.86	0.35	-1.21	0.67	-1.02	-3.23	0.02	-6.90	0.00	-1.88
Zimbabwe	-1.61	0.48	-1.27	0.64	-1.65	-3.09	0.03	-3.81	0.00	-3.17

TABLE A8
Univariate Unit Root Tests for Human Capital Index

	Levels Data					Differenced Data				
	ADF		Phillip & Perron		DFGLS	ADF		Phillip & Perron		DFGLS
Country	t-test	p-value	t-test	p-value	t-test	t-test	p-value	t-test	p-value	t-test
Algeria	-1.47	0.55	0.73	0.99	-1.79	-1.61	0.48	-2.92	0.04	-0.89
Argentina	0.08	0.96	-0.28	0.93	0.47	-2.71	0.07	-2.99	0.04	-2.54
Bangladesh	0.09	0.97	1.62	1.00	-0.55	-1.67	0.44	-2.66	0.08	-1.18
Bolivia	-0.99	0.76	1.00	0.99	-1.33	-1.52	0.53	-2.01	0.28	-1.09
Brazil	-0.36	0.92	1.52	1.00	-0.64	-1.82	0.37	-1.40	0.58	-1.74
Cameroon	-3.96	0.00	-2.40	0.14	-2.11	-0.30	0.93	-1.66	0.45	-0.83
Chile	-0.77	0.83	-1.65	0.46	0.21	-2.15	0.23	-2.55	0.10	-2.09
China	-1.16	0.69	-1.58	0.50	-0.30	-2.22	0.20	-2.13	0.23	-2.28
Colombia	-1.79	0.39	-1.36	0.60	-0.43	-2.71	0.07	-2.84	0.05	-2.79
Costa Rica	-3.41	0.01	-2.29	0.18	-0.67	-2.69	0.08	-3.35	0.01	-2.68
Cote d'Ivoire	-4.71	0.00	-1.51	0.53	-1.61	-0.84	0.81	-4.09	0.00	-1.06
Dom. Republic	3.30	1.00	1.31	1.00	1.68	-1.67	0.44	-4.80	0.00	-1.54
Ecuador	-2.87	0.05	-3.13	0.02	-0.86	-1.69	0.43	-1.80	0.38	-1.78
Egypt	-0.61	0.87	1.26	1.00	-1.14	-1.83	0.37	-2.44	0.13	-1.16
El Salvador	-0.65	0.86	-0.53	0.89	-0.40	-1.67	0.45	-1.69	0.43	-1.70
Ethiopia	0.28	0.98	3.90	1.00	-1.30	-1.48	0.54	-2.21	0.20	-0.71
Ghana	-6.17	0.00	-3.76	0.00	2.95	-1.77	0.40	-19.04	0.00	0.44
Guatemala	-1.60	0.48	-0.52	0.89	-0.92	-2.43	0.13	-2.79	0.06	-1.80
Guyana	-2.92	0.04	-1.03	0.74	-1.14	-1.83	0.36	-4.57	0.00	-1.34
Haiti	-1.69	0.44	-1.55	0.51	-1.10	-1.23	0.66	-1.28	0.64	-1.26
Honduras	-0.77	0.83	-1.17	0.69	-0.05	-2.23	0.19	-2.27	0.18	-2.24
India	1.72	1.00	4.50	1.00	0.49	-0.83	0.81	-0.86	0.80	-0.74
Indonesia	1.47	1.00	0.89	0.99	0.87	-2.38	0.15	-3.46	0.01	-2.31
Iran	2.86	1.00	5.35	1.00	-1.48	-1.74	0.41	-4.66	0.00	-0.43
Jamaica	-10.56	0.00	-10.10	0.00	-1.24	-1.56	0.50	-1.06	0.73	-1.94
Jordan	-1.44	0.56	-4.26	0.00	-0.42	-0.38	0.91	-1.00	0.75	-0.12
Kenya	-1.04	0.74	-1.31	0.63	-0.21	-2.37	0.15	-2.31	0.17	-2.42
Madagascar	-0.21	0.94	2.10	1.00	-1.53	-1.61	0.48	-3.79	0.00	-0.66
Malawi	0.77	0.99	2.23	1.00	-0.02	-1.51	0.53	-2.97	0.04	-1.05
Malaysia	-2.59	0.10	-3.26	0.02	-1.35	-0.74	0.84	-0.96	0.77	-0.94
Mali	-3.16	0.02	-2.25	0.19	-0.49	-1.74	0.41	-3.25	0.02	-1.45
Mauritius	-1.27	0.64	-2.61	0.09	-0.04	-1.81	0.38	-2.13	0.23	-1.73
Mexico	-0.78	0.83	-0.72	0.84	-0.35	-2.04	0.27	-2.05	0.27	-2.08
Morocco	1.30	1.00	8.43	1.00	-1.14	-1.06	0.73	-1.64	0.46	-0.29
Mozambique	-0.60	0.87	0.72	0.99	-0.74	-1.60	0.48	-1.62	0.47	-1.47
Nicaragua	3.38	1.00	6.26	1.00	-1.14	-1.86	0.35	-4.14	0.00	0.10
Nigeria	0.21	0.97	4.27	1.00	-0.83	-1.35	0.61	-1.23	0.66	-0.97
Pakistan	-1.10	0.72	-0.67	0.86	-0.84	-2.15	0.23	-2.20	0.21	-2.19
Panama	-1.89	0.34	-1.69	0.43	-0.80	-2.14	0.23	-2.18	0.21	-2.09
Paraguay	-1.03	0.74	-1.25	0.65	-0.34	-2.33	0.16	-2.21	0.20	-2.37
Peru	-0.50	0.89	-0.97	0.76	0.16	-2.41	0.14	-2.70	0.07	-2.29
Rwanda	-1.98	0.29	-1.93	0.32	-0.53	-1.98	0.30	-2.48	0.12	-2.10
Senegal	-1.87	0.35	-1.19	0.68	-0.46	-2.49	0.12	-3.13	0.02	-2.49
Sierra Leone	-3.94	0.00	-3.11	0.03	-0.78	-2.35	0.16	-2.99	0.04	-2.49
South Africa	0.29	0.98	1.49	1.00	0.03	-2.16	0.22	-2.13	0.23	-2.21
Sri Lanka	0.10	0.97	-0.24	0.93	0.52	-2.42	0.14	-2.77	0.06	-2.41
Tanzania	-0.48	0.89	1.59	1.00	-0.94	-1.86	0.35	-2.08	0.25	-1.11
Thailand	-0.92	0.78	0.76	0.99	-1.06	-1.66	0.45	-1.52	0.52	-1.45
Trin. & Tobago	-1.94	0.31	-2.33	0.16	-0.65	-2.02	0.28	-2.02	0.28	-2.06
Tunisia	-1.56	0.50	-2.09	0.25	-0.44	-1.76	0.40	-1.86	0.35	-1.85
Turkey	-0.38	0.91	0.54	0.99	-0.60	-1.98	0.30	-2.05	0.26	-1.96
Uganda	-0.24	0.93	0.68	0.99	-0.31	-2.15	0.22	-2.08	0.25	-2.17
Uruguay	-0.98	0.76	-1.71	0.43	0.02	-2.47	0.12	-2.35	0.16	-2.40
Venezuela	-1.62	0.47	-1.39	0.58	-0.96	-2.10	0.24	-2.14	0.23	-2.10
Zambia	-1.06	0.73	-0.48	0.90	-0.60	-2.17	0.22	-2.29	0.18	-2.17
Zimbabwe	-0.86	0.80	0.32	0.98	-0.82	-1.76	0.40	-1.77	0.40	-1.70

TABLE A9
Univariate Unit Root Tests for Openness

	Levels Data					Differenced Data				
	ADF		Phillip & Perron		DFGLS	ADF		Phillip & Perron		DFGLS
Country	t-test	p-value	t-test	p-value	t-test	t-test	p-value	t-test	p-value	t-test
Algeria	-1.12	0.71	-1.01	0.75	-0.98	-4.96	0.00	-4.61	0.00	-5.04
Argentina	-0.34	0.92	0.22	0.97	-0.37	-3.35	0.01	-4.22	0.00	-2.34
Bangladesh	0.28	0.98	-0.08	0.95	0.26	-4.01	0.00	-8.03	0.00	-4.08
Bolivia	-0.93	0.78	-1.13	0.70	-1.05	-3.74	0.00	-6.16	0.00	-2.86
Brazil	-0.01	0.96	0.01	0.96	0.17	-2.79	0.06	-4.17	0.00	-2.61
Cameroon	-1.65	0.46	-1.78	0.39	-1.42	-4.94	0.00	-5.38	0.00	-4.75
Chile	-0.45	0.90	-0.20	0.94	-0.14	-3.87	0.00	-4.47	0.00	-3.61
China	-0.62	0.87	-0.34	0.92	0.04	-5.06	0.00	-4.75	0.00	-4.71
Colombia	-0.35	0.92	-0.17	0.94	-0.39	-2.16	0.22	-4.00	0.00	-2.16
Costa Rica	0.54	0.99	0.54	0.99	0.47	-3.15	0.02	-4.25	0.00	-2.74
Cote d'Ivoire	-1.67	0.45	-2.24	0.19	-1.58	-5.34	0.00	-6.98	0.00	-4.65
Dom. Republic	-4.43	0.00	-3.72	0.00	-4.20	-5.38	0.00	-5.48	0.00	-5.47
Ecuador	-2.26	0.19	-1.83	0.37	-1.65	-2.68	0.08	-4.41	0.00	-2.76
Egypt	-1.31	0.63	-1.10	0.72	-1.36	-3.86	0.00	-4.05	0.00	-3.74
El Salvador	0.51	0.99	0.59	0.99	0.21	-3.17	0.02	-5.33	0.00	-3.08
Ethiopia	-1.31	0.62	-1.70	0.43	-1.07	-4.10	0.00	-7.04	0.00	-4.18
Ghana	-2.27	0.18	-2.22	0.20	-1.35	-3.88	0.00	-3.60	0.01	-3.46
Guatemala	-1.25	0.65	-1.27	0.64	-1.17	-2.98	0.04	-5.09	0.00	-3.03
Guyana	-2.27	0.18	-2.35	0.16	-1.71	-4.70	0.00	-5.92	0.00	-4.78
Haiti	-2.47	0.12	-3.10	0.03	-1.15	-4.44	0.00	-9.19	0.00	-3.60
Honduras	-2.62	0.09	-1.93	0.32	-2.17	-5.72	0.00	-4.49	0.00	-4.59
India	-1.01	0.75	-0.67	0.85	-0.40	-3.27	0.02	-5.52	0.00	-2.90
Indonesia	-1.96	0.30	-2.29	0.17	-1.57	-2.76	0.06	-6.13	0.00	-2.30
Iran	-0.73	0.84	-0.45	0.90	-0.75	-3.21	0.02	-4.19	0.00	-3.27
Jamaica	-1.07	0.73	-1.15	0.69	-1.18	-3.82	0.00	-5.51	0.00	-3.00
Jordan	-2.38	0.15	-1.69	0.43	-1.15	-3.25	0.02	-4.77	0.00	-2.74
Kenya	-2.98	0.04	-1.92	0.33	-1.74	-4.35	0.00	-5.76	0.00	-2.84
Madagascar	-1.99	0.29	-2.24	0.19	-1.24	-3.63	0.01	-5.23	0.00	-3.46
Malawi	-2.13	0.23	-1.79	0.39	-1.04	-5.08	0.00	-9.89	0.00	-3.95
Malaysia	0.48	0.98	0.50	0.98	0.59	-4.38	0.00	-4.81	0.00	-4.39
Mali	-1.40	0.58	-0.87	0.80	-0.86	-4.49	0.00	-6.47	0.00	-2.62
Mauritius	-1.83	0.37	-1.37	0.59	-1.86	-3.21	0.02	-3.66	0.00	-3.26
Mexico	0.96	0.99	1.61	1.00	0.57	-3.40	0.01	-3.73	0.00	-3.29
Morocco	-1.44	0.56	-2.05	0.26	-1.43	-4.70	0.00	-7.29	0.00	-4.42
Mozambique	-3.78	0.00	-2.99	0.04	-3.25	-4.24	0.00	-7.57	0.00	-2.24
Nicaragua	0.04	0.96	-0.07	0.95	-0.01	-4.14	0.00	-5.41	0.00	-4.19
Nigeria	-1.47	0.55	-1.41	0.58	-1.31	-1.94	0.32	-3.89	0.00	-1.93
Pakistan	-4.32	0.00	-1.96	0.30	-2.58	-5.87	0.00	-5.03	0.00	-3.32
Panama	-1.74	0.41	-1.78	0.39	-1.40	-5.13	0.00	-5.70	0.00	-5.23
Paraguay	-1.32	0.62	-1.33	0.61	-1.09	-2.73	0.07	-5.29	0.00	-2.76
Peru	-0.96	0.77	-1.59	0.49	-1.05	-3.40	0.01	-5.72	0.00	-1.96
Rwanda	-1.97	0.30	-2.58	0.10	-1.00	-5.92	0.00	-8.21	0.00	-5.02
Senegal	-1.21	0.67	-1.75	0.41	-0.94	-5.34	0.00	-9.67	0.00	-4.82
Sierra Leone	-1.89	0.33	-1.87	0.35	-1.45	-3.96	0.00	-4.68	0.00	-3.98
South Africa	-1.56	0.50	-1.26	0.65	-1.26	-3.43	0.01	-3.81	0.00	-3.32
Sri Lanka	-0.31	0.92	-0.38	0.91	-0.60	-3.53	0.01	-5.39	0.00	-3.28
Tanzania	-1.81	0.37	-1.87	0.35	-1.68	-5.11	0.00	-6.43	0.00	-4.25
Thailand	0.30	0.98	0.64	0.99	0.18	-4.07	0.00	-4.05	0.00	-3.61
Trin. & Tobago	-1.93	0.32	-2.16	0.22	-1.64	-5.95	0.00	-6.00	0.00	-5.83
Tunisia	-2.44	0.13	-2.63	0.09	-1.28	-3.32	0.01	-5.80	0.00	-3.04
Turkey	-0.25	0.93	-0.28	0.93	0.21	-3.92	0.00	-4.25	0.00	-3.83
Uganda	-1.28	0.64	-0.90	0.79	-0.98	-2.57	0.10	-3.21	0.02	-2.60
Uruguay	-0.06	0.95	-0.59	0.87	0.84	-3.79	0.00	-6.13	0.00	-2.63
Venezuela	-1.47	0.55	-1.79	0.39	-1.04	-4.66	0.00	-7.79	0.00	-4.67
Zambia	-2.07	0.26	-1.88	0.34	-0.73	-4.32	0.00	-6.39	0.00	-4.27
Zimbabwe	-1.39	0.59	-1.43	0.57	-1.20	-3.44	0.01	-4.29	0.00	-2.99

TABLE A10
Univariate Unit Root Tests for Budget Deficit

	Levels Data					Differenced Data				
	ADF		Phillip & Perron		DFGLS	ADF		Phillip & Perron		DFGLS
Country	t-test	p-value	t-test	p-value	t-test	t-test	p-value	t-test	p-value	t-test
Algeria	-2.67	0.08	-1.96	0.30	-2.41	-4.68	0.00	-6.54	0.00	-2.15
Argentina	-1.55	0.51	-1.87	0.35	-1.50	-2.86	0.05	-6.86	0.00	-2.91
Bangladesh	-3.88	0.00	-4.98	0.00	-3.84	-7.96	0.00	-8.93	0.00	-7.67
Bolivia	-2.32	0.17	-2.54	0.11	-2.35	-4.36	0.00	-6.00	0.00	-4.17
Brazil	-2.11	0.24	-1.94	0.32	-2.15	-3.96	0.00	-4.66	0.00	-4.02
Cameroon	-1.92	0.32	-2.58	0.10	-1.86	-5.72	0.00	-7.65	0.00	-5.55
Chile	-2.77	0.06	-2.42	0.14	-2.84	-4.48	0.00	-4.85	0.00	-2.79
China	-5.32	0.00	-3.76	0.00	-4.89	-8.45	0.00	-5.64	0.00	-2.70
Colombia	-2.84	0.05	-2.24	0.19	-2.71	-4.23	0.00	-4.13	0.00	-4.27
Costa Rica	-2.15	0.23	-3.02	0.03	-1.97	-7.93	0.00	-7.05	0.00	-4.11
Cote d’Ivoire	-8.29	0.00	-4.83	0.00	-1.91	-2.91	0.04	-2.11	0.24	-2.87
Dom. Republic	-2.73	0.07	-4.39	0.00	-1.33	-5.80	0.00	-9.30	0.00	-3.16
Ecuador	-4.83	0.00	-3.04	0.03	-1.98	-4.50	0.00	-3.86	0.00	-4.34
Egypt	-2.60	0.09	-2.48	0.12	-2.65	-5.45	0.00	-5.23	0.00	-5.55
El Salvador	-2.19	0.21	-3.19	0.02	-2.05	-3.99	0.00	-7.63	0.00	-2.37
Ethiopia	-3.03	0.03	-3.59	0.01	-2.68	-4.87	0.00	-7.08	0.00	-4.87
Ghana	-1.92	0.32	-2.19	0.21	-1.95	-5.01	0.00	-6.10	0.00	-4.50
Guatemala	-2.01	0.28	-2.33	0.16	-1.91	-5.17	0.00	-6.09	0.00	-4.84
Guyana	-1.65	0.45	-2.17	0.22	-1.63	-5.08	0.00	-7.52	0.00	-5.15
Haiti	-2.63	0.09	-2.24	0.19	-2.67	-3.29	0.02	-4.77	0.00	-2.76
Honduras	-3.20	0.02	-2.63	0.09	-2.75	-5.53	0.00	-5.27	0.00	-4.76
India	-1.39	0.59	-1.22	0.66	-1.17	-5.74	0.00	-6.79	0.00	-3.65
Indonesia	-4.66	0.00	-3.77	0.00	-1.18	-4.22	0.00	-5.43	0.00	-4.30
Iran	-9.53	0.00	-3.74	0.00	-2.07	-4.34	0.00	-7.75	0.00	-3.61
Jamaica	-2.58	0.10	-2.03	0.27	-1.01	-5.26	0.00	-7.89	0.00	-4.30
Jordan	-3.22	0.02	-4.44	0.00	-2.08	-5.65	0.00	-10.32	0.00	-5.72
Kenya	-1.57	0.50	-1.83	0.37	-1.39	-4.56	0.00	-6.78	0.00	-4.64
Madagascar	-1.87	0.34	-2.83	0.05	-1.71	-6.16	0.00	-8.39	0.00	-5.48
Malawi	-2.61	0.09	-3.82	0.00	-2.53	-4.62	0.00	-8.48	0.00	-4.69
Malaysia	-1.61	0.48	-1.79	0.39	-1.35	-9.82	0.00	-6.73	0.00	-8.86
Mali	-2.27	0.18	-5.58	0.00	0.13	-4.81	0.00	-8.93	0.00	-0.90
Mauritius	-2.39	0.14	-2.94	0.04	-2.06	-5.54	0.00	-6.14	0.00	-3.09
Mexico	-2.40	0.14	-2.05	0.27	-1.58	-4.57	0.00	-4.86	0.00	-4.56
Morocco	-2.11	0.24	-2.27	0.18	-1.73	-5.04	0.00	-4.56	0.00	-3.78
Mozambique	-2.29	0.17	-2.93	0.04	-2.15	-4.95	0.00	-7.31	0.00	-4.85
Nicaragua	-3.27	0.02	-6.02	0.00	-3.22	-6.20	0.00	-11.98	0.00	-6.30
Nigeria	-3.18	0.02	-4.96	0.00	-1.57	-5.44	0.00	-6.92	0.00	-1.69
Pakistan	-1.64	0.46	-1.72	0.42	-0.85	-5.24	0.00	-9.39	0.00	-5.18
Panama	-1.74	0.41	-2.54	0.11	-0.62	-10.77	0.00	-10.40	0.00	-4.32
Paraguay	-5.52	0.00	-4.24	0.00	-4.90	-7.85	0.00	-5.71	0.00	-7.74
Peru	-1.86	0.35	-2.73	0.07	-1.88	-4.66	0.00	-8.43	0.00	-4.27
Rwanda	-2.00	0.29	-4.03	0.00	-1.47	-6.05	0.00	-8.81	0.00	-2.27
Senegal	-2.47	0.12	-2.70	0.07	-2.28	-4.31	0.00	-6.66	0.00	-4.09
Sierra Leone	-3.16	0.02	-4.21	0.00	-1.43	-4.88	0.00	-9.31	0.00	-4.16
South Africa	-1.99	0.29	-1.94	0.31	-1.68	-7.21	0.00	-5.66	0.00	-6.56
Sri Lanka	-1.36	0.60	-2.04	0.27	-1.07	-3.75	0.00	-8.60	0.00	-3.77
Tanzania	-1.89	0.34	-2.54	0.11	-1.04	-8.61	0.00	-6.96	0.00	-6.34
Thailand	-3.14	0.02	-1.98	0.30	-2.64	-5.44	0.00	-4.99	0.00	-3.04
Trin. & Tobago	-3.37	0.01	-5.91	0.00	-3.22	-5.30	0.00	-12.35	0.00	-1.87
Tunisia	-2.47	0.12	-2.53	0.11	-1.95	-5.01	0.00	-5.86	0.00	-5.09
Turkey	-3.16	0.02	-3.15	0.02	-2.47	-4.97	0.00	-6.02	0.00	-5.08
Uganda	-1.86	0.35	-2.50	0.11	-1.16	-3.77	0.00	-6.90	0.00	-3.28
Uruguay	-2.32	0.16	-2.96	0.04	-1.97	-7.52	0.00	-6.92	0.00	-6.65
Venezuela	-5.17	0.00	-4.10	0.00	-2.88	-5.11	0.00	-4.85	0.00	-3.93
Zambia	-4.13	0.00	-4.97	0.00	-2.86	-5.66	0.00	-8.44	0.00	-5.70
Zimbabwe	-3.82	0.00	-2.66	0.08	-3.25	-3.58	0.01	-4.30	0.00	-3.33

TABLE A11
Univariate Unit Root Tests for Exchange Rate

	Levels Data					Differenced Data				
	ADF		Phillip & Perron		DFGLS	ADF		Phillip & Perron		DFGLS
Country	t-test	p-value	t-test	p-value	t-test	t-test	p-value	t-test	p-value	t-test
Algeria	0.77	0.99	1.48	1.00	0.34	-2.45	0.13	-3.37	0.01	-2.41
Argentina	-1.15	0.70	-0.71	0.84	-0.62	-2.90	0.05	-2.74	0.07	-2.73
Bangladesh	-1.06	0.73	-1.37	0.60	0.01	-4.61	0.00	-3.83	0.00	-4.48
Bolivia	-1.18	0.68	-0.65	0.86	-0.91	-2.81	0.06	-2.65	0.08	-2.79
Brazil	-0.84	0.81	0.83	0.99	-0.99	-1.84	0.36	-1.87	0.35	-1.75
Cameroon	-0.51	0.89	-0.48	0.90	-0.57	-3.70	0.00	-4.95	0.00	-3.72
Chile	-3.27	0.02	-3.09	0.03	-1.43	-2.93	0.04	-2.00	0.29	-2.96
China	-0.06	0.95	0.30	0.98	-0.16	-2.87	0.05	-3.76	0.00	-2.86
Colombia	-0.13	0.95	1.02	0.99	-0.36	-2.29	0.18	-2.21	0.20	-2.07
Costa Rica	-0.36	0.92	-0.01	0.96	-0.03	-3.98	0.00	-3.87	0.00	-3.75
Cote d'Ivoire	-0.51	0.89	-0.48	0.90	-0.57	-3.70	0.00	-4.95	0.00	-3.72
Dom. Republic	0.00	0.96	0.04	0.96	0.18	-3.30	0.01	-5.54	0.00	-3.23
Ecuador	1.62	1.00	3.09	1.00	0.89	-0.65	0.86	-1.22	0.66	-0.82
Egypt	-0.68	0.85	-0.30	0.93	-0.55	-3.23	0.02	-3.52	0.01	-3.22
El Salvador	-0.35	0.92	-0.27	0.93	-0.18	-3.77	0.00	-5.04	0.00	-3.75
Ethiopia	-0.20	0.94	0.69	0.99	-0.47	-2.86	0.05	-3.11	0.03	-2.88
Ghana	0.24	0.97	0.66	0.99	0.34	-3.43	0.01	-3.19	0.02	-3.32
Guatemala	0.03	0.96	0.35	0.98	0.05	-3.49	0.01	-4.01	0.00	-3.44
Guyana	-0.02	0.96	0.18	0.97	0.08	-1.76	0.40	-4.55	0.00	-1.69
Haiti	-0.94	0.77	0.24	0.97	-1.03	-2.99	0.04	-2.54	0.11	-2.98
Honduras	0.47	0.98	0.98	0.99	0.20	-3.11	0.03	-3.84	0.00	-3.07
India	0.75	0.99	1.54	1.00	0.28	-2.17	0.22	-3.39	0.01	-1.98
Indonesia	0.70	0.99	0.57	0.99	0.85	-4.23	0.00	-6.00	0.00	-4.31
Iran	-0.57	0.88	-0.50	0.89	-0.63	-3.66	0.00	-4.96	0.00	-3.69
Jamaica	-0.23	0.94	0.16	0.97	-0.02	-3.67	0.00	-3.73	0.00	-3.51
Jordan	-0.86	0.80	-0.43	0.90	-0.85	-3.81	0.00	-3.49	0.01	-3.84
Kenya	0.50	0.98	0.79	0.99	0.45	-3.43	0.01	-4.43	0.00	-3.30
Madagascar	0.81	0.99	1.16	1.00	0.53	-3.17	0.02	-4.09	0.00	-3.18
Malawi	2.08	1.00	3.53	1.00	0.85	-2.93	0.04	-3.09	0.03	-2.86
Malaysia	-1.37	0.59	-0.89	0.79	-1.34	-3.63	0.01	-4.20	0.00	-3.69
Mali	-0.51	0.89	-0.48	0.90	-0.57	-3.70	0.00	-4.95	0.00	-3.72
Mauritius	-0.31	0.92	0.06	0.96	0.01	-3.85	0.00	-3.90	0.00	-3.67
Mexico	-0.71	0.85	-0.06	0.95	-0.50	-2.94	0.04	-2.83	0.05	-2.76
Morocco	-0.84	0.81	-0.54	0.88	-0.75	-2.97	0.04	-3.45	0.01	-3.02
Mozambique	0.32	0.98	0.67	0.99	0.25	-2.95	0.04	-4.06	0.00	-2.88
Nicaragua	-0.57	0.88	-0.03	0.96	-0.50	-2.11	0.24	-2.95	0.04	-2.10
Nigeria	1.03	0.99	1.35	1.00	0.63	-2.41	0.14	-4.53	0.00	-2.34
Pakistan	-0.58	0.88	-0.30	0.93	0.27	-4.39	0.00	-4.91	0.00	-4.09
Panama	.	1.00	.	1.00	.	.	1.00	.	1.00	.
Paraguay	0.65	0.99	0.93	0.99	0.50	-2.24	0.19	-4.45	0.00	-2.13
Peru	-0.85	0.80	0.04	0.96	-0.75	-2.79	0.06	-2.43	0.13	-2.70
Rwanda	0.53	0.99	1.18	1.00	0.15	-2.66	0.08	-3.28	0.02	-2.69
Senegal	-0.51	0.89	-0.48	0.90	-0.57	-3.70	0.00	-4.95	0.00	-3.72
Sierra Leone	0.53	0.99	0.83	0.99	0.51	-2.37	0.15	-3.83	0.00	-2.32
South Africa	0.60	0.99	0.93	0.99	0.56	-4.26	0.00	-4.31	0.00	-4.11
Sri Lanka	-0.65	0.86	-0.41	0.91	0.37	-3.58	0.01	-6.12	0.00	-3.15
Tanzania	-0.47	0.90	0.69	0.99	-0.56	-1.90	0.33	-2.17	0.22	-1.77
Thailand	0.17	0.97	0.44	0.98	0.01	-3.87	0.00	-4.51	0.00	-3.91
Trin. & Tobago	-0.11	0.95	-0.01	0.96	0.16	-3.88	0.00	-5.21	0.00	-3.72
Tunisia	0.19	0.97	0.41	0.98	0.15	-2.54	0.11	-3.80	0.00	-2.59
Turkey	2.10	1.00	3.42	1.00	0.45	-1.86	0.35	-2.95	0.04	-1.83
Uganda	-0.55	0.88	-0.08	0.95	-0.30	-2.19	0.21	-2.94	0.04	-2.08
Uruguay	-1.54	0.52	-0.92	0.78	-0.51	-3.06	0.03	-3.61	0.01	-2.18
Venezuela	1.68	1.00	1.99	1.00	0.89	-2.31	0.17	-4.71	0.00	-2.17
Zambia	0.20	0.97	1.61	1.00	-0.20	-2.50	0.11	-2.45	0.13	-2.35
Zimbabwe	1.43	1.00	3.64	1.00	0.20	-2.62	0.09	-2.67	0.08	-2.52

TABLE A12
Univariate Unit Root Tests for Population

	Levels Data					Differenced Data				
	ADF		Phillip & Perron		DFGLS	ADF		Phillip & Perron		DFGLS
Country	t-test	p-value	t-test	p-value	t-test	t-test	p-value	t-test	p-value	t-test
Algeria	-2.91	0.04	-5.90	0.00	-4.51	0.96	0.99	2.05	1.00	0.24
Argentina	-4.37	0.00	-12.95	0.00	-1.36	-1.66	0.45	-0.12	0.95	-1.44
Bangladesh	-1.84	0.36	-5.48	0.00	-0.88	-0.65	0.86	-0.48	0.90	-0.56
Bolivia	0.54	0.99	-0.35	0.92	0.66	-2.90	0.05	-1.28	0.64	-2.78
Brazil	-3.21	0.02	-13.80	0.00	-4.69	-0.52	0.89	1.13	1.00	-0.71
Cameroon	-5.65	0.00	-1.68	0.44	-5.79	-1.84	0.36	0.09	0.97	-1.84
Chile	-0.45	0.90	-2.64	0.08	-0.03	-1.26	0.65	-1.17	0.69	-0.82
China	-0.96	0.77	-6.49	0.00	0.70	-2.76	0.06	-2.37	0.15	-0.72
Colombia	-4.34	0.00	-20.13	0.00	1.36	-1.14	0.70	-2.61	0.09	0.82
Costa Rica	-0.70	0.85	-2.87	0.05	0.01	-2.49	0.12	-1.51	0.53	-2.42
Cote d'Ivoire	-2.03	0.27	-13.76	0.00	-8.21	1.43	1.00	4.86	1.00	-0.80
Dom. Republic	-1.01	0.75	-10.36	0.00	0.16	-1.45	0.56	-1.15	0.70	-1.05
Ecuador	-2.83	0.05	-17.24	0.00	-5.71	1.89	1.00	2.90	1.00	0.58
Egypt	-1.72	0.42	-0.52	0.89	-1.67	-2.76	0.06	-0.80	0.82	-2.40
El Salvador	0.05	0.96	-1.71	0.42	0.98	-2.07	0.26	-2.31	0.17	-1.34
Ethiopia	-0.54	0.88	-0.52	0.89	0.34	-4.00	0.00	-5.62	0.00	-4.07
Ghana	-1.17	0.69	0.22	0.97	-1.20	-2.38	0.15	-1.40	0.58	-2.55
Guatemala	1.01	0.99	-0.98	0.76	1.47	-2.84	0.05	-1.89	0.34	-1.90
Guyana	-1.59	0.49	-2.92	0.04	-0.82	-1.77	0.40	-2.08	0.25	-1.27
Haiti	1.48	1.00	7.45	1.00	-0.36	-1.36	0.60	-1.22	0.67	-1.23
Honduras	-5.27	0.00	-3.25	0.02	-4.12	-1.04	0.74	-0.05	0.95	-1.19
India	-2.07	0.26	-11.05	0.00	-1.65	0.80	0.99	0.78	0.99	0.78
Indonesia	-3.42	0.01	-20.15	0.00	-1.44	-0.32	0.92	0.06	0.96	0.03
Iran	-2.83	0.05	-4.03	0.00	-2.44	-0.83	0.81	-0.03	0.96	-0.97
Jamaica	-1.99	0.29	-4.04	0.00	-0.55	-1.77	0.39	-1.42	0.57	-1.75
Jordan	-0.01	0.96	-0.16	0.94	0.30	-3.04	0.03	-4.24	0.00	-2.99
Kenya	-2.93	0.04	-6.18	0.00	-1.97	0.60	0.99	0.52	0.99	0.34
Madagascar	2.03	1.00	4.62	1.00	0.03	-1.48	0.54	-1.95	0.31	-1.12
Malawi	-1.92	0.32	-3.29	0.02	-0.66	-1.30	0.63	-1.31	0.62	-1.35
Malaysia	-0.13	0.95	0.67	0.99	-0.35	-1.67	0.45	-1.46	0.55	-1.70
Mali	0.01	0.96	3.29	1.00	-0.60	-1.94	0.31	-1.11	0.71	-1.85
Mauritius	-0.97	0.76	-3.20	0.02	0.33	-1.78	0.39	-1.85	0.36	-1.45
Mexico	-2.42	0.14	-31.48	0.00	-0.62	-1.79	0.39	-1.14	0.70	-1.03
Morocco	-1.01	0.75	-17.38	0.00	0.15	0.19	0.97	-1.21	0.67	1.00
Mozambique	-0.35	0.92	-1.21	0.67	0.15	-1.85	0.36	-1.53	0.52	-1.88
Nicaragua	-1.18	0.68	-3.52	0.01	-0.09	-1.85	0.36	-1.46	0.55	-1.68
Nigeria	-4.45	0.00	-1.36	0.60	-4.76	-1.16	0.69	0.36	0.98	-1.47
Pakistan	-3.47	0.01	-14.31	0.00	-1.01	-1.52	0.52	-0.18	0.94	-1.13
Panama	-2.03	0.28	-26.81	0.00	-0.55	-0.63	0.86	-0.62	0.87	0.79
Paraguay	-1.51	0.53	-1.45	0.56	-0.48	-1.81	0.37	-2.61	0.09	-1.73
Peru	-1.54	0.51	-15.77	0.00	-3.13	0.07	0.96	1.23	1.00	-0.05
Rwanda	-1.32	0.62	-1.35	0.61	-0.38	-3.55	0.01	-6.08	0.00	-3.61
Senegal	-1.64	0.46	-2.20	0.21	-0.25	-2.57	0.10	-2.80	0.06	-2.62
Sierra Leone	-3.44	0.01	4.48	1.00	-3.08	-1.78	0.39	-1.43	0.57	-1.99
South Africa	-2.53	0.11	-2.28	0.18	-2.64	-1.24	0.66	0.00	0.96	-1.59
Sri Lanka	0.60	0.99	-4.24	0.00	1.90	-2.22	0.20	-2.29	0.17	-1.05
Tanzania	-5.50	0.00	-2.45	0.13	-6.51	-0.86	0.80	3.95	1.00	-1.10
Thailand	-2.35	0.16	-15.19	0.00	-1.19	-1.56	0.50	-0.88	0.80	-1.04
Trin. & Tobago	-1.02	0.75	-2.02	0.28	-0.46	-1.85	0.36	-1.42	0.57	-1.84
Tunisia	-1.65	0.46	-1.71	0.43	-0.85	-1.17	0.69	-1.56	0.50	-1.22
Turkey	-1.47	0.55	-5.66	0.00	-0.54	-1.30	0.63	-0.79	0.82	-1.00
Uganda	1.39	1.00	1.12	1.00	0.95	-2.87	0.05	-1.79	0.39	-2.68
Uruguay	1.70	1.00	3.77	1.00	0.32	-1.82	0.37	-1.75	0.41	-1.89
Venezuela	-2.38	0.15	-9.23	0.00	-0.79	-0.72	0.84	-0.53	0.89	-0.49
Zambia	-3.07	0.03	-2.93	0.04	-3.59	-0.86	0.80	0.67	0.99	-0.94
Zimbabwe	-2.26	0.18	-3.58	0.01	-2.21	-1.38	0.59	-0.03	0.96	-1.47

TABLE A13
Univariate Unit Root Tests for Debt-to-GDP

	Levels Data					Differenced Data				
	ADF		Phillip & Perron		DFGLS	ADF		Phillip & Perron		DFGLS
Country	t-test	p-value	t-test	p-value	t-test	t-test	p-value	t-test	p-value	t-test
Algeria	-2.22	0.20	-1.62	0.47	-1.78	-3.02	0.03	-6.39	0.00	-1.85
Argentina	-1.35	0.61	-1.32	0.62	-1.14	-3.64	0.01	-5.71	0.00	-3.53
Bangladesh	-12.59	0.00	-2.33	0.16	-2.55	-3.31	0.01	-6.94	0.00	-2.22
Bolivia	-1.76	0.40	-1.26	0.65	-1.50	-2.67	0.08	-4.51	0.00	-2.17
Brazil	-2.78	0.06	-1.59	0.49	-2.54	-4.34	0.00	-5.34	0.00	-2.28
Cameroon	-1.17	0.69	-0.63	0.86	-0.47	-3.77	0.00	-5.52	0.00	-2.66
Chile	-2.09	0.25	-1.74	0.41	-2.00	-4.11	0.00	-4.40	0.00	-3.89
China	-2.74	0.07	-2.54	0.11	-1.68	-3.91	0.00	-5.62	0.00	-3.97
Colombia	-1.52	0.53	-1.53	0.52	-1.60	-2.32	0.17	-4.49	0.00	-1.51
Costa Rica	-0.76	0.83	-3.67	0.00	-0.62	-3.25	0.02	-8.72	0.00	-0.69
Cote d'Ivoire	-2.25	0.19	-1.27	0.64	-1.26	-2.07	0.26	-4.98	0.00	-1.44
Dom. Republic	-1.06	0.73	-1.11	0.71	-1.07	-3.25	0.02	-6.29	0.00	-2.35
Ecuador	-1.43	0.57	-1.11	0.71	-0.91	-3.53	0.01	-4.87	0.00	-3.06
Egypt	-1.49	0.54	-1.07	0.73	-1.21	-2.40	0.14	-3.99	0.00	-2.22
El Salvador	-1.67	0.45	-3.71	0.00	-0.47	-3.48	0.01	-6.33	0.00	-1.15
Ethiopia	-1.61	0.48	-1.15	0.70	-0.91	-2.67	0.08	-4.48	0.00	-2.16
Ghana	0.33	0.98	0.57	0.99	0.52	-5.46	0.00	-5.89	0.00	-4.53
Guatemala	-1.62	0.47	-1.14	0.70	-1.12	-2.99	0.04	-4.72	0.00	-2.30
Guyana	-2.84	0.05	-1.51	0.53	-1.48	-2.73	0.07	-6.04	0.00	-1.88
Haiti	-1.84	0.36	-1.78	0.39	-1.17	-4.87	0.00	-6.18	0.00	-4.85
Honduras	-3.23	0.02	-4.92	0.00	-0.04	-4.70	0.00	-7.23	0.00	-1.20
India	-1.35	0.61	-0.89	0.79	-1.30	-2.61	0.09	-3.70	0.00	-2.15
Indonesia	-0.89	0.79	-1.11	0.71	-1.07	-4.50	0.00	-5.84	0.00	-3.55
Iran	-2.95	0.04	-2.75	0.07	-2.22	-5.55	0.00	-5.47	0.00	-5.66
Jamaica	-1.49	0.54	-1.20	0.68	-1.52	-2.83	0.05	-4.09	0.00	-2.54
Jordan	-1.69	0.44	-1.88	0.34	-0.80	-2.53	0.11	-4.16	0.00	-2.51
Kenya	-1.58	0.49	-1.32	0.62	-1.16	-3.70	0.00	-6.33	0.00	-2.80
Madagascar	-0.73	0.84	-1.16	0.69	-0.70	-4.76	0.00	-9.73	0.00	-4.67
Malawi	-1.09	0.72	-0.92	0.78	-1.07	-5.49	0.00	-5.54	0.00	-4.14
Malaysia	-1.77	0.40	-3.13	0.02	-0.72	-4.46	0.00	-4.36	0.00	-2.31
Mali	-0.84	0.81	-0.86	0.80	-0.91	-4.31	0.00	-5.33	0.00	-4.01
Mauritius	-1.66	0.45	-1.20	0.67	-1.50	-2.36	0.15	-3.24	0.02	-2.29
Mexico	-1.72	0.42	-5.83	0.00	-0.50	-4.25	0.00	-9.51	0.00	-0.79
Morocco	-1.40	0.58	-2.20	0.21	-0.77	-2.79	0.06	-4.21	0.00	-1.91
Mozambique	-1.70	0.43	-1.83	0.37	-0.60	-5.23	0.00	-7.59	0.00	-5.01
Nicaragua	-1.79	0.38	-1.33	0.62	-1.15	-4.24	0.00	-4.15	0.00	-3.59
Nigeria	-1.32	0.62	-1.77	0.40	-0.55	-3.75	0.00	-4.99	0.00	-2.85
Pakistan	-3.69	0.00	-2.73	0.07	-3.64	-4.96	0.00	-5.48	0.00	-3.11
Panama	-2.39	0.15	-5.70	0.00	-0.36	-2.27	0.18	-5.42	0.00	-0.67
Paraguay	-2.05	0.26	-1.29	0.63	-2.04	-2.83	0.05	-3.40	0.01	-2.58
Peru	-2.00	0.29	-2.18	0.21	-2.00	-3.90	0.00	-6.24	0.00	-3.49
Rwanda	-1.29	0.64	-1.35	0.61	-0.33	-5.12	0.00	-5.77	0.00	-5.24
Senegal	-1.76	0.40	-1.38	0.59	-0.98	-3.25	0.02	-4.01	0.00	-2.96
Sierra Leone	-1.66	0.45	-0.98	0.76	-0.85	-5.67	0.00	-6.88	0.00	-3.13
South Africa	-1.05	0.73	-1.11	0.71	-1.01	-4.22	0.00	-5.55	0.00	-4.25
Sri Lanka	-2.07	0.26	-3.42	0.01	-0.40	-4.09	0.00	-6.10	0.00	-1.65
Tanzania	-7.01	0.00	-3.43	0.01	-4.94	-6.70	0.00	-11.30	0.00	-2.48
Thailand	-0.60	0.87	-3.93	0.00	1.09	-3.26	0.02	-12.16	0.00	-0.20
Trin. & Tobago	-1.13	0.70	-1.09	0.72	-1.05	-3.58	0.01	-5.29	0.00	-3.36
Tunisia	-1.73	0.42	-1.39	0.59	-1.79	-3.34	0.01	-4.16	0.00	-2.40
Turkey	-0.90	0.79	-0.79	0.82	-0.55	-3.97	0.00	-5.13	0.00	-4.00
Uganda	-1.37	0.60	-1.38	0.59	-1.26	-3.69	0.00	-5.72	0.00	-3.61
Uruguay	-1.82	0.37	-1.65	0.46	-1.63	-2.94	0.04	-5.24	0.00	-2.73
Venezuela	-2.09	0.25	-1.40	0.58	-1.66	-3.61	0.01	-4.38	0.00	-2.78
Zambia	-1.69	0.44	-1.55	0.51	-1.06	-4.02	0.00	-4.62	0.00	-4.06
Zimbabwe	-1.21	0.67	-0.69	0.85	-1.19	-3.28	0.02	-3.20	0.02	-3.11

TABLE A14
Univariate Unit Root Tests for Debt-Service-to-Export

	Levels Data					Differenced Data				
	ADF		Phillip & Perron		DFGLS	ADF		Phillip & Perron		DFGLS
Country	t-test	p-value	t-test	p-value	t-test	t-test	p-value	t-test	p-value	t-test
Algeria	-4.00	0.00	-1.74	0.41	-2.29	-3.74	0.00	-6.34	0.00	-1.78
Argentina	-1.16	0.69	-1.33	0.61	-1.22	-3.58	0.01	-5.97	0.00	-3.64
Bangladesh	-3.50	0.01	-3.82	0.00	-1.35	-6.79	0.00	-5.18	0.00	-4.41
Bolivia	-2.28	0.18	-1.86	0.35	-1.70	-3.20	0.02	-5.66	0.00	-2.80
Brazil	-1.86	0.35	-1.00	0.75	-1.87	-3.33	0.01	-4.34	0.00	-2.52
Cameroon	-2.00	0.29	-1.32	0.62	-0.86	-3.22	0.02	-7.20	0.00	-2.26
Chile	-2.39	0.14	-1.98	0.30	-2.16	-4.56	0.00	-4.11	0.00	-4.64
China	-2.87	0.05	-2.66	0.08	-0.97	-3.05	0.03	-4.63	0.00	-3.11
Colombia	-1.01	0.75	-1.06	0.73	-1.06	-2.72	0.07	-5.37	0.00	-2.22
Costa Rica	-0.57	0.88	-1.53	0.52	-0.67	-4.52	0.00	-10.15	0.00	-4.23
Cote d'Ivoire	-1.90	0.33	-1.48	0.54	-1.26	-2.83	0.05	-5.29	0.00	-2.26
Dom. Republic	-1.90	0.33	-2.49	0.12	-1.94	-4.53	0.00	-7.11	0.00	-3.89
Ecuador	-1.70	0.43	-1.83	0.37	-1.19	-3.92	0.00	-7.74	0.00	-3.44
Egypt	-1.07	0.73	-1.21	0.67	-1.18	-4.77	0.00	-5.86	0.00	-4.30
El Salvador	-1.76	0.40	-1.99	0.29	-1.79	-2.84	0.05	-6.28	0.00	-2.53
Ethiopia	-1.32	0.62	-1.55	0.51	-1.29	-4.19	0.00	-6.77	0.00	-4.10
Ghana	-0.97	0.77	-0.93	0.78	-0.91	-4.30	0.00	-5.03	0.00	-4.38
Guatemala	-1.46	0.56	-1.58	0.49	-1.48	-3.71	0.00	-5.81	0.00	-3.48
Guyana	-2.34	0.16	-1.89	0.34	-1.47	-4.44	0.00	-6.14	0.00	-3.37
Haiti	-2.17	0.22	-3.45	0.01	-2.21	-4.31	0.00	-9.04	0.00	-3.86
Honduras	-2.85	0.05	-2.18	0.22	-1.55	-4.55	0.00	-8.10	0.00	-2.93
India	-0.73	0.84	-0.77	0.83	-0.62	-3.23	0.02	-4.98	0.00	-3.28
Indonesia	-1.73	0.42	-1.09	0.72	-1.03	-4.05	0.00	-7.20	0.00	-2.13
Iran	-2.15	0.22	-1.94	0.32	-1.72	-4.24	0.00	-5.06	0.00	-4.28
Jamaica	-1.49	0.54	-3.06	0.03	-1.31	-5.10	0.00	-10.30	0.00	-4.84
Jordan	-2.75	0.07	-1.78	0.39	-1.15	-3.12	0.02	-6.26	0.00	-2.40
Kenya	-1.64	0.46	-1.52	0.52	-1.29	-3.43	0.01	-5.44	0.00	-3.07
Madagascar	-2.13	0.23	-3.47	0.01	-1.99	-5.33	0.00	-9.71	0.00	-5.27
Malawi	-1.84	0.36	-1.69	0.44	-1.59	-5.26	0.00	-6.01	0.00	-4.13
Malaysia	-1.67	0.45	-1.64	0.46	-1.13	-3.59	0.01	-5.36	0.00	-3.65
Mali	-0.89	0.79	-1.10	0.72	-0.83	-4.49	0.00	-6.55	0.00	-4.55
Mauritius	-1.25	0.65	-1.35	0.61	-1.22	-3.86	0.00	-4.89	0.00	-3.48
Mexico	-2.15	0.23	-1.78	0.39	-2.01	-5.13	0.00	-4.50	0.00	-5.00
Morocco	-1.94	0.31	-1.28	0.64	-1.47	-3.03	0.03	-5.69	0.00	-2.06
Mozambique	-1.93	0.32	-2.74	0.07	-1.31	-6.49	0.00	-8.81	0.00	-5.38
Nicaragua	-1.83	0.37	-2.35	0.16	-1.88	-4.50	0.00	-7.15	0.00	-4.59
Nigeria	-1.49	0.54	-1.28	0.64	-1.31	-3.17	0.02	-5.59	0.00	-2.65
Pakistan	-1.63	0.47	-2.15	0.22	-1.21	-7.45	0.00	-8.84	0.00	-7.60
Panama	-3.33	0.01	-3.25	0.02	-3.34	-4.89	0.00	-5.91	0.00	-4.81
Paraguay	-1.55	0.51	-1.94	0.31	-1.47	-3.75	0.00	-8.17	0.00	-3.44
Peru	-1.84	0.36	-2.57	0.10	-1.64	-5.12	0.00	-8.23	0.00	-4.96
Rwanda	-1.72	0.42	-2.88	0.05	-1.71	-4.76	0.00	-8.82	0.00	-4.01
Senegal	-2.56	0.10	-2.17	0.22	-1.76	-4.24	0.00	-6.35	0.00	-3.63
Sierra Leone	-2.50	0.11	-3.86	0.00	-2.56	-3.58	0.01	-8.51	0.00	-3.42
South Africa	-3.22	0.02	-4.14	0.00	-2.16	-5.37	0.00	-8.79	0.00	-5.45
Sri Lanka	-2.02	0.28	-1.78	0.39	-1.77	-4.38	0.00	-5.21	0.00	-3.92
Tanzania	-2.76	0.06	-1.71	0.43	-1.49	-3.89	0.00	-6.91	0.00	-2.25
Thailand	-0.91	0.79	-0.62	0.87	-0.67	-2.82	0.06	-5.24	0.00	-2.38
Trin. & Tobago	-1.24	0.65	-1.76	0.40	-1.21	-4.76	0.00	-8.46	0.00	-4.85
Tunisia	-1.38	0.59	-1.00	0.75	-1.47	-2.60	0.09	-3.32	0.01	-2.06
Turkey	-0.89	0.79	-0.77	0.83	-0.48	-4.30	0.00	-5.18	0.00	-4.20
Uganda	-1.90	0.33	-2.03	0.27	-1.75	-4.25	0.00	-6.01	0.00	-4.19
Uruguay	-2.43	0.13	-3.14	0.02	-2.45	-4.35	0.00	-7.42	0.00	-4.42
Venezuela	-2.31	0.17	-1.62	0.47	-1.53	-3.49	0.01	-5.94	0.00	-2.43
Zambia	-3.56	0.01	-4.58	0.00	-3.01	-5.51	0.00	-8.59	0.00	-5.55
Zimbabwe	-1.22	0.67	-0.89	0.79	-1.08	-2.38	0.15	-3.64	0.01	-2.27

7 REFERENCES

Agenor P R and Montiel P. J. (1999) “Development Macroeconomics”, Princeton University Press, Princeton. 2nd Edition.

Ahmed, S. & Rogers, J. 1995, "Government budget deficits and trade deficits Are present value constraints satisfied in long-term data?", Journal of Monetary Economics, Vol. 36, No. 2, pp. 351-374.

Ajayi, S. I. (1991) “Macroeconomic Approach to External Debt: The Case of Nigeria” Nairobi: AERC Research paper 8

Akaike, H. (1974), "A new look at the statistical model identification", Automatic Control, IEEE Transactions on, Vol. 19, No. 6, pp. 716-723.

Andrews D, Boote A.R., Rizavi S.S., Singh S. (1999), “Debt Relief for Low-Income Countries. The Enhanced HIPC Initiative”, International Monetary Fund, Pamphlet Series No. 51

Baltagi B and C Kao (2000) “Non-stationary Panels, Cointegration in Panels and Dynamic Panels: A Survey,” Advances in Econometrics, 15, 7-51.

Banerjee A (1999) “Panel Data Unit Root and Cointegration: An Overview,” Oxford Bulletin of Economic Statistics, 61, Specials Issue, 607-29.

Barrett R E and Chin S (1987) “Export-Oriented Industrializing States in the Capitalist World System: Similarities and Differences”, The Political Economy of East Asian Industrialism. Cornell University Press, p 32

Barro R and X Sala-i-Martin (2003) “Economic Growth”, Cambridge MIT Press

Barro R, G Mankiw and X Sala-i-Martin (1995) “Capital Mobility in Neoclassical Models of Growth”, American Economic Review, Vol. 85, 103-15

Beveridge, S. & Nelson, C.R. 1981, "A New Approach to Decomposition of Economic Time Series into Permanent and Transitory Components with Particular Attention to Measurement of the Business Cycle", Journal of Monetary Economics, Vol. 7, No. 2, pp. 151-74.

Bohn, H. (2007), “Are Stationarity and Cointegration Restrictions Really Necessary for the Intertemporal Budget Constraint?”, Journal of Monetary Economics, Vol. 54 pp. 1837–47

Bohn, H. (1998), "The Behavior of US Public Debt and Deficits", Quarterly Journal of Economics, Vol. 113, No. 3, pp. 949-963.

Bohn, H. (1995), "The Sustainability of Budget Deficits in a Stochastic Economy", Journal of Money, Credit and Banking, Vol. 27, No. 1, pp. 257-271.

Bohn, H. (1991), "The Sustainability of Budget Deficits with Lump-Sum and with Income-Based Taxation", Journal of Money, Credit and Banking, Vol. 23, No. 3, Part 2: Price Stability, pp. 580-604.

Bohn, H. (1991), Budget Balance Through Revenue Or Spending Adjustments?: Some Historical Evidence for the United States, Rodney L. White Centre for Financial Research.

Borensztein, E. (1990) “Debt Overhang, Credit Rationing and Investment”, Journal of Development Economics Vol.35.

Bosworth, B. P. and Collins, S. M. (2003), "The Empirics of Growth: An Update.", Brookings Papers on Economic Activity, , No. 2, pp. 113-207.

Brito D (2000) “Government Debt and Economic Growth in an Overlapping Generations Model”, Southern Economic Journal Vol. 66, No. 3, pp 754-65.

Callaghy, T. (2002), “Innovations in the Sovereign Debt Regime,” Background Paper: OED, Washington, DC.

Calvo G. A. (1998), “Growth, Debt and Economic Transformation: The Capital Flight Problem”, in *New Theories in Growth and Development* edited by Coricelli, Fabrizio, Massimo di Matteo and Frank Hahn, St. Martine’ Press, New York.

Campbell, J.Y. & Mankiw, N.G. (1987a), "Are Output Fluctuations Transitory?", The Quarterly Journal of Economics, Vol. 102, No. 4, pp. 857-880.

Campbell, J.Y. & Mankiw, N.G. (1987b), "Permanent and Transitory Components in Macroeconomic Fluctuations", The American Economic Review, Vol. 77, No. 2, Papers and Proceedings of the Ninety-Ninth Annual Meeting of the American Economic Association, pp. 111-117.

Chauvin, N.D. & Kraay, A. (2005), "What Has 100 Billion Dollars Worth of Debt Relief Done for Low-Income Countries?", Research paper draft, Princeton University/Inter-American Development Bank/World Bank

Chowdhurry, K. A. (1994) “Structural Analysis of External debt and Economic Growth: Some Evidence from Selected countries in Asia and Pacific”, Applied Economics, Vol. 26.

Claessens S (1990) “The Debt Laffer Curve: Some Estimates”, World Development, Vol. 18 No. 12.

Clark, P.K. (1987), "The Cyclical Component of US Economic Activity", The Quarterly Journal of Economics, Vol. 102, No. 4, pp. 797-814.

Clements, B., Bhattacharya, R. & Nguyen, T.Q. (2003), "External Debt, Public Investment, and Growth in Low-Income Countries", IMF Working Paper, WP/03/249.

Cline, W.R. (1984), “International Debt: Systemic Risk and Policy Response”, Institute for International Economics. Washington DC.

Cochrane, J.H. (1988), "How Big Is the Random Walk in GNP?" The Journal of Political Economy, Vol. 96, No. 5, pp. 893-920.

Cohen D. (1991) “Private Lending to Sovereign States” Cambridge, Mass: MIT Press

Cohen D. (1993) “Low Investment and Large LDC Debt in the 1980s,” American Economic Review, Vol. 83, pp 437-49.

Cohen D. (1995) “Large External Debt and (Slow) Domestic Growth: A Theoretical Analysis”, Journal of Economic Dynamics and Control, Vol. 19, pp 1141-63.

Cohen D. (1997) “Growth and External Debt: A New Perspective on the African and Latin American Tragedies,” Center for Economic Policy Research Discussion Paper, No. 1753, pp. 1-17.

Cohen D. and Sachs J. (1986), “Growth and External Debt Under Risk of Debt Repudiation,” European Economic Review, Vol. 30, pp. 529-50.

Corbridge, S. (1993), “Debt and Development”, Blackwell Oxford.

Cordella, T., Ricci, L.A. & Ruiz-Arranz, M. (2005), “Debt Overhang Or Debt Irrelevance?: Revisiting the Debt-Growth Link”, International Monetary Fund Working Paper, WP/05/223.

Corden W. M. (1988) “Debt Relief and Adjustment Incentives,” International Monetary Funds Staff Papers, Vol. 35, pp. 628-43.

Cuddington J T (1997), “Analysing the Sustainability of Fiscal Deficit in Developing Countries,” Policy Research Working Paper No 1784, the World Bank.

Degefe B. (1992) “Growth and Foreign Debt: the Ethiopian Experience: 1964-86”, Nairobi: AERC Research Paper 13

Depetrise C. N., and Kraay A., (2005), “What has 100 Billion Dollars Worth of Debt Relief Done for Low-Income Countries?” International Finance, Working Paper, downloaded from http://ideas.repec.org/f/c/pde251.html

Diaz-Alejandro C. F., (1981) “Stories of the 1930s for the 1980s”, Economic Growth Center, Yale University.

Dickey, D. A. and Fuller W. A. (1979) “Distribution of the Estimators for Autoregressive Time Series With a Unit Root,” Journal of the American Statistical Association, Vol. 74, No. 366, pp 427-431.

Dijkstra G. and Hermes N. (2001) “The Uncertainty of Debt Service Payments and Economic Growth of Highly Indebted Poor Countries: Is There a Case for Debt Relief?” Wider Development Conference on Debt Relief 17-18 August 2001.

Easterly W (2001) “Growth Implosions, Debt Explosions, and My Aunt Marilyn: Do Growth Slowdowns Cause Public Debt Crisis?” World Bank Policy Research Working Paper, No 2531.

Easterly W. and Rebelo S., (1993), “Fiscal Policy and Economic Growth: An Empirical Investigation,” Journal of Monetary Economics, Vol. 32, No. 3, pp 417-58.

Eaton J. and Gersovitz M., (1981), “Debt with Potential Repudiation: Theoretical and Empirical Analysis,” Review of Economics Studies, Vol. 48 pp.289-309.

Eaton, J. (1993), “Sovereign Debt: A Primer”, The World Bank Economic Review, Vol. 7, No. 2, pp 137-172.

Eisner, R., (1984), "Which Budget Deficits? Some Issues of Measurement and Their Implications," American Economic Review, pp. 138-143.

Elbadawi, A. I., Ndulu, J. B. and Ndungu, N. (1997) “Debt Overhang and Economic Growth in Sub-Saharan Africa”, in *External Finance for Low-income Countries*, edited by Zubair Iqbal and Ravi Kanbur, Washington D.C., IMF

Elliott, G. Rothenberg T. and Stock J., (1996): "Efficient Tests for an Autoregressive Unit Root," Econometrica, Vol. 64, No. 4, pp. 813-836.

Engle R. F. and Granger C W. J. (1987), “Cointegration and Error Correction: Representation, Estimation and Testing,” Econometrica Vol. 55, pp. 251-76.

Feve P and Henin P.Y. (2000), “Assessing Effective Sustainability of Fiscal Policy within the G-7,” Oxford Bulletin of Economic Statistics, Vol. 62, No. 2, pp.175-95.

Fischer S. (1993) “The Role of Macroeconomic Factors in Growth,” Journal of Monetary Economics, Vol. 32, No. 3, pp. 485-512.

Fisher I. (1930), “The Theory of Interest.” New York Macmillan.

Fisher R. A. (1932), “Statistical Methods for Research Workers,” Oliver & Boyd, Edinburgh, 4th Edition.

Forslid R. (1998) “External Debt and Ponzi-Games in a Small Open Economy With Endogenous Growth”, Journal of Macroeconomics, Vol. 20, No. 2, pp 341-9.

Gallup, J. L., Steven R. and Warner A., (1998), “Economic Growth and the Income of the Poor,” Manuscript. Harvard Institute for International Development.

Green W (2003) “Econometrics” Prentice Hall, New York

Groen J. J. J. and Kleibergen F. (2003)’ “Likelihood-Based Cointegration Analysis in Panels of Vector Error Models,” Journal of Business and Economic Statistics, 21, 295-318.

Gutierrez L (2003), “On the Power of Panel Cointegration Tests: A Monte Carlo Comparison,” Economics Letters, Vol. 80, pp. 105-11.

Hadri K (2000), “Testing for Stationarity in Heterogeneous Panel Data,” Econometric Journal, Vol. 3, No. 2, pp 148-61.

Hakkio C. S. (1995), “The US Current Account: The Other Deficit,” Economic Review, Federal Reserve of Bank of Kansas City, Third Quarter, pp. 11-24.

Hakkio C. S. and Rush M., (1991), “Is the Budget Deficit ‘Too Large’?” Economic Inquiry, Vol. 29, No. 3, pp. 429-45.

Hamilton, J.D. & Flavin, M.A. (1986), "On the Limitations of Government Borrowing: A Framework for Empirical Testing", The American Economic Review, Vol. 76, No. 4, pp. 808-819.

Hansen B. E. (1996), “Inference When a Nuisance Parameter is not Identified Under the Null Hypothesis”, Econometrica, Vol. 64, pp 413-30.

Hansen B. E., (2000), “Sample Splitting and Threshold Estimation”, Econometrica, Vol. 68, pp. 575-603.

Hansen H. (2001), “The Impact of Aid and External Debt on Growth and Investment: Insight from Cross-Country Regression Analysis”, Wider Conference on Debt Relief, Helsinki.

Hansen H. (2004) “The Impact of External Aid and External Debt on Growth and Investment”, in *Debt Relief for Poor Countries,* edited by Addison T., Hansen H. and Tarp F, Basingstoke: Palgrave MacMillan, Studies in Development Economics and Policy Series for UNU/WIDER.

Harris D. and Inder B. (1994), “A Test of the Null of Cointegration, in *Non-Stationary Time Series Analysis and Cointegration* edited by Hargreaves C., Oxford University Press, Oxford, 133-152.

Heston A., Summers R., and Aten B., (2006) “Penn World Table” Version 6.2, Centre for International Comparisons of Production, Income and Prices at the University of Pennsylvania

Hjertholm, P. (2000), “Analytical History of Heavily Indebted Poor Country (HIPC) Debt Sustainability Targets,” Institute of Economics, University of Copenhagen.

Husted S. (1992), “The Emerging US Current Account Deficit in the 1980s: A Cointegration Analysis,” Review of Economics and Statistics, Vol. 74, No. 1, pp. 159-162.

Im K. S., Pesaran H. M. and Shin Y., (1997), “Testing for Unit Roots in Heterogeneous Panels,” Department of Applied Economics, University of Cambridge.

Im K. S., Pesaran H. M. and Shin Y., (2003), “Testing for Unit Roots in Heterogeneous Panels, Journal of Econometrics, Vol. 115, pp. 53-74.

Imbs, J. & Ranciere, R. (2005), "The Overhang Hangover", World Bank Policy Research Working Paper No 3673.

IMF (2003), “Global Development Finance” IMF

IMF (2003), “Government Finance Statistics” IMF

IMF (2003), “International Financial Statistics” IMF

IMF and World Bank (2001), “The Challenge of Maintaining Long Term External Debt Sustainability,” April 20, 2001

Johansen S., (1995), “Likelihood-Based Inferences in Cointegrated Vector Autoregressive Models,” Oxford University Press, Oxford.

Joines, D. H., (1991), "How Large a Federal Budget Deficit Can We Sustain?," Contemporary Policy, pp.1-11

Jubilee Debt Campaign (2009), Country Debt Profile, downloaded from:

http://www.jubileedebtcampaign.org.uk/Country%20debt%20profiles+2790.twl#anchor5 on 12 June 2009

Jubliee Debt Campaign (2007), “Multilateral Debt Relief Initiative (MDRI),” Briefing by Jubilee Debt Campaign.

Kao C and Chiang M. H. (2000), “On the Estimation and Inference of a Cointegration Regression in Panel Data,” Advances of Econometrics Vol. 15, pp. 7-51.

Kao C., (1999), “Spurious Regression and Residual-Based Tests for Cointegration in Panel Data,” Journal of Econometrics, Vol. 90, pp. 1-44.

Karlsson S. and Löthgren M. (2000), “On the power and interpretation of panel unit root tests,” Economics Letters, Vol. 66, No. 3, pp. 249-255

Kremers, J.J.M. (1988), "Long-Run Limits on the US Federal Debt", Economics Letters, Vol. 28, No. 3, pp. 259-262.

Krugman P (1988), “Financing vs Forgiving a Debt Overhang: Some Analytical Notes,” Journal of Development Economics, Vol. 29, pp 253-68

Krugman, P.R. (1989), “Market-Based Debt-Reduction Schemes”, in *Analytical Issues in Debt*, edited by Jacob A. Frenkel, Michael P. Dooley and Wickham P. Washington: IMF.

Kuczynski, P.P. (1988), “Latin American Debt,” Johns Hopkins University Press.

Larsson R., Lyhagen J. and Lothgren M. (2000), “Likelihood-Based Cointegration Tests in Heterogeneous Panels,” Econometrics Journal, Vol. 4, pp. 109-142.

Lee, K.C., Pesaran, M.H. & Pierse, R.G. (1992), "Persistence of Shocks and their Sources in a Multisectoral Model of UK Output Growth," The Economic Journal, Vol. 102, No. 411, pp. 342-356.

Levin A. and Lin C. F. (1992), “Unit root Tests in Panel Data: Asymptotic and Finite Sample Properties,” University of California at San Diego, Discussion paper No. 92-93.

Levin A. and Lin C. F. (1993), “Unit root Tests in Panel Data: New Results,” University of California at San Diego, Discussion paper No. 93-56

Lucas, R. (1988) “On the Mechanics of Development Planning”, Journal of Monetary Economics, Vol. 22, No. 1, pp 3-42.

Maddala G S and Wu S. (1999) “A Comparative Study of Unit Roots Tests with Panel Data and a New Simple Test”, Oxford Bulletin of Economics and Statistics, special Issue, pp. 631-52.

Maddison A 1985, Two Crisis: Latin America and Asia, 1928-38 and 1973-83, OECD, Paris.

Makin J. (1984), “The Global Debt Crisis: America’s Growing Involvement,” New York: Basic Books

Mankiw, N. G, Romer, D. and Weil, D., (1992), “A Contribution to the Empirics of Economic Growth,” Quarterly Journal of Economics, Vol. 107, No. 2, pp. 407–37.

Mbanga, G. N. and Sikod, F. (2001), “The Impact of Debt and Debt Service Payments on Investment in Cameroon”, A final report presented at the AERC Biannual Research Workshop at the Grand Regency Hotel, Nairobi, May 26-31, 2001

Mbire, B. and Atingi, M (1997) “Growth and External Debt: The Ugandan Experience”, Nairobi: AERC Research paper 66.

McCallum B. T. (1984), “Are Bond-Financed Deficit Inflationary? A Ricardian Analysis,” Journal of Political Economy, Vol. 92, pp. 123-35.

McCoskey S. and C. Kao (1998) A Residual-Based Test of the Null of Cointegration in Panel Data, Econometric Review, Vol. 17, pp. 57-84.

MF and World Bank, 2001, "The Challenge of Maintaining Long-Run Sustainability", .

Milbourn R. (1997) “Growth, Capital Accumulation and Foreign Debt”, Economica, Vol. 64, pp. 1-13.

Ng, S. & Perron, P. 2001, "Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power", Econometrica, Vol. 69, No. 6, pp. 1519-1554.

Ng, S. and Perron P., (2001), "Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power," Econometrica, Vol. 69, pp 1519-54.

Osei, B (1995) “Ghana: The Burden of Debt Service Payment Under Structural Adjustment, AERC Research paper 33.

Pattillo C, Poirson H., and Ricci L. (2001) “External Growth and debt”, IMF Working paper 02/69

Pattillo C, Poirson H., and Ricci L. (2004) “What are Channels Through Which External Debt Affects Growth?”, IMF Working paper WP/04/15.

Pearce C, Greenhill R, Glennie J. (2005) “In the Balance: Why Debts Must be Cancelled Now to Meet the Millennium Development Goals,” London: Jubilee Debt. Available online at: http://www.makepovertyhistory.org/docs/inthebalance.pdf (Accessed on August 19, 2008).

Pedroni P. (2000), “Fully Modified OLS for Heterogeneous Cointegration Panels,” Advances in Econometrics, Vol. 15, pp. 93-130.

Pedroni P. (2004), “Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the PPP Hypothesis,” Econometric Theory, Vol. 20, pp. 597-625.

Pesaran M. H. and Shin Y. (1995), “Estimating Long-Run Relationships from Dynamic Heterogeneous Panels,” Journal of Econometrics, Vol. 68, pp. 79-113

Pesaran M. H., Pierse R.G. and Lee K.C., (1993), “Persistence, Cointegration and Aggregation: a Disaggregated Analysis of Output Fluctuations in the US Economy,” Journal of Econometrics, Vol.56 Nos.1/2, pp.57-88.

Phillips P. C. and Hansen B. E. (1990), “Statistical Inference in Instrumental Variables Regression with I(1) Processes,” Review of Economic studies, Vol. 57, pp. 99-125.

Phillips P. C. B. and Moon H. (2000), “Non-Stationary Panel Data Analysis: An Overview of Some Recent Developments,” Econometric Review, Vol. 19, pp. 263-86

Phillips P. C. B. and Perron P., (1988), “Testing for a Unit Root in Time Series Regression,” Biometrika, Vol. 75, No. 2, pp. 335-346

Phillips, P.C.B. and Perron, P. (1988), "Testing for a Unit Root in Time Series Regression", Biometrika, Vol. 75, No. 2, pp. 335-346.

Presbitero, A.F. (2006), "The Debt-Growth Nexus: A Dynamic Panel Data Estimation", Rivista Italiana degli Economisti, Vol. 11, No 3.

Presbitero, A.F. (2007), "The Debt-Growth Nexus in Poor Countries: A Reassessment", Economics Discussion Papers, No. 2007-17.

Quah D. (1994), “Exploiting Cross-Section Variation for Unit Root Inference in Dynamic Data,” Economics Letters, Vol. 44, pp. 9-19.

Ramsey, F. (1928), “A Mathematical Theory of Savings”, Economic Journal, Vol. 38, pp 543-59.

Reisen, H. (1985), “Key Prices for adjustment Towards Less External Indebtedness,” Development Centre of the Organisation for Economic Co-operation and Development, Paris.

Romer, P. (1986), “Increasing Returns and Long-Run Growth”, Journal of Political Economy, Vol. 98, No. 5, part II, S71-S102.

Sachs J. (1989), “The Debt Overhang Problem of Developing Countries”, Paper presented in memory of Carlos Diaz-Alejandro, Helsinki, August.

Sachs, J. D. (1988), "Conditionality, Debt Relief, and the Developing Country Debt Crisis," National Bureau of Economic Research Working Paper No. 2644.

Sachs, J., Huizinga, H. and Shoven, J.B. (1987), "US Commercial Banks and the Developing-Country Debt Crisis", Brookings Papers on Economic Activity, Vol. 1987, No. 2, pp. 555-606.

Saikkonen P. (1999), A"symptotically Efficient Estimation of Cointegration Regression," Econometric Theory, Vol. 58, pp.1-21.

Sala-I-Martin X (1997) "I Just Run Two Millions Regression", American Economic Review, Vol. 87, pp. 178-83.

Schclarek, A. (2004), "Debt and Economic Growth in Developing and Industrial Countries", Working Papers No. 34. Department of Economics, Lund University.

Schultz T. W. (1961), "Investment in Human Capital", The American Economic Review, Vol. 51, No. 1 pp. 1-17

Schwarz, G. (1978), "Estimating the Dimension of a Model", The Annals of Statistics, Vol. 6, No. 2, pp. 461-464.

Semmler W and Sieveking M (2000), "Critical Debt and Debt Dynamics," Journal of Economic Dynamics and Control, Vol. 24, No 5-7, 1-24

Serven L. (1997), "Uncertainty, Instability and Irreversible Investment: Theory, Evidence and Lessons for Africa", World Bank Policy Research Working Paper, No 1722

Shin Y. (1994), "A residual-Based Test of the Null of Cointegration against the Alternative of No cointegration," Econometric Theory Vol. 10, pp. 91-115.

Smith G. W. and Zin S. E. (1991), "Persistent Deficits and the Market Value of Government Debt," Journal of Applied Econometrics, Vol. 6, No. 1, pp. 31-44.

Smith R. P. (2000), "Estimation and Inference with Non-stationary Panel Time-Series Data," Working Paper, Department of Economics, Birkbeck College London.

Smith, Adam, (1776/1937) "An Inquiry into the Nature and Causes of the Wealth of Nations", Reprint, edited by Edwin Cannan. New York: Modern Library, 1937.

Smyth D. J. and Hsing Y., (1995), "In Search of an Optimal Debt Ratio for Economic Growth", Economic Policy, Vol. 13, No. 4, pp. 51-59.

Solimano A. (1993) "Chile." In The Rocky Road to Reform, edited Taylor L. 129-148, Cambridge, MIT Press.

Solow R., M (1957), "Technical Changes and the Aggregate Production Function", Review of Economics and Statistics, Vol. 39, pp. 312-320.

Stock J. and Watson M., (1993), "A Simple Estimator of Cointegration Vectors in Higher Order Integrated System, Econometrica, Vol. 61, pp. 783-820.

Taylor L. (1993) "Stabilization, Adjustment and Reform," In *The Rocky Road to Reform*, edited Taylor L. 39-94, Cambridge, MIT Press.

Trehan B. and Walsh C. E. (1988), "Common Trends, Intertemporal Budget Balance and Revenue Smoothing," Journal of Economic Dynamics and Control, Vol. 12, pp. 425-44.

Trehan B. and Walsh C. E. (1991) Testing Intertemporal Budget Constraints: Theory and Applications to U.S. Federal Budget and Current Account Deficits, Journal of Money, Credit and Banking, Vol. 23, No. 2, pp. 206-223.

Uctum, M. and Wickens, M. (2000), "Debt and Deficit Ceilings, and Sustainability of Fiscal Policies: An Intertemporal Analysis", Oxford Bulletin of Economics and Statistics, Vol. 62, No. 2, pp. 0305-9049.

Uzawa, H. (1965), “Optimal Technical changes in an Aggregative Model of Economic Growth”, International Economic Review, No 6 pp 18-31.

Were, M. (2001) “The Impact of External Debt on Economic Growth and Private Investment in Kenya: An Empirical Assessment”, Wider Development Conference on Debt Relief 17-18 August 2001, Helsinki.

Wickens, M.R., Uctum, M. (1991), “The Sustainability of Current Account Deficits: A Test of the US Intertemporal Budget Constraint,” London Business School & Centre for Economic Forecasting.

Wilcox D. W., (1989), “The Sustainability of Government Deficit: Implications of the Present Value Borrowing Constraint,” Journal of Money, Credit and Banking. Vol. 21, pp. 291-306.

Wilcox, D. W. (1989), "The Sustainability of Government Deficits: Implications of the Present-Value Borrowing Constraint," Journal of Money, Credit and Banking, Vol. 21, No. 3, pp. 291-306.

World Bank (2003), “African Development Indicators” World Bank

World Bank (2004) “World Development Indicators”, CD-ROM.

World Bank (Various years) “World Debt Tables”, World Bank

Wriston W (1986), “Risk and Other Four Letter Words,” New York: Harper and Row

Wu, J. L., Chen, S. L. and Lee, H. Y. (2001), "Are Current Account Deficits Sustainable? Evidence from Panel Cointegration", Economics Letters, Vol. 72, No. 2, pp. 219-224.

Ziesemer T. (1995), “Growth and Imported Capital Goods, Limited Export Demands and Foreign Debt”, Journal of Macroeconomics, Vol. 17, No1, pp 31-53.