THE IMPACT OF PUBLIC INFRASTRUCTURE INVESTMENT ON ECONOMIC GROWTH IN THAILAND

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Abstract

Infrastructure traditionally holds centre place in nations' economic planning. New infrastructure promotes economic growth, expands trade, reduces poverty and improves the environment. Its importance worldwide invites significant informed debate over the effects of public infrastructure investment on economic development.

In economic downturns, the weighting of infrastructure investment in national budgets makes it a frequent contender for substantial cuts. During the Asian economic crisis in 1997, many infrastructure projects in Thailand were suspended or terminated. The inability to maintain an appropriate level of expenditure led to substandard transport and utilities for the country, impeding its growth. Because of the crisis, a fiscal sustainability framework was established by the Thai government to ensure adequate levels of revenue and investment expenditure within a balanced budget.

This study investigates the effects of public infrastructure investment on economic growth under Thailand's fiscal sustainability framework. A recursive supply-side model based on the Standard Neoclassical Model framework is used using Thai national data on public revenue (taxes, non-tax revenue and debt) to estimate infrastructure investment. An aggregate production function is used based on quarterly time series data from 1993 to 2006. This period comprises economic circumstances in Thailand including recession and recovery. Variables were subjected to unit root test to justify stationary status. If all variables were stationary, the Ordinary Least Square (OLS) method was used in estimation. If all variables were non-stationary and of an order I(1), then the cointegration test was conducted for long-run equilibrium. If the variables confirm cointegration, then the Error Correction Model was estimated using OLS, as the error correction term is constructed to estimate for coefficients. If the variables were found to have a mix of stationary and non-stationary variables, then the Autoregressive Distributed Lag model was used in the estimation. Finally, a simulation process was conducted, based on the estimated model, termed Infrastructure Finance Model for Emerging Economies. Simulation was carried out with ex-ante and ex-post scenarios: to generate a time-path within the data time period to prove model consistency; and for time-path values beyond the time period to provide prediction for policy decisions. The simulation consists of five scenarios: maximum borrowing or 20 per cent of budget; 15 per cent of budget; 10 per cent of budget; 5 per cent of budget; and no borrowing, or no effect on budget.

The results indicate that public infrastructure investment has a mixed effect on domestic growth. A positive result is found in lagged public investment as a proportion of GDP at the third quarter, confirming that infrastructure capital has a positive significant effect on economic growth. However, a negative impact is found in lagged real government investment at the second quarter. As public investment increases, the demand for resources also increases and, given full capacity for the economy, this may lead to increased costs of private investment, resulting in a fall in private investment and thus reduce economic growth (crowding-out effect). Hence, under conditions of full capacity, an increase in public investment could result in negative impact on growth. The Infrastructure Finance model is therefore a useful indicator of private sector intentions for resource expenditure.

Declaration

"I, ***Thanapat Reungsri***, declare that the PhD thesis entitled ***The Impact of Public Infrastructure Investment on Economic Growth in Thailand*** is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work".

Si nature **Date**

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The honour of this success is dedicated to my mother, who passed away in a car accident in October 2007. She gave me the confidence to pursue my dream so that I could set out to make this doctoral degree a reality.

Of great importance is the person who made this honour possible; my wife Patama Suchikul Reungsri has always stood by my side, supporting and encouraging me. I also thank my daughter, Napaskul Suchikul Reungsri (Melbourne) for being my inspiration and making me laugh during hardship.

Dedication

Dedicated to the three ladies of my life

Mother, Sutusanee Reungsri

Wife, Patama Suchikul Reungsri

Daughter, Napaskul Suchikul Reungsri

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List of Abbreviations

ADF	Augmented Dickey-Fuller
AEC	Asian Economic Crisis
ARDL	Autoregressive Distributed Lag
BIBF	Bangkok International Bank Facility
BOB	Bureau of the Budget
BOT	Bank of Thailand
C-D	Cobb-Douglas
CGE	Computable General Equilibrium
CIT	Corporate Income Tax
CPI	Consumer Price Index
CRTS	Constant Returns to Scale
DB	Domestic Borrowing
DF	Dickey-Fuller
DW	Durbin-Watson
ECM	Error Correction Model
ETR	Effective Tax Rate
FB	Foreign Borrowing
FPO	Fiscal Policy Office
FTA	Free Trade Agreement
FY	Fiscal Year[1]
GDP	Gross Domestic Product
GNP	Gross National Product
HD	Harrod-Domar
ICOR	Incremental Capital Output Ratio
IFMEE	Infrastructure Finance Model for Emerging Economies
IMD	Institute for Management Development
IMF	International Monetary Fund
IMGPI	Import Goods Price Index
IPPI	Private Investment Price Index
JJ	Johansen and Juselius
LM	Lagrange Multiplier
L-R	Long-Run
MOF	Ministry of Finance
NBER	National Bureau of Economic Research
NEDB	National Economic Development Board
NESDB	National Economic and Social Development Board

[1] Fiscal Year in Thailand starts from October to September

Abbreviations (cont.)

NIEs	Newly Industrialising Economies
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
PDMO	Public Debt Management Office
PIT	Personal Income Tax
PPP	Public-Private Partnership
PT	Petroleum Income Tax
R&D	Research and Development
RI	Retained Income
RTG	Royal Thai Government
SALs	Structural Adjustment Loans
SBT	Specific Business Tax
SEC	Stock Exchange Commission
SNM	Standard Neoclassical Model
SOEs	State Own Enterprises
S-R	Short-Run
TFP	Total Factor Productivity
THB	Thai Baht
TL	Transcendental Logarithmic
UNESCO	United Nations Educational Scientific and Cultural Organization
VAR	Vector Autoregression
VAT	Value Added Tax

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Chapter 1 Introduction to Study

Infrastructure is a profound determinant of nationhood, a measure of a country's success on the world stage. Physical infrastructure may be viewed as the manifestation of a country's economic power; social infrastructure's measures are the social capital and the standard of living of its citizens. A country's infrastructure capital may accumulate over generations or centuries, or it may occur over mere decades, as in East Asia and the Arabian Gulf countries. A nation's physical infrastructure is generally taken to mean its public capital: its community buildings such as hospitals and schools; transport nodes of airports, seaports, rail and road networks; utility services such as water, power and waste services. Infrastructure in all its commercial manifestations is viewed by governments as the means to attract substantial private sector investment. This empirical research considers the manner by which a country's infrastructure program is funded, and the interrelationships between infrastructure development and economic growth experienced by developing countries, in particular, Thailand.

This introductory chapter provides the research elements. First, the preparation for the thesis is presented. Extant research on public infrastructure and its relationship to economic growth is noted, together with an overview of the Thai financial environment. Next is the statement of purpose followed by research objectives, explaining the framework of this empirical research. The scope of the research and its significance within the literature are next presented, followed by the methodology employed, based on quantitative analysis.

1.1 Research Antecedents

There is a high cost, both financial and national, to infrastructure capital development. Governments may choose their projects unwisely, or conditions may change which render their efforts obsolete, or, indeed, the infrastructure may not appear attractive to private industry. The challenge for governments, including the Royal Thai Government (RTG), is to balance infrastructure development planning and its expenditure to meet, but not exceed, the objectives of social capital, or socio-economic growth, and those of the private sector.

Public infrastructure strategies are of great interest to economic researchers. Using a range of methodologies, they explore the relationship between infrastructure and economic growth. Primary in the literature is a sequential work by Aschauer (1989 references) where, using production function method, the researcher finds high output elasticities for public infrastructure capital. This triggered a well-documented debate, generally empirically based, to define the relationship between public infrastructure and economic growth performance. Confirming Aschauer's results, a majority of studies[2] find a strong and positive relationship between the two variables; nevertheless, a significant number of researchers found little evidence to support the positive effects of public infrastructure on growth[3].

There is, however, relatively little discussion in the literature on the means by which governments finance their public infrastructure programs. The funds flow required for a particular public infrastructure program extending over several years can affect the economy as a whole. An example of a large undertaking is that of building new capital cities, Brasilia in 1960, and Naypyidaw in Myanmar/Burma in 2005. Brasilia's growth exceeded the planners' expectations, thus affecting Brazil's capacity to fund infrastructure elsewhere; whilst Rangoon's infrastructure and thus economic activity was adversely impacted by scarce resources directed north to the new city. Alternatively, the cities that Saudi Arabia is building for future generations in its regional areas offer the positive aspects of increased public and social capital, and are within the Kingdom's capacity to develop.

Infrastructure development funding varies according to a country's circumstances. To generate sustainable funding streams for projects, developing nations must trade successfully on the world market and attract private finance. With its established infrastructure and free-enterprise economy, and generally pro-investment policies, Thailand's robust economy is successful in attracting international investment with its attendant financial flows into public coffers. Indeed, the RTG relies on taxation for approximately 90 per cent of its revenue, the majority of which is indirect tax (65%). Hence, if the government wishes to increase infrastructure investments without reducing other government expenditures, it will need to increase revenue through taxation or borrowing. For infrastructure investment, further sources of finance are retained income and domestic and external debt (domestic and foreign borrowings). However, the revenue generated from all these sources is insufficient for the scale of infrastructure development that the government desires (MOF 2005).

[2] Dalamagas 1995a; Lau & Sin 1997; Munnell 1990, 1992a, 1993; Otto & Voss 1994; Ram & Ramsey 1989; Ramirez & Nazmi 2003; Wylie 1996)

[3] Ford & Poret 1991; Holtz-Eakin 1994; Holtz-Eakin & Schwartz 1995a & 1995b; Hulten & Schwab 1991b; Sturm & De Haan 1995).

As countries are subject to international scrutiny, the International Institute for Management Development (IMD) is one organisation that reports on the competitiveness of nations. Its World Competitiveness Scoreboard for 55 nations compares four competitiveness factors: economic performance, government efficiency, business efficiency and infrastructure. In 2008, Thailand was middle ranked at no. 27, index of 63, nevertheless up from no.33 the year before. Its ranking, and therefore its competitiveness, was less than Japan’s index 70; Malaysia, index 73; China, index 73.8; Taiwan, index 77; Australia, index 83.5; Hong Kong, index 95; and Singapore’s index of 99. USA’s index was 100. The results show that Thailand should focus on public and private sector efficiency and performance, and especially plan for infrastructure development (IMD 2008).

A country’s infrastructure expenditure may reach a percentage of Gross Domestic Product; it is thus discretionary, and vulnerable in times of budgetary restraint. This point is illustrated by the 1997-1998 Asian Economic Crisis (AEC) when the majority of Thailand’s infrastructure projects, both planned and in construction, were affected by budgetary restraint and subjected to a massive withdrawal of funding. This resulted in adverse social issues regarding inadequate public facilities, made worse by infrastructure deterioration and increasing population pressures. As part of its strategy to recover from the debilitating economic effects of the crisis, RTG used infrastructure investment as a means to revitalise the Thai economy; however, as noted, the government could not fund sufficient projects to meet its infrastructure program.

In the years following the AEC, Bangkok pursued preferential trade agreements with a variety of partners in an effort to boost exports and achieve high economic growth. Thailand became one of East Asia's best performers in 2002-2004. Then the economy, and infrastructure, was sequentially affected by the devastating 2004 Boxing Day tsunami, and the military coup of 2006, with recovery slowed until the late 2007 elections. Foreign investor interest was dampened in 2006 by a 30 per cent reserve requirement on capital inflows, and discussion of amending Thailand's rules governing foreign-owned businesses. Nevertheless, the Thai economy recovered, experiencing high export growth and GDP reached 4.5 per cent in 2007.

The RTG thus learned from its AEC experience. The Ministry of Finance (MOF) committed to a fiscal sustainability framework, including adequate funding for infrastructure investment. The framework is illustrated below at Table 1.1, Fiscal Sustainability Framework.

Table 1.1
Fiscal Sustainability Framework

Fiscal Indicator	**Target** (Percent)
Public debt/GDP	≤ 50
Debt service/budget	≤ 15
Budget balance	Balance
Capital expenditure/budget	≥ 25

Source**:** MOF (2005)

Table 1.1 outlines the four components of the targeted fiscal sustainability framework adopted in Thailand. The first component of the MOF framework targets the public debt to GDP ratio to 50 per cent. Second, servicing debt must remain under or equal to 15 per cent of the RTG's budget, which, third, should be balanced. The last item of the framework is that capital expenditure must be at least 25 per cent of the annual budget. The Framework thus restricts the MOF's flexibility in deficit financing (MOF 2005). A further financial response adopted by the RTG was the *Public Debt Management Act 2005*, which, inter alia, controls government debt. When budgetary expenditures exceed revenue, the MOF may borrow up to 20 per cent of budgetary expenditures plus allowance for extraordinary expenditures, and 80 percent of approved budgeting on debt principle repayment (RTG 2005).

Besides taxation, as noted above, public funds are sourced from retained income, that is, the revenue from state-owned enterprises (SOEs), minus expenditure, corporate income tax, dividends and distribution, and bonuses paid to employees. A history of retained earnings is shown at Table 1.2 Retained Income from Non-financial SOEs and GDP, 1993-2006, below.

Table 1.2

Retained Income from Non-financial SOEs and GDP, 1993-2006

Year	Retained Income (Billion Baht)	GDP (Billion Baht)	Per cent of GDP
1993	87.92	3,165.20	2.78
1994	108.79	3,629.30	3.00
1995	132.19	4,186.21	3.16
1996	148.33	4,611.04	3.22
1997	113.72	4,732.61	2.40
1998	116.14	4,626.45	2.51
1999	118.26	4,637.08	2.55
2000	123.13	4,922.73	2.50
2001	155.32	5,133.50	3.03
2002	183.48	5,446.04	3.37
2003	197.53	5,930.36	3.33
2004	201.71	6,576.83	3.07
2005	263.34	7,195.00	3.66
2006	233.85	7,820.93	2.99
Average			**2.97**

Source: BOT (2007)

At Table 1.2, retained income from public enterprises external to the financial sector shows a retraction and then slow growth after the 1996-1997 AEC, accelerating as the economy recovers. Similarly, retained income as a percentage of GDP rises until 2002 and then remains relatively stable, averaging 2.94 per cent over the decade.

Public financing for its infrastructure program is critical to Thailand's economy. This study explores issues which underlie the fiscal sustainability framework, and their existing and potential impacts on the country's economy. This empirical research is conducted through quantitative analysis techniques derived from statistical literature, and its findings therefore allow comparison with other economic research, and thus add to the body of knowledge.

1.2 Statement of Purpose

The majority of research, as noted above, supports a significant and positive relationship between public infrastructure and economic growth. Nevertheless, there is an element of risk involved for government policymakers who depend on such research to predicate economic outcomes from various strategies. This risk is especially relevant in Thai public funding, where there is no empirical study on the relationship between the two variables. The majority of related studies refer to the positive and significant relationship found by Aschauer (1989a); however, the impact of public infrastructure on economic growth in Thailand remains unclear.

Moreover, financing public infrastructure is a crucial issue, especially in emerging economies where budgetary surpluses are difficult to achieve and income flows are vulnerable to global forces (Merna & Njiru 2002). Because incomes are lower in developing countries, savings are low and thus investment is low. Older and stronger economies have the financial resources to recover quickly from an economic downturn. Generating sufficient public infrastructure funds arguably will remain an issue for Thailand, and academic inquiry is necessary to give some direction to its policymakers. This is the statement of purpose for this thesis.

In relation to the statement of purpose, this empirical research poses two questions, the first of which is *To what extent can the Thai government raise funds for infrastructure investment under its fiscal constraints?* This question should first be resolved, which allows the second question to be raised: *What is the impact of fiscal constraints on economic growth in Thailand?* To address the first question, a public revenue generation model is presented which estimates the public revenue available for public infrastructure investment under different conditions. The second question is answered using 1993 to 2006 government investment data, analysed by Aschauer’s production function approach.

As public investment outflows are continuous, the study, to answer the primary question on funds raising, simulates time-paths for investment capacity and economic growth. In such simulation processes, various scenarios are generated by placing parameters for government debt, including domestic and foreign borrowing variables. This methodology confirms the consistency of the model performance.

1.3 Study Objectives

The aim of this research is to identify the inputs and the processes comprising public infrastructure investment in Thailand. This study includes a literature survey, identification of relevant public finance data, then a quantitative analysis leading to conclusions and findings for the following objectives:

- define the effects of public infrastructure on economic growth in Thailand
- develop a public revenue generation model to determine the country's capacity to invest under fiscal policy constraints; acting through alternative public financing methods
- simulate the effects of public infrastructure on economic growth due to variations in fiscal policy constraints; again acting through alternative financing methods.

1.4 Research Scope and Significance

This study examines the effects of public infrastructure investment on economic growth in Thailand, by means of empirical research and quantitative analysis. It should be noted that, as the social consequences of infrastructure investment are difficult to measure and little data are available, the financial aspects of public infrastructure investment alone are analysed.

The scope and design of the research is as follows. First, a literature review is undertaken to identify the nature of extant research on infrastructure inputs and effects, and to analyse the themes that emerge from the findings. Further, international research is examined over the relevant period to find points of comparison with Thailand's experiences. Second, the study is timely, as public infrastructure investment has recently achieved a policy focus in Thailand. As Thailand is a developing country, this study extends research from its existing focus on the financial environments of mature economies to the dynamics of an emerging economy. Thirdly, this study concentrates on the quarterly time series data from 1993:Q1 to 2006:Q4. The period covers different economic circumstances in Thailand of recession and recovery. Moreover, the complete data on public revenue are only available from 1993 onward.

The significance of this research is embedded in the notion that adequate investment in national infrastructure is critical to socio-economic growth for Thailand, thus finance is an ongoing priority for the RTG. The circumstances regarding infrastructure finance, and the relationships between public infrastructure and economic growth, are the topics of considerable debate in developed economies; however, there are few Thai studies of this nature. Findings of researchers studying other economies under other conditions may indeed have relevance to the case in Thailand; nevertheless, these assumptions should be tested.

Moreover, researchers generally consider only public finance through either taxation and debt financing, or taxation and seigniorage financing[4]. In practice, governments may access various sources and combinations of finance. Sources for fiscal policy financing comprise taxation revenue, domestic and foreign borrowings, and retained income. If not already fully exploited, these facilities can contribute considerable additional public capital to permit funds flows to infrastructure development. The volume of potential finance available to RTG is therefore a significant element of this study.

In addition, empirical studies in Thailand focus on the market equation model, omitting the public infrastructure investment issue and financing sources. Thus, in this study, system estimation investigation permits the omitted elements to be addressed.

This study contributes to the literature through a series of innovative approaches and regional applications. It is timely and relevant to the RTG policymakers, as the following factors illustrate.

- There is no identified research that investigates public infrastructure expenditure's impact on Thai economic growth, presumably due to a lack of data. Public infrastructure-related studies for Thailand tend to rely on Aschauer (1989a) who found a significant and positive effect of public infrastructure on economic growth.
- The Thai literature does not distinguishing between public consumption and public investment. This research places emphasis on public investment, specifically, infrastructure investment. The intended effect of this emphasis is to provide specific knowledge and a deeper understanding of the impact of public investment, especially infrastructure, on the Thai economy. This facilitates more effective policymaking for investment-specific policies.
- The literature strongly supports the notion that public infrastructure investments significantly and positively affect economic growth. However, few studies address the financing of infrastructure and those that mention this aspect do so superficially. This study takes the approach that finance is a function of investment; investment is an indicator of economic growth; and these arguments may be 'located' within the RTG's fiscal sustainability framework.

[4] Espinosa-Vega & Yip 1999, 2002; Hung 2005; Levine & Krichel 1995; Ozdemir 2003; Palivos & Yip 1995

- The literature tends to consider only two sources of public financing: taxation and deficit financing. This study attempts to extend the research by including other sources of debt financing, and retained income.
- There are few Thai studies, as noted, and those researchers tend to use the market model equation for analysis without specifically addressing public infrastructure investment. This study includes infrastructure investment with quantitative analysis through a recursive supply-side system equation model.

1.5 Methodology

The methodology for this empirical research employs quantitative analysis. The computation for the estimation of public revenue and aggregate production function is based on quarterly time series data taken from the first quarter (Q1), 1993 to the fourth quarter (Q4), 2006. This timeframe encompasses a period of recession (the AEC) and Thailand's subsequent recovery despite natural disaster and political uncertainty.

The data were obtained from the Bank of Thailand, the National Economic and Social Development Board, the Ministry of Finance, the Revenue Department, the Excise Department, and the Customs Department. A recursive supply-side model based on the Standard Neoclassical Model framework is used. All variables used in the study are aggregate national data, and as such are subject to the unit root test using Dickey-Fuller and the Augmented Dickey-Fuller test to justify the stationary status. Implications of the unit root test result on the estimation procedures are first, no unit root, i.e., all variables are stationary, thus the Ordinary Least Square (OLS) method can be used in estimation. Second, if all variables in the equation are found to be non-stationary and of an order I(1), then the cointegration test can be conducted to find the existence of a long-run equilibrium relationship. If the variables confirm the existence of cointegration, then the conventional Error Correction Model is estimated using OLS which confines short-run dynamics and long-run equilibrium as the error correction term will be constructed using the Error Correction Model to estimate for coefficients. Third, if the variables are found to have a mixture of stationary and non-stationary variables, then the Autoregressive Distributed Lag model is used in the estimation.

Finally, a simulation process is conducted, based on the estimated model. The variable that has been paramatised in the model is the government borrowing including domestic borrowing and foreign borrowing. Simulation is carried out with ex-ante and ex-post scenarios. An ex-ante scenario involves generation of a time-path within the data time period to validate model consistency. The ex-post scenario involves generation of time-path values beyond the time period used during the analysis, and thus provides prediction for decisionmaking. The simulation consists of five scenarios: maximum borrowing or 20 per cent of budget; 15 per cent of budget; 10 per cent of budget; 5 per cent of budget; and no borrowing, or no effect on budget.

1.6 Chapter Summary

This thesis consists of seven chapters, the order of which follows. Chapter 1 introduces the study on the relationship between public infrastructure and economic growth, and comments on the factors that initiated the research, its purpose and methodology. Chapter 2, a comprehensive literature survey, explores the nature of extant research on public infrastructure, governments' varied means for funding and their preferred strategies, and differences between fiscal responses based on regional economic environments. Of particular interest to this study are reported findings and conclusions on the effects of public infrastructure programs on economic growth.

Considerable research, involving several theoretical approaches and models, focuses on the relationship between public infrastructure and economic growth, Chapter 3 reviews the model structures employed for the various analyses of this relationship; further, the chapter includes extant studies on financing infrastructure programs, the findings of which are used for later comparison in this study.

Chapter 4 returns to the empirical nature of this research and provides an overview of Thailand's environment, its economic and infrastructure development, together with an analysis of infrastructure investment demand. To meet the objectives of this thesis, that is, identifying potential funding (s1.3), the public finance structure in Thailand is reviewed.

The study's methodology and its analytical model design structure are discussed in Chapter 5, together with information on the data sources and the nature of their data. At this point, the selected econometric model estimation techniques are also discussed in preparation for the data analysis. Chapter 6 provides the estimation analysis and all results. The model simulation is conducted using ex-ante and ex-post techniques and the results are compared with extant research findings.

Chapter 7 summarises the major findings of the study, drawing conclusions from the findings, and notes policy implications for Thailand's decision makers. These include potential sources of finance which could be diverted to infrastructure, the relationship between infrastructure investment and economic development, and potential synergies that could assist Thailand's growth prospects. Finally, the limitations of the thesis are acknowledged, and there are suggestions for further research.

The thesis therefore embarks on its journey, holding the writer's aspirations to enjoin economic debate that will encourage and facilitate development in Thailand, for the wellbeing of its people, now and in the future.

Chapter 2 Context of the Research

Codified early in the Industrial Age by Adam Smith's 1776 *Inquiry into the Nature and Causes of the Wealth of Nations*, economic development can be viewed as the world's economic journey. The evolution of growth and the dynamics of economic development are subjects of intense research and debate. Central to this thesis, public infrastructure is accepted in the literature as an important component of economic development, and as such, the issue of infrastructure financing is raised. In this argument, the nature of a government's financed infrastructure program is critical to the country's socio-economic development, and its status among the world's communities.

This chapter reviews the research; theories relating to economic growth, the determinants of growth and the role taken by infrastructure. The chapter begins with a review of economic growth and development theory. The determinants of growth, impact of infrastructure development, indirect effect of growth and development, and the effects of public infrastructure investment are discussed. The focus then turns to the interrelationship between public infrastructure investment and economic growth; including the nature of infrastructure, its effects on economic growth and the related empirical studies. This is followed by the sources of public infrastructure finance, and empirical studies on the linkages between financing public infrastructure and economic growth.

2.1 Economic Growth

Economic development and *economic growth,* both progressive economic phenomena, are closely related. Until the 1960s, economic development theory was treated as an extension of conventional economic theory and therefore development was merely equated to growth. Growth, in this sense, is simply defined as an increase in national production (Hall 1983). However, Dudley Seers (1969) earlier argued that development should not be narrowly confined to growth; it should include social equity aspects, such as reduction and elimination of poverty, inequality, and unemployment.

Later, the economist Todaro (1989) broadened the concept of development to be

> *conceived of as a multidimensional process involving major changes in social structures, popular attitudes, and national institutions, as well as the acceleration of*

economic growth, the reduction of inequality and the eradication of absolute poverty (p.88).

Economic development, according to Todaro (ibid.), incorporates the social factors of education and health improvements, and environmental protection; with the economic benefits of efficient allocation of resources, and sustainable growth. Defining economic development through civic society concepts as well as those relating to the public and private sectors results in potential factors that are qualitative and rarely quantifiable (Jomo & Reinert 2005). Further, Hirschmann (1958) noted that, depending on economic needs or priorities, a government's focus for development can vary by country and by the times. Since the concept is broad and derived from qualitative factors, the measurement of development remains a challenge. However, the majority of empirical economists argue that accurate measurement of quantifiable outcomes can provide a proxy for the contributions of non-quantifiable effects.

To measure the effects of public investment in infrastructure for this study, a quantifiable indicator to approximate development is required. Economic growth is the leading indicator for this task, as it can be measured through Gross National Product (GNP) or Gross Domestic Product (GDP) and these are generally used as a proxy for overall economic development (Sen 1988).

2.1.1 Economic Growth Theory

Economic growth and its determinants are traditional sources for debate. Early work in the genre was undertaken by Harrod (1948) and Domar (1946), who independently used a Keynesian model to analyse economic growth in a closed-economy framework, thus jointly producing the Harrod-Domar (HD) model.

The HD model is based on three assumptions. First, the economy generates savings (S) at a constant proportion (s) of national income (Y):

$$S = sY \qquad (2.1)$$

where s is the marginal and average saving ratio.

Second, the economy is in equilibrium, that is, planned investments equal planned savings:

$$I = S \qquad (2.2)$$

Third, investment is determined by the expected increase in national income (ΔY) and a fixed technical coefficient v, known as Incremental Capital Output Ratio (ICOR):

$$I = v\,\Delta Y \qquad (2.3)$$

By definition, economic growth rate (g_y) is the change in income per unit of income

$$g_y = \frac{\Delta Y}{Y} \qquad (2.4)$$

Substitution of the relationship in equations (2.2) and (2.3) gives an alternative definition of growth as

$$g_y = \frac{s}{v} \qquad (2.5)$$

The above equation (2.5) implies that, if the underlying assumptions are fulfilled, then the economy grows at a rate determined by the parameters s and v.

However, at least two of these assumptions may not hold in practice. Firstly, the fixed ICOR implies that there is a fixed relationship between the amount of capital stock and the output. Secondly, since labour input is not introduced in the model, the assumption is made that the labour supply is elastic (Siggel 2005, p.38). Both these assumptions are weak and thus unlikely to hold.

A later model derived by collaboration between Solow (1956) and Swan (1956) relaxed the assumptions of fixed ICOR and the labour usage in the HD model. The modified model is known as the *Solow-Swan* or simply the *neoclassical* growth model. The key aspects of the Solow-Swan model are the addition of labour as a factor of production and a time-varying technology variable distinct from the capital and labour factors. Moreover, the Solow-Swan model assumes constant returns to scale (CRTS), diminishing returns with respect to each input, and positive elasticity of substitution between the inputs.

Shortly after, Solow's (1957) study showed that technological change accounted for almost 90 per cent of the US' economic growth in the late 19th and early 20th centuries. The increases in the factors of production (capital and labour) contributed relatively little to output growth, due to the law of diminishing returns[5]. Therefore, the researcher argued, technological progress or total factor productivity (TFP) is the major determinant of growth

[5] Law of diminishing returns: the return on investment decreases as more capital is introduced until the expected return from an increase in investment is below the investment cost.

and determined exogenously. Solow's findings suggest that technological progress allows greater options for input combinations to improve efficiency, leading to a higher level of economic growth.

However, Solow's model failed to explain how or why technological progress occurs. Arrow (1962) and Sheshinski (1967) advanced the model structure further by incorporating *learning by doing* behaviour to explain the increase in productivity due to technological progress. Their respective models explain that each technological discovery immediately spills across the entire economy and thus to a higher level of economic growth.

Romer (1986) provided an alternative model with a competitive framework to determine an equilibrium rate of technological progress, but conceded that the result of growth rate would not be Pareto optimal[6]. However, the competitive framework will not hold if discoveries depend partly on research and development (R&D) effort and if a given innovation spreads only gradually to others (producers). Under such a realistic environment, a decentralised theory of technological progress is required to accommodate the imperfect competition in the real economy.

Endogenous Growth Theory

The deficiencies in the neoclassical growth model led to the development of endogenous growth theory. The incorporation of R&D variables and imperfect competition into the growth framework began with Romer (1987; 1990). Other significant contributors include Aghion and Howitt (1992) and Grossman and Helpman (1991). In the endogenous growth model, technological advances result from R&D activity, and technological progress and knowledge accumulation are treated as endogenous variables, thus it is also termed the endogenous growth theory. According to the model, the long-run growth rate depends on a stable business environment: government policies and actions on taxation, law and order, provision of infrastructure services, protection of intellectual property rights, and regulation of international trade, financial markets, and other aspects of the economy. Hence, the government guides long-term growth (Barro 1997).

Investment is also an important determinant in the endogenous growth theory model, allowing improvement in productive capacity, and increasing profits that lead to growth. As noted, neoclassical growth theory assumes that, following the law of diminishing returns,

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6 Pareto optimal is the state when an alternative allocation of inputs cannot make one individual better off without making any other individual worse off (Salvatore 1994).

investment has a limited role in promoting economic growth and a continuous increase in the factors of production (investment) is unlikely to yield growth. Under endogenous growth theory and despite the law of diminishing returns, marginal factor productivity can be increased. For example, technical progress that is funded by capital investment increases productivity. Similarly, new skills through improved education and training, and better health, tends to increase the productivity of labour. Also, the endogenous growth approach argues that there is a role for government institutions that can overcome any market failures associated with the various types of investment. Hence, investment is crucial to economic development and growth. Further, endogenous growth theory states that the improved technology accessed by investment drives growth; thus, investment may contribute to a long-run rate of economic growth (Economic Planning Advisory Commission (Australia) 1995).

2.1.2 Determinants of Economic Growth

The brief summary of growth theory at s2.1.1 identifies three contributing factors: capital accumulation, human capital (including education and learning), R&D and innovation (improved technology). Stern (1991) postulated extensions to the standard growth determinants by including organisational management; the allocation of resources to directly productive sectors; and infrastructure. These factors are discussed below.

Organisational Management

Well managed organisations, Stern (1991) argued, increase output by minimising waste and improving efficiency, whilst poor management restrains productivity. For example, during the 1960s and 1970s India succeeded in increasing its savings rates, but due to inadequate management failed to attain a higher level of growth rate (Ahluwalia 1985).

Resource Allocation

For the second determinant, Stern (ibid.) found varying institutional arrangements regarding resource acquisition in developing countries' industrial sectors. In these cases, economic distortions can prevent optimum resource distribution, impeding economic growth and thus affecting social equity. In this context, inadequate resource allocation can result in reduced national productivity. Chenery (1979), and Chenery, Robinson and Syrquin (1986) found evidence to support this view.

Infrastructure

Stern's (1991) third factor, adequate infrastructure, is essential for productivity and growth and recognised as such since Adam Smith's 1776 vision of economic development. Transport in particular is an important factor for development. Smith expressed this as *no roads, no transport, no trade, no specialisation, no economies of scale, no productivity progress, and no development* (Prud'homme 2004).

Infrastructure spending predominates in public capital investment. Hence, public infrastructure investment is accepted as an essential component of economic development and growth. In low and middle-income countries, services associated with infrastructure account for seven to nine per cent of GDP. Infrastructure in these countries typically represents about 20 per cent of total investment and 40 to 60 percent of public investment (World Bank 1994). Moreover, the World Development Report (ibid.) concluded that one per cent increase in the stock of infrastructure is associated with one per cent increase in GDP across all observed countries. Hence, inadequate infrastructure results in low productivity, and if a country's economic situation deteriorates and infrastructure deficiencies overlap, such as communications and transport, the effect is compounded. Following Stern's growth theory determinants, Barro (1997) conducted a study to identify determinants across 114 countries, testing for a range of variables. Barro's findings extended Stern's growth factors to include levels of education, life expectancy, fertility, rule of law, government consumption, inflation, and the terms of trade. The researcher also tested for democracy; however, this result was weak.

Summary

Whilst all economic growth theories exhibit aspects which are relevant to this study, the endogenous growth model was selected as it more readily encompasses dynamic aspects of infrastructure development, technology and skills formation to explain economic growth. As public infrastructure development is government-driven, it affects both society and industry, directly and indirectly. The endogenous growth model is sufficiently flexible to incorporate the inherent variables of this study.

For the growth model determinants relevant to this thesis, Stern's 1991 model was adopted. Whilst it is acknowledged that Barro's 1997 socio-economic factors are reflected in the dynamics of the endogenous growth model, this researcher is unable to source reliable data in Thailand over the period 1993-2006, or indeed, pursue a largely qualitative analysis of social factors in the framework of this thesis. This empirical research is largely a quantitative analysis to identify the level of funding the Thai government, under its fiscal constraints, can realise for infrastructure investment. When this is resolved, the impact of fiscal constraints on economic growth in Thailand may then be examined.

2.2 Infrastructure Development

This study uses endogenous growth theory to explain the relationship between public infrastructure and economic growth. Investment in endogenous growth theory is a crucial factor of economic development and growth (s2.1.1). The theory states that the technology embodied in this investment drives growth; thus, investment is a contributor to long-run economic growth. Infrastructure investment is derived from both the public and private sectors, although the former provides socio-economic benefits for society through health, education and security (public good), and the latter provides its benefits through profits for investors, jobs, and taxes (private good).

The theoretical distinction between public and private good can also be explained using the characteristics of *rivalry* and *excludability*. Public good is non-rivalled and non-excludable which means, respectively, that consumption of the good by one individual does not reduce availability of the good for consumption by others; and that no one can be effectively excluded from using the good (Musgrave & Musgrave 1984). Using this argument, a public good, a hospital or a school, may offer profit to the private sector through construction, maintenance or operations; however, this occurs through public tender and contract. Whilst private philanthropists can donate public infrastructure, the overriding truism is that governments are the decision makers for public infrastructure programs and therefore also decide priorities and the financing mechanisms; hence, public investment provides a public good.

In an empirical study, Barro (1990) opined that public investment should be included in a production function as a separate variable from private capital stock, since private capital stock may not be a close substitute of public capital, especially in providing public goods. To a degree, the non-excludable characteristic distinguishes public services from private goods investment; however, other models for public infrastructure appeared in the last decade, including public-private partnerships.

2.2.1 Definitions

Public infrastructure refers to large scale civic construction which directly or indirectly promotes economic development. Although the term dates from the 1920s, referring then to public works such as roads, bridges and rail, it was not given greater attention until later last century (Prud'homme 2004). Definitions in the literature for infrastructure in its private production guise, and as a socio-economic public benefit, are now almost generic in their breadth. An earlier definition was developed by Nurske (1953), to the effect that infrastructure comprised elements that provide services for production capacity; Nurske also opined, perhaps less sector-related, that infrastructure is large and expensive installations. Hirschman (1958) and later Biehl (1994) defined infrastructure as capital that provides public services. Whilst the nature of infrastructure commonly appears to have a fundamental cross-sector aspect; that is, providing structures by government or management to achieve a goal or a desired outcome (production, distribution; communications, health, education), there is acceptance in the literature that infrastructure investment has a strong public involvement.

There is a body of opinion that determines public infrastructure from its private sector perspective. Argy, Linfield, Stimson and Hollingsworth (1999) and Prud’homme (2004), define the nature of economic infrastructure thus:

- it is long life construction with a long pay-back period
- it is capital intensive and cannot be directly consumed
- its genesis is associated with market failure
- there is a relatively high level of government involvement
- it has a location, as it is generally immobile
- it provides a service for both households and private enterprises.

However, social infrastructure for education and health is not included in this list of characteristics on the grounds that social infrastructure input improves the quality of labour for the private sector, and is not capital input. The argument taken in this study (s2.2.4) is that the socio-economic effects of public and private infrastructure are interlinked; however, the focus for this thesis is that economic infrastructure relates closely to economic growth and thus social infrastructure data are not analysed.

2.2.2 Measures

Public capital stock is often accepted as a proxy for infrastructure stock. Rietveld and Bruinsma (1998) opine that public capital stock differs from infrastructure as capital items such as telecommunications and oil pipelines are generally not of public capital origin. On the other hand, public capital such as defence materials and public service resources are not usually defined as infrastructure. However, Prud'homme (2004) argues that the elements accepted as public capital stock, but not infrastructure; and the elements taken as infrastructure, but not public capital stock, cancel out; the net result is that public capital stock equals infrastructure stock.

Units

Infrastructure is accounted as physical units and costs; roads, canals, and railways, for example, are measured in kilometres and public funds deployed. Measurement is difficult: to map the progression and the economic contributions of large infrastructure projects years of time-series data are required. Analysis of public capital stock also depends on the availability and quality of information, and in many developing countries long-term data are not available. Researchers therefore use proxies for public infrastructure: kilometres of paved roads, kilowatts of electricity generating capacity, and number of telephones (Canning & Pedroni 1999; Esfahani & Ramirez 2003).

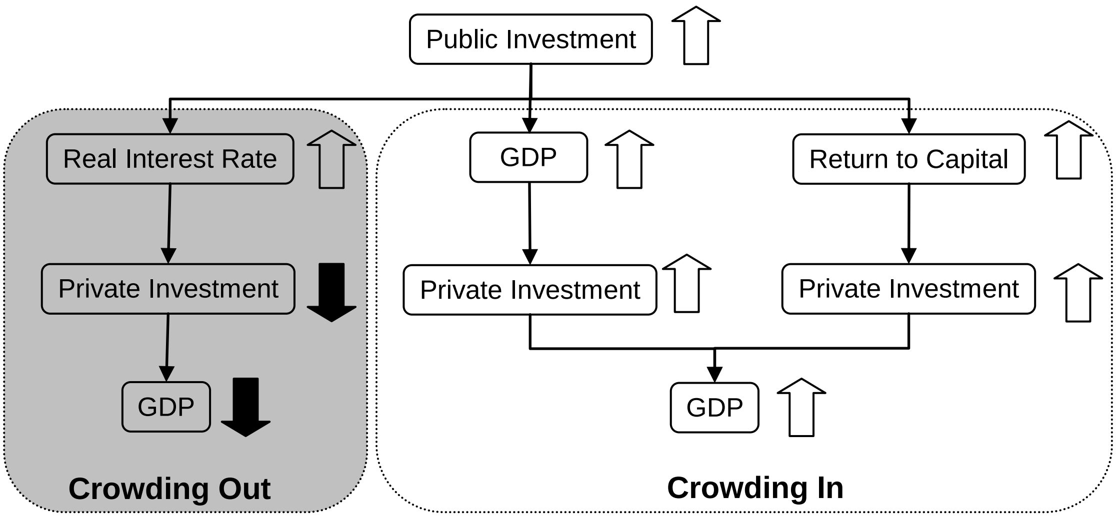
The advantage of using physical counts of infrastructure is that they are not reliant on national accounts, which can give prominence to the public investment provider. For instance, the electricity generating entity is not important (Romp & De Haan 2005). Nevertheless, the interpretation of physical measures is complicated and its analysis results difficult to compare; for example kilometres of two-lane roads are not comparable with kilometres of four-lane highways (Rietveld & Bruinsma 1998). Moreover, simple physical measures do not account for quality or purpose and thus such singular measures do not reflect the outcomes of government spending.

Finance

Financial investment is an alternative to address issues arising from unit measures, as financial data on capital stocks are generally available and infrastructure is costed as a flow variable: its annual investment. There are issues, however: costing requires adjustments for economic conditions and the cost of funding. Also, international or regional comparability is difficult given construction and payback time, accounting methodologies may differ, price indexes may change, and construction costs vary, particularly in developing countries, due to inefficiencies in government investment (Canning & Pedroni 1999, Pritchett 1996).

2.2.3 Economic Effects

By its scale, public investment impacts economic growth. Government may use investment as a budgetary measure to encourage private investment or to dampen demand. In the Keynesian economic paradigm, these effects of government expenditure are termed *crowding in* and *crowding out* (of private investment). These concepts are illustrated at Figure 2.1 Transition Mechanism of Public Investment (Aromdee, Rattananubal & Chai-anant 2005)



Source: Aromdee, Rattananubal, and Chai-anant (2005)

Figure 2.1: *Transition Mechanism of Public Investment*

Figure 2.1 shows that, as public investment increases, the demand for resources (including production factors such as capital and labour) also rises. This leads to an increase in interest rates and supply of capital and labour inputs, which, in turn, directly affect the cost of private investment, thus crowding it out of the money market. In this sequence of events, a cost increase for private investment may result in reduced output (GDP) caused by a fall in private investment. Hence, an increase in public investment may result in reduced economic growth (Aromdee, Rattananubal & Chai-anant 2005). The authors confirm Aschauer's (1989b) claims that the majority of public investment can have a negative effect on the level of private investment, that is, the crowding out aspect.

This view is challenged by Agenor and Montiel (1996), who state that in the case of developing countries, government budget deficits have a minimal effect on interest rates and the crowding out effect is thus minimised. The authors claim that public investment authorities in developing economies are more concerned with identifying funding sources than the interest rates involved. Public investment in developing countries may therefore have little crowding out effect on private investment (Rama 1993).

The crowding in effect occurs when public investment directly stimulates economic growth by increasing national income which in turn induces the private sector to increase investment. Moreover, public investment, especially in infrastructure, also creates a better investment environment for private investors by providing opportunities to increase production efficiency and raise the return on capital (Aromdee, Rattananubal & Chai-anant 2005).

In growth theory, the impact of infrastructure investment on GDP depends on its net effect on private investment. If the crowding out effect prevails, then the growth multiplier of infrastructure investment is negative. The reverse is applicable; if infrastructure investment produces a crowding in effect, then there is a positive result for the economy. Hemming, Kell and Mahfouz (2002) found that the multiplier effect in developing countries ranged from 0.6-1.4, indicating a high crowding in effect, whereas in developed countries they expect a relatively smaller or negative multiplier. In situations of financial asperity, therefore, there is a greater probability of a crowding out effect for developed economies. These tenets are explored further in s.2.3.

2.2.4 Social Effects

The importance of infrastructure in economic development dates from Adam Smith’s era, although its influence diminished over time. In the modern era, the status of infrastructure was reasserted after World War II and, since the 1960s it has emerged as a fundamental element of economic management. It was used in many countries to address war damage, when the World Bank and other organisations financed infrastructure renovation programs. Later, these programs were used to install technological advances in emerging economies for both humanitarian and economic purposes, the former for social benefits and the latter to permit trade with developed countries (Prud'homme 2004).

Infrastructure investment affects economic growth by increasing private sector productivity. It differs from other growth factors inasmuch as it is indirect; a facilitator in the production process. As a contributor to economic development, infrastructure development can assist by reducing production costs, diversifying production into higher return activities, and raising the population’s standard of living and wellbeing (East Asia Analytical Unit 1998, Kessides 1995, Prud'homme 2004).

Raising finance for public infrastructure investment is a priority for governments. Public finance occurs through taxes or borrowing; in the latter, government debt may crowd out private companies and individuals from money markets through raising interest rates and impacting inflation and thus productivity (s2.2.3). Funds flows necessary to finance infrastructure investment programs can also constrain public investment elsewhere within society; reducing resources available for more teachers or defence personnel. The modes of financing infrastructure investment, operations and maintenance can also contribute to internal and external imbalances. With program financing that is a measurable percentage of a country’s GDP (s2.1.2), investment in public infrastructure projects may result in a greater indirect effect on an economy than the measured direct socio-economic effects (Dalamagas 1995b, Hung 2005, Levine & Krichel 1995, Ozdemir 2003). A government focus on infrastructure, to the detriment of other funding priorities, can thus cripple developing economies, outweighing the positive direct and indirect socio-economic effects. These views are of concern to economists who state that financing of infrastructure has important implications on the macroeconomic stability of a country (Kessides 1995, Romp & De Haan 2005).

Infrastructure is not a direct factor in economic growth; however, it facilitates productivity by providing adequate utilities and networks. It has a social role as well, contributing to the well-being of citizens. Infrastructure development has a strong social role in ameliorating poverty, assisting income redistribution; and mitigating against environment degradation. These factors are discussed under.

Poverty Amelioration

Poverty and income inequality are frequent phenomena in developing countries; however, the two concepts differ. Poverty relates to the situation and income of citizens and the World Bank (1990) defines poverty as the inability to attain a minimal standard of living. The poor live in unsanitary surroundings, are unable to access clean water, have minimal travel mobility or communications and limited access to basic public infrastructure. Poor people are often farmers in regions with low productivity, and are subjected to drought, floods and environmental degradation. Others may have greater resources but are unable to reap the benefits because they lack access to social services and infrastructure (ibid.).

Infrastructure may ameliorate poverty. Access to clean water and sanitation has the most obvious and direct consumption benefits by reducing morbidity and mortality. Access to transport and irrigation seems to contribute to higher and more stable incomes, and thus enables the poor to better manage risk. Both transport and irrigation infrastructure are found to expand opportunities for non-farm employment in rural areas. Improved rural transport can also assist better farming practices by lowering the costs of modern inputs such as fertiliser transport. An adequate transport network reduces regional variations in food prices and the risk of famine by facilitating the movement of surplus food to deficit areas (World Bank 1990).

In urban areas, public infrastructure of transport and communications assists marginalised people on the outer fringes of the cities, giving them access to centralised services, employment; and social activities such as sport, visiting family and friends, and free entertainment (World Bank 1994). Further, construction and maintenance of infrastructure also contributes to poverty reduction by providing direct employment (National Economic and Social Development Board 2004). Economic growth and development result in a higher per capita income, which in turn leads to better living standards for citizens. There is a general consensus that, in the long run, growth and development can eliminate absolute poverty. However, empirical studies show that some sections of a community may suffer due to changes brought about by economic growth.

In Thailand, the Development Research Institute Foundation (2004) found that 90 per cent of the poor believe that provision of adequate roads and electricity supplies improve income, health, and education. Similar results were observed by Thomas and Strauss (1992), who observed that a child’s height in Brazil is significantly affected by the type and adequacy of local infrastructure, particularly the availability of modern sewerage, piped water and electricity.

Income Inequality

Income inequality, or income disparity, refers to relative living standards within a society. Governments can take measures to reduce the inequality of citizens’ varying incomes by improving the redistribution of productive assets (land, capital, labour skills); avoiding price and wage policies that benefit the urban upper and middle classes at the expense of marginalised members of society; discouraging the exploitation of public resources for private gain; and making taxes more progressive (World Bank 1980). Infrastructure equality assists income inequality; if infrastructure access is similar for all citizens, this relieves absolute poverty (World Bank 1994).

Research by Lee, Nielsen and Alderson (2007) questions these earlier optimistic sentiments. In a study on the interrelationships of income inequality, the state and the global economy, they found that most traditional measures of trade dependence have inconsistent or weak positive effects on inequality, while export commodity concentration has a negative effect. Whilst the effect of foreign investment on inequality is positive with smaller governments, this effect is reduced or negative, given a larger public sector.

Living Standards

A community receives direct benefits from infrastructure development. The introduction of a new mass transit system, for example, serves communities along the train's route, reduces local air pollution by limiting private transport; it may also increase land values. Nevertheless, despite these attractions, the influx of new residents taking advantage of the transport results in further public investment, requiring public land and resources for roads, schools and hospitals in the area. In this example, an individual's living standard is affected if freeway infrastructure reduces traffic congestion and travel time, accidents, and operating and maintenance costs for the vehicle. (Aschauer 1989a, Holtz-Eakin & Schwartz 1995a, Munnell 1992). However, an indirect effect on the environment may occur if the freeway results in residential development impinging on a park, for example, increasing visits that cause degradation of vegetation and disturbs wildlife.

Health is an important factor in quality of life. Xiaoqing (2005) concluded that investment in health can enhance people's confidence and human capital potential, increasing individuals' incomes, savings and consumption; this contributes to industry investment and thus economic growth. Xiaoqing's contribution confirms that of Haughwout (2002) who, in a study covering 33 states in the US, found that the household sector gained higher benefits from public investment than the business sector.

Industry

The benefits of infrastructure for industry, and thus employment, are indirect. Industry requires adequate infrastructure: power, water, telecommunications and transport; utilities that reduce production transaction costs and thus contribute to productivity (Haughwout 2002). A Nigerian study by Lee and Anas (1992) found that infrastructure accounted for nine per cent of industry establishment costs, half of this electricity. In Zimbabwe, transport accounts for 26 per cent of business expense (Kranton 1991). Further, a study by Kessides (1995) found that a good rural road network gave farmers access to distant and profitable markets for cash crops, enabling them to rise from subsistence farming.

Environment

Environmental concerns include protection of forests; wildlife habitats; air, water and arable land; thus the relationship between infrastructure and the environment is complex. A World Development Report (World Bank 1992) noted that efficient infrastructure assists the environment by facilitating transport (using rail instead of bulk road transport to reduce emissions, as an example); managing potable water supplies and waste water; and managing regional and national parks to ensure survival of plant and animal species.

Inadequate or badly planned infrastructure frequently has a negative impact on the environment. Poor management of toxic waste defiles the environment. Ill considered dam construction can reduce natural wildlife habitats, and fuelled power plants and vehicle emissions are important contributors to air pollution (National Economic and Social Development Board 2004, World Bank 1994).

Summary

Infrastructure investment has a socio-economic impact, immediate to the region it is located and generally to the nation, through the delivery of benefits and the issues it brings. For industry, appropriate infrastructure lessens production costs and provides new markets; it improves productivity by supplying healthy, skilled labour; it delivers a population a better standard of living, some poverty reduction and income redistribution, and infrastructure may preserve the environment to some extent. Nevertheless, inappropriate planning and execution of public infrastructure can have the opposite effect, leading to negative results in economic growth, social discontent and environmental degradation.

2.2.5 Studies on Development

A half century ago, infrastructure was adopted by governments and world organisations as a socio-economic instrument (s.2.2.4). However, empirical research did not appear for a further twenty years, in the 1980s. Using various analytical approaches, these researchers focused on linkages between infrastructure spending and GDP growth. The majority of the results show significant returns to infrastructure investment arising from growth-inducing effects (Aschauer 1989a, 1989b, 1989c; Easterly & Rebelo 1993; Munnell

1990; Otto & Voss 1994). Although earlier studies were generally conducted in developed countries, the findings suggest that infrastructure capital has positive and significant effects on economic growth (Kessides 1995). The later theoretical research of Hemming, Kell and Mahfouz (2002) did not wholly agree with these findings.

The empirical argument supporting infrastructure development's positive effects on growth in developed economies was also relevant for emerging economies. Canning and Fay (1993) show that the infrastructure variable is significant in developing countries and positively correlated with economic growth (s2.1). They investigated the contribution to economic growth from transportation networks, measured as aggregated kilometres of paved roads, and of railway lines. The study shows that output elasticity of transportation infrastructure is 0.10, implying a relatively high rate of return for developing countries.

These findings of positive and significant relationships were not universally shared. A significant group of researchers state that, due to econometric failure in estimation, infrastructural coefficients in earlier studies were overestimated (Garcia-Mila, McGuire & Porter 1996; Holtz-Eakin 1993; Holtz-Eakin & Schwartz 1995a; Hulten & Schwab 1991b, 1992; Tatom 1993). To address this shortcoming, the following empirical studies are presented, as they used alternative econometric estimation techniques, and modified the early empirical findings which resulted in smaller (or negative) rates of returns for infrastructure.

Hulten and Schwab (1991b) estimated the relationship between public infrastructure and economic performance at the state and local levels in USA using sources of growth analysis[7]. The result was that public infrastructure does not significantly impact on economic performance. The authors further pointed out that the effects of increases in public capital are greater during the early stages of a country's development; when the stock of public capital is still relatively low, than are exhibited by mature societies. Therefore, Aschauer's estimations using time series overestimated the impact of the growth in public capital (Hulten & Schwab 1992).

Tatom (1993) modified the macro time series analysis approach used by Aschauer and others using first differenced data to eliminate the non-stationary problem. The researcher's estimates yielded lower rates of return from public capital than those observed by Aschauer (1989a) or Munnell (1990). In some cases, these rates were negative and insignificant. In an

[7] Sources of growth analysis is an equation of growth associated with the production function. It is estimated using nonparametric index number techniques, and the importance of the various inputs is measured as the percentage of the growth rate of output accounted for by each input (Hulten and Schwab 1991b).

attempt to improve the analysis, Tatom included another relevant variable, energy prices, and tested for causality using a lead-lag causal relationship. The empirical finding suggested that the causation direction may be from output to infrastructure capital.

Holtz-Eakin (1993) revisited the empirical performance estimates using the Solow growth model (s.2.3.2) and data from each state in USA. The results were that a strong increase in the investment rate failed to yield a permanent increase in the rate of economic growth; however, there was temporary faster growth and an extended temporary growth period before the output per effective worker stabilised at a new, higher level. Later, Holtz-Eakin and Schwartz (1995a) developed an econometric growth model in an attempt to explicitly incorporate infrastructure, thus enabling further in-depth analysis of the empirical effects of public infrastructure investment on productivity. The authors found that raising the rate of infrastructure investment during the period 1971–1986 had little or no effect on productivity. Moreover, Garcia-Mila, McGuire, and Porter (1996) also investigated output and public capital relationship at state level in the USA. Again using first difference estimation to eliminate the non-stationary problem, they found that public capital has an insignificant negative elasticity on level of output.

In Thailand, Ratwongwirun (2000) studied the effects from 1971 to 1996 of government expenditure on economic performance to estimate the optimal size of government expenditure. The empirical results showed that the marginal productivity of real government investment is negative and insignificant. This finding reflected the fact that most government investments are large infrastructure projects that take years in construction time. Further, government investment can be accounted as unproductive if it is used for the purpose of maintenance or expansion of the existing facilities, and not for economic improvement.

The results of this discussion are therefore inconclusive, despite the view of a majority of researchers who find for a significant and positive result for infrastructure expenditure on economic growth. The outcomes of studies to determine infrastructure investment on GDP are dependent on factors in the subject environment, and on the methodology of the researchers. There appears a trend among studies that emerging economies may benefit from infrastructure investment in stable economic and political conditions; however, such an analysis is beyond the scope of this literature analysis. The review on quantitative approaches and estimation techniques used in this study is further discussed in Chapter 3.

2.2.6 Summary

Important to this study, researchers view the contribution of public investment to economic growth as a case for further research. Milbourne, Otto and Voss (2003) indicate that further study is required to clarify the following points. Firstly, public investment projects provide final goods or services that are not directly linked to private production of goods and services. Secondly, public investment can be viewed as secondary infrastructure investment that provides complementary services to private production; for example, transport and communication networks. Further, and as discussed in s2.2 and s2.2.4, public good has an important role in correcting socio-economic imbalances. Whilst public/private models of infrastructure investment are becoming popular, the infrastructure agenda, priority and decision to proceed remain with government and therefore it is reasonable to consider public investment in isolation from private investment (s2.2.4).

2.3 Infrastructure Finance

Apart from the direct benefits and issues relating to public infrastructure investment, the means of financing this investment is also important. Public infrastructure investments generally require large financial commitments, and public finance remains the traditional source of funds for investment in infrastructure projects, especially in developing countries. Compounding infrastructure investment levels, as Jorgenson (1991) pointed out, the analyses of public investments are optimistic, as they fail to consider the full cost of funding. A government, through its monopoly characteristics and strong, continuous public interest, usually finances, owns and operates much of a country's infrastructure. Hence, infrastructure investment requires substantial and sustained funding, which many countries find difficult to generate, and governments adopt various strategies to meet the shortfall; increasing taxes and raising funds from domestic and foreign financial markets.

2.3.1 Sources

A government's primary revenue source, according to public finance theory, is taxes; however, they are not the sole source, as fees and charges including rents, and government borrowing also add considerable funds to government budgets (Ulbrich 2003). The options confronting a government, including advantages and disadvantages of each, are discussed in this section.

Taxation

The public finance tool of the majority of governments is taxes. There are various forms of taxation, for example, income tax, sales tax, property tax, value added tax, export tax, import tax.

In 1776, Adam Smith (1776) developed criteria for good taxation in *The Wealth of the Nations*. Batt (1999) updated Smith's efforts, citing seven criteria for effective taxation:

1. *Neutrality – good tax should not change economic decisions of businesses and households that they would have made without tax.*
2. *Efficiency – if neutrality cannot be maintained, at least deadweight loss as a result of taxation should be minimal.*
3. *Equity – refer to the equality of taxation in both dimensions: horizontally and vertically. Horizontal equity means tax under the same situation should be equal. Vertical equity means tax burden should be equally distributed among different income levels.*
4. *Administration – good tax should be easy to manage and collect.*
5. *Simplicity – complicated tax can be hard to manage and allow tax avoidance.*
6. *Stability – means that good taxation should be able to provide a certain level of revenue under any economic circumstances.*
7. *Sufficiency – the tax collection should be enough to cover government expenditure. In fact, government must realise their ability to collect tax and match income to expenditure.*

The argument in favour of taxation as a means of funding infrastructure is that it distributes costs across a broad base. In this view, general taxation is most likely to be the fairest means of financing infrastructure as the benefits of that infrastructure are widely shared. Where the community is the beneficiary, effective taxation means that the community pays.

Taxation funds, however, are an inefficient means of financing infrastructure investment, as tax is levied according to factors generally unrelated to final use. General tax receipts do not encourage the efficient use of infrastructure services. In other words, those who pay tax may not use the infrastructure, while those who use the infrastructure may pay less than the actual usage. Further, taxes can distort economic outcomes. They do not merely redistribute income and resources as they involve *excess burden* or *deadweight loss*[8]'. Further, funding long life infrastructure projects through immediate tax receipts results in high costs and low returns for current taxpayers; whereas benefits over the life of the infrastructure asset

[8] Excess burden or deadweight loss refers to the distortion factor when buyers change their behaviour to avoid paying tax.

are also realised by future users. This raises concerns not only over the dynamic efficiency, but also with regard to the issue of intergenerational equity (Allen Consulting Group 2003).

Borrowing

As general taxation receipts are insufficient for infrastructure programs, the majority of developing countries rely on both domestic and international borrowing to finance development. Although borrowing creates debt, arguably a type of tax on future generations, such public debt is offset by future infrastructure benefits. In this situation, debt financing results in a reasonable match of benefits and costs over time and this is consistent with intergenerational equity. As noted, government borrowing for development is the subject of continuing interest and debate among economists. Chhibber and Dailami (1990) and Serven and Solimano (1992), among others, state that public investment financed by bank borrowing crowds out private investment with an attendant negative effect on economic growth (s2.2.3).

Government bonds are a popular means for governments to raise funds, with researchers arguing that, as households are assumed to be the majority bond holders, debt is thus internalised and the effect on the economy is minimised (Becker & Paalzow 1996). However, if the government bonds are held by financial intermediaries, the results are somewhat different. This contrary view is that issuing government bonds to fund infrastructure programs leads to an increase in interest rates, crowding out private investment and depressing national investment overall (Deawwanich 1999, Mukma 2002).

Fees and Charges

Although taxes and fees constitute public payments, they are distinct. Tax is involuntary, whereas a fee is voluntary and paid during the purchase of government services or use of public utilities. Second, tax revenue is used for general public purposes, whereas the revenue from a fee is used to cover the cost of providing a specific service (Ulbrich 2003).

Public fees and charges fall into three categories. The first, licences and permits, relate to the right to engage in certain activities ranging from fishing to operating a business. The second category concerns charges on citizens who wish to use government services such as garbage pickup or tollways. The third group are payments for services to hybrid public-private entities separated in some way from government. The advantage of using fees and charges, in theory, is that this form of payment maximises value from the infrastructure or service as there is an assumed direct relationship between usage and fees. This results in the best allocation of resources between public infrastructure and other sectors of the economy

(Ulbrich 2003). However, it is difficult to assign user charges in a manner that achieves perfectly efficient pricing, that is, to determine the optimal price. Previously, socio-economic aspirations by governments attempted to set prices by differentiating types of user. For example, in the case of electricity commercial users were charged more than households. With the introduction of market reforms and cost-reflective pricing, these cross-subsidies have generally been unwound in the interests of enhancing efficiency and lowering the costs for all users (The Allen Consulting Group 2003). However, as governments usually do not aim to profit from their services, the revenue generated from fees and charges is severely limited.

Private Sector

Whilst the majority of public infrastructure in all countries was previously financed by the public sector, governments are now approaching the private sector. This joint venture, Public-Private Partnership (PPP), is a government service or private business venture which is funded and operated through a partnership of government and one or more private sector companies. Cohen and Percoco (2004) summarise the rapid development of PPP structures thus:

- impossibility to finance infrastructure projects from state budgets
- traditional contracting was creating delays in execution and cost overruns
- inefficient operation, management and maintenance of the project.

In a legislative and institutional framework, flexible enough to accommodate the above objectives, governments invite private sector construction, financing and operation of projects to achieve

- an acceleration of their infrastructure investment program
- to transfer risk from the public to the private sector
- use of project financing to assure an adequate return to investors and to meet debt service obligations to lenders.

2.3.2 Studies on Financing

The relationship between taxation and borrowing for public financing, and economic growth engenders significant debate in the literature. A selection of the debate is reviewed in this section.

The majority of taxation studies conclude that higher taxes have a negative impact on output growth. A growth accounting framework developed by Solow (1956, s2.1.1) predicates that GDP is determined by a country's economic resources, the size and skill levels of its labour force, and the size and technological productivity of its capital stock. Using this framework, Engen and Skinner (1999) identified aspects of taxes that affect economic growth: higher taxes can discourage the investment rate or net growth in capital stock; reduce labour participation or work hours; and lower research and development activity, which in turn discourages productivity improvements. The researchers suggested that tax policy can also shift investment from high tax to lower tax sectors which may also lower productivity. Lastly, taxes discourage the labour force from pursuing higher productivity, thus distorting efficiency in human capital.

Empirical studies show results that support the Solow model. Skinner (1988) conducted a comparative study on taxation among African countries and concluded that income, corporate and import taxation led to greater reduction in output growth than average export and sales taxation. In another early work studying more than 60 countries, Koester and Kormendi (1989) found that the marginal tax rate has a negative impact on GDP. Similarly, Dowrick (1992) investigated the effect of taxation on GDP in OECD countries between 1960 and 1985. The result shows a strong negative effect of personal income tax, which does not appear for corporate taxes.

In a recent study, Ngongang (2008) found that the effect of taxation on growth is inconclusive. It depends on a function of the theoretical framework (neo-classical or endogenous growth models), the production factor on which the tax is levied (i.e. taxes on capital or labour), on production techniques and the process of human capital accumulation.

Public Debt

Governments' proclivity to raise debt to fund finance public works, as noted at s2.3.1, impacts economic growth. Public debt can consist of domestic (internal) debt and foreign (external) debt. Debt financed from taxation was observed by Diamond (1965) as directly reducing value for individual taxpayers, reducing their savings and capital stock. This has a negative effect on GDP. Whilst Diamond's observation applies to both internal and external debt, the additional effect of servicing domestic debt is a further reduction in capital stock arising from the substitution of government debt for physical capital in individual portfolios (Diamond 1965). In the case of external debt, the use of foreign reserves may constrain a country's capacity to import, with an impact on economic growth (Siggel 2005). In an associated study, Dalamagas (1995a) tested a hypothesis concerning budgetary conditions and found support inasmuch as the manufacturing production index is negatively related to public capital formation in periods of large budget deficits and positively related in periods of low budget deficits.

There is significant debate on the impact of public debt on GDP. Using Barro's (1990) endogenous growth model, Dalamagas (1995b) estimated the impact of debt-financed public spending on the total output of 54 sample countries in the post-1960 period. The results show that the ratio of deficit financing to GDP is robustly correlated with productivity and therefore a major negative impact could arise only in countries with high levels of government debt. This was confirmed by Clements, Bhattacharya and Nguyen (2003), who examined external debt financing in low-income countries. Their results suggest that debt has a deleterious effect on growth only after it reaches a threshold level, estimated at 50 per cent of GDP for the face value of external debt, and as 20 to 25 per cent of GDP for its estimated net present value. Lin and Sosin (2001) examined the relationship between government foreign debt and the growth rate of per capita GDP based on a total sample of 77countries, without significant result. In a sample of 54 developing countries (including 14 heavily indebted poor countries), the inclusion of three additional explanatory variables (budget balance, inflation and openness) did not find statistically significant negative effect of external debt on growth (Hansen 2001).

Government fiscal policy has an important role in infrastructure development through its impact on economic and social development; however, intervention by governments has in many cases failed to promote efficient or responsive delivery of services, especially where infrastructure services are financed and managed exclusively by the public sector (Barro 1990, Merna & Njiru 2002). Further, the financial debt models adopted by government policy are also of consequence to a country's GDP (Barro 1990, Dotsey 1994, Ireland 1994, Palivos & Yip 1995, Turnovsky 1992).

Whilst the majority of researchers acknowledge public infrastructure's positive effect on growth, the impact of financing such investment also needs to be taken into consideration. Recent growth model studies regarding public investment in infrastructure make the assumption that public capital is financed by income tax, which, as noted, causes distortions in finance flows and social equity (Barro 1990, Barro & Sala-I-Martin 1992, Glomm & Ravikumar 1994 & 1997, Greiner & Semmler 2000).

In a study on the nature of financial models used for public funding, Aschauer (1998) investigated money creation versus income tax. The researcher separated productive and unproductive expenditures, productive funding being that which expedites production in the private sector. Aschauer found that optimal public finance requires productive government expenditure to be financed through money creation and unproductive government expenditure with income tax. Following a similar model for optimal composition of government public capital to Espinosa-Vega and Yip (2002), Hung (2005) made a theoretical derivation using models where social geography and limited communication create a demand for public investment. Hung showed that, as optimal financing involves utilisation of both income tax and debt, the optimal income tax rate is likely to be less than the output elasticity of public capital, confirming the empirical literature.

As noted, the effect of public infrastructure investment on GDP is compounded when the government policy regarding financing method is included. The majority of studies in relation to this issue are theoretical derivations, assuming that the infrastructure financing options are either tax or deficit or both. These studies use taxation and deficit finance at the aggregate level, where further research is required to differentiate the funds flows.

2.4 Conclusion

This chapter reviews the theory of economic growth and shows that under an endogenous growth theory framework, government investment policy is fundamental to a country's economic growth. Public infrastructure investment is a major component of government expenditure; hence, infrastructure investment is an important determinant of GDP. The consensus of empirical studies is that, in certain circumstances, there is a significant positive relationship between public infrastructure and economic growth. This result is, however, dependent on a number of factors which have yet to be investigated.

To date, the primary source of infrastructure funding is public finance, and as one of the few common characteristics of infrastructure, capital funding is of the order of percentages of a country's total expenditure. Infrastructure therefore has a direct and substantial impact on the economy and is a priority in government strategy, policy and execution. Public financing is also reviewed in this chapter, with the observation that few studies have linked public financing with public investment and economic growth. This study analyses infrastructure investment using disaggregated tax and borrowing data. Government policies vary regarding sources of public funding, tax or debt, and these are further differentiated by fiscal policies. Tax and debt policies differ on the amounts that can be generated and allocated without sacrificing fiscal sustainability. As this is the principle of infrastructure funding, this study investigates Thailand's ability to fund public infrastructure, and the impact on GDP whilst maintaining a feasible fiscal sustainability.

Chapter 3 Methodology Review

As a factor in economic growth, the nature of public infrastructure investment acquired a significant body of research over the last few decades. Theoretical and empirical studies, and literature reviews, identify aspects of infrastructure investment and seek to establish principles for this important sector of an economy. As discussed in the previous chapter, Context of the Research, empirical studies on growth theory have mixed results; location, timing within the world economic cycle, and the status of a particular country's economy, are matters that militate against defining public infrastructure investment in economic growth. The general consensus, however, is that infrastructure influences economic growth directly and indirectly, but the effects differ according to circumstances. Positive effects include service provision, related external benefits and a *crowding in* effect, whereas negative effects also include service-related externalities and a *crowding out* effect.

An appropriate methodology to obtain robust findings from available data is a basic tenet for good analysis. A study's methodology and scope are crucial to its findings and its value to the body of knowledge. This study is empirical research, therefore in this chapter, quantitative models and analyses are explored to identify the optimum model to fit the data and meet the terms of the research. The majority of quantitative researchers exploring the investment factor in growth used either a single equation or a systems model to analyse the data and obtain comparable findings. Studies by Sturm, Kuper and de Haan (1996); Sturm (1998); and Romp and de Haan (2005) evaluate these models, the selection of which they find are determined by the study objectives and the nature of the available data.

This chapter is presented as follows. First, there is an explanation and discussion of single equation models: primal for production function, direct profit function, or cost functions and dual for indirect profit or cost functions. The advantages and disadvantages of model functions are reviewed by way of the literature. Following this, the systems model is presented as a supply side or a market models, and these are similarly discussed through research findings. Finally, the selection of the appropriate model for this study is made, based on an assessment of all available models.

3.1 Model Overview

This study analyses infrastructure investment using disaggregated tax and borrowing data (s2.4) to investigate the Royal Thai Government's ability to fund public infrastructure whilst maintaining fiscal sustainability, and the effect of this investment on GDP. As an empirical case, this quantitative research adopts the convention of using one of a number of models preferred by economists to analyse the data. As noted in the introduction above, associated findings from the literature are then available to this research for confirmation or otherwise; similarly, the findings from this research are comparable to support or not support extant and future research findings. To address comparability, single equation models and system models are introduced and discussed.

In the literature, models using the single equation model can be categorised as primal and dual approaches. The primal approach includes estimation of the production function, or direct cost or profit functions; whilst the dual approach estimates indirect cost or profit functions. The second group, the systems model, is presented as either a supply side or a market model, that is, both the supply and demand aspects of the economy. The market model can be further divided into intermediate product and non-intermediate product market models. The non-intermediate product market model consists of causal and non-causal structural model estimations. All approaches are documented as a flow chart in Figure 3.1 Structure of Reviewed Approaches.

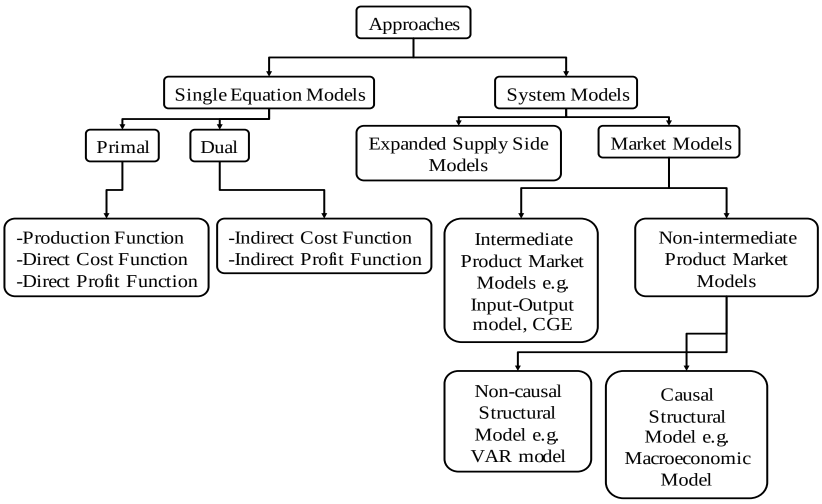


Figure 3.1 *Structure of Reviewed Approaches*

3.2 Single Equation Models

A single equation model is an estimation equation with one single dependent variable and one or more explanatory variables (Gujarati 1995). The emphasis is on estimating and predicting the average value of the dependent variable, conditional upon the given values of the explanatory variables. Therefore, the cause-and-effect relationship in this model commences with the explanatory variables and runs to the single dependent variable.

An empirical study may therefore use a single equation model to explain infrastructure development by describing the estimation model from the supply side. Hence, the case represents the production analysis issues described by either primal or dual models. The primal model is based on the direct specification of the production function that may include explicit behavioural objectives. The dual models are indirect specifications of production derived from behavioural objectives and the underlying technological relationship.

In this study, discussion on primal modelling includes a summary of direct technological functions and behavioural (possible) justifications for optimality, which may be verified after estimation through the functions.

3.2.1 Production Function

A production function is defined as a transformation function that specifies the minimum level of input requirements to produce a given level of output, using the chosen technology. A production function therefore denotes a set of technologically efficient points in a production set. This definition holds for both aggregate and disaggregate forms of production and thus can be written under a multiple inputs case as

$$Y = f(X_i) \qquad (3.1)$$

where Y is output level, X_i is the level of the i^{th} input, and $i = 1, 2, \ldots n$.

The function is assumed be a finite non-negative real value function for all non-negative and finite X_i ; monotonic and convex functions; twice continuously differential where all inputs and outputs are a homogeneous production function; product and price relationship are known with certainty; and the goal is to maximise production (Chambers 1988). Taken together, these assumptions are known as the regularity condition of technology.

Two aspects of production specifications used in infrastructure studies are the Cobb-Douglas (C-D) function and the Transcendental Logarithmic or translog (TL) function. These are explained below.

Cobb-Douglas Function

The C-D function was first introduced in 1928 to describe the relationship between manufacturing output, labour input and capital (Cobb & Douglas 1928). Since then it has been widely used by economists. The structure of C-D function is

$$Y = \alpha \, X_1^{\beta_1} \, X_2^{\beta_2} \ldots X_n^{\beta_n} \qquad (3.2)$$

where α is the coefficient of multifactor productivity; Y is output level; X_i is the level of the ith input and $i = 1, 2, \ldots n$.

The C-D function is a first order approximation to the arbitrary function (3.1). Inputs contribute to multiplicative increment in output levels and they do not interact. Non-linear form of C-D can be transformed to log-linear function

$$\ln Y = \ln \alpha + \sum_{i=1}^{n} \beta_i \ln X_i \qquad (3.3)$$

where $\ln$ is the natural logarithm.

C-D function assumes constant and unit elasticity of substitution and the returns to scale depends on the size parameters of α and βs.

Studies of public capital expenditure and its relationship with economic growth, as noted, came into prominence during the 1980s (s2.2.5). Since then, the majority of quantitative analyses use the C-D specification because of its simplicity. Ratner (1983) estimated an aggregate production function for USA private business, 1949 to 1973. The results identified[9] public capital as a significant input, having an output elasticity value of 0.06. However, the seminal study by Aschauer (1989a) used a C-D production function and examined USA data, 1949-1985. The results were that service infrastructures such as hospitals, educational buildings, and conservation and development structures were, if at all, minor contributors to aggregate US productivity; whilst economic infrastructure such as roads, airports, mass transit, and water systems were significant contributors. Aschauer's estimate for public infrastructure capital showed a high overall output elasticity value of 0.36.

[9] There are tense changes in this chapter to reflect the dates of the findings and subsequent argument. Recent argument follows convention and findings are in present tense.

Aschauer's work renewed empirical researchers' interest in public infrastructure investment. A significant number of follow up studies showed results that confirmed Aschauer's findings. Ram and Ramsey (1989), for example, also estimated aggregate production functions for private output from annual USA data, 1949 to 1985. Their estimates indicated public capital had an important positive effect on private output, with an elasticity value of 0.24. Munnell (1990, s.2.2.5) also found results similar to Aschauer's findings. Using USA data, 1949 to 1987, the researcher's estimate of public capital elasticity of output was 0.34 but, later, regarded it as too large to be credible (Munnell 1992, p. 191).

Using C-D aggregate production function on Australian annual data, 1966 to 1990, Otto and Voss (1994) repeated Aschauer's study to estimate the effect of general public capital stock on private sector output. They found a strong positive effect from public capital on private sector output. Estimated output elasticity for public capital was in the region of 0.4, higher than the estimate reported by the USA studies.

Aggregated time series data, Munnell and Cook (1990) opined, is prone to the causation or multiplier[10] effect, and they used American states-level cross-section data to avoid the causation issue. They assumed that, in these data, the reverse effects flow from productivity to public infrastructure that may inflate estimates is less likely to occur, that is, the disaggregated data reduced the probability of spurious correlation between productivity and infrastructure, usually high in aggregate data. Moreover, with the disaggregated data, the spillover benefit effect between regions also appeared reduced. Munnell (1992, 1993) observed that elasticity values at the state level were lower than that of the national level, but still remained substantial, arguing that due to large spillover benefits for smaller geographical areas, it is harder to capture the benefit of public infrastructure investment (Munnell 1992).

However, using such disaggregated data led to another specification issue. Holtz-Eakin (1994) claimed that the application of Ordinary Least Squares (OLS) techniques used by Munnell and Cook (1990), and Garcia-Mila and McGuire (1992), in estimating the impact of public infrastructure on economic growth allowed bias and could deliver inconsistent estimates. Holtz-Eakin argued that the estimation failed to account for local data, or states-specific effects such as the differences in productivity that stem from location, climate and endowment variations. Further, use of the C-D production function by researchers presents the following points of contention (Bhanu Murthy 2002):

[10] It describes how an increase in some economic activity starts a chain reaction that generates more activity than the original increase.

- it cannot manage a large number of inputs
- the function is based on restrictive assumptions that perfect competition exists in the factor and product markets
- it assumes constant returns to scale (CRTS)
- serial correlation and heteroscedasticity are common problems in this type of function
- labour and capital are correlated and the estimates are bound to be biased
- unitary elasticity of substitution is unrealistic
- it has a restriction on functional form
- single equation estimates are given to inconsistency
- it cannot measure technical efficiency levels and growth effectively.

As a result, empirical studies use flexible functional forms to estimate the effect of a production relationship, discussed below.

Transcendental Logarithmic Function

Economists utilise a flexible functional form of estimation such as the Transcendental Logarithmic (TL) production function, which is a generalisation of the C-D function. TL production function is conceptually simple and does not impose a priori restrictions on elasticity of substitution and return to scale (Chambers 1988). The functional form of TL production function can be expressed as

$$\ln Y = \ln \alpha + \sum_{i=1}^{n} \beta_i \ln X_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} \ln X_i * \ln X_j \qquad (3.4)$$

where Y is output; X_i and X_j are inputs; $i,\ j = 1, 2, \ldots n$.

TL function is a second order approximation to the arbitrary function (1) and therefore more flexible. Inputs contribute to multiplicative increment in output levels and allow for interaction within and between inputs. TL is an improvement over C-D, as it allows for substitution and the returns to scale and output elasticity to vary with the size and type of input. While C-D allows researchers to separately investigate the impact of each input to production, TL captures input substitution effects. In other words, TL facilitates understanding of the effect of combined inputs on the output.

Empirical studies using TL production function, for example, Merriman (1990) estimated the relationship between public capital and regional output for nine Japanese regions using panel data[11], 1954 to 1963, finding that public capital has a positive significant impact on national output, with elasticity of 0.43 to 0.58. Dalamagas (1995a) investigated public capital formation's effect on Greek manufacturing sector performance. Using time-series data, 1950 to 1992, the researcher concluded that public investment had a positive impact on the Greek manufacturing sector, with a high elasticity of 0.53. Charlot and Schmitt (1999) examined the role of public infrastructure growth in 22 regions in France, 1982 to 1993. To evaluate region-specific elasticity, they used TL production functions with three inputs: private capital, employment and public capital. They concluded there was a positive effect of public capital on regional wealth.

However, the advantages of TL function are subject to implementation issues. Webster and Scott (1996) opined the coefficient estimations of TL function are less precise than those of C-D function and there is a possibility of multicolinearity[12]. Further, as the flexible functional form requires a greater number of terms, there is an issue in interpreting numerous coefficients. Despite the differences in functional methodologies used by empirical researchers, there is a commonality in their results that confirms a positive significant relationship between public infrastructure and economic growth. Nevertheless, a number of studies found only weak positive support for the public infrastructure effect at the aggregate level (Ford & Poret 1991; Holtz-Eakin & Schwartz 1995a, 1995b; Sturm & De Haan 1995); or at the regional level (Hulten & Schwab 1991b; Holtz-Eakin 1994; Evans and Karras 1994a, 1994b) show that when regional or time specific variables are controlled using estimations of fixed or random effects, the estimated effects of public infrastructure are considerably reduced and may cancel out. The model Aschauer (1989a) employed, supported by a significant body of opinion, was argued using factors which could create issues with analysis and thus Aschauer's findings: *model specification*, *causality*, and *spurious regression*.

The primary issue from the work by Aschauer (1989a) is model specification. Duggal, Saltzman and Klein (1999) explain that all studies based on the production function approach treat public capital as a factor of production, similar to that of private capital and labour. However, in standard marginal productivity theory, the market determines per unit cost of factors of production, which in turn determines the optimal use of the factor. In reality, a unit cost of public capital is not determined by the market, as public investment is financed through general tax revenues or government debt. To address this issue, researchers may use

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[11] Panel data - data set containing observations on multiple phenomena in multiple time periods.

[12] Multicollinearity - where two or more predictor variables in a multiple regression model are highly correlated.

public capital as a technology factor during the estimation. Nevertheless, in an empirical study, Sturm (1998) found that using public capital as either a factor of production or a technology factor makes no difference.

The second issue, reverse causation, or the direction of causality between public capital and growth, was not satisfactorily explained. Aschauer (1989a, 1989b, 1989c) and Munnell (1992), for example, assumed causation to run from public capital to growth. However, it is also possible that economic growth can contribute to an increase in public capital (Eisner 1991, Gramlich 1994). For example, Tatom (1993) tested for causality via a series of lead-lag type of analyses, finding that the direction of causation may be from growth through to capital. Causality may cycle: as output increases, there are greater savings to devote to capital formation, thus infrastructure investment is caused by output growth, which in turn creates further infrastructure (Hulten & Schwab 1993). The causation cycle involves a simultaneity bias (Gramlich 1994).

It has long been recognised that sets of non-stationary variables can move together over time. Granger (1981) formalised this concept, defining such sets as cointegrated variables, which over time produced various tests for cointegration and techniques for working with cointegrated variables (Hall, Anderson & Granger 2001). Non-stationarity[13] among variables could provide a spurious relationship and this issue was raised by Aaron (1990) and Gramlich (1994) as a challenge to Aschauer's (1989a) findings. Spurious regression exaggerates the relationship between public capital and growth and should be eliminated to determine the relationship between the two variables (Munnell 1992). Estimation using first difference[14] is recommended as a potential solution to this issue (Aaron 1990, Hulten & Schwab 1991a, Jorgenson 1991, Tatom 1991). Their results from first differences showed the effect of public capital as relatively small, possibly negative, and generally not statistically significant. Tatom (1993), for example, modified the aggregate time series analysis approach used by Aschauer and others using first differenced data, finding lower rates of return on public capital, insignificant and possibly negative, than that reported by Aschauer (1989) or Munnell (1992). In addition, Garcia-Mila, McGuire and Porter (1996) investigated output and public capital at state level in USA; whilst OLS with fixed state effects provided significant elasticities, first difference estimation with fixed state effects gave

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[13] Non-stationarity: a time series data set that violates one or more of the stationary properties including the mean and the variance of the variable is constant over time and the correlation coefficient between the variable and its lag depends on the length of the lag but on no other variable.

[14] First difference: a member of a sequence that is formed from a given sequence by subtracting each term of the original sequence from the next succeeding term.

negative, insignificant elasticities. Nevertheless, there is an issue with first-differencing specification, as it loses the long-term (co-integrated) relationship that may exist among the variables in the data. Munnell (1992) advised that, instead of applying first difference, the variables should be tested for co-integration, adjusted, and estimated accordingly.

Apart from the estimation challenges, there are structural issues with the production function. A production function considers only the physical relationship of inputs and outputs, therefore market information, such as prices and costs or inputs supply functions, are ignored. Such information is required to establish a valid production relationship that complements the decision making process in a business environment or economy (Chambers, 1988).

This review of the literature concerning the production function approach to estimate public infrastructure's effect on economic growth has not given a clear outcome. Whilst earlier studies found a positive significant relationship, later studies reported an insignificant relationship which could also be negative. However, the majority of researchers found a positive relationship between public infrastructure investment and economic growth. The studies using a production function approach are subject to various estimation issues including model specification, reverse causation and spurious regression.

3.2.2 Cost function

The production function approach to estimate the effect of infrastructure investment on GDP is inadequate because it ignores the monetary aspect of inputs (Berndt & Hansson 1992, Morrison & Schwartz 1996). The argument holds that the production function omits factor input prices, causing bias in the estimated coefficients, and that the preferable approach to estimation is cost function. The cost function approach incorporates business behaviour theory: that producers minimise factor costs by controlling factor inputs (Chambers 1988). The cost function process approximates the input levels at a given level of output to minimise cost. Such minimisation can be mathematically framed as constrained optimisation

$$C = \sum_{i=1}^{n} r_i \; X_i + \lambda\left(\overline{Y} - f\left(X_i\right)\right) \qquad (3.5)$$

where C is total cost of production, r_i is price of ith input, X_i is the level of ith input, and $\overline{Y}$ is fixed level of output.

Given that the production function follows the regularity condition, then maximising the constrained cost function yields conditional (uncompensated) input $\left(X_i^*\right)$ demand functions. Minimum cost is signified by the criterion that marginal cost is equal to marginal product.

$$X_i^* = X_i \left(Y, r_1, r_2, \ldots, r_n\right) \qquad (3.6)$$

where X_i^* is the optimal level of ith input, r_i is price of ith input, X_i is the level of ith input, and Y is level of output.

Substitution of the conditional input demand functions into the production function provides an optimal output function along the expansion path.

The cost function approach shows the effects of public investment on cost savings and on private input demand at a given level of production. Assuming that public capital is externally provided by the government as a free input, the effects of infrastructure and scale on costs and the cost-output relationship can be estimated (Munnell 1992). Conrad and Seitz (1994) stated that this approach can also be used to study the monetary benefit of infrastructure investment.

Of the researchers who employed the cost function approach, Lynde and Richmond (1992) investigated the effects of infrastructure on the costs of private production in USA. The researchers employed a TL cost function to analyse annual time-series data for the non-financial corporate sector, 1958 to 1989, finding that, as it reduced costs, public capital was a productive input and that public capital was complementary to private capital, not a substitute. Morrison and Schwartz (1996) modelled the effect of public infrastructure investment on input costs and thus on the productivity of private firms. Using state-level data for USA manufacturing firms, 1970 to1987, they concluded that infrastructure investment had a positive significant return for manufacturing firms, and thus improved productivity. The net benefits of infrastructure investment depended also on the social costs of infrastructure investment, which are not part of this study, and the relative growth rates of output and infrastructure.

Using a cost function approach to study spatial spillovers in USA, Cohen and Morrison Paul (2004) analysed data from 48 states, 1982 to1996. They found a significant contribution to productivity from public infrastructure investment, concluding that infrastructure investment lowered manufacturing cost and evinced a spillover effect. If the stock of infrastructure of a neighbouring state was not included, the elasticity was on average -0.15, comparable to other studies. When the spillover effect to other states was taken into account, the average elasticity increased to –0.23, thus recognising spatial linkages increased the estimated effects of interstate infrastructure investment.

Little benefit from public capital for the private manufacturing sector was detected by Moreno, López-Bazo and Artis (2003), however. They estimated cost functions for 12 manufacturing sectors in Spanish regions, 1980 to1991, and concluded that the average cost elasticity of public capital was just -0.022, not of the same magnitude as USA-based studies. This raises the issue of differing dynamics of national economies.

3.2.3 Profit function

The profit function model estimates an input level and a corresponding output level that maximises profit. Such maximisation can be mathematically structured as an unconstrained optimisation problem as

$$\pi = pY - C = pY - \sum_{i=1}^{n} r_i \; X_i \qquad (3.7)$$

where $Y = f\left(X_i\right)$ and π is profit, C is total cost of production, r_i is price of ith input, X_i is the level of ith input, p is the price of output, and Y is the level of output.

Given that the production function follows the regularity condition, substituting the production function for Y in the profit equation and then maximising the profit function yields optimal input $\left(X_i^*\right)$ demand functions. Maximum profit is signified by the criterion that the marginal value product is equal to the input price. The input demand function corresponds to the profit maximisation criterion, or the compensated demand function.

$$X_i^* = X_i \left(p, r_1, r_2, \ldots, r_n\right) \qquad (3.8)$$

Substitution of the optimal input demand function into the production function provides the optimal output function; therefore optimal output is a function of a set of input and output prices.

To investigate the contribution of public capital services to the rate of profit, Lynde (1992) applied the C-D profit function to data of USA's non-financial corporate sector, 1958-1988. A positive significant effect was found between the public capital and corporate sector's profits; therefore an increase in public investment can affect productivity. Lynde and

Richmond (1993a) used TL profit function to estimate the impact of public capital on private sector output and productivity, using USA annual data from 1958-1989. They found that the estimated elasticity of output with respect to public capital was 0.2, and therefore infrastructure was an important part of the production process.

3.2.4 Dual function

The product supply and input demand functions consistent with a firm's optimising behaviour are obtained from the dual approach. In the dual method, the firm's optimising strategies can be directly structured using other functions, indirect profit or cost functions. The product supply and input demand equations are obtained through partial differentiation of the indirect function and thus the dual approach is an efficient methodology compared to the primal approach, provided the required prices and quantity information are available.

Indirect Cost Function

The indirect cost function for a single product with *n* variable inputs is

$$\tilde{C} = \tilde{C}\left(Y, r_1, r_2, \ldots, r_n\right) \qquad (3.9)$$

where $\tilde{C}$ is the indirect cost, r_i is price of ith input, and Y is level of output.

The above indirect cost function represents the minimum cost for a given level of input and output prices. Indirect cost function is a real valued function that is non-decreasing in input prices and weakly concave in input prices. Further it is homogeneous of degree zero in input prices.

Following the concept of envelope theorem, Shephards's lemma gives the ith input demand functions

$$\frac{\partial \tilde{C}}{\partial r_i} = X_i^*\left(Y, r_1, r_2, \ldots, r_n\right) \qquad (3.10)$$

The literature contains a significant number of studies using dual cost functions. Berndt and Hansson (1992) applied the dual cost function approach to a Swedish annual time-series data, 1960 to 1988. With changes in infrastructure capital, the researchers found significant effects on labour requirements for the total manufacturing sector and also on the aggregate private sector of the Swedish economy. An increase in public infrastructure capital was also found to contribute to reductions in private sector costs. Comparison of the estimated results from cost function models, both production function and cost function, yielded robust results.

In the UK, Lynde and Richmond (1993b) examined the role of public investment in output growth and manufacturing productivity. Using a TL function for quarterly data on UK manufacturing, 1966Q1 to 1990Q2, they found that public infrastructure had a significant effect on the level of manufacturing sector production and its costs. Conrad and Seitz (1994) examined the economic benefits of West German public infrastructure on private production cost and total factor productivity (TFP) using annual data from 1961-1988. The authors treated public infrastructure as an additional external input and used a dual cost function to estimate the shadow-prices[15] of public infrastructure services with respect to manufacturing, trade and transport, and the construction industries. They found public infrastructure a significant contributor to cost savings in private production and that it was complementary to private investment. Further, public infrastructure contributed to total factor productivity. In Spain, Ezcurra, Gil, Pascual and Rapún (2005) applied the duality approach on panel data, 1964 to 1991, to investigate the impact of infrastructure on productivity at the regional level. Public capital was included in regional cost functions as an unpaid factor of production. Results show that public infrastructure investment noticeably reduces private costs and increases overall productivity.

Indirect profit function

The indirect profit function for a single product with *n* variable inputs is

$$\tilde{\pi} = \tilde{\pi}\left(p, r_1, r_2, \ldots, r_n\right) \qquad (3.11)$$

The above indirect profit function represents the maximum profit for a given set of output and input prices. Indirect profit function is a real valued function that is non-decreasing in output price and non-increasing in input prices and convex in all prices. Further, it is homogeneous of degree one in all prices and homogeneous degree zero in input prices.

Following the concept of envelope theorem, Hotelling's lemma states

- output supply function

$$\frac{\partial \tilde{\pi}}{\partial \rho} = Y^*\left(\rho, \gamma_1, \gamma_2, \ldots, \gamma_n\right) \qquad (3.12)$$

- i^{th} input demand function

[15] Shadow price: the maximum price that management will pay for an extra unit of a limited resource

$$\frac{\partial \tilde{\pi}}{\partial \gamma_i} = - X_i^* \left(\rho, \gamma_1, \gamma_2, \ldots, \gamma_n\right) \qquad (3.13)$$

A Mexican study by Mamatzakis (2007), using an indirect profit function framework, measured the effects of infrastructure investment on industrial productivity. The study finds that returns to infrastructure capital are significant and positive. Further, deconstruction of total factor productivity growth reveals that economic performance is enhanced by infrastructure investment.

3.2.5 Function Analysis

Single equation models are predicated on the assumption that, to maximise profits, firms minimise production costs and factor inputs conditional on their factor prices. As both cost and profit functions are based on management decision, these functions may be described as behavioural approaches. This provides the opportunity to study the effects of public infrastructure on cost savings and on private input demand at a given level of production.

Behavioural models also require adaptation to address issues that arise during analysis. One such issue, especially when using a flexible function form, is data set availability. This form consists of cross-product or second-order terms, requiring a large number of parameters for estimation and thus a large database. Further, although the inclusion of second-order variables improves analysis, this addition often leads to multicollinearity (Romp & De Haan 2005). The data set should therefore be sufficiently extensive and variable to reduce the incidence of multicollinearity, and panel data that combine dimensions of time and region or sector to increase variability are preferred. Besides data-gathering issues, the behavioural models have other limitations; first, the models do not account for the crowding out effect (Ezcurra et al. 2005). Discussion at s.2.2.3 concluded that, although investment in public capital may raise the cost of private capital, the chances of this outcome occurring are reduced in a static economic environment. Next, the cost and profit function approaches assume a path of causality (s3.2.1) from public infrastructure capital to output productivity. Hence, the model structure does not permit the verification of a two-way or circular causation effect. As discussed above, researchers query a set linear and progressive causality and call for further investigation.

Sturm, de Haan and Kuper (1998) note that many authors estimating a cost or profit function adjust the stock of public capital by an index, such as the capacity utilisation rate, to reflect its use by the private sector. Two reasons have been advocated for adjusting the stock of public capital. First, public capital is a collective input that a firm must share with the rest of the economy. However, since most types of public capital are subject to congestion, the amount of public capital that one firm may employ will be less than the amount supplied. Moreover, the extent to which a capacity utilisation index measures congestion is dubious. Second, firms might have some control over the use of the existing public capital stock. For example, a firm may have no influence on the highways provided by the government, but can vary its use of existing highways by choosing routes. Therefore, there are significant swings in the intensity with which public capital is used.

Finally, there is a specification issue: the standard behavioural model assumes that all endogenous variables adjust to their equilibrium level within one period. Using the standard behavioural approach, Sturm and Kuper (1996) reported severe autocorrelation[16]. This issue can be resolved by adopting an ECM[17] representation within a translog cost function; although the authors found that several first-order conditions were no longer satisfied. A further specification issue mentioned by Dowrick (1994) is that the factors' prices are not obviously exogenous, as employers and employees or labour unions are expected to determine wages. Moreover, long term information regarding employees' productivity and investment in training implies that in the short term, firms' behaviour does not meet the long term neoclassical framework of homogeneous inputs and perfect information.

Despite the differences in technique, analysis of the literature shows a similarity between cost and profit function studies and those using the production function approach. The majority of findings report that public infrastructure reduces cost, or otherwise increases private sector profit. However, the estimated effects of the former are generally less than those of the production function approach.

3.3 System Models

An economic system describes the operations of all economic agents or forces of an economy in full or in partial forms; in terms of demand behaviour and supply behaviour, or supply behaviour alone, and in equilibrium status. Full form economic processes are referred to as the full market system model, the partial form is the semi-market system model. Both models provide a set structural equation. The market models in full form can be further

[16] Autocorrelation: The correlation of a variable with itself over successive time intervals

[17] ECM Error Correction Model is a representation of a multivariate process in first differences with corrections in levels described as an equation framework.

grouped as either having intermediate product markets (full equilibrium model), or not (partial equilibrium model). The partial model is useful for studying either supply or demand data, as it assumes the functionality of the rest of the market is fixed.

3.3.1 Full Market Models

The full market model is described in two forms, the first containing the characteristic of intermediate product, the other without such characteristic. These are described below.

In a market model with intermediate products, researchers use a social accounting matrix to represent a balance of all transactions that occur in an economy. With a structured matrix, demand and supply of all components of an economy or sector are brought into equilibrium. A subset of this matrix, an input-output model incorporating forward and backward linkages, provides an analysis of the industry or sector dynamics. Computable General Equilibrium (CGE) models use economic data to estimate the reaction of an economy or sector to changes in policy, technology or other factors. The CGE models use comparative statistics, generating values for endogenous variables, however, they provide only for an initial equilibrium and a new equilibrium after change; they do not convey information on the adjustment process or the manner by which change moves through a sector or an economy. Refinements to CGE models involve a dynamic adjustment process for short- and medium-term analysis for structured terms up to seven years (Dixon & Malakellis 1995).

Using the dynamic CGE model, Kim (1998) analysed the effects of transport investment on the Korean economy to determine the relationship between public infrastructure and economic performance. The researcher found a relationship, however, at a cost of price inflation. The elasticity of infrastructure investment in Korea with respect to GDP, export, private utilities, and inflation depended on institutional restrictions on the inflow of foreign capital and therefore reduced government's finance options for infrastructure projects.

In the second form of the full market model, that is, without intermediate products, an economic system is described through demand behaviour, supply behaviour and equilibrium status. The structural equation model under this classification includes both causal and non-causal elements, as the market model structural simultaneous equation describes

$$Y_t = g\left(Y_{t-n}, X_t, X_{t-n}, \beta, \upsilon\right) \quad (3.14)$$

where Y is the endogenous variables (quantity of demand and supply); X is the exogenous variables, these are time dependent and either given (strictly exogenous) or to be decided (controls or instruments); β is the time invariant parameters determined by formal estimation or imposed; and υ is the stochastic (disturbance) terms.

To maintain equilibrium, the model system may have one or more identity equations, apart from demand and supply. In defining the empirical situation, both Y and X in the estimation structure may contain quantity and price variables. The market clearing process feeds back prices into the behavioural equations for demand and supply enabling simultaneous determination of the equilibrium quantities. However, there is an estimation issue occurring through correlation between explanatory (lagged endogenous) variables and disturbance terms.

The estimation structure formed on the basis of causalities is determined through simultaneous estimation approaches, such as two-stage or three-stage least squares, ascertained by the identification status of the economic system. The model structure without causal links is estimated using the Vector Autoregression (VAR) procedure (see under). According to the causality specification characteristic, the estimation procedures can be divided into two groups: specified causation and non-specified causation. Specified causation describes the assumption that a change in one variable has an effect on another variable; in this study, causality is assumed linear from public infrastructure to economic growth.

Macroeconomic Causal Structural Equation Model

Thailand's economy is described by many macroeconomic models which are constructed by various public and private organisations. Each focuses on a certain aspect, for example, the Bank of Thailand has a monetary macroeconomic model. However, there are no Thai structural models on the effects of government investment on the country's economy: existing models show government investment, combined with government consumption, as total government expenditure (as described, Economic Development Consulting Team 2006). This assumption implies that there is no distinction between government investment and government consumption.

Majority research, nevertheless, finds the effect of government consumption on GDP is not significant compared with government investment's impact. Using data from 47 countries in an early analysis, Kormendi and Meguire (1985), found no significant relation between average growth rates of real GDP and average growth rates of government consumption input in GDP. Further, Grier and Tullock (1987) extended the analysis to 115 countries, using a pooled cross-section, time series analysis on government consumption. They found a significant negative relation between the growth of real GDP and the growth of the government consumption share of GDP. Landau (1983) studied 104 countries on a cross-sectional basis, using an earlier form of the Summers-Heston (1984) data. The researcher found significant negative results between the growth rate of real GDP per capita and government consumption expenditures as a ratio to GDP. Finally, Barro (1996) investigated the determinant of economic growth using panel data of 100 countries, 1960 to 1990, finding that, for a given starting level of real per capita GDP, the growth rate is negatively related with government consumption.

Whilst the majority of studies[18] found that government investment was favourable to economic growth; government consumption was reported in the negative. There is a clear difference between public investment and public consumption, and attention to this difference is overdue in the literature.

Macroeconomic Studies

The following research on the public infrastructure effect on economic growth concerns authors who used a macroeconomic model approach.

To investigate the impact of government investment on the Thai economy, Mukma (2002) constructed a small macroeconomic model, using different sources of finance, domestic and external debt. The model consisted of three sectors: private sector except for finance, monetary and banking sector, and government sector. Mukma's results indicate that government investment can stimulate aggregate demand regardless of the source of finance. However, the researcher did not pursue differentiation between forms of government investment to nominate consumption or infrastructure. The Bank of Thailand's macroeconomic model was used by Aromdee, Rattananubal, and Chai-anant (2005) to estimate the impact of large public infrastructure projects, the Thai *mega-project*[19]. The authors' findings are that such investments stimulate growth. Although the study's intent was to investigate the impact of public infrastructure investment, the model did not differentiate between elements of government expenditure (consumption and investment), and

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[18] Aschauer 1989a, 1989b, 1989c; Easterly & Rebelo 1993; Munnell 1990; and Otto & Voss 1994

[19] A mega-project is a large-scale Thai public investment relating to the period 2005 to 2009, each valued in excess of THB 1 billion (Ministry of Finance 2005). The policy was implemented by a former prime minister, but downgraded in 2006.

infrastructure per se was not pursued for its possible impacts. The mega-project investment enters the macroeconomic model as additional government expenditure.

Appropriate studies from the literature using a macroeconomic approach are presented, as there is little extant Thai research.

In the Netherlands, Westerhout and van Sinderen (1994) modelled the effects of public policies and external factors on the Netherlands' economic growth, 1958 to 1989. Using a small macroeconomic model of four reduced-form simulation equations, the authors found that the rate of growth of output depends on the private gross investment rate, whereas the private gross investment rate was assumed to be positively related to the rate of growth of public investment. Westerhout and van Sinderden's estimation results showed that the long-run coefficient on the rate of growth of public investment for the private gross investment rate was 0.23. The coefficient for the gross private investment rate in the output growth equation was 0.48. The long run elasticity of public investment to GDP was thus 0.11 (0.23 times 0.48) and causality ran from public to private investment.

In an Indian case, Levine and Krichel (1995) constructed a closed economy growth model comprising factors driven by capital externalities arising from both private capital and public infrastructure. The authors' findings were that fiscal policy, comprising income tax rate, the mix of government spending between infrastructure and public consumption, and long-run government debt as a ratio of GDP, significantly affect the long-run growth rate. Following the model of Levine and Krichel (1995), Ozdemir (2003) constructed a small, but open economy model of endogenous growth in Turkey and analysed the effect of public infrastructure investment and the debt/GDP ratio on long run GDP growth. The results were that infrastructure and fiscal policy can significantly affect the long run optimal growth rate. A greater proportion of total government expenditure on infrastructure led to higher economic growth; however, there is an optimal level of infrastructure expenditure in the total government expenditure.

Macroeconomic Non-causal Structural Model: Vector Autoregression

This estimation procedure does not specify the causality between infrastructure and economic growth, allowing causality to run freely between variables. For instance, the causality might run from output to public capital, or against conventional assumption (Cullison 1993). All the variables in a VAR are treated symmetrically, including an equation for each variable explaining its evolution based on its own lags and the lags of all the other variables in the model.

The VAR allows feedback from output to public capital and indirect links between variables (Kamps 2005). Aschauer (1989b) and Erenburg (1993) report a complementary relationship of these indirect effects between public capital and private capital. The VAR approach also allows long run relationships among the model variables. Sturm, de Haan and Kuper (1998) pointed out that the VAR approach resolved issues relating to the production function, cost function and profit function studies, by minimising theoretical restriction. According to Sturm, Jacobs and Groote (1999), a general VAR model with p lags, the VAR (p) model, for a vector Y of k endogenous variables has the following form

$$Y_t = \sum_{i=1}^{p} A_i Y_{t-i} + D_t + e_t \qquad (3.15)$$

where $A_i, i = 1, \ldots, p$ are $(k \times k)$ matrices of parameters, D_t is a vector of deterministic variables, like a constant and a trend, and e_t is a k-vector of disturbances with mean zero and variance-covariance matrix Σ .

An unrestricted VAR model can be estimated by standard OLS, which will yield consistent and asymptotically normally distributed estimates, even if variables are integrated and possibly co-integrated (Sims, Stock & Watson 1990).

To test the effects of various types of government spending on economic growth, Cullison (1993) used the VAR model. The results indicate that government spending on education and labour training have statistically significant effects on future economic growth. Using VAR framework, Sturm, Jakobs, and Groote (1995) found strong evidence of a positive impact of infrastructure investment on the Netherlands' GDP in the 19th century. However, using VAR with quarterly data of the Australian economy, Otto and Voss (1996) found no evidence of causality from private production to public capital stocks. Moreover, there was strong evidence indicating that public investment is highly responsive to private investment but that private investment did not generate public infrastructure investment.

The VAR approach was used by Pereira (2000) to study dynamic feedback effects between public investment and the private sector, finding the long term aggregate public investment crowds in private investment (elasticity of 0.229) and private employment (elasticity of 0.007), and that it has a positive impact on private output (elasticity of 0.043).

Thus the impact of public investment on economic growth is significant, and the indirect effects of infrastructural investment confirm that public capital can promote economic growth. Kamps (2005) used VAR to estimate the dynamic effects of public capital for a large set of OECD countries, finding evidence for positive output effects of public capital in OECD countries, but scarce evidence for positive employment effects. Pereira and Andraz (2005) used VAR to investigate the effects of public investment in transport infrastructure on private investment, employment and output in Portugal. Estimation results suggest that public investment crowds in private investment and employment, and has a strong positive effect on output, with a long-term rate of return of public investment on output of 16 percent.

A disadvantage of VAR is that, as noted, the model requires a large number of parameters to be estimated (Sturm 1998). Sturm et al. (1995) used VAR to examine the impact of infrastructure investment on the Netherlands' GDP, commencing with three endogenous variables, then each extra lag function incorporated into the model brought in nine extra parameters, causing a reduction in the degrees of freedom. Moreover, if lag structures differ across variables, Ahking and Miller (1985) and Thornton and Batten (1985) show that the imposition of common lag lengths can distort the estimates and may lead to misleading inferences concerning causality.

Moreover, even in a simple VAR model some choices with respect to the specification of the model have to be made, and all of them may affect the estimated responses and, thus, alter the conclusions about the link between public investment and economic growth. For instance, to simulate the cumulative response functions, restrictions with regard to ordering are imposed. These restrictions are rationalised by invoking assumptions of exogeneity and/or pre-determinedness, both of which can only be derived from theoretical considerations. In the absence of ordering assumptions, the non-structural VAR model can be used to characterise the data, but it cannot be used to spell out causation (Romp & De Haan 2005).

Some studies specify VAR models in first differences, without testing for cointegration, while others explicitly test for cointegration. Some studies specify VAR models in levels, following the argument of Sims, Stock and Watson (1990) that OLS estimates of VAR coefficients are consistent even if the variables are non-stationary and possibly cointegrated. Moreover, in most studies, the long-run response of output to public capital shock is positive. However, as pointed out by Kamps (2004), most studies fail to provide any measure of uncertainty surrounding the impulse response estimates, making it impossible to judge the statistical significance of the results.

In conclusion, the majority of studies found that public infrastructure investment leads to a long-run significant and positive effect to output, or to GDP. However, the results under VAR are considerably less than from the production function approach. For example, Everaert (2003) finds public capital has less impact on economic growth than was reported by Aschauer (1989a). Kamps (2004) suggested that the high returns to public capital using the production function approach could be accounted for by feedback effects from output to public capital.

3.3.2 Partial Market Models

This study investigates the relationship between infrastructure investment and national growth. This relationship may be approached through a supply side partial market model. The supply side analysis is structurally similar to the market model, with no intermediate product markets, and in a partial form representing the supply side. Such a model is often used at the industry or sector level to analyse their contributions to national product or growth. This system consists of input-generating equations that feed into the final production equation in a recursive manner. In general notation, the structure of this model system is

$$Y_t = g(Y_{t-n}, X_t, X_{t-n}, \beta, \upsilon) \qquad (3.16)$$

where Y is the dependent variable (quantity supply of output or input)

X is the independent variables, time dependent and either given (exogenous) or to be decided (controls)

β is the time invariant parameters determined by formal estimation or imposed

υ is the stochastic (disturbance) term.

Besides the estimation equations, the model can include one or more identity equations for the equilibrium status to be maintained during the input generation process.

As no empirical study using this approach for public capital and economic growth was identified, the incidence is noted of Peter and Verikios (1996) using similar modelling to investigate the impact of immigration on the incomes of the resident population. The authors adopted the Standard Neoclassical Model (SNM), to expand the variables L (labour) and K (Capital) in the Cobb-Douglas production function, including identity equations to allow incorporation of foreign and government ownership of capital, and variations in the capital stock.

3.4 Model Review

A literature review of methodology is fundamental to empirical analysis. The aims of this study are predicated on selection of analytic techniques to assess data and reach optimal conclusions and findings. This requires a comparison of models suitable for analysis of the impact of public infrastructure development on national growth and public finance of infrastructure investment. The selected approach must meet the criteria of addressing the study objectives, that the model obtains valid estimates, and that, conversely, data are available to fully populate the selected model.

The single equation models were found inappropriate for this study because they answer the question *What is the impact of physical constraints on economic growth in Thailand?* and not the question *To what extent can the Thai government raise funds for infrastructure investment under its fiscal constraints?* Moreover, the single equation assumes one-way causation from public capital to economic growth. In fact, many studies found evidence for reverse causation, i.e., a feedback loop from output to public capital and back to output (Batina 1998, Eisner 1991, Gramlich 1994, Hulten & Schwab 1993). For the purposes of this study, therefore, a systems model is preferable.

The selection of a systems model for this study is predicated partly upon the availability of data to meet the model's parameters. The intermediate and non-intermediate market models consist of both demand and supply sides of the economy and thus require copious aggregate and disaggregated data on both quantities and prices (s3.1). The price and demand (intermediate and final) data are sparsely recorded in developing countries, including Thailand; an incomplete data set is a critical limitation for full system models. Moreover, the full market model is not an efficient approach for this study's purposes as it provides extraneous information outside the scope of the study, which focuses on the supply side.

The partial market model of supply side is thus selected as suitable methodology for this study. To meet the study's criteria, the production function in the market model is expanded to include the factor of public finance infrastructure, which is generated through the public finance model. The addition of the public finance component to the supply model allows the simultaneous investigation of the effects of public infrastructure investment on economic growth, and explores the Thai government's capacity for public infrastructure investment under fiscal constraint.

The treatment of public infrastructure investment as an additional factor of production in the model allows the direct estimation of the impact of public infrastructure investment on economic growth. To investigate the capacity of the Thai government, given its fiscal constraints, to invest in infrastructure, the infrastructure investment variable is extended to include all relevant public finance sources which are then estimated. These values are added to the production function through an overall public investment factor.

3.5 Conclusion

This chapter reviews the empirical approaches used in investigating the impact of public capital on economic growth. The objective of this chapter is to select the most suitable approach for this study by comparing relevant methodologies. The review concludes that the optimal quantitative approach for this study is an expanded supply side market model. The proposed model serves the purpose of the study by estimating the impact of public infrastructure investment on economic growth, given the public finance available for Thai infrastructure investment. Further, the data available for this research are adequate to meet the partial market supply side model's parameters for processing estimations which can meet this study's objectives.

Following this model selection and as part of the study's methodology, an empirical public finance model is developed to estimate the sources and optimal amounts of public finance available to the Thai government. Prior to developing the public finance model, the nature of Thailand's public finance system, its structures and their roles in the financial system, are presented and discussed in Chapter 4.

Chapter 4 Study Context: Thailand

Infrastructure development, by its nature, impacts each country's economy differently. Infrastructure development may be viewed in the context of funds available to a government, and the application of those funds to facilitate the infrastructure best suited to drive growth. Whilst all world governments arguably undertaken development, each is unique in the manner by which infrastructure is funded and implemented over time. Factors in implementation include economic strength as an emerging or developed economy, government policies regarding business and regional sectors, and new technologies. To place this research in its context, Thailand's economic background is explored.

This chapter comprises three sections. The first provides a brief history of Thailand economic development, using the country's National Economic and Social Development Plans, which began in 1961 and, for the purpose of this study, ended with the ninth which was finalised in 2006. The prevailing economic situation of the time, thus the focus of each plan, and level of growth are discussed. To place Thailand's experience in context and assist the Thai government's future strategies for public infrastructure investment, the next section is an analysis of public infrastructure in relevant countries. Finally, the discussion moves to Thailand's public finance for infrastructure investment. Sources of funding for public infrastructure projects are explored, including tax and non-tax revenue, deficit financing through domestic and foreign borrowings, and alternative financing.

4.1 National Economic and Social Development Plans

At the end of World War II in 1945, Thailand's economy was in recession, requiring significant finance to revive the economy. With limited domestic resources, Thailand raised funds from the World Bank to rebuild its infrastructure after the depredations of the war. These funds were employed in the construction of basic public infrastructure such as roads, railways, irrigation networks and electric power generation. From these early beginnings, accessing foreign funds became an acceptable and routine matter for Thai economic management (Paitoonpong & Abe 2004). Further, there was an urgent need to monitor funds flows and accede to international pressure to formalise public money management in the country. This led to the establishment of the National Economic Development Board (NEDB) and the Bureau of the Budget (BOB) in 1959 and the Fiscal Policy Office (FPO) in 1961.

These three organisations, together with the Bank of Thailand (BOT), determine the annual budget allocation.

In 1961, the NEDB, as the government's economic planning agency, developed the country's first five-year plan, the *National Development Plan,* which formalised the sources and expenditure of funds for the period, with continuing infrastructure restoration a large factor of the expenditure. Later, in 1972, a social development dimension was incorporated into the economic development agenda, the plan became the *National Economic and Social Development Plan,* and the agency adopted the title as the National Economic and Social Development Board (NESDB). The national development plans have a crucial role in guiding public investment and public resource allocation in Thailand.

For the last 40 years, therefore, infrastructure has played an important role in Thailand's public investment and economic development. However, the importance of public infrastructure investment varied according to the national priorities, demand, resource availability, and relevant external factors over the years.

4.1.1 First Plan 1961–1966

The objective of the first five-year plan was to achieve higher economic growth. As the government well recognised the importance of public infrastructure in facilitating productivity, priority was given to continuing the post-war reconstruction of transport, electricity, communications and water (Abonyi & Bunyaraks 1989). During the first plan, the Thai economy grew rapidly across agricultural, manufacturing and service sectors. Table 4.1 First Plan GDP Growth 1961 – 1966, shows that the annual GDP growth rate averaged 9 per cent across all sectors while the manufacturing sector experienced the highest growth of 12.5 per cent.

Table 4.1
First Plan GDP Growth 1961 – 1966

Sector	**Percentages**					
	1962	**1963**	**1964**	**1965**	**1966**	**Average**
Agricultural	7.4	9.1	1.7	4.1	12.8	7.0
Manufacturing	12.8	9.2	10.5	15.4	14.5	12.5
Service	5.9	6.9	8.6	6.9	8.7	7.4
Average	**8.7**	**8.4**	**6.9**	**8.8**	**12.6**	**9.0**

Source: NESDB (2004)

While the main objective of the first plan was economic growth, public infrastructure investment, especially transport, was the driver to support development. Note that from the first to the fourth plans, transport and communications were combined. A total of 17,660 million baht was allocated for the plan as follows

Transport and communications	7,360 m.baht (41.7%)
Social infrastructure	5,560 m.baht (31.5%)
Energy	4,740 m.baht (26.8%) (NESDB 2004).

Expansion of the road network in the 1960s had a considerable impact on the agricultural sector development by providing farmers with direct access to external market as well as access to uncultivated land (Warr 1993a, Siamwalla 1997, National Economic and Social Development Board [NESDB] 2004). During the first plan (1961-1966), infrastructure investment on the combined transport and communications program was the highest with 41.7 per cent followed by social infrastructure and energy with 31.5 and 26.8 per cent, respectively.

As an example of infrastructure development, water management in 1960 was crucial to feed Thailand's 26 million people. Rice and market gardeners farmed the rich central plains, using nineteenth century canals to carry floodwaters from the Chao Phraya and other rivers. Irrigation commenced between the world wars, and by 1950 the irrigated area totalled nearly 650,000 hectares. By 1960 over 1.5 million hectares had been irrigated, almost entirely in the Centre and in the North. Assistance from the World Bank included financing of the important multipurpose Bhumibol Dam (completed in 1964) on the Mae Nam Ping and the Sirikit Dam (completed in 1973) on the Mae Nam Nan. These dams, both of which have associated hydroelectric power-generating facilities, impound water at two large reservoir locations in the Chao Phraya Basin. Other World Bank-financed projects were also carried out in this basin during the 1970s, and by the end of the decade nearly 1.3 million hectares had controlled water flow in the rainy season, and about 450,000 hectares had it in the dry season. Figure 4.1., illustrates the country's regional water infrastructure as of 2006, which has not changed at the time of writing this thesis.

Source: UNESCO 2006[20]

Figure 4.1 *North and Central Thailand: Water Infrastructure, 2006*

[20] Accessed 10 January 2009 from http://www.unesco.org/water/wwap/wwdr/wwdr2/case_studies/img/thailand_big.gif

4.1.2 Second Plan 1967–1971

The second economic plan, whilst focused on growth, was widened to incorporate education and employment initiatives to meet Thailand's long term aspirations for national development. The economy's focus was also moved from an emphasis on public expenditure to facilitating private investment, The high average GDP growth of the first plan declined to 7.1 per cent in this period; however, GDP growth was affected by the agricultural sector, which continued its fluctuations. The slowdown in overall economic performance was also related to less foreign investment due to global conditions (Warr & Nidhiprabha 1996, Dixon 1999). Table 4.2 Second Plan GDP Growth 1967-1971 records these statistics.

Table 4.2
Second Plan GDP Growth 1967-1971

Sector	Percentages					
	1967	**1968**	**1969**	**1970**	**1971**	**Average**
Agricultural	-2.2	10.4	7.4	9.9	4.2	5.9
Manufacturing	13.9	7.5	10.1	-2.2	9.1	7.7
Service	12.0	7.4	6.9	9.5	3.1	7.8
Average	**7.9**	**8.4**	**8.1**	**5.7**	**5.4**	**7.1**

Source: NESDB (2004)

The second plan's infrastructure program nearly doubled to 32,245 million baht, made up as follows

Transport and communications	17,000 m.baht (52.7%)
Social infrastructure	10,275 m.baht (31.9%)
Energy	4,970 m.baht (15.4%) (NESDB 2004).

Thailand's implementation of basic infrastructure during the first two development plans in the 1960s was concentrated on the central region north of Bangkok; irrigation, power and telecommunication services for the provinces were left for later plans (Warr 1993b). These imbalances led to a concentration of development, hence population, in the central plains at the expense of the other regions. Therefore, by the end of the second plan, this centralisation was unassailable and, despite attempts at regionalisation, the bulk of Thailand's industry remains in this area. The public infrastructure investment pattern during this period was similar to the first plan, with transport and communications at 52.7 per cent, social infrastructure public at 31.9 per cent and energy at 15.4 per cent.

4.1.3 Third Plan 1972–1976

The pace of social infrastructure was lagging economic development for the third economic plan in 1973, thus there was a renewed emphasis to bring social capital into Thailand's economic recovery. This prompted a change in name as well as direction to the "National Economic and Social Development Plan" and the proportion of public expenditure applied to health, education, and the regional infrastructure rose considerably (Warr 1993a). However, to maintain Thailand's economy in a world-wide economic downturn and an oil crisis, business sector development remained the principal beneficiary of funding under the new plan.

The oil crisis of 1973–1974 resulted in a fourfold increase in the price of oil. Oil imports almost trebled in cost in 1974, and oil's share of Thailand's imports rose from 11.1 per cent to 19.6 per cent (Dixon 1999). As a consequence of the crisis, inflation grew significantly, from a low 4.9 per cent in 1972, up to 15.4 per cent in 1973 and 24.3 per cent in 1974 (Hansanti 2005). Hence, economic growth slowed further during the third plan to an average of 6.6 per cent per year. The impact of the oil crisis on Thai economy was nevertheless considered minor compared to many other oil-importing developing countries (Warr 1993a). Table 4.3 Third Plan GDP Growth 1972-1976 illustrates these points.

Table 4.3
Third Plan GDP Growth 1972-1976

Sector	**Percentages**					
	1972	**1973**	**1974**	**1975**	**1976**	**Average**
Agricultural	-1.5	8.4	3.1	4.1	5.6	4.0
Manufacturing	9.3	11.9	4.2	5.6	16.3	9.4
Service	4.8	9.8	5.3	5.0	7.1	6.4
Average	**4.2**	**10.0**	**4.2**	**4.9**	**9.7**	**6.6**

Source: NESDB (2004)

The infrastructure program for the third plan continued to rise sharply to 57,346 million baht, as shown

Transport and communications	22,543m.baht (39.3%)
Social infrastructure	20,052m.baht (35%)
Energy	14,751m.baht (25.7%) (NESDB 2004).

Whilst the investment pattern in the third plan continues, with transport and communications accounting for 39.3 per cent of funding, social programs and energy were at

35 and 25.7 per cent respectively. However, compared to the second plan, the proportion of transport and communications investment declined, taken up by the other two programs.

4.1.4 Fourth Plan 1977–1981

The objective of the fourth economic and social development plan was to assist economic recovery, which was improving by 1976, and to continue work on the country's economic and social infrastructure.

The economy had a mixed performance over this period with robust growth for the first two years, followed by the adverse effects of high world interest rates and a second oil crisis in 1979–1980. This resulted in reduced demand, and thus prices, for Thailand's exports. Overall, GDP maintained an average of 6.6 per cent per year, attributed in part to the government's continuing public investment despite a severe downturn in domestic savings (Warr & Nidhiprabha 1996). As a result, the government borrowed increasingly from the World Bank and the International Monetary Fund (IMF) to maintain its program.

Table 4.4 shows trends in productivity for the fourth plan. Common to all developing nations, Thailand's manufacturing and service sectors were growing whilst, as a contributor to GDP, the agricultural sector continued its overall decline.

Table 4.4
Fourth Plan GDP Growth and Infrastructure Program 1977-1981

Sector			**Percentages**			
	1977	**1978**	**1979**	**1980**	**1981**	**Average**
Agricultural	2.7	10.7	-2.3	0.8	5.1	3.4
Manufacturing	15.3	10.6	6.7	3.6	7.1	8.7
Service	10.2	9.1	7.9	6.9	5.5	7.9
Average	9.9	10.1	4.1	3.8	5.9	6.6

Source: NESDB (2004)

Infrastructure expenditure of 86,460 million baht for this plan comprised

Transport and communications	37,175m.baht (43%)
Social infrastructure	33,335m.baht (38.6%)
Energy	15,950m.baht (18.4%) (NESDB 2004).

In this plan, whilst maintaining its social program, expenditure shifted to energy, transport and communications, through an increase in defence expenditure. Energy infrastructure served the two objectives of meeting increasing demand in the industrial sector as well as reducing dependence on imported energy for 43 million Thais. Warr (1993b) suggested that the shift was a result of military coup d'état in 1976, with the military government allowing State Owned Enterprises (SOEs) to borrow directly from abroad, using government guarantees to finance their capital investments. Hence, between 1978 and 1983 there was a steady increase in expenditure by the SOEs, financed by foreign borrowing.

Bangkok, as the capital and centre of development, was expanding rapidly at this time (NESDB 1996). This was due to its location on the delta of the Chao Phraya River and at the centre of the country, and thus it is the hub for transport and distribution. Further, Bangkok is the administrative centre for its centralised government.

4.1.5 Fifth Plan 1982–1986

During this period, as a result of the second oil crisis and prevailing world conditions, interest rates increased, trade slowed and commodity prices fell. The fifth plan's objectives were to maintain credibility in international financial markets, with an element of economic restructure; however, its average rate of annual growth declined to 5.1 per cent.

Foreign reserves as a percentage of GDP reduced from 12 per cent in 1970 to 3 per cent in 1985. A borrowing program from the World Bank and IMF, commenced in the fourth plan, became an integral part of the fifth plan through two Structural Adjustment Loans (SALs); the first in March 1982 for US$150 million and the second in April 1983 for US$175.5 million (Paitoonpong & Abe 2004). External debt rose to US$16 billion, of which about US$12 billion was long-term debt. The debt-service proportion increased from 17 per cent in 1980 to about 26 per cent in 1985. This highly indebted situation was made more difficult by the government's budget deficit of more than 5 per cent of GDP over the five-year period (Warr & Nidhiprabha 1996).

As shown in Table 4.5, GDP growth rate declined in every sector.

Table 4.5
Fifth Plan GDP Growth 1982-1986

Sector	**Percentages**					
	1982	**1983**	**1984**	**1985**	**1986**	**Average**
Agricultural	2.5	4.8	4.4	4.5	0.4	3.3
Manufacturing	5.1	10.5	8.2	1.4	8.0	6.6
Service	6.6	2.9	4.7	6.9	5.9	5.4
Average	**4.7**	**6.1**	**5.8**	**4.3**	**4.8**	**5.1**

Source: NESDB (2004)

The plan’s infrastructure more than doubled to 201,427 million baht. For this plan, transport and communications were separated, as presented

Transport	53,784m.baht (26.7%)
Communications	33,945m.baht (16.9%)
Social infrastructure	19,340m.baht (9.6%)
Energy	94,358m.baht (46.8%) (NESDB 2004).

This plan saw the decentralisation of the dominant Bangkok metropolis by the introduction of infrastructure to encourage regional industrial development, such as the Eastern Seaboard Project, a new economic region. The planned developments included the Map Ta Phut chemical industrial area some 200 kilometres (km) to the south-east of Bangkok in Rayong province and the non-polluting export-oriented Laemchabang Industrial Estate in Chonburi, 150km from Bangkok. Complementary infrastructure included ports, utilities (power and water) and social infrastructure. However, the early 1980s recession delayed such development; proposals were repeatedly reduced in scope, postponed, or sometimes abandoned (Dixon 1999).

Despite the economic downturn, energy demand continued to rise, and this accounted for the bulk of this plan’s infrastructure expenditure, at 46.8 percent. Transport, now separated from communications, commanded 26.7 per cent of the program, whilst social infrastructure was decimated, falling from a third of infrastructure expenditure in the previous period to less than a tenth, and recording a decline in actual baht terms.

4.1.6 Sixth Plan 1987–1991

International competitiveness and self-reliance of the economy were the principles for the sixth plan. At this time, emerging economies were taking international productivity advice (World Bank, IMF, UNESCO) to reduce their public sector numbers and direct attention to encourage the swift development of the private sector (Abonyi & Bunyaraks 1989).

The period saw dramatic economic growth. Following the mixed results from the previous decade, GDP growth in the five year cycle ranged from 8 per cent to 13 per cent, and averaged nearly 10 per cent (Phongpaichit & Baker 2002). Whilst recovery from the late eighties downturn gave grounds for this growth, it was accelerated by

- increased export competitiveness through depreciation of the baht, tied to the falling US dollar

- foreign investment, especially from the Newly Industrialising Economies (NIEs), including Taiwan and Hong Kong, which curbed the rising labour costs in their own economies and led to production expansion in Thailand
- low oil prices in relation to Thailand's export commodities (Warr & Nidhiprabha 1996).

As depicted in Table 4,1987-1991, the manufacturing sector was a major contributor to GDP, recording the highest growth rate of 17.5 per cent in 1989.

Table 4.6

Sixth Plan GDP Growth 1987-1991

Sector	**Percentages**					
	1987	**1988**	**1989**	**1990**	**1991**	**Average**
Agricultural	0.1	10.5	9.6	-4.7	7.3	4.5
Manufacturing	14.1	16.4	17.5	16.1	12.1	15.2
Service	10.0	12.1	9.3	12.7	6.1	10.1
Average	**8.1**	**13.0**	**12.1**	**8.0**	**8.5**	**9.9**

Source: NESDB (2004)

Infrastructure development increased significantly after the early 1980 recession, reaching 521,888 million baht for this plan

Transport	189,120m.baht (36.3%)
Communications	69,506m.baht (13.3%)
Social infrastructure	29,420m.baht (5.6%)
Energy	233,822m.baht (44.8%) (NESDB 2004).

The Eastern Seaboard Project continued, combining road, rail, utility and social infrastructure to become fully integrated over the region. The project was aimed at foreign investment to create local employment (NESDB 1996).

Energy continued to lead infrastructure development with social infrastructure continuing its decline as a proportion of the infrastructure program, although expenditure increased in term s of baht.

4.1.7 Seventh Plan 1992–1996

The seventh five-year plan changed to social objectives, given sustainable economic growth: continue the decentralisation initiatives to improve social equity, improve the country's human capital, and Thailand's quality of life for its citizens, including attention to the environment (Hewison 1993).

In the early nineties, the Thai private money market gained impetus from relaxation of financial regulations, including foreign exchange. At this time Japan and Europe in particular were experiencing low interest rates, thus low domestic investment and high liquidity, and as a result of financial liberalisation, capital from Europe and Japan moved into Thailand. Further, the Stock Exchange Commission (SEC) Act in 1992 and the Bangkok International Bank Facility (BIBF) in 1993 facilitated a deeper money market (Mukma 2002). However, exploitation of this new source of revenue was mitigated by rising costs of production, lack of skilled labour, overloaded infrastructure, congestion and pollution, and the opening of low-cost operational locations such as Vietnam and China (Dixon 1999). As a result, the Thai growth rate dropped significantly as presented in Table 4.7, Seventh Plan, to 6.8 per cent average over the period. The key sectors remain manufacturing and service with the growth rate of 9.6 and 7.9 per cent respectively.

Table 4.7
Seventh Plan GDP Growth 1992-1996

Sector	Percentages					
	1992	**1993**	**1994**	**1995**	**1996**	**Average**
Agricultural	4.8	-1.3	5.3	2.5	3.8	3.0
Manufacturing	9.9	10.5	10.1	10.5	7.0	9.6
Service	7.5	9.3	8.9	9.0	4.6	7.9
Average	**7.4**	**6.2**	**8.1**	**7.3**	**5.1**	**6.8**

Source: NESDB (2004)

The infrastructure program for the seventh plan was 825,310 million baht, distributed as follows

Transport	477,266m.baht (57.8%)
Communications	36,213m.baht (4.4%)
Social infrastructure	76,540m.baht (9.3%)
Energy	235,291m.baht (28.5%) (NESDB 2004).

Thailand's population was 56 million in 1992 and the infrastructure facilities of the previous decades were insufficient to cope with its modest birth rate of 1.4 per cent[21]. Utility and transport networks, inadequately funded, were incomplete. Ports, roads and telecommunications demand rose; Bangkok received notoriety through its perennial traffic

[21] United Nations, 1996. Accessed 12 January 2009 from http://www.unhchr.ch/tbs/doc.nsf/0/2618198217c6efc1c125642d004e8478?Opendocument

congestion (Warr 1993a, Pendergast & Pendergast 2002). In response, the government initiated long-term infrastructure investment projects, noted at Table 4.8 Response Plan for 1990-2001.

Table 4.8
Critical Infrastructure Response Plan 1990-2001

Project	**Estimated Investment ($US million)**	**Duration**
All Energy-related Projects	11,071	1992–1996
2,000,000 Telephone Lines (Bangkok)	3,922	1992–1996
Hopewell Elevated Rail (Bangkok)	3,137	1991–2001
Expressway, 2nd & 3rd Stages (Bangkok)	2,054	1991–2000
1,000,000 Telephone Lines (Provinces)	1,961	1992–1996
Skytrain (Bangkok)	1,804	1997
Second International Airport (Bangkok)	1,600	2000
Provincial Highways	1,145	1990–1995
Electric Train (Bangkok)	784	1993–1996
Ekamai-Ramindra Expressway (Bangkok)	412	1994–1996
Don Muang Tollway (Bangkok)	408	1991–1994
Optical Fibre Network	373	1992–1993
National Satellite Project	216	1993

Source: Hewison (1993, p.32)

As described in Table 4.8, the projects included expressways, mass transport, port development and telecommunications. To assist in this massive program, legal reforms were instituted to enable the private sector to participate in infrastructure development (Pendergast & Pendergast 2002).

The transport component of the critical response plan gained strongly over the period to become the dominant infrastructure investment sector at 57.8 per cent. Social infrastructure also nearly doubled from the sixth plan to reach 9.3 per cent, whilst communications dropped from 13 per cent in the sixth plan to only 4.4 per cent, although in baht terms, the amount halved. The planned effect was to divert funding from energy and communications projects, concentrating on improving the transport dilemma for the central region. However, due to the effect of the 1997 economic crisis, funds flows severely deteriorated thus impacting the timelines for infrastructure, as discussed under.

4.1.8 Eighth Plan 1997–2001

Thailand experienced severe economic conditions in 1997 and 1998. The Asian financial crisis occurred during the eighth plan, which, initiated before the crisis, concentrated on social infrastructure to improve citizens' economic equity and lifestyles. Before the crisis, the country was experiencing a liquidity shortage and a large capital outflow and found it had insufficient international reserves. There was instability in the financial system with high levels of interest rates, inflation and non-performing loans causing a dramatic contraction of GDP, and a very high unemployment rate (NESDB 2003). Due to speculation on the national currency in early 1997, financial institutions began to collapse. The Bank of Thailand was unsuccessful in raising sufficient funding to support the baht and sought assistance from the IMF in August 1997. As a condition of the IMF assistance, the baht was floated free on 2 July 1997 and it continued to lose value during this period (Phongpaichit & Baker 2002).

In late 1998, due to a pre-crisis real estate bubble and subsequent house prices collapse, the proportion of non-performing loans rose to 47 per cent of all credit; interest rates rose to around 20 per cent; inflation reached 9.2 per cent; and the unemployment rate rose to almost 5 per cent. Negative GDP growth occurred for the first time in Thailand, with a 1997 GDP growth of –3.7 per cent and –8.2 per cent in 1998. Earlier, government stimulus measures to improve private consumption included reducing the value-added tax from 10 to 7 per cent and cutting taxes on petroleum products. The economy began its recovery in 1999 with GDP growth of 4.1 per cent, led by the manufacturing sector and an increase in domestic demand assisted by government intervention (Paitoonpong & Abe 2004). Private industry also responded, for example tourism increased, due to a lower exchange rate and a tourism campaign *Amazing Thailand*, and by 1999, incoming tourists reached 8.6 million. Table 4.9 illustrates this outcome.

Table 4.9
Eighth Plan GDP Growth and Infrastructure Program 1997-2001

Sector	**Percentages**					
	1997	**1998**	**1999**	**2000**	**2001**	**Average**
Agricultural	-12.5	-1.5	2.3	7.2	3.5	-0.2
Manufacturing	2.0	-13.0	9.6	5.3	1.7	1.1
Service	-0.5	-10.0	0.4	3.7	2.3	-0.8
Average	**-3.7**	**-8.2**	**4.1**	**5.4**	**2.5**	**0.0**

Source: NESDB (2004)

Table 4.9 shows Negative GDP growth in the first two years as the government, assisted by the private sector, worked through the severe impacts on the economy. At the end of the period, GDP growth was on average zero. However, the manufacturing sector still maintained some growth for four from five years, whilst the other sectors deflated two from five years, and remained deflated over the period.

Planned infrastructure expenditure was 777,864 million baht, with expenditure again favouring transport and communications:

Transport	287,931m.baht (37%)
Communications	102,227m.baht (13.1%)
Social infrastructure	74,537m.baht (9.6%)
Energy	313,169m.baht (40.3%) (NESDB 2004).

The Asian economic crisis devastated the infrastructure investment plan; the government could not continue the program as planned (NESDB 2005). The new criteria for productivity projects during the crisis were that they contributed to productivity, generated foreign income, required low import content and were innovative. However, social infrastructure projects were not affected. By 1999, when Thailand began to recover from the recession, the NESDB revisited its critical infrastructure investment program and reinstated over 80 projects (Bank of Thailand 2000).

In the eighth plan, therefore, infrastructure expenditure declined. The focus shifted from transport and communications to the energy sector, which received 40.3 per cent of expenditure. Social infrastructure maintained its proportion of the program.

4.1.9 Ninth Plan 2002–2006

Based on the King’s leadership, the ninth five-year plan sought economic efficiency. It was designed to focus on people and attain a balance of economic, social, political and environmental development (NESDB 2003). Although sustainable development was earlier adopted as a tenet for economic reform, it was codified in this plan through the establishment of the National Sustainable Development Council in 2003. The aim of the council was to balance economic, social and environmental development to ensure sustainable growth for the country (Bangor 2004). With the prevailing economic conditions, GDP growth reached 7.4 per cent in 2003. Table 4.10 for 2002-2006 shows the outcome of this period.

Table 4.10
Ninth Plan GDP Growth 2002-2006

Sector	Percentages					
	2002	2003	2004	2005	2006	Average
Agricultural	0.7	12.7	-2.4	-1.9	3.8	2.6
Manufacturing	6.3	5.6	6.4	5.9	4.6	5.8
Service	4.8	3.9	7.1	5.3	3.9	5.0
Average	**3.9**	**7.4**	**3.7**	**3.1**	**4.1**	**4.5**

Source: NESDB (2008)

The infrastructure program was considered crucial in Thailand's sustainable and balanced development. By continually monitoring and investing in appropriate infrastructure for the private and public sectors, and especially for social welfare and the environment, the country could maintain stability and prosper. Thus the total amount of investment for the ninth plan increased significantly to 936,792 million baht, maintaining a pattern of transport and energy to meet the needs of the 2006 population of 65 million

Transport	385,316m.baht (41.1%)
Communications	142,360m.baht (15.2%)
Social infrastructure	177,588m.baht (19%)
Energy	231,528m.baht (24.7%) (NESDB 2004).

4.1.10 Summary of Plans and Infrastructure Investment

As an emerging economy, Thailand's success at maintaining steady growth fluctuated over the forty years of the nine economic development plans. This record is set out at Table 4.11 summary for 1962-2006

Table 4.11
Summary of GDP Growth During the Nine Plans 1962-2006

Sector	GDP Averages per 5-year Plan								
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
	Percentages								
Agricultural	7.0	5.9	4.0	3.4	3.3	4.5	3.0	-0.2	2.6
Manufacturing	12.5	7.7	9.4	8.7	6.6	15.2	9.6	1.1	5.8
Service	7.4	7.8	6.4	7.9	5.4	10.1	7.9	-0.8	5.0
Average GDP	**9.0**	**7.1**	**6.6**	**6.6**	**5.1**	**9.9**	**6.8**	**0**	**4.5**

Source: NESDB (2004, 2008)

The table shows that, apart from the effects of the 1997 Asian crisis, the country maintained a positive GDP growth which reached its peak of 13 per cent in 1988. Thailand's early growth resulted from significant export expansion and later, through foreign capital after financial deregulation. However, inflow funds were not so much direct investment as bank loans and portfolio capital, thus they fuelled the domestic market boom, and created an asset bubble. A further issue for maintaining stability occurred when companies were permitted to issue international debt instruments as private placements without application to the Security Exchange Commission.

The Asian financial crisis in 1997 impacted Thailand's fragile economy, which at the time had private foreign debt estimated at $US90 billion. GDP growth in 1998 was at its nadir at -8.2 per cent. With the economic stimulation package put forward by the government, the economy recovered and GDP growth resumed growth in 1999. Thailand's government used its experience for financial stimulus during the Asian crisis to plan for sustainable growth and economic efficiency. The tenet of economic efficiency was introduced to reach sustainability.

Thailand used infrastructure investment as its principal economic development instrument. The following Table 4.12 for the 1962-2006 infrastructure programs show the expenditure averages across the 5-year plans and highlights the priorities within each plan.

Table 4.12

Summary of Nine Plans Infrastructure Program 1962-2006

Sector	**Plan**								
	1st	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**
	Billion Baht								
Transport	7.4	17.0	22.5	37.2	53.8	189.1	477.3	287.9	385.3
Communications					33.9	69.5	36.2	102.2	142.4
Social Infrastructure	5.6	10.3	20.1	33.3	19.3	29.4	76.50	74.5	177.6
Energy	4.7	5.0	14.8	16.0	94.4	233.8	235.3	313.2	231.5
Total	**17.7**	**32.2**	**57.3**	**86.5**	**201.4**	**521.9**	**825.3**	**777.9**	**936.8**

Note: from the first to the fourth plan, transport and communications were integrated

Source: NESDB (2004, 2008)

The table shows that transport and energy were the priorities for infrastructure investment. During the initial plans, communication and social infrastructure were secondary to nation-building. Later, when the basics were in place, attention turned to social issues for the seventh and subsequent plans. This table illustrates the relationships between government policy and infrastructure expenditure and GDP growth, although this premise is yet to be proven.

4.2 Thailand's Infrastructure

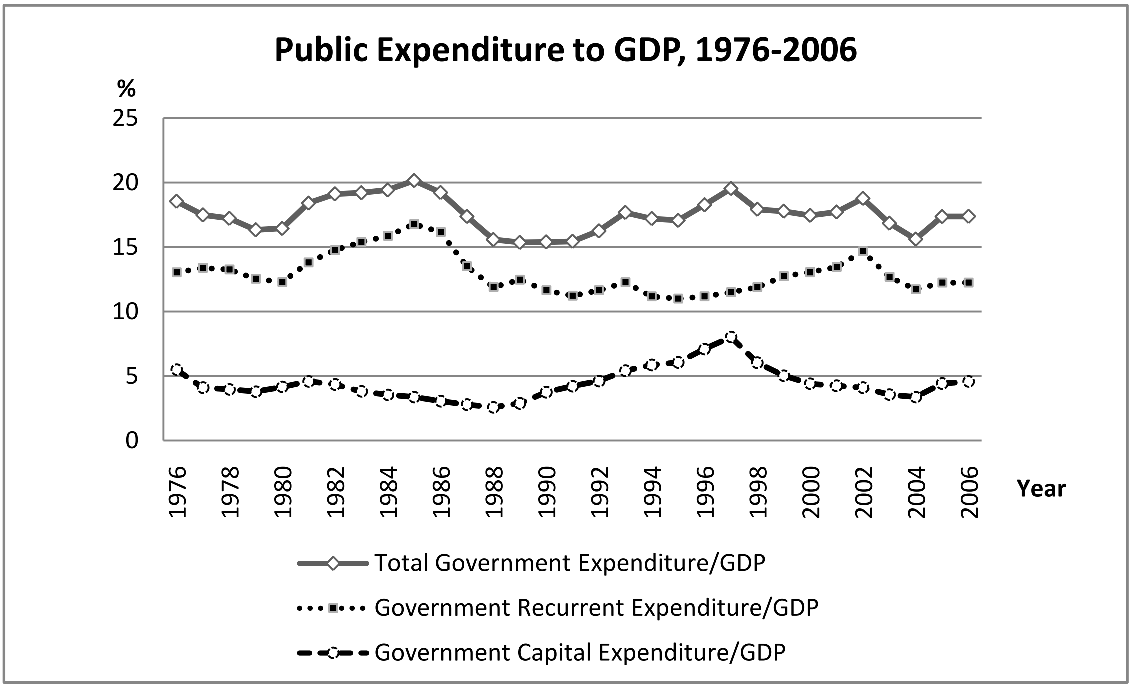
> *Developing countries face an enormous challenge in meeting the infrastructure requirements of the growing population* (Merna & Njiru 2002).

As an emerging economy, Thailand has mixed success balancing its economic instruments to achieve sustainable growth. Infrastructure investment is a social and a business necessity, and a source of great expenditure. Nevertheless, such expenditure is based on national priorities and does not guarantee sufficient infrastructure to meet all economic and social requirements. In this section, Thailand's infrastructure is analysed and the findings presented.

4.2.1 Expenditure

Infrastructure expenditure, if not directly available, may be traced through public capital expenditure which is thus used as a proxy. Capital expenditure contributes to capital formation: funding attributed to economic policy and fixed assets, whereas recurrent expenditure includes social and public expenses (Bureau of the Budget 2006).

Figure 4.2 shows public expenditure as a proportion of GDP, recurrent expenditure to GDP, and capital expenditure to GDP.



Source: Bureau of the Budget (1977-2007)

Figure 4.2 *Public Expenditure to GDP, 1976-2006*

Figure 4.2 illustrates that capital expenditure from 1976 to 2006 was less than recurrent expenditure at all times. Total public expenditure over the period averaged 17.5 per cent of GDP and the capital contribution was 4.5 per cent of GDP. Following the Asian economic crisis in 1997, the rate of capital expenditure declined for seven consecutive years from 1997 to 2004. This inability to maintain public infrastructure resulted in traffic congestion and underperformance of public utilities. Apart from the impetus of the Asian financial crisis, infrastructure expenditure remained a set proportion of public expenditure (Aromdee, Rattananubal & Chai-anant 2005).

Transport congestion and inadequate public utilities significantly increased private sector costs, constraining GDP and the country's living standards (Foreign Affairs and Trade, Australia 1998). As adequate infrastructure is a prerequisite for growth, it is necessary to determine a level of infrastructure that allows reasonable growth (s2.1.2, Prud'homme 2004). To explore this point, other countries' experiences regarding the effects of infrastructure investment on their GDP can be identified, and comparison made with Thailand. Such information can be gained from sources such as international organisations, or directly from a given country.

4.2.2 International Competitiveness

There are several international organisations that provide rankings for nations' infrastructure expenditures, such as the International Institute for Management Development (IMD), which publishes the World Competitiveness Yearbook. The IMD ranks 60 contributing countries on economic performance, government efficiency, business efficiency, and infrastructure. The institute's criteria for infrastructure competitiveness are the extent to which basic technological, scientific and human resources meet the needs of business (International Institute for Management Development 2004).

Seven countries were selected from the World Competitiveness Yearbook as subjects for this study; Thailand; leading economies USA and Japan; a potential leader, China: regional economic leaders Singapore and Korea; and a neighbouring country, Malaysia. The comparison at Table 4.13 indicates that Thailand was the least competitive of the selected countries, and with the exception of 2002, was in decline for the period 2000 - 2004.

Table 4.13
Selected Countries Ranked for Competitiveness, 2000-2004

Country	2000	2001	Year 2002 IMD Ranking 1–60.	2003	2004
Thailand	41	46	42	49	50
USA	1	1	1	1	1
Japan	3	5	6	3	2
China	35	40	37	41	41
Singapore	12	14	12	12	9
Korea	28	26	23	30	27
Malaysia	32	35	31	31	30

Source: IMD World Competitiveness Yearbook (2004)

Whilst Thailand remains near the end of the rankings, the country is not in a position to attract investment or to increase productivity. Until this situation is resolved, the country will remain an emerging economy, unable to fully utilise its resources to improve conditions for its citizens. Thailand thus needs infrastructure development to stay competitive in world markets.

Another indicator for international comparison is infrastructure stock. Using best practice average price, Fay and Yepes (2003) estimated the value of world infrastructure stock in 2000 and this is presented at Table 4.14 World Infrastructure Stocks.

Table 4.14
World Infrastructure Stocks, per Capita Income, 2000

Sector	Low Income Countries	Middle Income Countries	High Income Countries	World	Thailand
			Per Cent		
Electricity	25.6	48.1	40.1	40.4	**32.1**
Roads	50.9	28.1	44.9	41.0	**55.4**
Water & sanitation	14.5	9.9	4.7	7.5	**4.0**
Rail	7.2	7.0	4.1	5.3	**3.2**
Telecommunications	1.8	6.9	6.2	5.8	**5.3**
Total	100	100	100	100	100

Source: Fay and Yepes (2003) and NESDB (2004)

The table above shows that the roads sector is the leading infrastructure stock for low income countries, accounting for 50.9 per cent of total infrastructure stocks. Thailand is classified by NESDB (2004) as between the low and middle per capita income countries.

Middle income countries are investing in power, electricity, which is the major sector at 48.1 per cent. In high income countries, electricity and roads are both priorities, at 40.1 and 44.9 per cent respectively. Thus transport and power are the largest world infrastructure sectors at a combined 80 per cent of total value. Water and sanitation receive relatively lower priority as per capita income increases, while the reverse occurs in the case of telecommunications. This could be attributed to basic infrastructure for water accounts for future growth, whilst telecommunications is subject to rapid technological change and requires constant upgrading. Roads have the largest proportion of infrastructure stock in Thailand, followed by electricity. However, rail, water and sanitation stocks are lower in Thailand than the average for low-income countries, while telecommunications is higher. The outcomes of both approaches result in the observation that Thailand lags the world in infrastructure development, supporting the findings of Merna and Njiru (2002). Nevertheless, this observation belies the fact that developing countries often lack investment funds. Public finance through taxation in small developing economies is frequently inadequate to finance their infrastructure programs, due to their low tax bases and smaller investment opportunities. Hence, funding for projects is scarce, and loans difficult to obtain.

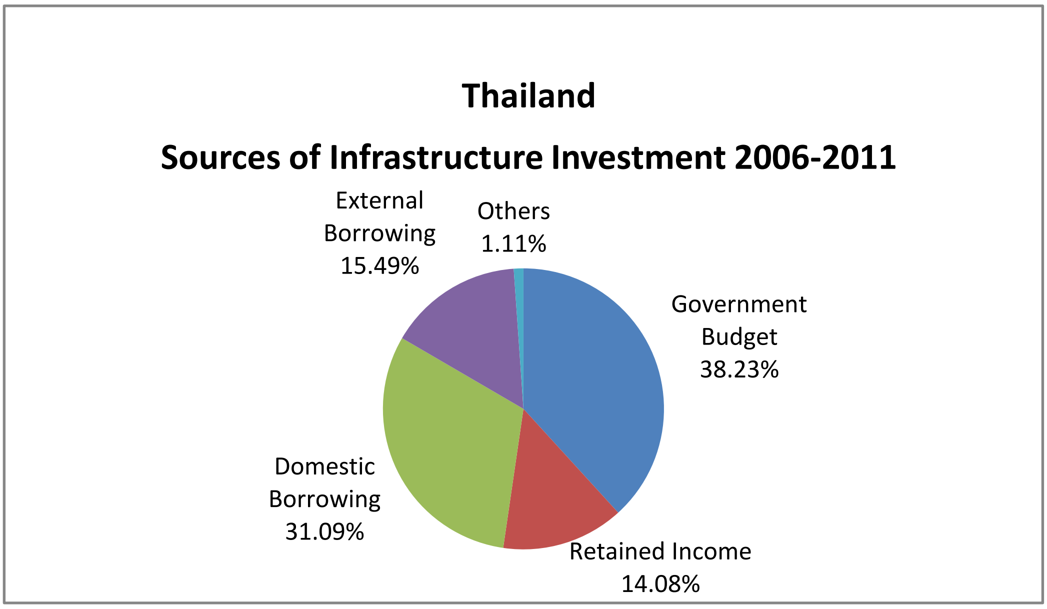
The next section investigates potential sources for funding available to the Thai government to support infrastructure investment.

4.3 Sources of Infrastructure Finance

Financing infrastructure in the south-east Asian developmental state could be achieved at the external level through foreign direct investment, debt and aid, and at the internal level with taxation, public revenues and spending, domestic private saving and investment. The tax to GDP ratio is rather low, current revenues in the East Asia-Pacific region averaged some 12 per cent of the GDP (Sindzingre 2007). Whilst taxes are a major source of public finance for the developed world's governments, there are options: appropriating resources, selling assets, user charges, printing money and social service contributions. Further, the majority of taxes distort economic activity, creating inefficiencies and economic loss. Thus governments use monetary instruments for macroeconomic policy, to the extent that monetary policy may become a budget financing issue. (Abelson 2008).

Traditionally, a country's public sector was the sole provider of infrastructure, using general taxation or external funding from international agencies. For developing countries, the most pressing issue for infrastructure development is shortage of capital, exacerbated by low incomes, little savings, and therefore low investment and difficulty in raising international finance (Merna & Njiru 2002). The move towards private provision of infrastructure services across south-east Asian developing countries was motivated by disenchantment with the inefficiency and poor performance of state-owned monopolies, the need for new investments and modernisation to meet rapid growth in demand, and fiscal constraints, along with the desire to extend service access to the poor (Besant-Jones, 2006).

In the case of Thailand, the sources for infrastructure expenditure are taxation through the budget, domestic and foreign debt, and retained income from public enterprises. However, the government is considering other sources of funding such as public-private partnerships (PPP) and privatisation to support its infrastructure program. However, Figure 4.3 shows that projects from 2006 to 2011 are primarily using debt finance (46.6%) and taxation through the budget (38.23%).



Source: MOF (2007)

Figure 4.3 *Sources of Infrastructure Investment 2006-2011*

Whilst recurrent expenditure receives the greater proportion of public expenditure, capital expenditure through infrastructure receives some 25 per cent of available funds (s.4.2.1). This is insufficient to provide the private sector with the infrastructure services (transport, utilities, skills) it requires to be competitive (s4.2.2). It is therefore important to investigate all sources of public revenue for Thailand.

4.3.1 Public Revenue

The Royal Thai Government (RTG) derives revenue through taxes and non-tax sources, including retained income from SOEs. Table 4.15 Public Revenue Sources 1993-2006 shows the type of gross public revenue received, triennially, as a percentage of total income.

Table 4.15
Public Revenue Sources 1993-2006

Source	Type of Tax	1993-1996 %	1997-2000 %	2001-2004 %	2005-2006 %	1993-2006 %
Revenue Department		**52.94**	**57.81**	**57.60**	**65.42**	**58.44**
Personal Income Tax (PIT)	Direct	10.86	13.09	11.14	10.94	11.51
Corporate Income Tax (CIT)	Direct	17.30	15.11	17.93	22.02	18.09
Petroleum Tax (PT)	Direct	0.42	0.92	1.91	2.79	1.51
Business Tax	Indirect	0.18	0.03	0.01	0.00	0.05
Value Added Tax (VAT)	Indirect	20.12	25.15	24.67	27.20	24.28
Specific Business Tax (SBT)	Indirect	3.38	3.07	1.45	1.98	2.47
Stamp Duties	Indirect	0.65	0.40	0.48	0.47	0.50
Other	Non-Tax	0.03	0.03	0.02	0.02	0.03
Excise Department		**19.95**	**20.08**	**21.49**	**17.48**	**19.73**
Petroleum and Petroleum Products Tax	Indirect	6.78	7.89	6.83	4.81	6.58
Tobacco Tax	Indirect	2.72	3.43	3.23	2.42	2.95
Distilled Spirits Tax	Indirect	2.71	2.11	2.06	2.02	2.22
Fermented Liquors Tax e.g. Beer	Indirect	1.88	3.00	3.40	3.06	2.83
Motor vehicles Tax	Indirect	4.86	2.35	4.66	3.93	3.95
Non-alcoholic beverages Tax	Indirect	0.82	0.86	0.82	0.71	0.80
Electrical appliances Tax	Indirect	0.15	0.14	0.21	0.23	0.18
Motorcycles Tax	Indirect	0.00	0.07	0.13	0.13	0.08
Batteries Tax	Indirect	0.00	0.05	0.06	0.07	0.05
Horse-racing course Tax	Indirect	0.00	0.01	0.01	0.01	0.00
Golf course Tax	Indirect	0.00	0.01	0.02	0.03	0.02
Perfumes Tax	Indirect	0.01	0.01	0.01	0.01	0.01
Playing Card Tax	Indirect	0.01	0.00	0.00	0.00	0.00
Night club and discotheque Tax	Indirect	0.00	0.00	0.00	0.01	0.00
Turkish or sauna and Massages Tax	Indirect	0.00	0.00	0.01	0.01	0.00
Miscellaneous Excise Revenue	Non-Tax	0.02	0.15	0.03	0.03	0.06
Customs Department		**16.11**	**9.75**	**9.83**	**6.69**	**10.59**
Import Duties	Indirect	15.92	9.54	9.64	6.49	10.40
Export Duties	Indirect	0.00	0.00	0.02	0.02	0.01
Others	Non-Tax	0.18	0.20	0.18	0.18	0.18
Total Revenue, Excise, Customs		**89.00**	**87.64**	**88.93**	**89.58**	**88.76**
Other departments		**11.01**	**12.36**	**11.07**	**10.42**	**11.22**
Other government agencies	Non-Tax	5.46	5.90	4.69	4.45	5.12
Treasury Department	Non-Tax	0.00	0.00	0.24	0.21	0.11
Revenue from selling stock	Non-Tax	0.00	0.00	0.56	0.00	0.14
Privatisation of SOEs	Non-Tax	0.00	0.00	0.15	0.01	0.04
SOEs	Ret. Income	5.55	6.46	5.43	5.75	5.80
Total non-tax revenue and Ret. Income		**11.24**	**12.75**	**11.31**	**10.64**	**11.48**
Gross tax revenue		**88.76**	**87.25**	**88.69**	**89.36**	**88.52**
Public Revenue		**100**	**100**	**100**	**100**	**100**

Source: Monthly data, MOF (2008)

Sources of Revenue

Table 4.15 informs that internal public revenue predominantly relies on taxation, averaging 88.8 per cent from 1993 to 2006. It is collected by three departments under the Ministry of Finance (MOF), Revenue, Excise and Customs. The Revenue Department's array of taxes contributes over half all Thailand's public income (58.4% average over the period), including Personal Income Tax (PIT), Corporate Income Tax (CIT), Value Added Tax (VAT), Specific Business Tax (SBT), Stamp Duties, and Petroleum Income Tax (Revenue Department 2008a).

The Excise Department is the second largest collector of public income, averaging 19.8 per cent of public revenue. It is responsible for excise duties on goods and services including: alcohol and tobacco products; petroleum products and vehicles; household goods including electrical appliances and non-alcoholic beverages; sporting items such as yachts, horse racing, golf courses; and entertainment and personal service venues. More than 90 per cent of the excise tax revenue is collected from the top six products: petroleum and petroleum products, tobacco, distilled spirits, vehicles, and beverages (Excise Department 2008).

Averaging 10.6 per cent of total public revenue, the Customs Department collects customs taxes and duties; plus it acts as agent collecting VAT for the Revenue Department, excise for the Excise Department, and municipal tax for local administrations. It also has responsibility for managing all import-export related matters (Customs Department 2008). Whilst import duties were traditionally the greater proportion of its income, Free Trade Agreements (FTA) have more than halved this source of revenue over the period. It should be noted that Table 4.15 is gross tax revenue, subject to rebates and export compensation. Revenue collected at Table 4.15 includes direct and indirect tax.

Direct tax impacts a person or entity's disposable income; an increase in the direct tax rate can reduce private expenditure (consumption and investment) and is thus an *income effect*. Indirect tax, imposed on goods and services, leads to price increases and a decline in consumption. It therefore has a *price effect* (Ulbrich 2003).

The trends in direct and indirect tax collections over the last four triennia are described in Table 4.16.

Table 4.16
Direct and Indirect Tax Trends, 1993-2006

Tax	**Triennial Years**				
	1993-1996	**1997-2000**	**2001-2004**	**2005-2006**	**Average 1993-2006**
	Percentages				
Direct	32.25	33.27	34.89	39.98	**35.10**
Indirect	67.75	66.73	65.11	60.02	**64.90**
Total	100	100	100	100	100

Source Monthly data MOF (2008)

The above table shows that indirect taxes dominated tax collection in Thailand from 1993 to 2006 and were generally two-thirds of all taxes. However, indirect taxes were trending down as a proportion of tax collections.

Direct Tax

Table 4.17 Direct Tax Revenue Components, 1993-2006 shows that, of the three direct taxes collected by the Revenue Department: PIT, CIT and Petroleum Income Tax (PT), CIT, except during the Asian crisis, was the largest contributor to *internal revenue* from 1993 to 2006 at an average of 18.1 per cent (calculated from Table 4.15). However, the revenue from CIT declined in the triennium 1997-2000 when the country was in recession, following the Asian economic crisis. Following this pattern, PIT also dropped by one-fifth over the decade.

Table 4.17
Direct Tax Revenue Components, 1993-2006

Tax	Triennial Years				
	1993-1996	1997-2000	2001-2004	2005-2006	Average 1993-2006
	Percentages				
Direct Tax (DTAX)					
Personal Income Tax (PIT)	42.93	47.27	38.90	33.94	**40.76**
- Withholding PIT	14.22	19.39	20.89	19.24	**18.43**
- PIT on Interest and dividends	18.16	18.32	6.71	4.40	**11.90**
- Annual PIT	2.21	2.34	3.29	2.98	**2.70**
- Other PIT	8.33	7.22	8.00	7.33	**7.72**
Corporate Income Tax (CIT)	56.80	50.00	55.78	59.16	**55.43**
- Annual CIT	17.29	12.50	14.09	15.93	**14.95**
- Half-yearly CIT	16.72	12.35	15.33	17.65	**15.51**
- CIT: Service Cos.& Repat. Profits	7.52	9.91	9.30	8.64	**8.84**
- Withholding CIT	11.03	11.21	14.04	14.78	**12.77**
- Other CIT	4.25	4.03	3.02	2.16	**3.36**
Petroleum Income Tax (PT)	0.27	2.73	5.33	6.90	**3.81**
Total	100	100	100	100	100

Source: Monthly data MOF (2008)

Personal Income Tax

PIT is a direct tax levied on the income of all persons who have resided in Thailand for a cumulative 180 days or more in a tax year. A resident is subject to tax on all income regardless of its source, a non-resident is subject to tax only on income earned from sources within Thailand (Revenue Department 2008a).

Tax may be levied on the following residents' income: wages paid in Thailand or abroad and monetary or non-monetary salary package items, such as travel, accommodation, living expenses, dependants' expenses; repatriated income (wages, interest, dividends, pensions); capital gains; and royalties. As described in Table 4.18, tax is assessed using a progressive system on net income[22]

[22] Taxes increase when income rises (Ulbrich 2003)

Table 4.18
Personal Income Tax Rates, 2006

Annual Taxable Income (Baht)	Tax Rate Per Cent
0 - 150,000	Exempt
150,001 - 500,000	10
500,001 - 1,000,000	20
1,000,001 - 4,000,000	30

Source: Revenue Department (2008c)

The Ministry of Finance categorises personal tax thus: withholding PIT, PIT on interest and dividends, annual PIT and other PIT as described in Table 4.19 Personal Income Tax Components, 1993–2006.

Table 4.19
Personal Income Tax Components, 1993-2006

Personal Income Tax	**Triennial Years**				
	1993-1996	**1997-2000**	**2001-2004**	**2005-2006**	**Average 1993-2006**
	Percentages				
Withholding PIT	32.49	41.41	53.62	56.87	**46.10**
PIT (Interest & Dividends)	43.46	38.19	18.00	14.39	**28.51**
Annual PIT	3.62	4.34	6.22	5.73	**4.98**
Other PIT	20.44	16.06	22.17	23.01	**20.42**
Total	100	100	100	100	100

Source: MOF (2008)

Whilst withholding tax on salaries and earned income was the largest average component of PIT (46.1%), it increased significantly over the period to reach 56.87 per cent average per annum for the triennium 2005-2006. The two personal taxes, earned income and capital income, provided some 70 per cent of revenue from this source; however, withholding tax increased significantly over the period, with a commensurate decline in earnings from interest and dividends, particularly in 2001-2004. The reason is partly due to the sharp fall in interest rates after the Asian economic crisis. Annual PIT is an annual adjustment to withholding tax and is relatively consistent. Other PIT, the third largest component, includes withholding tax for the public sector plus purchased public service contracts, personal tax adjustments at half-year and property tax. The average of PIT, 1993-2006, from other sources is 20.42 per cent.

Withholding PIT

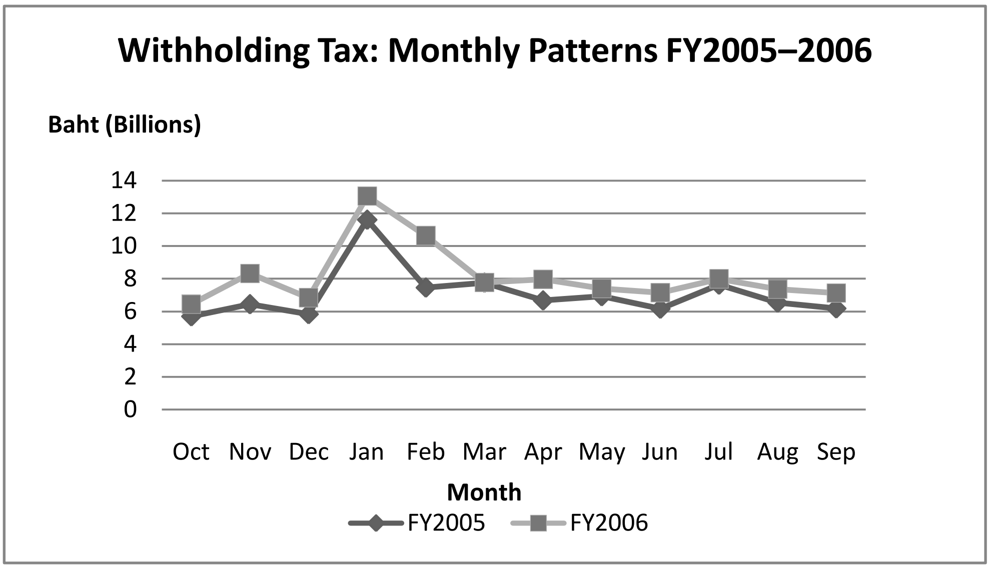
Businesses retain taxes on behalf of their employee for the Revenue Department. Table 4.20 Withholding Tax Rates, 2006 displays the relevant tax rates. Each employee receives a tax certificate at the end of the taxation year in September as a credit against annual or half-yearly assessable income tax payable.

Table 4.20
Withholding Tax Rates, 2006

Types of income	**Tax Rate Per Cent**
Employment income	> 30
Rents and prizes	5
Ship rental charges	1
Service and professional fees	3
Public entertainer remuneration	
Thai resident	5
Non-resident	>30
Advertising fees	2

Source: the Revenue Department (2008c)

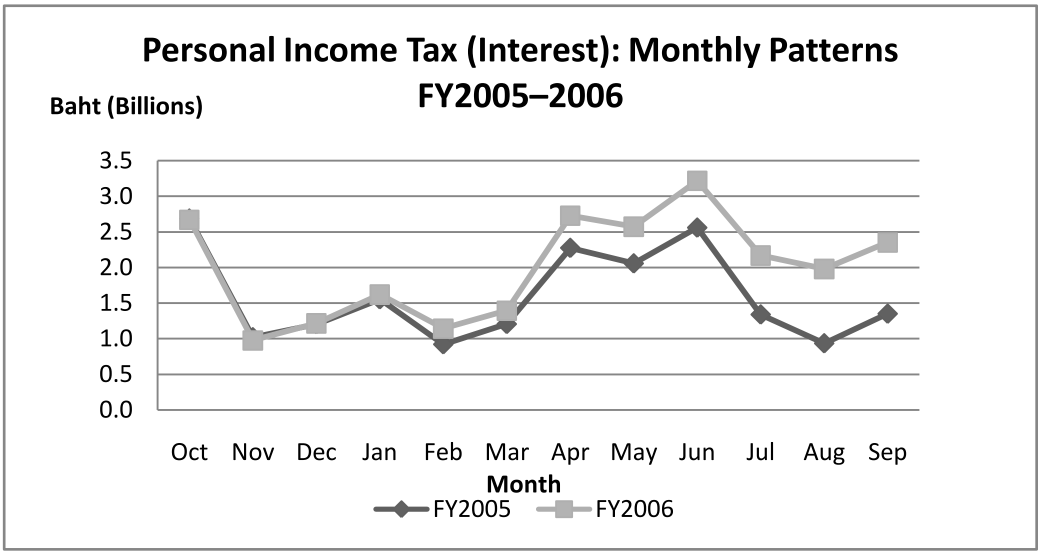
Figure 4.4 Withholding Tax: Monthly Patterns FY2005–2006 compares the revenue of withholding PIT on salary collected monthly for fiscal years 2005 and 2006. The pattern shows that a significant peak in January, as Thai companies pay bonuses in January.



Source: MOF (2008)
Figure 4.4 *Withholding Tax: Monthly Patterns FY2005–2006*

PIT Interest and Dividends

Interest results from either savings or term deposits and banks generally withhold 15 per cent tax from interest income, which for saving deposits is paid biannually in June and December and for term deposits is paid one month after the expiry date. Figure 4.5 shows a three year comparison of PIT on interest collected on a monthly basis from fiscal year 2005 to 2006. The figure indicates a significant peak in June due to the saving deposit interest payment.



Source: MOF (2008)

Figure 4.5 *Personal Income Tax (Interest): Monthly Patterns FY2005–2006*

Interest payments which are exempt from 15 per cent withholding tax are

- bonds or debentures issued by a government organisation
- saving deposits if interest is less than 20,000 baht per year
- loans paid by a finance company
- financial institutions' products relating to agriculture, commerce or industry.

Dividends from a registered company or a mutual fund attract 10 per cent withholding tax for Thai residents.

Annual Personal Income Tax

The annual PIT payment for each calendar year is finalised within three months. Deductions and allowances are allowable against gross PIT and these are described in Table 4.21, Personal Income Tax Deductions and Allowances 2006.

Table 4.21
Personal Income Tax: Deductions and Allowances 2006

Income	**Indicative Deduction**
Leasing Property	
- Buildings	30%
- Agricultural Land	20%
- Other Land	15%
- Vehicles	30%
- Other Property	10%
Professional Fees	30% ;60% for medical professionals
Contractors’ Supplies	Actual expense or 70%
Other Income	Actual expense or variable to 85%
Indicative Allowances	
Spouse	30,000 baht
Child, Conditional	17,000 baht each (limited to three children)
Parents, Conditional	30,000 baht each
Life Insurance, Conditional	<50,000 baht each
Provident or Equity Fund Contributions	<15% of income
Home Mortgage Interest	<50,000 baht
Social Insurance Contributions	Amount paid
Charitable Contributions	<10% of income

Source: Revenue Department (2008c)

Other PIT

Other sources of personal income tax are public sector employment, leases on public property, public services provision from contractors’ payments, and adjustments to half-yearly and annual PIT. Revenue stems largely from income from public property, and income from public services, 25 and 26 per cent of total other PIT respectively (Bureau of the Budget 2006).

Corporate Income Tax

Company tax is levied on all companies operating in Thailand; foreign companies pay tax only on that proportion of net profit arising from business carried out in the country. However, foreign companies pay CIT on gross income from service fees, interest, dividends, rents and professional fees. Although the CIT rate is usually 30 per cent on net profit, the rates vary depending on types of taxpayers. The tax bases and rates are presented in Table 4.22 Corporate Income Tax, 2006.

Table 4.22
Corporate Income Tax, 2006

Taxpayer	Tax Base	Rate
Small Company[23]	Net profit <1m.baht	15%
	Net profit 1m-3m baht	25%
	Net profit > 3m baht	30%
Stock Exchange of Thailand (SET) Company	Net profit 300m. baht	25%
	Net profit > 300m. baht	30%
New Company on the SET	Net profit	25%
New Company on Market for Alternative Investment	Net profit to 5 tax periods	20 %
	Net profit after 5 tax periods	30 %
Bank Income from International Source	Net profit	10 %
Foreign Company: International Transport	Gross receipts	3%
Foreign Company Receiving Dividends Only	Gross receipts	10%
Foreign Company: Receiving Other Income Only	Gross receipts	15%
Foreign Company: Expatriating Profit	Amount repatriated	10%
Profitable Association or Foundation	Gross receipts	<10%
Regional Operating Headquarters	Net profit	10%

Source: Revenue Department (2008b)

Corporate Income Tax is categorised as annual CIT, half-yearly CIT, service sector CIT and repatriated profit into Thailand, withholding CIT, and other CIT. Table 4.23 shows the changes in collection patterns 1993 - 2006.

Table 4.23
Corporate Income Tax 1993-2006

Corporate Income Tax Component	**Triennial Years** 1993-1996	1997-2000	2001-2004	2005-2006	Average 1993-2006
			Per Cent		
Annual	26.33	21.88	24.12	26.34	**24.67**
Half-yearly	24.91	22.82	23.65	25.86	**24.31**
Service Sector, Repatriated Profits	16.15	21.86	18.46	16.11	**18.14**
Withholding	23.88	24.91	27.97	27.84	**26.15**
Other	8.73	8.53	5.80	3.85	**6.73**
Total	100	100	100	100	100

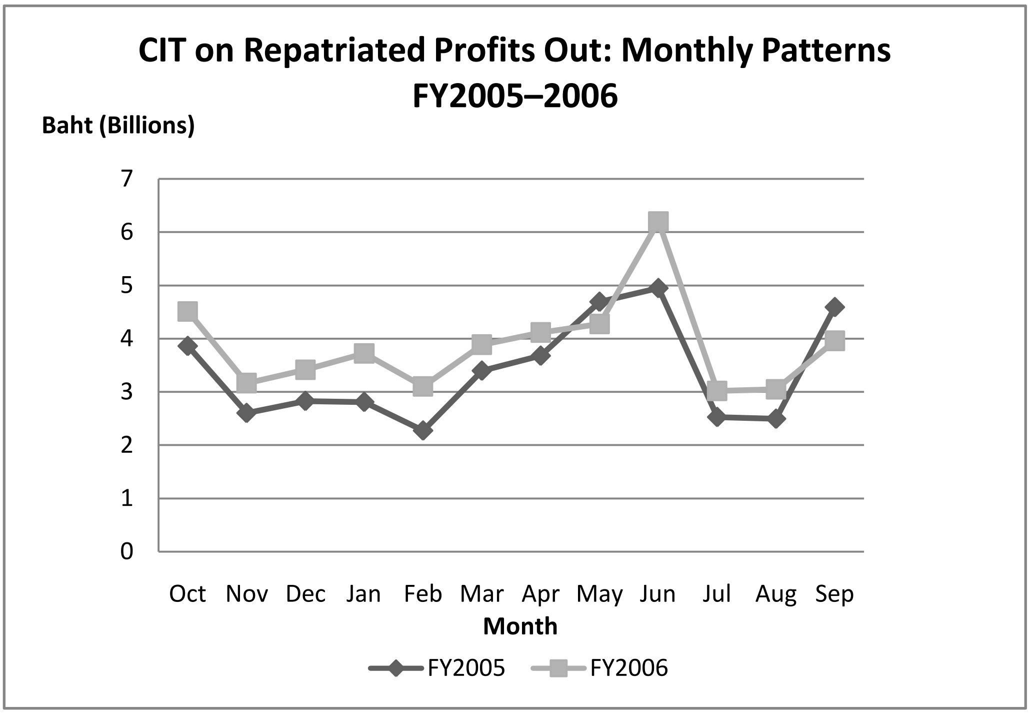
Source: MOF (2008)

The main sources of company tax at Table 4.23 are derived from annual, half-yearly and withholding taxes. This division reflects the timing of CIT payments by businesses, as they select a more advantageous manner of tax payments.

Companies in Thailand estimate annual net profit and tax liability and pay biannually. The half-yearly CIT is paid within 60 days after it becomes due, and annual CIT, the adjusted final payment, is due within 150 days after the company closes its accounts, generally in December. Thus annual tax payments peak in May, and half-yearly taxes in August (Revenue Department 2008a). However, companies differ in their accounting year: State Own Enterprises (SOEs) may use a fiscal year (October-September) and most Japanese companies use the Japanese fiscal year (April-March).

CIT on Repatriated Profits

Foreign companies that repatriate profits to their international head offices are liable for 10 per cent remittance tax, payable within a week (Revenue Department 2008a). However, CIT does not apply to overseas payments for goods, certain business expenses, repayment of loans and returns on capital investment, or dividends or interest payments remittances. Figure 4.8 CIT on Repatriated Profits Out: Monthly Patterns 2005–2007 shows tax collection patterns on foreign companies repatriating their profits for fiscal year 2005 and 2006. Payments peak in June.



Source: Ministry of Finance (2008)

Figure 4.6 *CIT on Repatriated Profits Out: Monthly Patterns FY2005–2006*

Withholding CIT Certain types of income paid to companies are subject to withholding tax at source. The withholding tax rates depend on the types of income and the tax status of the recipient. The tax withheld will be credited to the taxpayer.

Table 4.24
Withholding CIT Tax Rates, 2006

Types of Income	Withholding Tax Rate
Dividends	10%
Interest	10% if paid to associations or foundations, 1% in other cases
Royalties	10% if paid to associations or foundations, 3% otherwise
Advertising Fees	2%
Service and professional fees	3% if paid to Thai company or domiciled foreign company- 5% if paid to foreign company not domiciled in Thailand
Prizes	5%

Source: the Revenue Department (2008b)

Table 4.24 shows withholding tax CIT rates on different forms of income. Further, government agencies are also required to withhold one per cent tax on all income paid to companies. For income paid to non-domiciled foreign companies Thai companies withhold tax at the time of payment (Revenue Department 2008a).

Other CIT

This CIT includes property tax, withholding tax of the public sector, charities and associations (Revenue Department 2008a). Similar to other PIT, the majority of other CIT collection is from property tax and withholding tax on public sector, accounting for 15 and 27 per cent of total other CIT respectively (Bureau of the Budget 2006).

Petroleum Income Tax

This relates to income derived from the petroleum operations of companies involved with government petroleum concessions, and to companies purchasing oil for export from a concession holder. Whilst petroleum tax is classified as CIT, its specific purpose rates it as a direct tax component. Income subject to this tax includes: gross income from sale or disposal of petroleum, gross income arising from transfer of any property or right-related petroleum business, any other petroleum income. The tax rate for most operators is between 50 to 60 per cent of profits (Revenue Department 2008a).

Indirect Tax This is a significant contributor at more than half total tax revenue. Indirect tax comprises value added tax (VAT), excise tax, import duties, and specific business tax (SBT). Table 4.25 6 details indirect tax trends for 1993-2006.

Table 4.25
Indirect Tax 1993-2006

Indirect Tax Component	Triennial Years				
	1993-1996	1997-2000	2001-2004	2005-2006	Average 1993-2006
			Per Cent		
Value Added Tax	33.78	43.45	42.63	50.38	**42.56**
- Domestic	17.70	26.03	23.58	27.48	**23.70**
- Imported	16.08	17.42	19.05	22.89	**18.86**
Import Duties	6.26	16.45	16.39	11.92	**12.75**
Specific Business Tax	5.72	5.39	2.52	3.63	**4.32**
Excise Tax	34.24	34.71	38.46	34.07	**35.37**

Source: MOF (2008)

Table 4.25 illustrates that VAT contributes the most revenue with the average of 42.56 per cent, followed by Excise Tax collected by the Customs Department at 35.37 per cent.

Value-Added Tax

VAT first appeared in France and become the dominant sales tax in the Europe by the late 1960s (Ulbrich 2003), and it replaced a range of business taxes in Thailand in 1992. VAT relates to goods and services delivered in Thailand, whether originating internally or imported. VAT is now an important source of public revenue (Revenue Department 2008a).

Under VAT, value added at every stage of the production process is subject to tax. All importers are also subject to VAT, which is imposed by the Customs Department Upon delivery of the goods. The VAT cycle is a month; and if in surplus can be rebated generally as a tax credit. However, certain activities are excluded from VAT and are subject to a Specific Business Tax (SBT) and these are listed below:

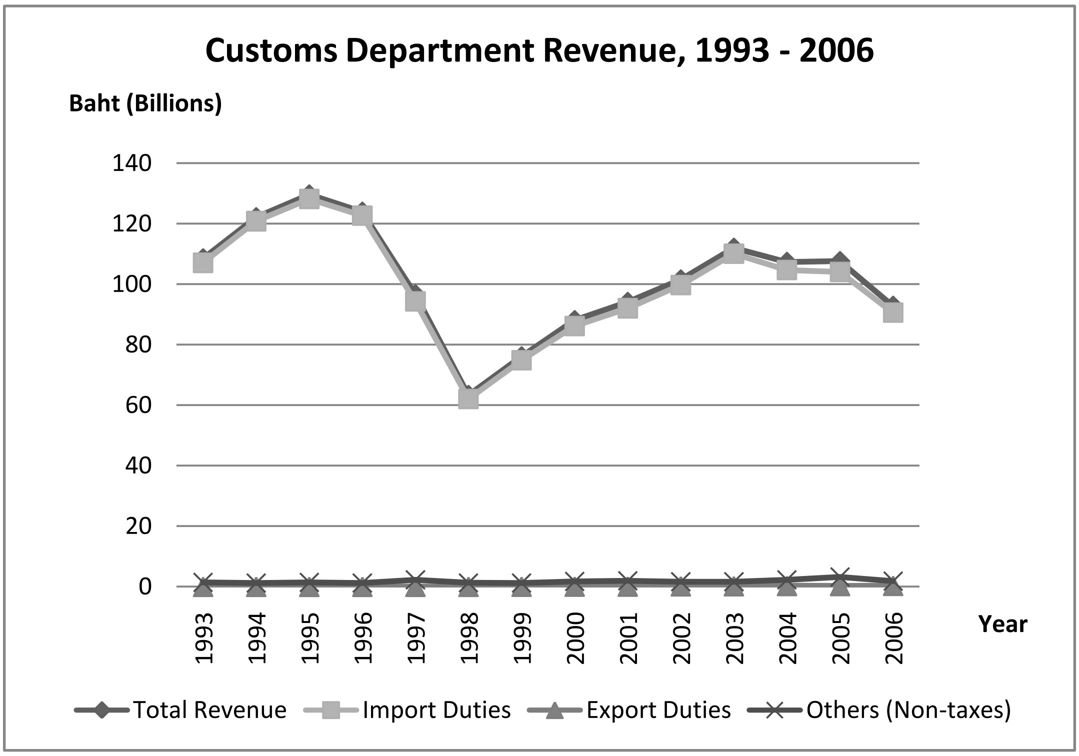
- small entrepreneur whose annual turnover is less than 1.2m. baht
- sales and import of unprocessed agricultural and related goods
- sales and import of newspapers, magazines and textbooks
- basic services such as
    - transport - domestic transport and international land transport
    - health care services provided by government and private hospitals and clinics
    - educational services provided by government and educational institutions,
    - professional services – medical, auditing, lawyers
    - rental of fixed properties
- cultural services such as amateur sports, services of libraries, museums, zoos
- employment of labour, research and technical services and services of entertainers
- exempt goods imported into Export Processing Zones and under the Customs Tariff Act
- imported goods held by the Customs Department for re-export
- religious and charitable services, government agencies and local authorities (Revenue Department 2008e).

Import Duties

Customs revenue encompasses, et alia, import/export taxes and duties: customs duties; excises for the Excise Department; and VAT for the Revenue Department. Import duties are collected from cargo, insurance and freight. The rates range between 0 to 10 per cent with the exception of automobiles, at 80 per cent. Other fees collected by the Customs Department include surcharges under the *Investment Promotion Act B.E.2520 (1977)*[24], fees under customs laws such as Customs seal fees, and other legislation such as lighthouse fees under the *Law of Navigation in Thai Waters* (Customs Department 2008).

As noted, import duties are the main revenue component at an average annual percentage of 98 of the total Custom Department's revenue from 1993-2006, see Figure 4.7

[24] It has been amended twice. The first was in B.E.2534 (1991) and the second was in B.E.2544 (2001).



Source: MOF (2008)

Figure 4.7 *Customs Department Revenue, 1993 - 2006*

Thailand plans for import-export balance, Thailand's imports, ranging from raw materials and value-added supplies for industry to consumer goods, are reaching 50 per cent of GDP and increasing, as exports are encouraged with few monetary impediments. Figure 4.7 illustrates the revenue generated by import duties as a percentage of the total for the year. The impact of the Asian crisis and a slow recovery is visible from 1996.

Specific Business Tax

SBT is an indirect tax introduced in 1992 to replace business taxes that were not transferred to VAT. This tax is imposed on businesses whose added value is difficult to define, such as banking, finance, insurance, pawnshops and real estate (Revenue Department 2008a). Government agencies are exempt from SBT, which is computed monthly, see Table 4.26 Special Business Tax, 2006.

Table 4.26
Specific Business Tax 2006

Business	Tax Base	Tax Rate
Banking & Finance	Interest, discounts, service & other fees, forex profits	3%
Life Insurance	Interest, service & other fees	2.5%
Pawn Brokerage	Interest, remuneration from selling overdue property	2.5%
Real Estate	Gross receipts	3%
Repurchase Agreement	Selling & repurchasing price difference	3%
Factoring	Interest, discounts, service fees and other fees	3%

Note: Local tax at the rate of 10 % is imposed on top of SBT.

Source: Revenue Department (2008d)

Excise Tax

This tax, the responsibility of the Excise Department, is collected on selective commodities and services; goods including luxury items and petroleum products as noted, and services including horse racing and golf courses. The Excise Tax Tariff is rated on an ad valorem[25] basis or at a specific rate, whichever is higher. Most goods and services are subject to ad valorem tax; however, for petroleum and petroleum products and non-alcoholic beverages, the rate varies. All goods subject to excise tax also remain subject to VAT (Excise Department 2008). The taxes are presented at Table 4.27 Excise Tax Components, 1993-2006.

24 ad valorem tax is a percentage tax; revenue increases through both volume and price (Ulbrich 2003).

Table 4.27
Excise Tax Components, 1993-2006

Excise Tax	**Triennial Years**				
	1993-1996	**1997-2000**	**2001-2004**	**2005-2006**	**Average 1993-2006**
	Percentages				
Petroleum and Petroleum Products Tax	34.09	39.49	31.92	27.55	33.26
Tobacco Tax	13.72	17.13	15.10	13.99	14.98
Distilled Spirits Tax	13.33	10.50	9.37	11.38	11.14
Fermented Liquors Tax e.g. Beer	9.36	14.87	15.79	17.63	14.41
Motor Vehicles Tax	24.45	11.65	21.70	22.38	20.05
Non-alcoholic Beverages Tax	4.12	4.31	3.82	4.03	4.07
Sub-total Value Components	**99.07**	**97.95**	**97.69**	**96.96**	**97.92**
Electrical Appliances Tax	0.75	0.69	0.99	1.34	0.94
Motorcycles Tax	0.00	0.33	0.61	0.74	0.42
Batteries Tax	0.00	0.25	0.30	0.40	0.24
Horse-racing Course Tax	0.01	0.04	0.02	0.03	0.03
Golf Course Tax	0.00	0.06	0.10	0.15	0.08
Perfumes Tax	0.04	0.04	0.05	0.07	0.05
Lead Crystal Products Tax	0.00	0.00	0.01	0.02	0.01
Wool Carpets Tax	0.00	0.01	0.01	0.01	0.01
Playing Card Tax	0.03	0.02	0.02	0.02	0.02
Yachts Tax	0.01	0.00	0.00	0.00	0.00
Chlorofluorocarbon Substance (CFCs) Tax	0.00	0.00	0.01	0.01	0.01
Night Club & Discotheque Tax	0.00	0.00	0.01	0.04	0.01
Turkish, Sauna & Massages Tax	0.00	0.00	0.03	0.07	0.03
State Lottery Tax	0.00	0.00	0.00	0.00	0.00
Transformed Marble and Granite Tax	0.00	0.00	0.00	0.00	0.00
Miscellaneous Excise Revenue (Non-Taxes)	0.08	0.61	0.14	0.14	0.25
Sub-total Remaining Components	0.93	2.05	2.31	3.02	2.10
Excise Department Revenue	100	100	100	100	100

Source: MOF (2008)

However, as shown in table 4.27, the six categories encompassing oil products, beverages and tobacco contributed 97.92 per cent of excise revenue.

Non-tax Revenue and Retained Income

Non-tax revenue is collected from government fees and charges, and other miscellaneous government revenue. Retained income (RI) is calculated from the revenue of state own enterprises (SOEs), less expenditures, CIT, dividends and bonuses. Table 4.28 summarises these subsidiary revenue components as a percentage of total public revenue.

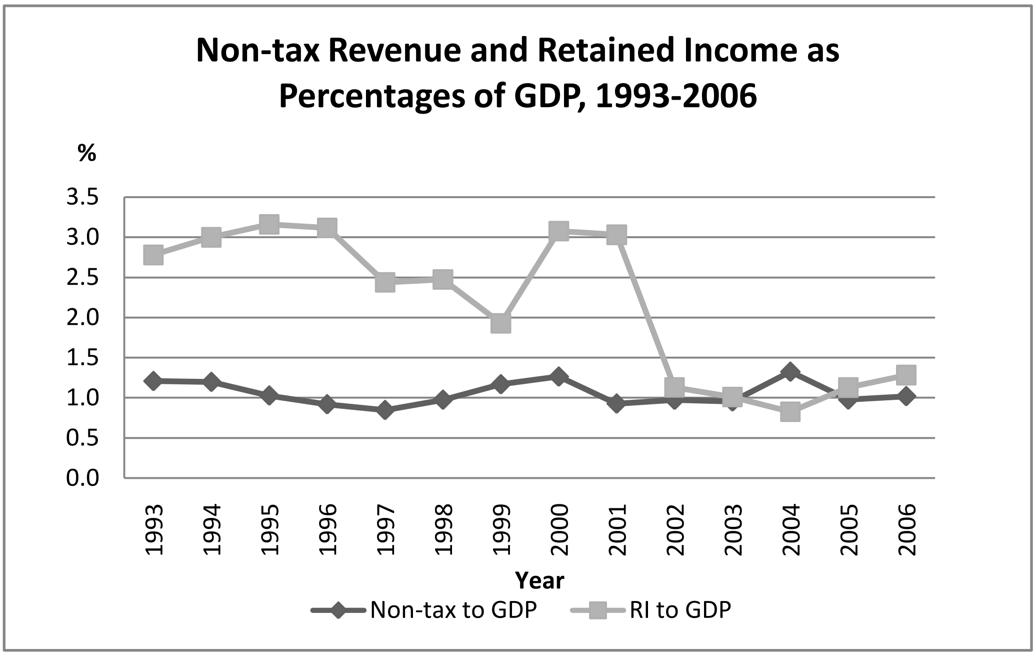
Table 4.28

Non-tax Revenue and Retained Income Components of Public Revenue, 1993-2006

Non-tax Revenue and Retained Income	**Type of Tax**	**Triennial Years 1993-1996**	**1997-2000**	**2001-2004**	**2005-2006**	**Average 1993-2006**
		Percentages				
Revenue Department						
Other	Non-Tax	0.03	0.03	0.02	0.02	**0.03**
Excise Department						
Miscellaneous Excise Revenue	Non-Tax	0.02	0.15	0.03	0.03	**0.06**
Customs Department						
Others	Non-Tax	0.18	0.20	0.18	0.18	**0.18**
Other Departments						
Other Government Agencies	Non-Tax	5.46	5.90	4.69	4.45	**5.12**
Treasury Department	Non-Tax	0.00	0.00	0.24	0.21	**0.11**
Revenue from Selling Stock	Non-Tax	0.00	0.00	0.56	0.00	**0.14**
Privatisation of SOEs	Non-Tax	0.00	0.00	0.15	0.01	**0.04**
SOEs	Ret. Income	5.55	6.46	5.43	5.75	**5.80**
Total Non-tax Revenue		**5.69**	**6.29**	**5.88**	**4.89**	**5.68**
Total Retained Income		**5.55**	**6.46**	**5.43**	**5.75**	**5.80**

Source: MOF (2008)

Table 4.28 shows that non-tax revenue and retained income accounted for an average of 5.68 and 5.80 per cent of total public revenue respectively. Both average percentage of non-tax revenue and retained income peaked during 1997-2000 at 6.29 and 6.46 per cent respectively. The contribution made by each revenue stream is depicted at Figure 4.8.



Source: MOF (2008), NESDB (2008)

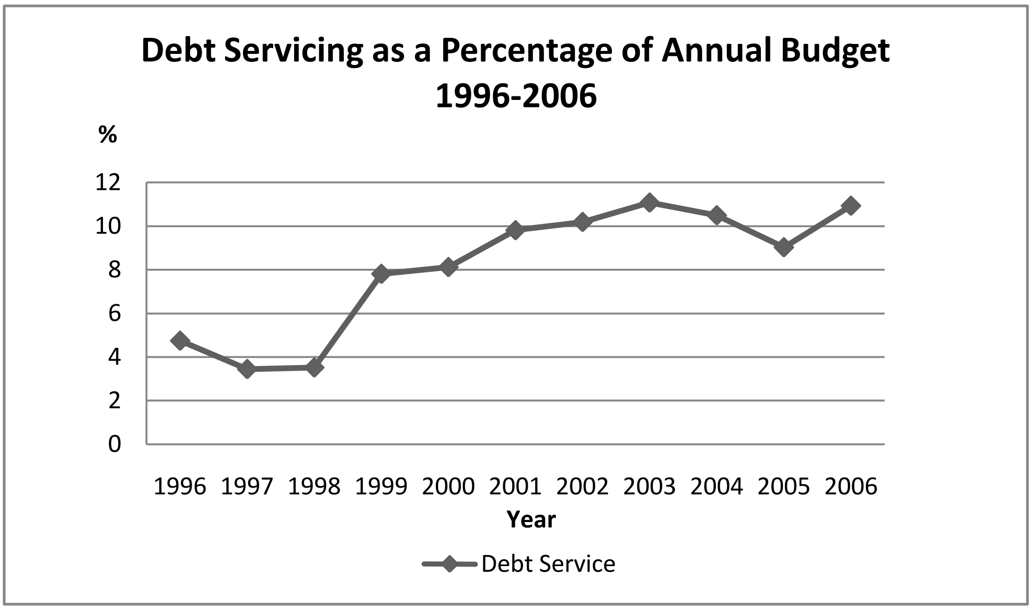
Figure 4.8
Non-tax Revenue and Retained Income as Percentages of GDP, 1993-2006

From 1993–2006 the average percentages of GDP for non-tax revenue and retained income were 1.06 and 2.17, respectively. Figure 4.08 shows that non-tax revenue remained relatively stable in relation to GDP retained income fluctuated, with a significant decrease from 3.03 per cent of GDP in 2001 to 1.13 per cent of GDP in 2002 due to the decline in SOEs revenue as a delay impact from the Asian Economic Crisis.

4.3.2 Deficit Financing

Thailand shares world concern regarding deficit financing. International practices to control fiscal deficit include the European Union's Stability and Growth Pact which maintains a goal of maximum budget deficit of three per cent of GDP and maximum debt to GDP of 60 per cent annually. There are exceptions: a country experiencing economic difficulties has five years to manage recurring deficits. Moreover, a country can legitimately exceed limits if expenditure is directed toward achieving European policy goals, or fostering international solidarity through education, research, defence or financial aid (Feldstein 2005).

After the 1997 Asian economic crisis, the Ministry of Finance established a fiscal sustainability framework, balancing government expenditure with an adequate level of revenue. In Thai legislation, a deficit must be financed domestically, that is, through Treasury or other government bonds. Further, there are regulatory requirements for public debt to remain at 50 per cent or less of GDP, debt service to annual budget at 15 per cent or less, the budget is to be in balance, and capital expenditure must be 25 per cent or more of the annual budget (MOF 2005). Figure 4.9 illustrates the decline in debt servicing since 2000.



Source: PDMO (2008b)

Figure 4.9 *Debt Servicing as a Percentage of Annual Budget 1996-2006*

Further, the country has maintained its regulatory debt conditions for the decade to 2006 well under 15 per cent.

The fiscal balances for Thailand from 1993–2006 are described in Table 4.29 Fiscal Balance 1993-2006.

Table 4.29
Fiscal Balance 1993-2006

Year	**Revenue**	**Expenditure**	**Budget Deficit(-)/ Surplus**
		Baht (Billions)	
1993	574.93	521.07	**53.87**
1994	683.14	581.05	**102.09**
1995	776.68	642.72	**133.96**
1996	853.20	819.08	**34.12**
1997	847.70	931.71	**-84.01**
1998	717.78	842.86	**-125.08**
1999	713.08	833.06	**-119.99**
2000	745.14	853.19	**-108.06**
2001	775.80	908.61	**-132.81**
2002	876.90	955.50	**-78.60**
2003	1,012.59	996.20	**16.39**
2004	1,109.42	1,109.33	**0.09**
2005	1,241.24	1,276.75	**-35.51**
2006	1,388.73	1,279.72	**109.01**

Source: BOT (2008b)

During the Asian economic crisis, there were continuing budget deficits from 1997 through to 2002. Using expansionist fiscal policy, the government maintained the funding of its deficits domestically. Although 2003 and 2004 were surplus years, 2005 saw another downturn, requiring further financial input to fund a deficit.

Capital expenditure compared to total budget expenditure is described at Table 30. Capital expenditure must be maintained at least 25 per cent of budget expenditure, which was achieved until 2000, and restored in 2006.

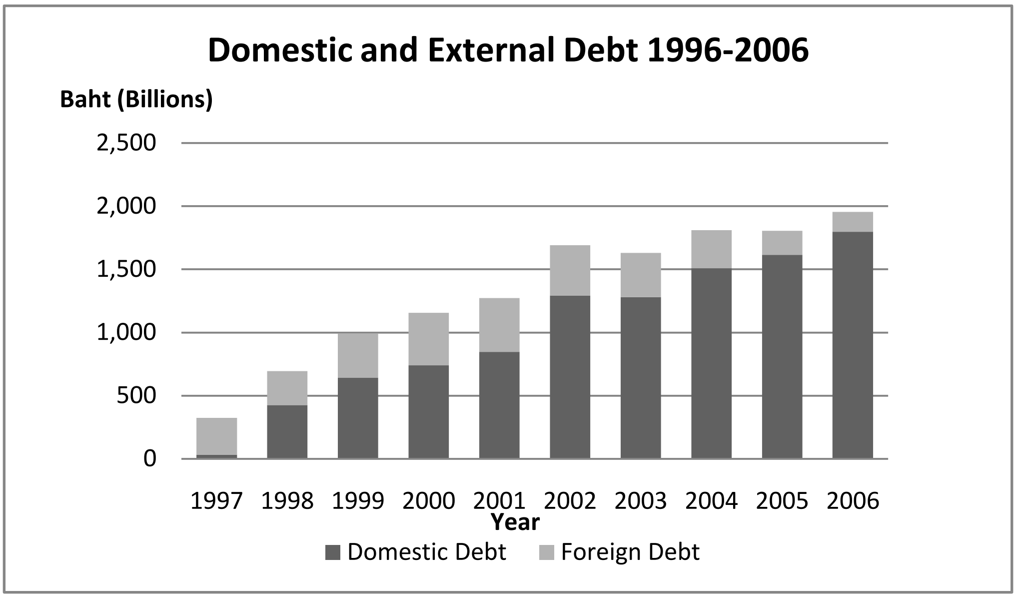
Table 4.30
Capital Expenditure Proportionate to Budget Expenditure 1993-2006

Year	**Budget Expenditure**	**Capital Expenditure**	**Capital as a Percentage**
	Baht (Billions)		
1993	521.07	171.61	**32.93**
1994	581.05	212.98	**36.65**
1995	642.72	253.84	**39.49**
1996	819.08	327.29	**39.96**
1997	931.71	380.05	**40.79**
1998	842.86	279.26	**33.13**
1999	833.06	233.53	**28.03**
2000	853.19	217.10	**25.45**
2001	908.61	218.58	**24.06**
2002	955.50	223.62	**23.40**
2003	996.20	211.49	**21.23**
2004	1,109.33	221.50	**19.97**
2005	1,276.75	318.67	**24.96**
2006	1,279.72	358.34	**28.00**

Source: BOT (2008b)

Government debt is also regulated by the *Public Debt Management Act, 2005* (Royal Thai Government 2005). When recurring or additional expenditure exceeds revenue, the Ministry of Finance may seek debt to 20 per cent of total budget expense, and 80 per cent of further approved expenditure.

Domestic and international public debt is depicted at Figure 4.10 Domestic and External Debt 1997-2006. As noted, debt levels rose abruptly as a consequence of the Asian crisis, the increase then slowed. The majority of outstanding public debt is domestic debt. The proportion of outstanding foreign debt has been declining since 2002. The nature of Thailand’s debt is discussed in the following section.



Source: PDMO (2008b)

Figure 4.10 *Domestic and External Debt 1997-2006*

Domestic Debt

Domestic debt is used to finance budget deficits and stabilise the financial system and can be further defined by creditor and by instrument. Creditors include the Bank of Thailand, commercial banks[26], Government Savings Bank, financial institutions[27] and others[28]. Debt instruments include bonds, treasury bills and promissory notes. Bonds are a financial instrument issued by the government, state enterprises, or legal financial institutions established by law. Generally, government bonds are longer-term debt with a maturity date of more than 12 months. On the other hand, treasury bills are short term securities of less than 12 months, sold through competitive bidding at a discount price. At maturity, the owner of the bill will receive value to the face of the bill. Promissory notes are issued by the government to an entity for the repayment of a loan or other debt.

Domestic debt holders are identified at Table 4.31 Holders of Government Domestic Debt 1993-2006.

[26] Domestically-registered commercial banks, international banking facilities, branches of foreign banks and financial institutions.

[27] Companies, civil service pension funds, non-financial market mutual funds, insurance companies.

[28] Local government, non-financial corporations, households, non-profit institutions and non-residents.

Table 4.31

Holders of Government Domestic Debt 1993-2006

Year	Bank of Thailand	Commercial Banks	Government Savings Bank	Others	Net Domestic Debt
			Baht (Billions)		
1993	-14.13	-18.12	-8.40	-3.70	-44.35
1994	-16.21	-15.26	-19.70	-7.70	-58.87
1995	-4.46	-9.32	-10.97	-5.83	-30.59
1996	2.05	-21.32	-3.57	-2.29	-25.12
1997	3.57	7.55	18.00	2.63	31.76
1998	139.85	154.19	43.38	89.51	426.93
1999	88.95	254.95	136.70	161.78	642.37
2000	80.68	304.58	130.72	224.96	740.94
2001	112.90	318.72	101.87	312.20	845.69
2002	94.41	398.47	126.21	674.80	1,293.88
2003	91.72	301.85	130.57	755.14	1,279.28
2004	102.38	311.27	117.58	977.35	1,508.58
2005	104.84	288.66	101.75	1,119.41	1,614.65
2006	92.47	374.59	82.01	1,248.41	1,797.48

Note: Others include financial institutions and other holders.

Source: Bank of Thailand (2008a)

Foreign Debt Thailand did not access public foreign debt until after the crisis in 1997, when debt was sourced externally to revitalise the economy. However, there was little international interest in Thailand's ability to achieve economic expansion. With limited sources for external funding, the proportion of foreign debt to total government debt declined from 1998, as indicated in Table 4.32 Net External Debt to Total Public Debt 1993-2006. Note that external debt was negative during the economic surpluses of 1993-1996.

Table 4.32

Net External Debt to Total Public Debt 1993-2006

Year	Net External Debt	Total Debt	External/ Total Debt
	Baht (Billions)		Percentage
1993	-4.35	-48.70	0
1994	-17.43	-76.30	0
1995	-4.86	-35.45	0
1996	-3.67	-28.79	0
1997	293.78	325.54	90.25
1998	267.28	694.21	38.50
1999	348.73	991.10	35.19
2000	415.65	1,156.58	35.94
2001	427.17	1,272.86	33.56
2002	397.28	1,691.16	23.49
2003	351.84	1,631.12	21.57
2004	301.86	1,810.44	16.67
2005	242.60	1,857.25	13.06
2006	156.56	1,954.04	8.01

Source: Bank of Thailand (2008b)

Regulation on National Debt Policy, B.E. 2528, limits foreign borrowing and foreign debt service may not exceed 9 per cent of the expected value of exports. Moreover, the government cannot borrow more than $US1billion in any year. In normal circumstances, all foreign borrowings must be used on commercially proven investment projects. However, in exceptional situations such as the 1997 crisis, external debt was raised to revitalise the economy.

4.4 Summary

Whilst this chapter is an account, first of Thailand's plans to meet its economic and social obligations in the last half century; and second, an aggregate of Thailand's finances over a decade, it is also important to explore the country's challenges. The Kingdom's ability to continue to develop from an agrarian society to its rich future as a developed economy is predicated on its ability to grow the human and social capital of its citizens. This requires a delicate balance of acquiring funding from all available sources, and applying such funding on a balance of current account services and preparation for the future, that is, infrastructure. Current account services may be viewed as usage of prior infrastructure: hospitals, schools, security, utilities and transport are services that exist because of infrastructure priorities on previous five-year plans. For the purposes of this study, however, infrastructure development is further defined as value projects that have a direct impact on the country's productivity, and that is the focus of this study.

Productivity is the aim of value infrastructure expenditure, and Thailand lags in world rankings with its ability to maintain infrastructure, even for its modest population growth. Whilst power and roads are relative to world averages, the important categories of rail, water and telecommunications require attention to meet the demands of globalisation placed on the country's private sector. Further, the Kingdom's ability to undertake infrastructure expenditure is impacted by its economic circumstances such as the Asian crisis, and indeed, the world financial crisis that is unfolding 2008-2009, subsequent to the data available to this study.

Thailand, as noted in the final section of s4.3.2, limits its external debt, with annual acquisition ($US1 billion/baht 35billion) and servicing restrictions (9% expected exports). This debt is generally used on value infrastructure projects. External debt as a percentage of total debt fell rapidly during the decade under review, as a consequence both of self-imposed Thai restrictions and an inability to source international funding. Nevertheless, borrowings grew rapidly over the decade as a consequence of the Asian crisis and debt has maintained its growth through domestic sources. Further sources of revenue to maintain modest infrastructure aims during extended periods of budget deficit are necessary.

In the next chapter, the case for the choice of methodology for this study is discussed and the evidence presented.

Chapter 5: Methodology and Analytic Model

The theoretical and empirical reviews in chapters 2 and 3 discuss analytical models to examine the effects of Thailand's public infrastructure expenditure on the country's economic growth. Chapter 2 determined that, although there is a significant positive relationship between capital expenditure and economic growth, this result is dependent on factors that require further investigation. The chapter 3 review concluded that the optimal quantitative approach to estimate the impact of such investment on GDP is an expanded supply side market model. This research is therefore conducted using the recursive Standard Neoclassical Model (SNM). The model also estimates funding demands and domestic and external debt levels; the Thai experience regarding these matters is described in chapter 4.

As constructed, the supply side SNM model contains a set of identities and behavioural equations to explain funding generation and the effects of public infrastructure on economic growth. An important contributor to model construction is the nature of funding for infrastructure investment, and the assumption adopted for this model is that government generates public debt under the fiscal sustainability framework for this purpose.

This chapter consists of six sections. First, methodology, draws from the approaches reviewed in chapter 3 to justify the method employed in this study. Second, the conceptual framework is presented as a diagram. Third, using the structure of the adopted model, the relationships between variables is explained in terms of identity and behavioural equations. The next section examines the nature and issues relevant to the data and their sources. The final section discusses estimation, taking regard of the econometric procedures for the study.

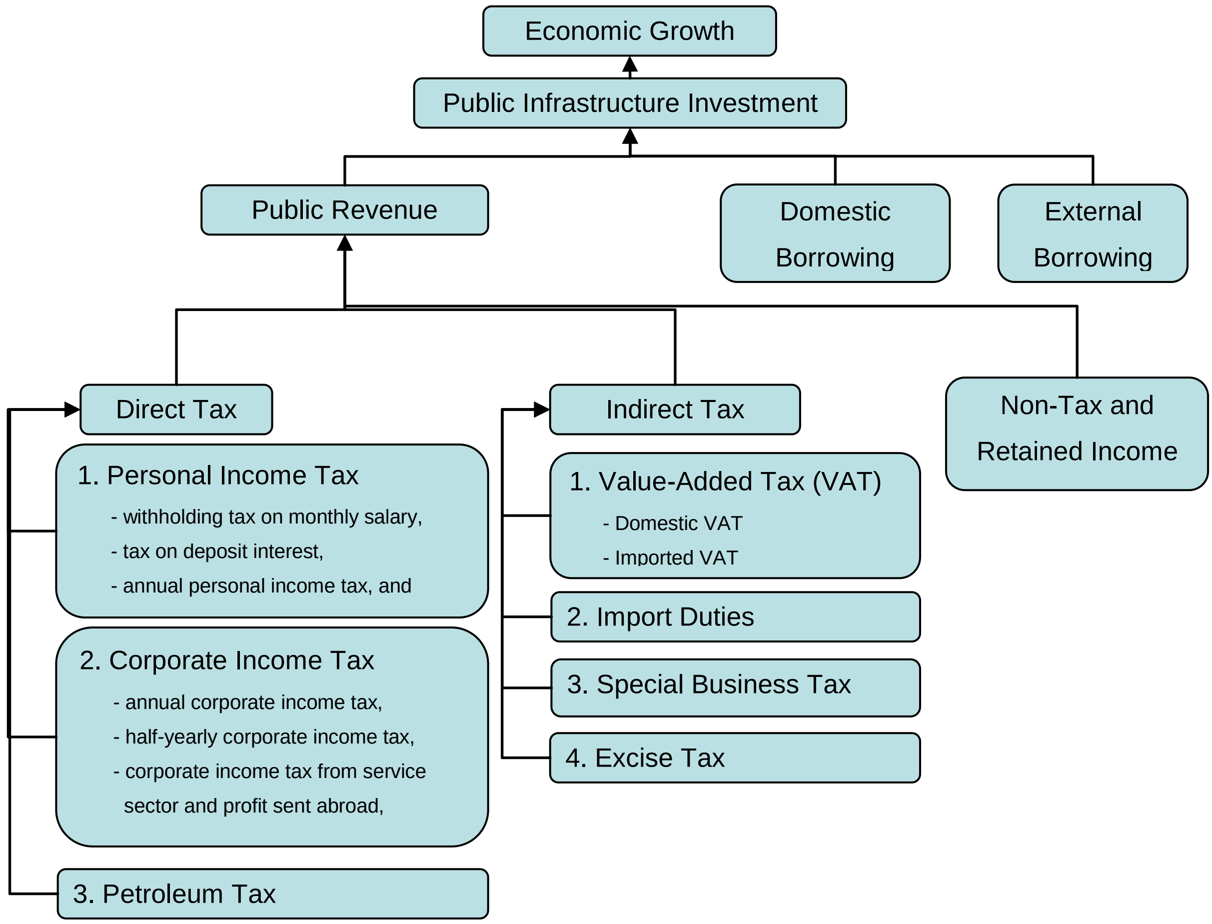
5.1 Methodology

The methodologies employed in research on the impact of public infrastructure on economic growth were discussed in chapter 3, Methodology Review. The outcome from this discussion found the majority of empirical studies used single-equation supply side models and incorporated production, cost and profit functions. These models have the advantage of simplicity; however, profit and cost functions require price data which are difficult to source in developing countries. The single equation approach is inadequate, not allowing the inclusion of the finance sources implicit in this study: tax revenue, domestic borrowing, foreign borrowing, and retained income. Moreover, the single-equation model is sensitive to problems of causation and multicollinearity. Economic theory may indicate, and economic data may not reject, that there is more than one endogenous variable in the system (Crihfield & Panggabean 1995). Therefore, a system model should be applied.

System models are market models that incorporate both supply and demand; however, the focus of this study is the supply side of the Thai economy, as demand-side data is scarce. Hence, an expanded supply side model was selected (s3.4). This is discussed in the following section.

5.2 Conceptual Framework

The Royal Thai Government derives revenue through taxes and non-tax sources, including retained income from SOEs (s4.3.1). These sources are explained graphically at Figure 5.1 Public Revenue Sources for Infrastructure Investment.



Source : Bureau of the Budget 2006

Figure 5.1 *Public Revenue Sources for Infrastructure Investment*

The variables in Figure 5.1 are consistent with the public finance model constructed by the Economic Development Consulting Team for the Thai Bureau of the Budget (Bureau of the Budget 2006).

5.3 Model Structure

The supply side model consists of two parts; revenue generation for investment and national production generation. For the purposes of this study, and for consistency in the model, revenue generation and national production are considered as the first and second parts, respectively. The objective of such a structure is to ensure that government capacity is contained within the fiscal sustainability framework.

The greater part of public revenue is generated from two forms of taxation: direct and indirect, discussed at s4.3, with direct taxes described at Table 4.16 through to Table 4.24 and indirect tax from Tables 4.25 to 4.27. Direct tax comprises personal and corporate income tax, and petroleum tax. PIT is further divided withholding tax, tax on interest, annual and other PIT; CIT consists of annual and half-yearly taxes, tax on the service sector and foreign companies repatriating profits, withholding and other taxes. Indirect taxes are subdivided into VAT for domestic goods and imports, import duties, special business tax, and excise. In addition, there are non-tax revenues: retained income, and domestic and foreign debt. The public investment total is then applied to formulate public capital stock for the aggregate production function.

In the second part, the aggregate production function is constructed to estimate the impact of public infrastructure on economic growth by including public capital stock as a factor of production. The linkage between the public finance model and aggregate production function model is made via the public investment.

5.4 Model Components

In financing public investment, Thailand uses conventional sources: government budget (equal to revenue for the previous period), domestic and external borrowings, and retained income from SOEs for the latest period (Fiscal Policy Research Institute 2005). Hence, the public investment financing is stated

$$IG_t = a\ BUD_t + b\ DB_t + c\ FB_t + d\ RI_{t-1} \qquad (5.1)$$

where IG_t is the government investment at time *t*

a, b, c, d are weighted proportions of each public financing method

BUD_t is the government budget at time *t*

DB_t is the domestic borrowing at time *t*

FB_t is the foreign borrowing at time *t*

RI_{t-1} is the retained income at time *t*-1.

5.4.1 Budget Overview

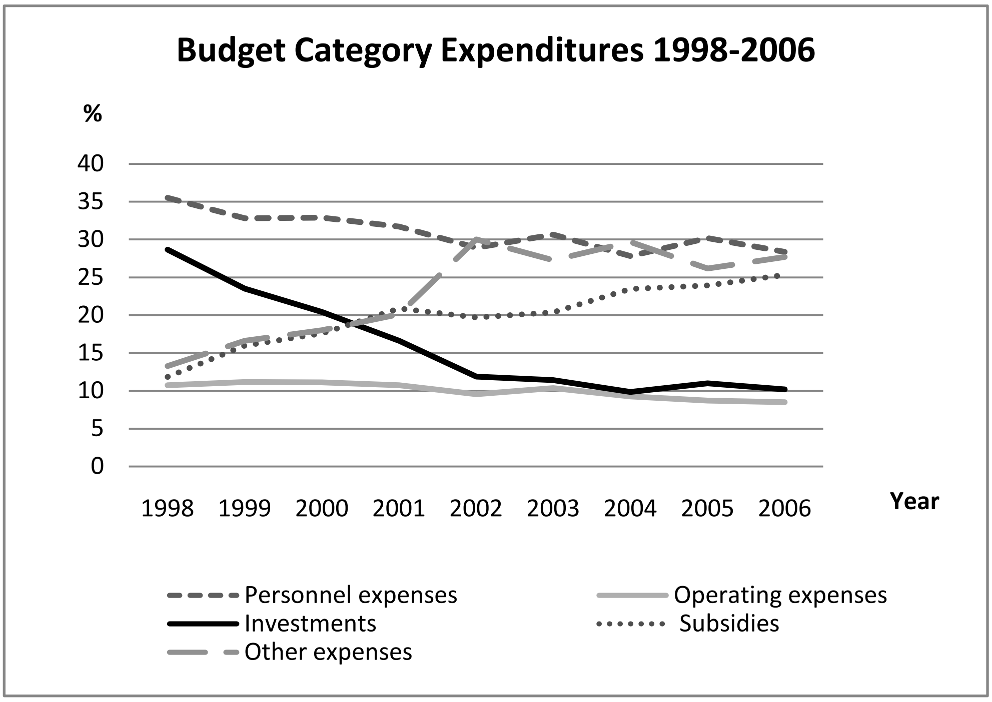
The government's budget is categorised into personnel, operations, investment, subsidies and other expenses. For the purposes of this study, weightings for revenue categories were generated from past patterns of expenditure. The budget components are shown at Table 5.1.

Table 5.1
Budget Expenditure Categories 1998-2006

Fiscal Year	Total Budget Baht billion.	Category									
		Personnel Baht b.	**Per Cent**	**Operations Baht b.**	**Per Cent**	**Investment Baht b.**	**Per Cent**	**Subsidies Baht b.**	**Per Cent**	**Other Baht b.**	**Per Cent**
1998	830.00	294.79	35.52	89.08	10.73	237.70	28.64	98.18	11.83	110.25	13.28
1999	825.00	270.66	32.81	91.86	11.13	193.61	23.47	131.86	15.98	137.01	16.61
2000	860.00	283.02	32.91	95.26	11.08	175.56	20.41	151.29	17.59	154.87	18.01
2001	910.00	288.44	31.70	97.40	10.70	150.92	16.58	190.02	20.88	183.22	20.13
2002	1,023.00	295.83	28.92	97.46	9.53	121.29	11.86	201.39	19.69	307.02	30.01
2003	999.90	306.51	30.65	103.16	10.32	114.01	11.40	203.63	20.36	272.60	27.26
2004	1,163.50	323.60	27.81	107.31	9.22	114.30	9.82	273.16	23.48	345.13	29.66
2005	1,200.00	362.08	30.17	104.53	8.71	131.69	10.97	287.46	23.95	314.24	26.19
2006	1,360.00	385.64	28.36	115.42	8.49	137.99	10.15	344.49	25.33	376.46	27.68
Average			**30.98**		**9.99**		**15.92**		**19.90**		**23.20**

Source: Bureau of the Budget (1999-2007)

Investment expenditure in the above table was on average 15.92 per cent of Thailand's total budget from 1998-2006; fell to 2003 and rose strongly in 2005. Figure 5.2 illustrates the percentages of the annual budget absorbed by the various categories.



Source: Bureau of the Budget (1999 to 2007)

Figure 5.2 *Budget Category Expenditures 1998-2006*

The changes in investment expenditure trend over the period overstate the budget proportion of investment expenditure in the recovery years after the Asian economic crisis. Budget share for investment from 2002 to 2006 was 10.84 per cent; therefore, the weight a in equation (5.1) is 0.1084.

Assuming a balanced budget policy, as stated in the fiscal sustainability framework, the previous year's revenue funds the current year's budget.

$$BUD_t = GOVREV_{t-1} \qquad (5.2)$$

where BUD_t is the public budget at period *t*

$GOVREV_{t-1}$ is the government revenue of period *t*-1.

Equation 5.1 can now be described as

$$IG_t = a\ GOVREV_{t-1} + b\ DB_t + c\ FB_t + d\ RI_{t-1} \qquad (5.3)$$

Domestic Debt

Domestic debt instruments of the Royal Thai Government and its enterprises are bonds, promissory notes, treasury bills and other loans. Treasury bills, promissory notes and other loans are short-term loan instruments and not appropriate for financing long-term public infrastructure. Therefore, only domestic bonds are appropriate for financing projects and are used in this study as a proxy for public investment finance. Public debt categories are detailed below.

Table 5.2
Categories of Domestic Public Debt 2002-2006

Year	**Public Domestic Debt Percentages**				
	Bonds	**Promissory Notes**	**Treasury Bills**	**Other Loans**	**Total**
2002	85.14	4.11	7.63	3.12	100
2003	86.21	5.45	6.18	2.17	100
2004	82.64	5.06	7.60	4.70	100
2005	83.20	4.29	9.21	3.30	100
2006	83.30	3.02	9.30	4.38	100
Average	**84.10**	**4.39**	**7.98**	**3.53**	**100**

Source: Bank of Thailand (2008a)

Table 5.2 shows the categories of public domestic debt, 2002 to 2006. Bonds were the majority source of domestic debt, at an average of 84.1 per cent. Prior to 1999, domestic borrowing comprised only bonds and promissory notes (s4.6.2) the remaining instruments were introduced after that date. Further, due to the financial crisis, the average usage of each instrument stabilised only after 2002. Weight *b* in equation (5.1) is 0.841.

Foreign Debt

The Thai government cannot increase its foreign debt by more than $US1 billion per annum, and all foreign borrowings must be used on viable investment projects (s4.6.3, Royal Thai Government 2005). Hence, all foreign debt drawn to support public investment projects is fully utilised and therefore weight *c* in equation (5.1) has a value of 1.

Retained Income

The retained revenue of the SOEs was derived from the following equation

RI = Revenue – Expenditure – Corporate Income Tax (CIT) – Dividends – Bonuses

Generally, SOEs in Thailand spend all retained income from the current period on investment projects in the next period. These data are displayed under.

Table 5.3
State Owned Enterprises: Retained Income and Capital Expenditure 1993-2006

Year	Retained income	Capital expenditure	Difference *
		Baht, millions	
1993	87,920.00	127,751.00	-39,831.00
1994	108,788.00	121,989.00	-13,201.00
1995	132,187.00	148,113.00	-15,926.00
1996	148,334.67	137,073.33	11,261.33
1997	113,718.93	194,356.29	-80,637.36
1998	116,137.50	193,937.30	-77,799.80
1999	118,255.42	176,037.22	-57,781.80
2000	123,128.46	202,318.30	-79,189.84
2001	155,322.66	171,744.12	-16,421.46
2002	183,477.95	108,560.24	74,917.71
2003	197,528.14	132,945.23	64,582.92
2004	201,705.54	182,905.24	18,800.30
2005	263,343.29	264,962.59	-1,619.30
2006	233,845.99	236,650.55	-2,804.57

*Further finance required if negative.

Source: Bank of Thailand (2007)

Table 5.3 shows that for 10 years in the analysis period, the SOEs expended greater amounts on capital than their retained income permitted. Therefore, it is assumed that all retained income will in future be used for capital expenditure. Hence, the value of d in equation (5.1) is 1.

Given the calculated and assumed value of *a, b, c* and *d*, the identity equation is

$$IG_t = 0.1084\, GOVREV_{t-1} + 0.841\, DB_t + FB_t + RI_{t-1} \qquad (5.4)$$

To investigate this source of funds function, government revenue equates with tax and non-tax sources (s4.3). The summation is stated as an identity equation

Thailand's budget has two components: tax and non-tax revenue (Ministry of Finance 2007). These are expressed as

$$GOVREV_t = TAX_t + NONTAX_t \qquad (5.5)$$

Retained income from the SOEs and non-tax revenue was calculated from the GDP growth rate. Equations for retained income and non-taxable revenue respectively, are

$$RI_t = (1 + GDPG)(RI_{t-1}) \qquad (5.6)$$

$$NONTAX_t = (1 + GDPG)(NONTAX_{t-1}) \qquad (5.7)$$

5.4.2 Defined Revenue Streams

The greater part of government revenue, some 90 per cent, is received from taxes (Ministry of Finance 2007). Characteristics of Public Revenue at s4.3, notes that gross tax revenue is subject to rebates and export compensation. Therefore, net tax revenue is equal to gross tax revenue (GROSSTAX) minus the export compensation (XCOMP) and tax rebates. Tax rebates include a VAT rebate (VATRBATE) and other rebates (OTREBATE). Given the components, the tax revenue is stated as an identity equation:

$$TAX_t = GROSSTAX_t - XCOMP_t - VATRBATE_t - OTREBATE_t \qquad (5.8)$$

where $GROSSTAX_t$ is the gross total of tax revenue at time *t*

$XCOMP_t$ is the export compensation at time *t*

$VATRBATE_t$ is the VAT rebate

$OTREBATE_t$ are other rebates (including PIT and CIT) at time *t*.

Export compensation (XCOMP) refers to an impost of one per cent of gross tax revenue (GROSSTAX) which is placed into a fund to promote export activity. The identity equation is

$$XCOMP_t = (0.01)(GROSSTAX_t) \qquad (5.9)$$

For the other components, $VATRBATE_t$ and $OTREBATE_t$, the proportion coefficients were obtained through trends in recent data. This was calculated for *VATRBATE* as the VAT rebate as a percentage of VAT, and for *OTREBATE*, rebates for both PIT and CIT as a percentage of combined PIT and CIT. The results for 1993 to 2006 are presented below.

Table 5.4
Rebate Trends for VAT and PIT/CIT 1993 to 2006

Year	**VATRBATE/VAT**	**OTREBATE/(PIT+CIT)**
	Percentage	
1993	0.34	0.02
1994	0.34	0.02
1995	0.30	0.02
1996	0.19	0.01
1997	0.28	0.01
1998	0.27	0.05
1999	0.32	0.05
2000	0.25	0.04
2001	0.31	0.05
2002	0.29	0.05
2003	0.27	0.03
2004	0.31	0.05
2005	0.28	0.05
2006	0.33	0.05
Average	**0.29**	**0.04**

Source: Ministry of Finance (2007)

In Table 5.4, rebate averages for VAT showed consistency over the period, averaging 29 per cent of VAT subject to rebate, while the discounts for PIT and CIT were generally 3 per cent of combined personal and corporate income taxes. $VATRBATE_t$ and $OTREBATE_t$ can therefore be calculated as the following identity equations

$$VATRBATE_t = (0.29)(VAT_t) \quad (5.10)$$

$$OTREBATE_t = (0.04)(PIT_t + CIT_t) \quad (5.11)$$

where PIT_t is PIT at time *t*

CIT_t is CIT at time *t*

VAT_t is VAT at time *t*.

There are two types of tax: direct tax and indirect tax, expressed as

$$GROSSTAX_t = DTAX_t + IDTAX_t \qquad (5.12)$$

These are stated as identity and other equations in the following sections.

5.4.3 Direct Tax Equations

Direct tax in Thailand consists of three components: PIT, CIT and Petroleum Income Tax (PT) collected by the Revenue Department. The direct tax identity equation is

$$DTAX_t = PIT_t + CIT_t + PT_t \qquad (5.13)$$

where PIT_t is the personal income tax at time *t*

CIT_t is the corporate income tax at time *t*

PT_t is the petroleum tax at time *t.*

Personal Income Tax

This tax comprises withholding PIT, PIT on interest, annual PIT, and other PIT. Hence, the personal income tax identity equation is stated

$$PIT_t = PIT1W_t + PIT2I_t + PIT3A_t + PIT4O_t \qquad (5.14)$$

where $PIT1W_t$ is withholding PIT at time *t*

$PIT2I_t$ is PIT on interest at time *t*

$PIT3A_t$ is annual personal income tax at time *t* and

$PIT4O_t$ is other personal income tax at time *t.*

The greatest source of withholding PIT in Thailand is from salaries, where employers on behalf of the Revenue Department retain three per cent from each employee's salary. Salary and bonus levels are reliant on the success of the firm; if the company is profitable then employees' income rises. Individual companies' performances reflect the economic climate, therefore GDP may be used as a proxy to explain salary levels and thus withholding taxes

$$PIT1W_t \quad = \quad f(GDP) \qquad (5.15)$$

where $PIT1W_t$ is withholding PIT collection at time *t* and

GDP is gross domestic product.

Interest is a secondary source of personal income tax from savings and term deposits. Thai banks withhold 15 per cent of interest income; for savings accounts, interest is paid twice each year, for short term deposits interest is paid, and tax collected, one month after the term expires (s4.4.1). Therefore, in estimating PIT on interest, analyses are required on each. Savings deposit interest payments are made in January (Q1) and July (Q3), hence, the equation is

$$RSD_t = \phi \sum_{n=1}^{2} \left(SD_{t+1-n} \frac{SD\_R_{t+1-n}}{100} \right) \tag{5.16}$$

where RSD_t is the personal interest revenue from savings deposits

ϕ is the variable equal to 1 for Q1 and Q3, 0 for Q2 and Q4

SD_{t+1-n} is the amount of savings deposit at period *t* (when n=1) or period *t*-1 (when n=2)

SD_R_{t+1-n} is the savings deposit interest rate at period *t* (when n=1) or period *t*-1 (when n=2).

Term deposits are usually three months' duration and they account for 65 per cent of total PIT from this source. The revenue from term deposits can be stated

$$RTD_t = \left(TD_{t-1} \frac{TD\_R_{t-1}}{100} \right) \tag{5.17}$$

where RTD_t is personal interest revenue from term deposit at time *t*

TD_{t-1} is term deposit total from the last period

TD_R_{t-1} is the term deposit interest rate from the last period.

Considering equations 5.17 and 5.16, the total tax income from interest rates may be stated

$$TR = \left[\left(TD_{t-1} \frac{TR\_R_{t-1}}{100} \right) + \phi \sum_{t=1}^{2} \left(SD_{t+1-n} \frac{SD\_R_{t+1-n}}{100} \right) \right] \tag{5.18}$$

where TR is the total tax revenue from interest sources.

Therefore, the PIT function of interest is

$$PIT2I \quad = \quad f(TR) \tag{5.19}$$

where $PIT2I$ is PIT on interest.

As noted at s.4.4.1, annual PIT is due by the following March. As tax policies vary according to the economic circumstances of the country, calculations for annual PIT are complex. The Thai economy was subject to volatility through periods of high growth, the Asian economic crisis, and subsequent recovery (s4.1.10). This instability led to fluctuations in the employment rate which, in turn, affected annual PIT revenue. Hence, estimating annual tax revenue using behavioural equations is a challenge. In this case, the Effective Tax Rate (ETR) method is used to calculate annual PIT revenue from the latest tax structure. The annual PIT is therefore stated as an identity equation

$$PIT3A_t = \left(\frac{PIT3A_{t-4}}{\sum_{i=5}^{8} GDP_{t-i}} \right) \sum_{i=1}^{4} GDP_{t-i} \tag{5.20}$$

where $PIT3A_t$ is the annual PIT at time t

$PIT3A_{t-4}$ is the annual PIT at time t-4 (four periods prior, or the relevant quarter last year)

GDP_t is the nominal GDP at time t.

Other PIT comprises public property leases and sales, and income from public employees' withholding tax, half-yearly and remaining PIT. PIT on income from public property and income from public services accounts for 25 and 26 per cent of total other PIT, respectively. The income derived from public property moves in response to commercial banks' private loans, as this is the practice when purchasing property (Bureau of the Budget 2006). Hence, the aggregate of commercial banks' private loans is used as a proxy in estimating tax income from property. Further, a report by the Economic Development Consulting Team found that income from public sources is dependent on public consumption (ibid.). Therefore, government consumption can be used as a proxy to estimate the income from public services. The equation for other PIT is expressed as a behavioural equation

$$PIT4O \quad = \quad f(LOAN, CG) \tag{5.21}$$

where $PIT4O$ is other PIT

$LOAN$ is the commercial banks' private loan levels, including non performing loans

CG is government consumption.

Corporate Income Tax

Corporate taxes consist of annual CIT, half-yearly CIT, CIT on the service sector and foreign companies' repatriated profits, withholding CIT, and other CIT. These sources can be expressed as

$$CIT_t = CIT1A_t + CIT1H_t + CIT2F_t + CIT3W_t + CIT4O_t \qquad (5.22)$$

where $CIT1A_t$ is annual CIT at time *t*

$CIT1H_t$ is half-yearly CIT at time *t*

$CIT2F_t$ is CIT on service sector & repatriated profits from foreign firms at time *t*

$CIT3W_t$ is withholding CIT at time *t*

$CIT4O_t$ is other CIT at time *t*.

Company taxes are calculated and paid biannually (s4.4.2). The first half-payment is due within 60 days after the first six months, and the balance within 150 days after the accounting year is finalised. As noted, the Thai accounting period is January to December (Q4) and annual CIT is due by the following May (Q3), while the half-yearly CIT is due in August (Q3) of the accounting year. Annual CIT follows half-yearly CIT; therefore annual CIT can be estimated from that source

$$CIT1A = f(CIT1H) \qquad (5.23)$$

where $CIT1A$ is the annual CIT

$CIT1H$ is the half-yearly CIT.

Corporate profits fluctuate, especially following economic shocks such as the Asian crisis. Moreover, as noted in s4.4.2, accounting periods vary during the year for the private and public sectors. A behavioural equation is not a suitable predictor when historical data fluctuates, thus an Effective Tax Rate (ETR) equation is used to calculate half-yearly CIT revenue.

The half-yearly CIT is a levy on a firm's revenue, which is dependent on GDP; and similar to equation 5.10, can be used to calculate half-yearly CIT revenue. The equation is expressed as

$$CIT1H_t = \left[\frac{CIT1H_{t-4}}{\sum_{i=5}^{6} GDP_{t-i}} \right] \sum_{i=1}^{2} GDP_{t-i} \tag{5.24}$$

where $CIT1H_t$ is half-yearly CIT at time t

GDP_t is the nominal GDP at time t.

Justified by Bureau of the Budget (2006), GDP is used as a proxy to estimate tax revenue from CIT on the service sector and repatriated profits of foreign companies to their headquarters. The equation for service sector and repatriated profits is thus

$$CIT2F = f(GDP) \tag{5.25}$$

where $CIT2F$ is the CIT on service sector and repatriated profits of foreign firms

GDP is gross domestic product.

Withholding CIT is a levy on revenue and collected on a monthly basis. GDP is used in lieu of appropriate data on this tax, data for which are not available in detail. The predictor equation for withholding CIT follows

$$CIT3W = f(GDP) \tag{5.26}$$

where $CIT3W$ is withholding CIT

GDP is gross domestic product.

Other CIT includes withholding tax on the public sector, foundation and aid agencies, property tax, and the remaining CIT. Data show that other CIT has on average property tax and withholding tax for the public sector for 15 and 27 per cent of total other CIT, respectively (Bureau of the Budget 2006). As with PIT4O (equation 5.15), the income derived from public property tends to move in accordance with the commercial bank private loans aggregate. Hence, the commercial bank private loans level is used as a proxy in estimating income from property transactions.

Moreover, the public sector's CIT withholding tax reflects by government investment in SOEs. The more government invest in SOEs, the more SOEs are likely to make profit. Therefore, government investment can be used as a proxy to estimate the withholding tax on public sector (Bureau of the Budget 2006). The estimate for other CIT can be stated as a behavioural equation

$$CIT4O = f(LOAN, IG) \tag{5.27}$$

where $CIT4O$ is other CIT

$LOAN$ is the commercial banks' aggregate private loans

IG is government investment.

Petroleum Tax

This tax is levied on income derived from petroleum operations of companies party to a petroleum concession, and of firms purchasing oil for export from a concession holder. Petroleum is an important economic input in Thailand, and usage is dependent on the current economic environment, thus GDP. The petroleum tax is stated in the following equation

$$PT = f(GDP) \tag{5.28}$$

where PT is the petroleum tax

GDP is gross domestic product.

5.4.4 Indirect Tax Equations

There are four components of indirect tax: VAT, import duties, excise and specific business tax (SBT) which may be expressed as

$$IDTAX_t = VAT_t + IMDUTI_t + SBT_t + EXCISET_t \tag{5.29}$$

where $IDTAX_t$ is indirect tax at time *t*

VAT_t is value added tax at time *t*

$IMDUTI_t$ is import duties at time *t*

SBT_t is specific business tax at time *t*

$EXCISET_t$ is the excise tax at time *t*.

VAT, as noted at s4.3.1, was first introduced in Thailand in 1992 for goods and services produced domestically and imported. VAT equations can therefore be presented as an identity;

$$VAT_t = VATD_t + VATIM_t \qquad (5.30)$$

where $VATD_t$ is VAT collected from domestic activities at time *t*

$VATIM_t$ is VAT collected from imports at time *t*.

VAT revenues are estimated from the domestic and imports VAT bases. Domestic VAT is estimated from consumption expenditure of both private and public sectors. As VAT is an incremental tax, a net credit could be due to a company and claimed in the following period for both VAT bases. The estimate for the VAT base uses three variables

$$VATDB = f(CP, CG, VATIMB) \qquad (5.31)$$

where $VATDB$ is the domestic VAT base

CP is private consumption

CG is government consumption

$VATIMB$ is the import VAT base.

Estimation value of domestic VAT base is then calculated by introducing the VAT rate.

The value of the import VAT base is dependent upon the value of imported goods. The variables used in estimating import VAT base are therefore quantity and price

$$VATIMB = f(IMG, IMGPI) \qquad (5.32)$$

where $VATIMB$ is the import VAT base

IMG is the import of goods in baht

$IMGPI$ is the import price index.

The estimation value of imports VAT base is then calculated by using the VAT rate.

Import Duties

Thailand imports a wide variety of materials and products, as noted at s4.5, with import duties higher on luxury goods than that imposed on necessities. The characteristics of imports are not constant; therefore the effective tax rate from this source varies. For example, a high proportion of low value-added imported commodities results in a low rate for import duties; whereas in a better economic climate, more luxury goods attract higher rates for import duties. With fluctuating import duties rates, regression analysis is not acceptable, and the effective tax rate for the latest period is used as a predictor. Import duty is calculated using the value of imported goods times the effective tax rate; the effective tax rate is calculated from the total import duties for the previous period, divided by the value of imported goods in the previous period

$$IMDUTI_t = (ETR\_IM_t)(IMG_t) \qquad (5.33)$$

$$ETR\_IM_t = \frac{IMDUTI_{t-1}}{IMG_{t-1}} \qquad (5.34)$$

where $IMDUTI_t$ is the import duty at time *t*

ETR_IM_t is the import effective tax rate at time *t*

IMG_t is the value of imported goods at time *t.*

Specific Business Tax

SBT is imposed on businesses where VAT is difficult to define; such as banking, finance, insurance, pawnshops and real estate. This sector is not subject to VAT. An average of 82 per cent of total SBT in the decade to 2006 was derived from tax on loan interest paid by financial institutions (Bureau of the Budget 2006). Thus, loan interest tax revenue from this sector is used as a proxy to estimate SBT revenue.

$$SBT = f(FIR) \qquad (5.35)$$

$$FIR = \left(DC_t \left(\frac{MLR_t}{100} \right) \right) \qquad (5.36)$$

where SBT is specific business tax;

FIR is tax revenue from financial sector's loan rates

MLR is the minimum loan rate

DC is domestic credit.

Excise

This tax is imposed on items such as gasoline and petroleum products and luxury or leisure goods including tobacco, liquor, soft drinks, playing cards and crystal. Moreover, sports services are also subject to excise, such as horse-racing courses and golf courses. The Excise Tax Tariff is applied on an ad valorem basis or at a specific rate, whichever is higher. All excise taxes are integrated into one equation using the effective excise tax rate from the Excise Department and GDP which is expressed thus

$$EXCISET_t = \left(\frac{EXCISET_{t-1}}{GDP_{t-1}}\right) GDP_t \qquad (5.37)$$

where $EXCISET_t$ is the excise tax at time t

GDP_t is the nominal GDP at time t

$\left(\frac{EXCISET_{t-1}}{GDP_{t-1}}\right)$ is the effective excise tax rate for the previous period.

5.4.5 Non-tax Revenue Equations

Other, non-tax revenues derived from government agencies and retained income from the SOEs are calculated through GDP, as defined by the Economic Development Consulting Team (Bureau of Budget 2006). SOEs operate as private entities; therefore revenues depend on the economic performance of the country, or GDP. Non-tax revenue, including fees and charges by the government agencies, is also subject to the economic environment, or GDP, as described

$$RI_t = (1 + GDPG)(RI_{t-1}) \qquad (5.38)$$

$$NONTAX_t = (1 + GDPG)(NONTAX_{t-1}) \qquad (5.39)$$

where $GDPG$ is GDP growth rate at market prices.

Foreign Debt

The Royal Thai Government accesses external funding under constraints that include specific investment project or an emergency, such as the Asian economic crisis in 1997 (s4.3.2). The National Debt Policy states that debt service should not exceed 9 per cent of the expected export value each year and limits imported public funds to $US1 billion. This is expressed in the following equation

$$FDS_t \leq 0.09 * EEX_t \tag{5.40}$$

$$FB_t \leq 1 billion \$US \tag{5.41}$$

where FDS_t is foreign debt service at time *t* (debt service = interest + principle payment)

EEX_t is the expected export value at time *t*

FB_t is foreign borrowing at time *t.*

Domestic Debt

The Ministry of Finance is empowered to access debt financing as required, conditional on such borrowing not exceeding 20 per cent of budgetary expenditures plus planned expenditure, or 80 per cent of the approved budgeting on payment of principal, whichever reaches the limit first (The Royal Thai Government 2005). This is stated as follows

$$DB_t + FB_t \leq 0.2 BUD_t \tag{5.42}$$

$$DB_t + FB_t \leq 0.8 PRINC_t \tag{5.43}$$

where DB_t is domestic borrowing at time *t*

BUD_t is budget allocation at time *t*

$PRINC_t$ is the amount of total principal repayments at time *t.*

To maintain fiscal sustainability, further restrictions are placed on debt financing. The restrictions state that the proportion of public debt to GDP must be 50 per cent or less and debt service as a percentage of annual budget must be 15 per cent or less (s4.6).

5.4.6 Production Function

The effects of public infrastructure on output growth in Thailand, discussed at s3.2.1, is calculated through a modified production function, following Nazmi and Ramirez (1997)

$$Y = A\ f\left(L, K_p, K_g\right) \qquad (5.44)$$

where Y is real aggregate output;

A is factor productivity;

L is labour force;

K_p is private capital stock

K_g is public capital stock.

By treating public capital as a separate input in the production function, the impact of changes in public investment on output growth may be estimated. However, equation (5.38) cannot be estimated directly because consistent public capital stock quarterly time series data are not available for Thailand. To overcome this problem, researchers apply a dynamic production function that uses percentage growth rates of model variables.

Hence, equation (5.44) can be restated

$$y = \beta_0 + \beta_1 \frac{\Delta L}{L_{t-1}} + \beta_2 \frac{IP_t}{Y_{t-1}} + \beta_3 \frac{IG_t}{Y_{t-1}} \qquad (5.45)$$

where y is output growth ($y = \frac{\Delta Y}{Y_{t-1}}$)

β_0 is productivity growth

β_1 is the elasticity of output with respect to labour

β_2 is the marginal productivity of private capital

β_3 is the marginal productivity of public capital

$\frac{\Delta L}{L_{t-1}}$ is the growth of labour force rate ($\Delta L = L_t - L_{t-1}$)

$\frac{IP_t}{Y_{t-1}}$ is the private investment to output ratio at time t

$\frac{IG_t}{Y_{t-1}}$ is the public investment to output ratio at time t.

5.5 Raw Data and Sources of Data

The estimation of public revenue and aggregate production function is based on quarterly time series data from 1993Q1 to 2006Q4. The period of 13 years (1993 – 2006) was selected because of the data availability. The complete set of data is only available from 1993 onward. The data are obtained from the Bank of Thailand (BOT), the National Economic and Social Development Board (NESDB), the Ministry of Finance (MOF), the Revenue Department, the Excise Department, and the Customs Department. The list of data and sources are presented in Table 5.5. Sources of Data

Table 5.5 *Sources of Data*

	Symbol	Variable	Source
1	AD	Annual depreciation	NESDB
2	CG	Government consumption	NESDB
3	CIT	Corporate income tax	Revenue Dep.
4	$CIT1A$	Annual corporate income tax	Revenue Dep.
5	$CIT1H$	Semi-annual corporate income tax	Revenue Dep.
6	$CIT2F$	Corporate income tax from foreign company disposing profit out of Thailand	Revenue Dep.
7	$CIT3W$	Withholding corporate income tax	Revenue Dep.
8	$CIT4O$	Other corporate income tax	Revenue Dep.
9	CPI	Consumer price index	NESDB
10	CP	Private consumption	NESDB
11	DB	Domestic borrowing	BOT
12	DC	Domestic credit	BOT
13	$EXCISET$	Excise tax collection	Excise Dep.
14	FB	Foreign borrowing	BOT
15	GDP	Nominal Gross Domestic Product	NESDB
16	$GDPR$	Real Gross Domestic Product (1988=100)	NESDB
17	IG	Public investment	NESDB
18	$IMGPI$	The import goods price index (in baht)	NESDB
19	IMG	Value of imported goods	NESDB
20	$IMDUTI$	Amount of import duties	Customs Dep.
21	IP	Private investment	NESDB
22	$IPPI$	Private investment price index	NESDB
23	L	Labour force	NESDB
24	$LOAN$	Commercial banks private loans including non-performing loans	BOT
25	MLR	Minimum lending rate	BOT
26	$NONTAX$	Revenue from non-tax	MOF
27	$OTREBATE$	Other rebates (including PIT & CIT)	Revenue Dep.
28	$PIT1W$	Withholding tax on salary income	Revenue Dep.
29	$PIT2I$	Personal income tax from interest income	Revenue Dep.
30	$PIT3A$	Annual personal income tax	Revenue Dep.
31	$PIT4O$	Other personal income tax	Revenue Dep.
32	$PRINC$	Principal payment of debt	MOF
33	PT	Petroleum tax	Revenue Dep.
34	RI	Retain income of State Own Enterprises (SOEs)	MOF
35	SBT	Specific business tax	Revenue Dep.
36	SD	Amount of saving deposit	BOT
37	SD_R	Saving deposit interest rate	BOT
38	TD	Amount of term deposit	BOT
39	TD_R	Term deposit interest rate	BOT
40	$VATDB$	Domestic VAT base	Revenue Dep.
41	$VATIMB$	Import VAT base	Revenue Dep.
42	$VATRBATE$	Value Added Tax (VAT)' rebates	Revenue Dep.
43	$XCOMP$	Export compensation	Revenue Dep.

5.6 Data Transformation

Where inflation is a significant factor, the conventional means to obtain model variables for estimation is to use the real value of variables, rather than nominal values. In this study, a variable inflation rate for Thailand is accepted as a significant factor. Thus, variables in this study are transformed into real term using appropriate deflators for the baseline data. For example, nominal PIT values were deflated by using the consumer price index (CPI), nominal CIT were converted into real value by using private investment price index (IPPI), and imports VAT was converted using the import goods price index (IMGPI). The reason for discount by multiple indices is because of the suitability for each variable. For example, nominal PIT which is an income tax is highly related to consumption. Hence, it should be discounted into real terms with the consumer price index (CPI). Nominal CIT is the corporate income tax which is logically related to private investment. Hence, it should be converted into real value by using the private investment price index (IPPI). Imports VAT is definitely related to imported goods. Hence, it should be converted using the import goods price index (IMGPI).

The adjusted data are presented in Table 5.6 Data Transformation.

Table 5.6
Data Transformation

	Symbol	Variables	Transformation
1	ADR	Real annual depreciation	AD, IPPI
2	CGR	Real government consumption	CG, CPI
3	$CIT1AR$	Real annual corporate income tax	CIT1A, IPPI
4	$CIT2FR$	Real corporate income tax from offshore companies repatriating profits	CIT2F, CPI
5	$CIT3WR$	Real withholding corporate income tax	CIT3W, CPI
6	$CIT4OR$	Real other corporate income tax	CIT4O, CPI
7	CPR	Real private consumption	CP, CPI
8	$GDPR$	Real GDP	GDP, CPI
9	IGR	Real public investment	IG, IPPI
10	$IMGR$	Real value of imported goods	IMG, IMGPI
11	IPR	Real private investment	IP, IPPI
12	$PIT1WR$	Real withholding tax on salary income	PIT1W, CPI
13	$PIT4OR$	Real other personal income tax	PIT4O, CPI
14	PTR	Real petroleum tax	PT, IPPI
15	$VATDBR$	Real domestic VAT base	VATD, CPI
16	$VATIMBR$	Real import VAT base	VATIMB, IMGPI

However, real term is not applicable for all variables. For example, PIT for interest (PIT2I) are tax revenues derived from deposit interest revenue. This item is based on deposit interest revenue of depositors.

The macroeconomic variables at Table5.2 are plotted at a quarterly frequency, and together with the effects of the Asian crisis, volatility is evident, as shown in Appendix A: Plot of Variables. Both regular and irregular variables are displayed. Prior to estimation, this high variability is smoothed using the conventional technique, the ratio to moving average procedure[29].

In this study, variables are presented in log format for two reasons: one is the non-linear characteristic of the model, the other is to minimise the effects of the units of measurement and to reduce fluctuation (Bureau of the Budget 2006). Those variables taking a natural logarithm are denoted as *L* e.g. LGDPR, or, natural logarithm of real gross domestic product.

Finally, some variables operate in the first difference, denoted as D. For example, $DLGDPR_t = LGDPR_t - LGDPR_{t-1.}$

5.7 Estimation Issues

This section discusses theoretical and methodological issues related to estimations of Thailand's public revenue and aggregate production function.

5.7.1 Stationary and Non-stationary

In this study, time-series data of macro economic variables are used in estimation and thus the data generating processes exhibit trends and volatility which could result in a non-stationary issue. Stationary in time-series data refers to a stochastic time series that has three characteristics, as described.

First, a variable over time has a constant mean, denoted as

$$E(Y_t) = \overline{Y} \qquad (5.46)$$

where $E(Y_t)$ is the expected value of variable Y at period *t*

$\overline{Y}$ is the average value Y .

[29] Originally developed by Macauley at NBER (Su 1996).

Thus an expected value of Y at different time periods is fixed and at average value. Hence the data generating process Y is not a trend.

Second, variance of a variable over time is constant, denoted as

$$Var(Y_t) = \sigma^2 \qquad (5.47)$$

where $Var(Y_t)$ is the variance of variable Y at period *t*

σ^2 is the variance of *Y*.

Therefore the variance of Y at different time periods is constant. Hence the data generating process of *Y* is not stable.

Third, covariance between any two time periods is correlated, denoted as

$$Corr(Y_t, Y_{t-n}) = \bar{r}_{t,t-n} \qquad (5.48)$$

where $Corr(Y_t, Y_{t-n})$ is the correlation of variable Y between time period *t* and *t-n*.

Further, the correlation value is constant and depends on the difference between the time periods. Thus the data generating process of *Y* expresses statistically valid joint distribution of *Y* variable values. If one or more of these criteria is violated, then the data generating process of the time-series data is a non-stationary series (Gujarati 1995).

If dependent and independent variables are characterised with non-stationarity, the regression estimation is expected to encounter a spurious relationship problem. A spurious relationship result in the estimated parameter using Ordinary Least Square (OLS) is highly significant, and the coefficient of determination (R^2) is very high (Granger & Newbold 1974). In other words, the relationship between dependent and independent variables is dominated by common trends among variables.

The majority of raw data in economic time series are non-stationary because they normally exhibit some trends over time which can be removed by using first difference (Maddala 1992). This researcher found unusual volatility in the variables due to the 1997 Asian economic crisis; a similar issue could be resolved using Chaikin's Volatility adjustment procedure[30]. However, this procedure requires high frequency data for an adequate number of data points. Data points for the variables in this study comprise 1993Q1 to 2006Q4 and are insufficient to calculate the H-L average. It was concluded that the volatility issue in this study, reflected in four only prime data points during the Asian economic crisis, does not constitute sufficient data to permit a result using this technique, which requires high frequency data such as stock market price or exchange rates. Chaikin's Volatility adjustment is therefore not adopted. Moreover, the 4-step Moving Average instrument was not applicable as there was a limited number of 56 observations from 1993Q1 to 2006Q4. In using the 4-step Moving Average, the data would be further reduced to 53 observations. Further, when estimating the variable in the behavioural equation where lag variables are applied, the econometric program, Microfit, had insufficient data to provide a result. Hence, the assumption is made that applying first difference to the data can remove the non-stationary issue.

5.7.2 Testing for Unit Roots

In time series literature, several unit root tests are available, including the Dickey-Fuller (DF) and the augmented Dickey-Fuller (ADF) tests. Assuming Y_t is a time series variable that is integrated of order I(1) without drift[31], these tests can be applied by altering the autoregressive process as follows.

$$Y_t = Y_{t-1} + \varepsilon_t \qquad (5.49)$$

where Y_t and Y_{t-1} are present and immediate past values of a variable, respectively

ε_t is a stationary error term at time t.

Equation 5.43 can be expressed in the following form:

$$Y_t = (1+\theta)Y_{t-1} + \varepsilon_t \qquad (5.50)$$

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30 It is calculated by first calculating an exponential moving average of the difference between the daily high and low prices. Chaikin recommends a 10-day moving average. $H\text{-}L\ Average = Exponential\ moving\ average\ of\ (High - Low)$.Next, calculate the percent that this moving average has changed over a specified time period. Chaikin again recommends 10 days.

$$\left(\frac{(H\text{-}L\ Average) - (H\text{-}L\ Average\ n\text{-}periods\ ago)}{H\text{-}L\ Average\ n\text{-}periods\ ago}\right) * 100$$

31 This equation allows for appropriate unit root analysis.

where θ is an arbitrary parameter.

When θ = 0, then equation 5.50 equals equation 5.49. After rearranging equation 5.50, the following equation is obtained:

$$\Delta Y_t = Y_t - Y_{t-1} = \theta Y_{t-1} + \varepsilon_t \qquad (5.51)$$

If θ = 0 and ε_t is stationary, then Y_t ~ I(1), and if -2 < θ < 0, then Y_t is a stationary process. Based on the above modification, Dickey-Fuller (1979) proposed a test of $H_0 : \theta = 0$ against $H_a : \theta < 0$. If the null hypothesis is accepted, then the process is I(1), i.e. Y_t ~ I(1). Dickey and Fuller considered the following three different equations to test for the presence of unit roots:

$$\Delta Y_t = \theta Y_{t-1} + \varepsilon_t \qquad (5.51)$$

$$\Delta Y_t = a_0 + \theta Y_{t-1} + \varepsilon_t \qquad (5.52)$$

$$\Delta Y_t = a_0 + \theta Y_{t-1} + a_2\, t + \varepsilon_t \qquad (5.53)$$

The differences among the above regression equations depend on the presence of a_0, constant (drift), and $a_2\, t$ deterministic term (time trend), all of which are termed nuisance parameters. Test results can be based on OLS estimations. The above equations represent the first order autoregressive process (a process depending only on one lag value). The test can be extended for higher order autoregressive processes. The extended DF test for higher order equations is the ADF test. Considering a p^{th} order autoregressive process, equations 5.46 to 5.48 can be extended as:

$$\Delta Y_t = a_1 Y_{t-1} + \sum_{j=1}^{p} \gamma_j\, \Delta Y_{t-j} + \varepsilon_t \qquad (5.54)$$

$$\Delta Y_t = a_0 + a_1 Y_{t-1} + \sum_{j=1}^{p} \gamma_j\, \Delta Y_{t-j} + \varepsilon_t \qquad (5.55)$$

$$\Delta Y_t = a_0 + a_1 Y_{t-1} + a_2\, t + \sum_{j=1}^{p} \gamma_j\, \Delta Y_{t-j} + \varepsilon_t \qquad (5.56)$$

where a_0 and t are the constant and the time trend, respectively.

Both the DF and the ADF tests assume that the errors are statistically independent and have a constant variance. Thus, an error term should be uncorrelated with the others, and has constant variance.

Analyses are conducted based on the results of DF and ADF test. A summary of the steps involved in each test follows.

1. Check for unit roots in the process of the variable with the time trend and the constant terms in equation 5.56. If a null hypothesis of $H_0 : a_1 = 0$ is not rejected (at the DF critical value), there are unit roots. If the null is rejected, then check for the presence of the time trend, a_2, in equation 5.56. If the time trend is significant and if the presence of unit roots is not rejected according to the conventional *t*-value, it can be concluded that the process of the variable has unit roots with the time trend. If both are rejected, then it can be concluded that the process is stationary.
2. If there is not time trend, i.e. null is rejected in equation 5.56, then check for the unit roots and the constant term in equation 5.55. First, check the process for unit roots at the DF critical value. If there are no unit roots, it can be concluded that there are no unit roots in the process, which means that the variable is stationary. If a constant term is significant, then check the results for unit roots. If H_0 is not rejected according to the *t*-value, it can be concluded that the process of the variable has unit roots with the constant. If H_0 is rejected, it can be concluded that the process has no unit roots.
3. If there is no constant, check the process with neither constant nor time trend in equation 5.54. If there are no unit roots, the process is stationary; otherwise, it would have unit roots.
4. If there are unit roots in any of these hypothesis tests, check the variable in first difference form to check for two unit roots. If there are no unit roots, then it can be concluded that the process in an I(1) process (Chambers 1988).

If dependent and independent variables fail the stationary test, the data generating process of these variables are non-stationary. These tests are performed on both levels and first differences of both variables. During this test order of lag terms need to be specified and since the data in this study are quarterly, the ADF(4) is chosen for the unit root analysis (see s5.8 for further explanation).

Implications of the unit root test result on the estimation procedures are first, no unit root, i.e. all variables are stationary, thus OLS can be used in estimation. Second, if all variables in the equation are found to be non-stationary and of an order I(1), then the cointegration test is conducted to find the existence of a long-run (L-R) equilibrium relationship. If the variables confirm the existence of cointegration, then the conventional Error Correction Model (ECM) is estimated using OLS, confining short run dynamics and long-run equilibrium, as an error correction term is constructed to estimate for coefficients. Third, if the variables are found to have a mixture of stationary and non-stationary variables, then Autoregressive Distributed Lag (ARDL) model is used in the estimation.

5.7.3 Error Correction Model

Initially, ECM was devised to describe a relationship between the short-run dynamic and the long-run equilibrium (Sargan 1964). Granger and Weiss (1983) and Engle and Granger (1987) pointed out that if two variables are cointegrated at the first differenced order, their relationship can be expressed as the ECM by taking past disequilibrium as explanatory variables in the dynamic behaviour of current variables (Maddala and Kim 1998).

The ECM method corrects the equilibrium error in one period by the next period, which can be presented

$$\Delta Y_t = a_0 + a_1 \Delta X_t + a_2 \mu_{t-1} + \varepsilon_t \qquad (5.57)$$

where $\Delta Y_t = Y_t - Y_{t-1}$,

a_1 and a_2 are the dynamic adjustment coefficients

μ_{t-1} is the lag of residual that represents the short-run disequilibrium adjustment

of the estimate of the long-run equilibrium error term

ε_t is the random error term (Gujarati 1995).

5.7.4 Cointegration

If two variables are cointegrated at the first differenced order I(1), their relationship can be expressed as the ECM (s.5.6.3, Granger & Weiss 1983, Engle &Granger 1987). Cointegration refers to the existence of long-run equilibrium between two or more time series variables which are individually non-stationary at their level form (Gujarati 1995).

Suppose Y_t and X_t are regressed as follows:

$$Y_t = a_0 + a_1 X_t + \varepsilon_t \qquad (5.58)$$

where a_1 is the cointegrating parameter. If rearranged, equation 5.58 is

$$\varepsilon_t = Y_t - a_0 - a_1 X_t \qquad (5.59)$$

Y_t and X_t are cointegrated if the two variables are integrated at the same order and a random walk (ε_t) in equation 5.54 must be stationary at the level form (ε_t = I[0]). Thus, equations 5.58 and 5.59 allow the conclusion that Y_t and X_t are individually I(1), they have stochastic trends since their linear combination in equation 5.54 is I(0). Hence, there is a long-run equilibrium relationship between Y_t and X_t, or they are cointegrated as they do not drift far apart over time (Engle & Granger 1987).

The cointegration test is a fundamental procedure in a time-series model. In this study, Johansen (1988, 1991) and Johansen and Juselius (JJ) (1990, 1992, 1994) cointegration tests are applied to identify the cointegrating relationship or relationships among variables. If there is at least one valid cointegrating vector, then the estimate of a long-run relationship can be estimated. Once a long-run relationship is established, then the dynamic behaviour among the relevant variables can be estimated using ECM, where the S-R and L-R relationship are represented.

However, if the Johansen-Juselius Maximum Likelihood Cointegration Tests fail to justify the existence of a cointegrating vector, then only the S-R relationship in first difference should be modelled, including all appropriate lags using OLS.

5.7.5 Autoregressive Distributed Lag

ARDL is adopted for a mixture of stationary and non-stationary variables, The advantage of ARDL over the conventional ECM is that it can be applied irrespective of whether the regressors are I(0) or I(1). Hence, it avoids the pretesting problems associated with standard cointegration analysis which requires the classification of the variables into I(1) and I(0). The ARDL procedure is two staged. First, the long-run relation between variables is tested using the F-statistic to determine the significance of the lagged levels of the variables in the error correction form of the underlying ARDL model. In the second stage, the coefficients of the long-run relations are estimated to infer their values.

In the case of quarterly data, the maximum order of lags in the ARDL model is 4[32]. The general error correction version of the ARDL (4,4,4) model in the variables Y, X_1, and X_2 is

$$\begin{aligned}\Delta Y_t = \beta_0 + \sum_{i=1}^{4} \beta_{1i}\, \Delta X_{1,t-i} + \sum_{i=1}^{4} \beta_{2i}\, \Delta X_{2,t-i} + \sum_{i=1}^{4} \beta_{3i}\, \Delta Y_{t-i} \\ + \beta_4\, Y_{t-1} + \beta_5\, X_{1,t-1} + \beta_6\, X_{2,t-1} + \varepsilon_t\end{aligned} \quad (5.60)$$

[32] The order of 4 is determined by the seasonality repeat of quarterly data; each finishes as an annual result.

where Δ is the first difference operator or changes from period *t-1* to *t*.

The hypothesis tested in this study is the null of non-existence of the long-run relationship, defined

$$H_0 : \beta_4 = \beta_5 = \beta_6 = 0$$

and against

$$H_1 : \beta_4 \neq 0, \beta_5 \neq 0, \beta_6 \neq 0$$

The F-statistic is estimated thus

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{4} \beta_{1i} \, \Delta X_{1,t-i} + \sum_{i=1}^{4} \beta_{2i} \, \Delta X_{2,t-i} + \sum_{i=1}^{4} \beta_{3i} \, \Delta Y_{t-i} + \varepsilon_t \qquad (5.61)$$

then the variable addition variables test is performed by adding $Y_{t-1}, X_{1,t-1}, \textit{and } X_{2,t-1}$ into the equation. The F-statistic tests the joint null hypothesis that the coefficients of these variables are zero for this level (denoted as F[Y\$X_1$, X_2]) and this is compared to the critical value bounds computed by Pesaran, Shin and Smith (1996) (Appendix B: F-table).

If the F-statistic is below the lower bound or above the upper bound of the critical value, then the null of no long-run relationship between Y, X_1, and X_2 is rejected irrespective of the order of integration. Next, the significance of the lagged level variables in the error correction model explaining $\Delta X_{1,t}$ and $\Delta X_{2,t}$ is considered. Following the procedure for the F-statistic of F(X_1\Y, X_2) and F(X_2\Y, X_1) the results are compared with the critical value. If there is a rejection of the H_0 of no long-run relationship, then the test results suggest that there is a long-run relationship between Y, X_1, and X_2. The variables X_1 and X_2 can be treated as long-run forcing variables for the explanation of Y. Hence, the estimation of long-run coefficients and the associated model can now be accomplished using ARDL. On the other hand, if the test results in accepting H_0, then variables X_1 and X_2 cannot be treated as long-run forcing variables for the explanation of Y and the model should be estimated in the short-run dynamic equilibrium using the first differenced variables.

5.8 Estimation Procedure

In the estimation, each equation is estimated using an econometric program Microfit version 4.0. For each estimated equation, the data in Microsoft Excel format are transferred into Microfit and, then, proceed with the following procedure. The relevant variables were smoothed to remove variation caused by regular collection-events, thus a trend-stationary series was expected. The estimation procedure began with all relevant analytical model variables visually checked for non-stationarity. Those variables observed to have non-stationarity were then tested with Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) unit root procedures. Both level value and first difference for the relevant variables were tested. Equations in the model showed variables in a clearly trended series, while others were not. Further, variables such as DLPIT1WR, LPIT2I and LTR evinced a weakly trended pattern (see Appendix A: Plot of Variables). The DF and ADF unit root test results were therefore reported as 'without trend' and 'with trend' cases. The details of the results are attached at Appendix C: Unit Root Test.

Following the identification of the stationary status of variables, short-run (S-R) and long-run (L-R) equilibrium relationships were estimated. Initial estimation included all possible lag permitted by the data, and run as a general model. To obtain a statistically valid specific model from the general model, Hendry's (1995) approach of general-to-specific modelling is applied for this study's purposes. This process adopts 4 lags of the explanatory variables, then gradually eliminates the insignificant variables to find the model that best fits the data. Whilst determining the best fit model, the status of model validation and diagnostic statistics (autocorrelation and heteroscedasticity) were also observed and provide test result in Appendix E: Diagnostic Tests. The significance of variables was not considered.

For the purposes of this study, the Durbin-Watson (DW) statistic was not selected as a diagnostic indicator because of its underlying assumption: *the regression model does not include lagged value(s) of the dependent variable as one of the explanatory variables* (Gujarati 1995). Therefore, the Lagrange Multiplier (LM) test of residual serial correlation was used.

5.9 Simulation Procedure

Simulation is based on the estimated model where government borrowings, domestic borrowing (DB) and foreign borrowing (FB), are paramatised. Simulation is carried out with ex ante and ex post scenarios. The ex ante scenario involves the generation of a time-path within the time period used during the analysis to establish consistency in the model. The ex post scenario involves generation of time-path values beyond the time period of the data to assist predictions for decision making.

The simulation consists of five scenarios: maximum borrowing (20% of budget), 15 per cent of budget, 10 per cent of budget, 5 per cent of budget, and no borrowing (0). The results of each scenario are discussed and compared in the next chapter, chapter 6, Model Estimation and Simulation.

5.10 Conclusion

This chapter presents the methodology and the model to examine the effects of public infrastructure investments on economic growth in Thailand. The methodology incorporates the means by which the government funds such investment and uses the recursive Standard Neoclassical Model (SNM) comprising two parts: Thailand's public finance or revenue, and its aggregate production function.

The first part, public revenue, is primarily generated from two forms of taxation: direct and indirect. In addition, non-tax revenue is discussed, together with domestic and external debt sources. These sources are functionalised to calculate funds available for public investment, used to formulate public capital stock and feed into the aggregate production function.

The second part, the aggregate production function, estimates the effects of public infrastructure on economic growth by treating public capital stock as a factor of production. The linkage between public finance and aggregate production function is made via public investment. As constructed, the model contains a set of identities and behavioural equations using quarterly time series data from various government agencies, 1993Q1 to 2006Q4. The calculated and estimated equations are then combined to simulate economic growth for Thailand for a range of budgetary scenarios, that government generates public debt under borrowing constraints ranging from maximum to zero. The results are presented and discussed in the next chapter.

Chapter 6: Model Estimation and Simulation

This study examines the effects of public infrastructure investments on economic growth in Thailand. The construction of the research is discussed, including the later chapters for methodology and the supply side system model. As part of the methodology, the previous chapter argued for the selection of estimation equations and preparation of the variables for the model. This chapter has the estimation results of the specified equations. The supply side model estimation is presented as two sections: public investment finance and national production function.

Public investment finance comprises equations relating to the sources of Thailand's investment funds, tax and non-tax. Since 90 per cent of the Royal Thai Government's revenue is taxation, the estimates primarily focus on this source. Tax collection is represented by a series of estimable equations, while other sources such as domestic and foreign borrowings, retained income and non-tax revenue are represented with identity equations.

The production function section is an estimation of infrastructure investment on Thailand's GDP. Public infrastructure investment is placed as a factor of production in the production function to investigate its impact on Thailand's economic growth. The investment finance estimate is inserted into the production function as government investment.

Finally, estimated and identity equations were combined to form the model for simulation of GDP time-paths. The simulation of time-paths is developed under five parameters for quarterly government debt. Ex ante and ex post scenarios were modelled, with the ex ante scenario generating a time-path within the time period of the analysis to verify the performance consistency of the model. The ex post scenario generates time-path values beyond the analysis and thus provides an economic policy model. A discussion of the nature and the outcomes of this research follows.

6.1 Public Revenue Estimation

As noted, the research methodology incorporates government investment sources and uses the recursive Standard Neoclassical Model comprising two parts: Thailand's public finance, and its aggregate production function. The estimations for the tax-derived items, the non-tax items and the production function follow.

6.1.1 Estimation PIT

Estimation procedures were applied to withholding PIT, PIT on interest, annual PIT and other PIT using model equations derived in chapter 5.

Withholding PIT

From equation 5.15 (s5.4.3), the withholding PIT revenue function can be structured as

$$PIT1W_t \quad = \quad f\left(GDP_t\right) \qquad (5.15)$$

To discount the impact of inflation (s5.6), the model variables were measured in real terms. Moreover, the natural logarithm was applied to the variables. Hence, the estimate function is

$$LPIT1WR_t \quad = \quad f\left(LGDPR_t\right) \qquad (6.1)$$

where $LPIT1WR_t$ is log of real withholding PIT collection at time *t*

$LGDPR_t$ is log of real GDP (1988 price) at time *t*.

During the estimation of LPIT1WR function, LPIT1WR and LGDPR were smoothed to remove variation caused by regular collection-events, thus a trend-stationary series was expected. Smoothed LPIT1WR and LGDPR were visually checked for non-stationarity (Appendix A: Plot of Variables). The results showed that both LPIT1WR and LGDPR were trended series. Following visual inspection, the time-series properties of the variables were tested using DF and ADF unit root procedures. The details of the results are attached at Appendix C: Unit Root Test. The summarised results are presented in Table 6.1.

Table 6.1
Withholding PIT/GDP Variables: Unit Root Test Results

Variables	**Level/First Difference**	**DF**		**ADF(4)**	
		Without Trend	**With Trend**	**Without Trend**	**With Trend**
LPIT1WR	Level	-0.7263	-1.1387	-0.6432	-2.7384
	First Difference	-1.9818	-1.9482	-1.9906	-1.9094
LGDPR	Level	1.2223	-0.1300	0.3473	-1.6097
	First Difference	-1.7652	-2.0616	-2.5354	-2.7508

For level variables
95% critical values for ADF statistic (without trend) = -2.9241
95% critical values for ADF statistic (with trend) = -3.5066

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9256
95% critical values for ADF statistic (with trend) = -3.5088

Test result decisions were made by comparing statistical values from each table with critical values for variables in the same category. In Table 6.1, the ADF value of level LPIT1WR without trend (-0.6432) was compared to the 95 per cent critical value for ADF statistic (without trend) shown below the table (-2.9241). If the statistical value was less than the critical value, then there was no unit root; otherwise the variable had unit root. In the case of LPIT1WR, the statistical value was greater than the critical value (-2.9241 < -0.6432), which indicated unit root in the variable level LPIT1WR without trend. Table 6.1 shows that both LPIT1WR and LGDPR had unit root at level as well as at first difference. However, taking first difference on the data removes non-stationary caused by trend (s5.6.2). Therefore, both variables were I(1).

The results confirmed that the data generating process of both variables were non-stationary and an integrated order of one; hence the model coefficient estimation proceeded to ECM. In the ECM, first estimation was made to establish the existence of a statistically valid L-R relationship using the Johansen and Juselius (JJ) cointegration test procedure (s5.7.4). The detailed output of the test is at Appendix D: Cointegration Tests. Both maximum Eigen and trace values showed no valid cointegrating relationship between the variables LPIT1WR and LGDPR (r = 0).

As the result indicated no cointegrating vector between LPIT1WR and LGDPR the model was estimated using the first difference of the variables, representing only the S-R relationship. Estimation initially proceeded with the general model having all required lags, using OLS. As the periodicity of the study data was quarterly, four lags, the maximum number, were used in the initial model. Using Hendry's general-to-specific approach, the statistically valid specific model is presented as

$$\begin{aligned} DLPIT1WR_t &= 0.0035583 + 1.1338\ DLPIT1WR_{t-1} - 0.50097\ DLPIT1WR_{t-2} \\ &\quad + 0.47732\ DLGDPR_{t-3} \end{aligned} \tag{6.2}$$

(Adj. $R^2 = 0.87106$)

All estimated coefficients of the specified model were significant, with p-values less than 0.05 (Appendix E: OLS Results). The model's explanatory power is validated at 87 per cent; the F-value for model fit was under 0.05. The model diagnostic statistics (autocorrelation and heteroscedasticity) were also observed and provide test result in Appendix F: Diagnostic Tests. The p-values of the diagnostic test statistics (chi-square and F-statistics) were greater than 0.05, implying that the model estimation was free from estimation issues such as serial correlation and heteroscedasticity.

The equation 6.2 showed the S-R real PIT1W elasticities with respect to lagged real PIT1W at the first quarter, lagged real PIT1W at the second quarter, and real GDP were 1.1338, -0.50097 and 0.47732 respectively. The estimation indicated that the changes in lagged log of real withholding PIT revenue at the first quarter ($DLPIT1WR_{t-1}$) and lagged log of real GDP at the third quarter ($DLGDPR_{t-3}$) had a positive effect on the change in log of real withholding PIT revenue ($DLPIT1WR_t$).

This result was consistent with expectations. Tax is levied predominantly on salaries and therefore an increase in the last quarter revenue collection leads to an increase for the current period. Similarly, an increase in real GDP resulted in higher salaries and bonuses for employees and thus led to an increase in withholding tax revenue. Also, the model estimate inferred that the transition process of an increase in the real GDP to an increase tax revenue collection was almost a year (lagged three quarters). There was an unexpected negative sign in the change in lagged log of real withholding PIT revenue at the second quarter ($DLPIT1WR_{t-2}$). The negative sign in the change in lagged log of real withholding PIT revenue at the second quarter means that an increase in the last two quarters' revenue collection leads to a decrease for the current period. This unexpected result could be caused by volatility of DLPIT1WR as shown in the graph. The graph of DLPIT1WR seems to have a strong seasonality which results from the fact that the greater part of pay rises and bonuses occur in the first quarter of each year were a fluctuation in PIT1W revenue.

PIT on Interest

The identity equation for personal income tax on interest (s5.4.3) is

$$PIT2I = f(TR) \quad (5.19)$$

Since this tax is derived from interest are based on the interest rate, there was no need to discount for inflation and the variables were estimated in nominal terms. With the natural logarithm applied to the variables, the estimate function is

$$LPIT2I_t = f(LTR_t) \quad (6.3)$$

where $LPIT2I_t$ is log of the PIT on interest at time *t*

LTR_t is log of the total revenue from interest at time *t*.

During the estimation of the LPIT2I function, LPIT2I and LTR were smoothed to account for variations in the deposit interest payment periods (s5.4.3). The visual check found that LPIT2I and LTR clearly indicated a negative trended series. Hence, the stationary property of the variables was tested using the DF and ADF unit root procedures.

The DF and ADF tests are summarised below. The details of the result are presented in Appendix C: Unit Root Test.

Table 6.2
PIT on Interest: Unit Root Test Results

Variables	**Level/First Difference**	**DF**		**ADF(4)**	
		Without Trend	**With Trend**	**Without Trend**	**With Trend**
LPIT2I	Level	-0.5007	-1.7489	-1.6858	-2.0599
	First Difference	-1.1660	-0.9028	-1.6551	-1.2178
LTRR	Level	-0.5738	-0.7167	-1.6971	-2.2212
	First Difference	0.4160	0.6543	-1.4333	-0.9060

For level variables
95% critical values for ADF statistic (without trend) = -2.9241
95% critical values for ADF statistic (with trend) = -3.5066

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9256
95% critical values for ADF statistic (with trend) = -3.5088

Table 6.2 shows that both LPIT2I and LTRR had unit root at the level value. Taking the first difference on the data removed non-stationarity caused by trend. Therefore, both variables were I(1).

To establish a statistically valid LR relationship in the ECM, the L-R effect was estimated by comparing JJ statistics with the critical value at 95 per cent. The result showed no valid cointegrating relationship (r = 0) among the variables LPIT2I and LTR. The model was then estimated using first difference of the variables, representing only the S-R relationship. The statistically valid specific model is presented below.

$$DLPIT2I_t = 1.2641\, DLPIT2I_{t-1} - 0.60887\, DLPIT2I_{t-2} + 0.15916\, DLTR \qquad (6.4)$$

(Adj. $R^2 = 0.92902$)

All estimated coefficients of the specified model were significant, with p-values less than 0.05 (Appendix E: OLS Results). The model's explanatory power is validated at 92 per cent. The equation 6.4 shows that the S-R PIT2I elasticities with respect to lagged PIT2I at the first quarter, lagged PIT2I at the second quarter, and total revenue from interest were 1.2641, -0.60887 and 0.15916 respectively. The change in lagged log of PIT on interest revenue at the first quarter ($DLPIT2I_{t-1}$) and the change in log of total revenue from interest rate at the current period (DLTR) should have a positive effect on the change in log of PIT on interest revenue ($DLPIT2I_t$).

With an increase in PIT on interest revenue in the last quarter, a continuing increase in the current period revenue was expected. Similarly, an increase in total revenue from interest immediately resulted in higher PIT on interest revenue because the tax is automatically deducted. However, the negative sign shown in the change in lagged log PIT on interest revenue at the second quarter ($DLPIT2I_{t-2}$) was unexpected. It may be caused by greater volatility in the data set as savings deposit interest payments are made biannually, in January (Q1) and July (Q3), leading to a fluctuation in the PIT2I revenue for that quarter.

Other PIT

Estimation of other PIT is a behavioural equation at s5.4.3

$$PIT4O \quad = \quad f(LOAN, CG) \qquad (5.21)$$

To discount for inflation, the variables were estimated in real value; except for LOAN, which had year-to-year growth. Moreover, natural logarithm was applied to all variables except for growth of LOAN, as a negative value of LOAN growth cannot be a log. Hence, the estimate function is

$$LPIT4OR = f(GLOAN, LCGR) \quad (6.5)$$

where $LPIT4OR$ is log of real other PIT

$GLOAN$ is year-to-year growth of commercial banks' private loans including non performing loans

$LCGR$ is log of real government consumption.

For estimation of the LPIT4OR function, LPIT4OR and LCGR variables were smoothed to remove fluctuations caused by collection-events to show a trend-stationary series. The visual check result showed both LPIT4OR and LCGR were trended series, while GLOAN was unlikely to have trend. LPIT4OR had a significant fall from 1996Q1 to 2002Q4, which may reflect the Asian economic crisis. To account for this, the dummy variable (D) was used to capture the impact of the crisis in each quarter 1996Q1 to 2002Q4 with a value of 1, remainder as 0. The DF and ADF tests are summarised in Table 6.3 and the details of the results are at Appendix C: Unit Root Test.

Table 6.3
Other PIT: Unit Root Test Results

Variables	**Level/First Difference**	**DF** Without Trend	**DF** With Trend	**ADF(4)** Without Trend	**ADF(4)** With Trend
LPIT4OR	Level	.99885	-.49467	.053008	-1.0249
	First Difference	-1.4924	-1.9364	-1.5264	-2.0333
GLOAN	Level	-2.4455	-1.9857	-2.2360	-1.4580
	First Difference	-5.7513	-5.9146	-3.4035	-3.8060
LCGR	Level	.49505	-.66055	-.35740	-2.0130
	First Difference	-2.8428	-2.8181	-2.8481	-2.8714

For level variables
95% critical values for ADF statistic (without trend) = -2.9241
95% critical values for ADF statistic (with trend) = -3.5066

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9256
95% critical values for ADF statistic (with trend) = -3.5088

Table 6.3 shows that LPIT4OR, GLOAN, and LCGR had unit root at the level variable. After taking first difference, while GLOAN was unit root free, LPIT4OR and LCGR had unit root. However, taking the first difference on the data removed non-stationary caused by trend (s5.7.1). Therefore, both variables were I(1).

The results confirm that the data generating process of all variables were non-stationary and integrated order of one; the ECM was applied with first estimation to establish a valid L-R relationship using the JJ procedure. The details of the test are provided in Appendix D: Cointegration Tests.

Both maximum Eigen and trace values proved two or less cointegrating relationships (r <= 2) among the variables LPIT4OR, GLOAN and LCGR; therefore r = 2. The estimate statistic indicated that GLOAN was insignificant in the L-R; therefore, GLOAN was deleted by treating it as zero. The estimates of L-R cointegrating vectors are given in Appendix G: Long Run Cointegration Test. The LR equilibrium is

$$ECM = LPIT4OR - 1.2652\,LCGR \qquad (6.6)$$

where *ECM* is the estimated error correction term.

Once the L-R was specified, the ECM was estimated to determine the dynamic behaviour of LPIT4OR. After experimenting with the general form of the ECM, the following model was found best.

$$\begin{aligned} DLPIT4OR_t = & -0.39136 + 0.82038\,DLPIT4OR_{t-1} - 0.40083\,DLCGR_{t-3} \\ & -0.074996\,ECM_{t-1} - 0.026062\,D \end{aligned} \qquad (6.7)$$

(Adj. $R^2 = 0.84349$)

All estimated coefficients of the specified model were significant, with p-values less than 0.05 (Appendix E: OLS Results). The model's explanatory power is validated at 84 per cent. The change in lagged log of other PIT (equation 6.7) at the first quarter ($DLPIT4OR_{t-1}$) had a positive effect on the change in log of other PIT (DLPIT4OR) as expected. On the other hand, the error correction term (ECM_{t-1}) and a dummy variable for the Asian crisis (D) had a negative effect on the change in log of other PIT (DLPIT4OR). The result was also consistent with expectations; when there was an increase in the other PIT last quarter, there was an increase in the current period's revenue. ECM confirmed a L-R equilibrium among the variables in equation 6.7. The negative sign shows that the system corrected its previous period's disequilibrium. The dummy variable (D) inferred that during the crisis period, 1996Q1 to 2002Q4, other PIT revenue was less than any other period.

However, the unexpected negative sign in the change in lagged log of real government consumption at third quarter ($DLCGR_{t-3}$) may refer to the Thai government's attempts to revitalise the economy by maintaining its expenditure. Public consumption did not fall during the crisis, as was the case for the other PIT revenue, resulting in the negative relationship.

The above model suggested that the SR real other PIT elasticities with respect to lagged real other PIT at the first quarter and lagged real government consumption at the third quarter were 0.82038 and -0.40083 respectively. The estimated coefficient of the error correction term was -0.074996, and the system corrected its previous period's disequilibrium by 7.5 per cent each quarter. The estimated coefficient of the dummy variable of period 1996Q1 to 2002Q4 was -0.026062; during the period, the revenue collection was 2.6 per cent less than other periods.

6.1.2 Estimation CIT

CIT consists of annual CIT, half-yearly CIT, CIT on the service sector and foreign companies repatriating their profits from Thailand, withholding CIT and other CIT. This is expressed at s5.4.3 as

$$CIT_t = CIT1A_t + CIT1H_t + CIT2F_t + CIT3W_t + CIT4O_t \qquad (5.22)$$

Annual CIT

The annual CIT was estimated from the half-yearly corporate income tax.

$$CIT1A \quad = \quad f(CIT1H) \qquad (5.23)$$

To discount for inflation, the variables were estimated at real value. Moreover, the natural logarithm was applied on the variables. Hence, the estimate function is

$$LCIT1AR \quad = \quad f(LCIT1HR) \qquad (6.8)$$

where $LCIT1AR$ is the log of real annual CIT

$LCIT1HR$ is the log of real half-yearly CIT.

For estimation of LCIT1AR function, LCIT1AR and LCIT1HR were smoothed for a trend-stationary series. The visual check result was that both LCIT1AR and LCIT1HR were trended series. LCIT1AR showed a significant fall from 1997Q2 to 2000Q4 due to the Asian crisis, and an adjusting dummy variable (D) was included at value 1 for 1997Q2 to 2000Q4, otherwise 0. The next test was the DF/ADF unit root tests, the results for this are summarised and presented below (see Appendix C: Unit Root Test).

Table 6.4

Annual CIT: Unit Root Test Results

Variables	Level/First Difference	DF Without Trend	DF With Trend	ADF(4) Without Trend	ADF(4) With Trend
LCIT1AR	Level	0.9448	-1.0413	0.06794	-1.0221
	First Difference	-3.0401	-3.4162	-1.7421	-2.3922
LCIT1HR	Level	-1.2607	-2.0719	-1.1777	-2.1218
	First Difference	-4.0581	-4.0355	-2.3558	-2.4031

For level variables
95% critical values for ADF statistic (without trend) = -2.9241
95% critical values for ADF statistic (with trend) = -3.5066

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9256
95% critical values for ADF statistic (with trend) = -3.5088

Table 6.4 shows that LCIT1AR and LCIT1HR had unit root at the level variable and at first difference. As taking first difference on the data removed non-stationary caused by trend (s5.7.1), both variables were assumed I(1). The data generating process found all variables were non-stationary and integrated order of one. To establish a statistically valid LR relationship in the ECM, the JJ procedure was used. The detail output of the test is at Appendix D: Cointegration Tests.

Both maximum Eigen and trace values had one or less cointegrating relations (r <= 1) among the variables LCIT1AR and LCIT1HR, therefore (r = 1). The estimates of long-run cointegrating vectors are given in Appendix G: Long Run Cointegration Test. The LR equilibrium is

$$ECM = LCIT1AR - 1.1003 * LCIT1HR \qquad (6.9)$$

where *ECM* is the estimated error correction term.

Once the L-R relationship was specified, the ECM was estimated to determine the dynamic behaviour of the LCIT1AR. To obtain a statistically valid specific model from the general model, Hendry's general-to-specific approach was adopted. The best fit specific model is presented below.

$$\begin{aligned} DLCIT1AR_t = {} & 0.5871\, DLCIT1AR_{t-1} - 0.38556\, DLCIT1AR_{t-3} \\ & - 0.044042\, ECM_{t-1} - 0.046302\, D \end{aligned} \qquad (6.10)$$

(Adj. R^2 = 0.5097)

The change in lagged of log annual CIT at the first quarter ($DLCIT1AR_{t-1}$) had, as expected, a positive effect on the change in log of annual CIT ($DLCIT1AR_t$) (equation 6.10). The error correction term (ECM_{t-1}) and a dummy variable of the Asian crisis (D) were also expected to have a negative effect on the change in log of annual CIT ($DLCIT1AR_t$). When there was an increase in the annual CIT in the previous quarter, an increase in the current period is expected. ECM validated a L-R equilibrium for variables in equation 6.10. The negative sign showed that the system corrected its previous period's disequilibrium. The dummy variable (D) inferred that, during the crisis period of 1997Q2 to 2000Q4, there were less annual CIT collected than any other period. The unexpected negative sign in the change in lagged log of annual CIT at third quarter ($DLCIT1AR_{t-3}$), reflected the Thai government's revitalisation process. Hence, government consumption did not fall as far as CIT revenue and resulted in the negative relationship.

The above model stated that S-R real annual CIT elasticities with respect to lagged real annual CIT at the first quarter and lagged real annual CIT at the third quarter were 0.5871 and -0.38556 respectively. The estimated coefficient of the error correction term was -0.044, thus the system corrected its previous period's disequilibrium by 4.4 per cent a quarter. The estimated coefficient of the dummy variable of period 1997Q2 to 2000Q4 was -0.0463, the annual CIT was 4.63 per cent less.

CIT Service Sector and Repatriated Foreign Profits

CIT on the service sector and foreign companies remitting profits from Thailand was estimated from GDP (s5.4.3). The estimation model is

$$CIT2F = f(GDP) \quad (5.25)$$

To discount for inflation, the variables were estimated as real value. Natural log was applied to the variables. Hence, the estimate function is

$$LCIT2FR = f(LGDPR) \quad (6.11)$$

where $LCIT2FR$ is the log of real CIT, service sector & repatriated profits

$LGDPR$ is the log of real GDP.

Both variables, LCIT2FR and LGDPR were visually checked for non-stationarity, resulting in a trended series (see Appendix A: Plot of Variables). This was followed by the

DF/ADF unit root procedures, summarised at Table 6.5 , and the details of the results are at Appendix C: Unit Root Test.

Table 6.5
CIT Service Sector and Repatriated Foreign Profits: Unit Root Test Results

Variables	Level/First Difference	DF		ADF(4)	
		Without Trend	With Trend	Without Trend	With Trend
LCIT2FR	Level	-4.1857	-5.6579	-1.8265	-2.3007
	First Difference	-13.7740	-13.6332	-3.3275	-3.3023
LGDPR	Level	-.53874	-2.0537	-.47068	-2.6130
	First Difference	-6.3486	-6.3027	-2.4823	-2.4969

For level variables
95% critical values for ADF statistic (without trend) = -2.9241
95% critical values for ADF statistic (with trend) = -3.5066

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9256
95% critical values for ADF statistic (with trend) = -3.5088

Table 6.5 shows that LCIT2FR and LGDPR had unit root for variables both at level and first difference; however, taking the first difference on the data removed non-stationarity caused by trend. Therefore, both variables were I(1) and ECM was applied to establish a valid L-R relationship using the JJ procedure. The result indicated that there was at least one cointegrating relationship (r <= 1) between LCIT2FR and LGDPR (Appendix D: Cointegration Tests).

The estimates of long-run cointegrating vectors are given in Appendix G: Long Run Cointegration Test. The L-R equilibrium relationship is

$$ECM = LCIT2FR - 1.4226 * LGDPR \qquad (6.12)$$

where *ECM* is the estimated error correction term.

The ECM was applied and the LCIT2FR was modelled as

$$\begin{aligned} DLCIT2FR_t = & -4.8471 - 0.56232\ DLCIT2FR_{t-1} - 0.052689\ DLCIT2FR_{t-2} \\ & + 1.5652\ DLGDPR_{t-2} + 1.3316\ DLGDPR_{t-3} - 0.43369\ ECM_{t-1} \end{aligned} \qquad (6.13)$$

(Adj. $R^2 = 0.66275$)

All estimated coefficients of the specified model were significant, with p-values less than 0.05 (Appendix E: OLS Results). The model's explanatory power is validated at 66 per cent. The change in lagged log of real GDP at the second and the third quarter ($DLGDPR_{t-2}$,

$DLGDPR_{t-3}$ respectively) of equation 6.13 were expected to have positive effect on the change in log of CIT on service sector and foreign companies' repatriated profits ($DLCIT2FR_{t-2}$) and the lag one quarter of the error correction term (ECM_{t-1}) had a negative effect on the change in ($DLCIT2FR_t$) as expected. An increase in the real GDPR in the previous quarters two and three showed an increase in the current period CIT2F as well. ECM results were for a long-run equilibrium relationship for the variables in equation 6.13.

However, the negative effect of the change in lagged log of CIT on service sector and foreign companies' repatriated profits tax at the first and the second quarters ($DLCIT2FR_{t-1}$, $DLCIT2FR_{t-2}$) on the change in log of CIT et al. ($DLCIT2FR_t$) was unexpected. The explanation for the negative effect of the variables could be the timing of remittances; that they might not occur regularly in succeeding quarters. Equation 6.13 denoted that the S-R real CIT et al. elasticities with respect to lagged real CIT et al. at the first and the second quarters were -0.56232 and -0.052689 respectively; and lagged real GDP at the second and the third quarters, 1.5652 and 1.3316 respectively. The estimated coefficient of the error correction term was -0.43369, thus the previous period's disequilibrium was corrected 4.3 per cent each quarter.

Withholding CIT

The estimation model of the withholding CIT from s5.4.3 is

$$CIT3W = f(GDP) \qquad (5.26)$$

To discount inflation, the variables were estimated in real value; natural logarithm was applied on the variables. The adjusted estimate function is

$$LCIT3WR_t = f(LGDPR_t) \qquad (6.14)$$

where $LCIT3WR_t$ is log of the real withholding CIT collection at time *t*

$LGDPR_t$ is log of the real GDP (1988 price) at time *t*.

In this estimation of LCIT1WR function, LCIT1WR and LGDPR were smoothed for a trend-stationary series and checked for non-stationarity (Appendix A: Plot of Variables). The result shows that both LCIT1WR and LGDPR were trended series. LCIT3WR exhibited a significant fall from 1997Q3 to 2001Q3 due to the Asian crisis and a dummy variable (D) equal to 1 was entered from 1997Q3 to 2001Q3, otherwise D is 0. The variables were then tested by DF/ADF unit root procedures; the results summarised under and full results at Appendix C: Unit Root Test.

Table 6.6

Withholding CIT: Unit Root Test Results

Variables	Level/First Difference	DF		ADF(4)	
		Without Trend	With Trend	Without Trend	With Trend
LCIT3WR	Level	-0.89779	-0.21084	-0.65174	-1.9785
	First Difference	-1.3211	-1.5462	-1.7884	-2.0213
LGDPR	Level	1.2223	-0.13001	0.3473	-1.6097
	First Difference	-1.7652	-2.0616	-2.5354	-2.7508

For level variables
95% critical values for ADF statistic (without trend) = -2.9241
95% critical values for ADF statistic (with trend) = -3.5066

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9256
95% critical values for ADF statistic (with trend) = -3.5088

Table 6.6 showed that both LCIT3WR and LGDPR had unit root at level and at the first difference; however, taking first difference on the data removed non-stationary caused by trend (s5.7.1). As both variables were I(1), ECM was applied to test for a valid L-R relationship using JJ. As both maximum Eigen and trace values show no valid cointegrating relationship (r = 0) between LCIT3WR and LGDPR (Appendix D: Cointegration Tests), the model was estimated using the first difference of the variables, representing only the S-R relationship. Therefore, estimation proceeded with the general model having four lags, using OLS. Hendry’s general-to-specific approach was applied and the best fit specific model is presented

$$DLCIT3WR_t = 1.3573\ DLCIT3WR_{t-1} - 0.54066\ DLCIT3WR_{t-2} + 0.36637\ DLGDPRCMA_t \quad (6.15)$$

(Adj. R^2 = 0.93392)

The equation 6.15 shows that the S-R real CIT3W elasticities with respect to lagged real CIT3W at the first quarter, lagged real CIT3W at the second quarter, and real GDP were 1.3573, -0.54066, and 0.36637 respectively.

Changes in lagged log of real withholding CIT at the first quarter ($DLCIT3WR_{t-1}$) and the change in log of real GDP ($DLGDPR_t$) had a positive effect on the change in log of real withholding CIT ($DLCIT3WR_t$). This tax is levied on the monthly revenue of companies; therefore an increase in the last quarter revenue collection was expected to lead to an increase in the current period collection. Moreover, an increase in real GDP results in higher company revenue, led to an increase in withholding tax revenue. The negative sign change in lagged log of real withholding CIT tax at the second quarter ($DLCIT3WR_{t-2}$) with a noticeable fall 1997Q3 to 2001Q3in the CIT3WR, possibly resulted from the Asian crisis. This effect was noted as a fluctuation in the CIT3W data. However, the dummy variable (D) for those periods was deleted as statistically insignificant during the Hendry's general-to-specific approach.

Other CIT

The behavioural equation for other CIT at s5.4.3 is

$$CIT4O \quad = \quad f(LOAN, IG) \qquad (5.27)$$

The variables were discounted for inflation, except LOAN where year-to-year growth was used; natural logarithm was applied, except for the negative value of LOAN which cannot take log. Hence, the estimate function is denoted as

$$LCIT4OR \quad = \quad f(GLOAN, LIGR) \qquad (6.16)$$

where $LCIT4OR$ is the log of real other CIT

$GLOAN$ is year-to-year growth of private banks' loans including non performing loans

$LIGR$ is the log of real government investment.

LCIT4OR, GLOAN, and LIGR were checked for non-stationarity and were found without trend (Appendix A: Plot of Variables). Peaks in the analysis occurred at the second and third quarters each year; therefore, dummy variables (D2 and D3) were added to the model. D2 was the dummy variable of each second quarter and denoted 1, other quarters were 0. D3 was similarly placed for each third quarter as 1, where other quarters were 0. DF/ADF unit root was applied and the results are at Table 6.7 (Appendix C: Unit Root Test).

Table 6.7

Other CIT: Unit Root Test Results

Variables	Level/First Difference	DF Without Trend	DF With Trend	ADF(4) Without Trend	ADF(4) With Trend
LCIT4OR	Level	-6.3738	-7.5516	-1.4483	-3.4015
	First Difference	-9.1556	-9.0596	-3.8138	-3.7757
GLOAN	Level	-2.4455	-1.9857	-2.2360	-1.4580
	First Difference	-5.7513	-5.9146	-3.4035	-3.8060
LIGR	Level	-4.9402	-5.7730	-1.4763	-1.8798
	First Difference	-11.5597	-11.4356	-3.2488	-3.1744

For level variables
95% critical values for ADF statistic (without trend) = -2.9190
95% critical values for ADF statistic (with trend) = -3.4987

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9202
95% critical values for ADF statistic (with trend) = -3.5005

Given that the statistical table value was less than the critical value, then there was no unit root, and Table 6.7 shows that LCIT4OR, GLOAN, and LIGR had unit root at the level variable. After taking first difference, all variables were unit root free. Therefore, all variables were I(1); thus were non-stationary, with integrated order of one. The ECM was applied for L-R equilibrium using the JJ procedure, results below (Appendix D: Cointegration Tests).

The result showed that there were one or less cointegrating relation (r <= 1) among the variables LCIT4OR, GLOAN, and LIGR. As GLOAN was insignificant in the L-R the variable was deleted at zero value. It was noted that peaks were occurring at the second and third quarters each year and dummy variables added to capture the peaking pattern. The estimates of LR cointegrating vectors were given in Appendix G: Long Run Cointegration Test. The L-R equilibrium relationship is

$$ECM = LCIT4OR - 0.77\,LIGR \qquad (6.17)$$

where *ECM* is the estimated error correction term.

The ECM was estimated to determine the dynamic behaviour of the LCIT4OR with the LR relationship as the error correction component and S-R vector as difference variables relationship. Using Hendry's general-to-specific modelling approach, the following model was found best fit.

$$
\begin{aligned}
DLCIT4OR_t = & -1.0964 - 0.35037\ DLCIT4OR_{t-1} - 0.36279\ DLCIT4OR_{t-2} \\
& - 0.2706\ DLCIT4OR_{t-3} + 1.1601\ DGLOAN_{t-1} - 0.67814\ ECM_{t-1} \quad (6.18) \\
& + 0.43186\ D2 + 0.42696\ D3
\end{aligned}
$$

(Adj. $R^2 = 0.93163$)

All estimated coefficients of the specified model were significant, with p-values less than 0.05 (Appendix E: OLS Results). The model's explanatory power is validated at 93 per cent. Equation 6.18 shows that the change in lagged log of other CIT at the first, second, and third quarters ($DLCIT4OR_{t-1}$, $DLCIT4OR_{t-2}$ and $DLCIT4OR_{t-3}$) had a negative effect on the change in log of other CIT ($DLCIT4OR_t$) which was unexpected. As this tax was paid once yearly, if payments were concentrated in any quarter, revenues for the other quarters would be lower.

On the other hand, a change in the growth of LOAN, the dummy variable of the second and third quarters (D2 and D3 respectively), had a positive effect; while the lagged error correction term (ECM_{t-1}) had a negative effect on the change in log of other CIT ($DLCIT4OR_t$), as expected. Growth in commercial banks' private loans leads to higher revenue in other CIT. The dummy variables of the second and third quarters (D2 and D3) inferred that other CIT revenues were higher than the remaining quarters in any particular year. ECM suggested the validity of a L-R equilibrium among the variables in equation 6.18.

The above model posits that short-run real other CIT elasticities with respect to lagged real other CIT at the first, second, and third quarters and lagged growth on the commercial banks' private loans at the first quarter were -0.35037, -0.36279, -0.27060, and 1.1601 respectively. The ECM coefficient was -0.67814 thus the previous period's disequilibrium was corrected by 67.8 per cent per quarter. The coefficients of dummy variables for the second and third quarters were 0.43186 and 0.42696 respectively: in those quarters, revenue was 43.2 and 42.7 per cent higher.

6.1.3 Estimation Petroleum Tax

Petroleum usage in Thailand is a function of the economic environment, GDP was therefore used as a proxy for PT revenue (s5.4.3)

$$PT = f(GDP) \qquad (5.28)$$

The variable was estimated as real value and natural logarithm applied

$$LPTR_t \quad = \quad f\left(LGDPR_t\right) \qquad (6.19)$$

where $LPTR_t$ is log of the real petroleum tax collection at time *t*

$LGDPR_t$ is log of the real GDP (1988 prices) at time *t*.

LPTR and LGDPR were checked for non-stationarity, LGDPR was a trended series but LPTR required further analysis (Appendix A: Plot of Variables). DF/ADF unit root procedures are at Table 6.8 (Appendix C: Unit Root Test).

Table 6.8
Petroleum Tax: Unit Root Test Results

Variables	Level/First Difference	DF Without Trend	DF With Trend	ADF(4) Without Trend	ADF(4) With Trend
LPTR	Level	-4.8159	-5.7854	-.75515	-2.3209
	First Difference	-6.9037	-6.8129	-3.1832	-3.2549
LGDPR	Level	-4.8159	-5.7854	-.75515	-2.3209

For level variables
95% critical values for ADF statistic (without trend) = -2.9378
95% critical values for ADF statistic (with trend) = -3.5279

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9400
95% critical values for ADF statistic (with trend) = -3.5313

Table 6.8 shows that LGDPR was stationary (I[0]) while LPTR was non-stationary (I[1]) at the level variable. After taking first difference, LPTR become stationary. Therefore, the variables were a mix of I(0) and I(1) and, the coefficient estimation was preceded by Autoregressive Distributed Lag (ARDL). However, as the LGDPR data set showed trend, LGDPR was cointegrated with I(1), ECM was applied in lieu of ARDL. First estimation in the ECM using JJ procedure was made to establish a valid L-R relationship, see under and Appendix D: Cointegration Tests.

The cointegration tests showed no cointegrating vector between LPTR and LGDPR. With no valid cointegration, the model was estimated using first difference, representing only the S-R relationship. Analysis for the general model (four lags) using OLS was followed by Hendry's general-to-specific approach. Except for C and $DLPTR_{t-3}$, coefficients of the specific model were significant at 95 per cent, p-values less than 0.05. The coefficient for $DLPTR_{t-3}$ was significant at 90 per cent (Appendix E: OLS Results). The model is

$$DLPTR_t = -0.62358\, DLPTR_{t-1} - 0.73906\, DLPT_{t-2} - 0.29356\, DLPTR_{t-3} + 28.0173\, DLGDPR_{t-2} \quad (6.20)$$

(Adj. R^2 = 0.68822)

The equation 6.20 shows that the S-R real petroleum tax revenue elasticities with respect to lagged real petroleum tax revenue at the first, second, and third quarters and real GDP were -0.62358, -0.73906, -0.29356 and 28.0173, respectively.

The model 6.20 shows that changes in lagged log of real GDP at the second quarter ($DLGDPR_{t-2}$) should have a negative effect on the change in log of real petroleum tax ($DLPTR_t$), as expected. An increase in real GDP results in higher consumption of petroleum and therefore petroleum tax revenue. An unexpected negative in lagged log of real petroleum tax at the first, second, and third quarters ($DLPTR_{t-1}$, $DLPTR_{t-2}$ and $DLPTR_{t-3}$) had a negative effect on the change in log of real petroleum tax ($DLPTR_t$). This tax is similar to corporate taxes, affecting petroleum companies, thus the pattern of tax payments may also be clumped in certain quarters.

6.1.4 Estimation Indirect Taxes

There are four components of indirect tax: VAT, Import Duties, Specific Business Tax (SBT) and Excise Tax (s5.4.4)

$$IDTAX_t = VAT_t + IMDUTI_t + SBT_t + EXCISET_t \quad (5.29)$$

VAT

To avoid issues relating to changing rates, the base VAT year price was estimated, then commodity price and VAT rate changes included to calculate VAT revenue.

The identity equation for VAT (s5.4.4)

$$VAT_t = VATD_t + VATIM_t \quad (5.24)$$

Domestic VAT base estimation used three explanatory variables.

$$VATDB = f(CP, CG, VATIMB) \quad (5.25)$$

Variables were estimated in real terms and natural logarithm applied

$$LVATDBR = f(LCPR, LCGR, LVATIMBR) \quad (6.21)$$

where $LVATDBR$ is the log of real domestic VAT base

$LCPR$ is the log of real private consumption

$LCGR$ is the log of real government consumption

$LVATIMBR$ is the log of real import VAT base.

In this estimation of LVATDBR function, variables were smoothed to reduce collection anomalies, then checked for non-stationarity (Appendix A: Plot of Variables). All series appeared trended. DF/ADF unit root tests are at Table 6.9 below (Appendix C: Unit Root Test).

Table 6.9
Domestic VAT: Unit Root Test Results

Variables	Level/First Difference	DF Without Trend	DF With Trend	ADF(4) Without Trend	ADF(4) With Trend
LVATDBR	Level	1.9020	-.37444	.51401	-1.2330
	First Difference	-2.3256	-2.4410	-1.8367	-2.3420
LCGR	Level	.49505	-.66055	-.35740	-2.0130
	First Difference	-2.8428	-2.8181	-2.8481	-2.8714
LCPR	Level	.94696	-.43340	.22776	-1.3680
	First Difference	-1.5536	-1.7250	-1.9061	-2.1139
LVATIMBR	Level	-.12165	-.74415	-.87461	-1.3392
	First Difference	-1.4661	-1.7222	-1.9991	-2.4799

For level variables
95% critical values for ADF statistic (without trend) = -2.9241
95% critical values for ADF statistic (with trend) = -3.5066

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9256
95% critical values for ADF statistic (with trend) = -3.5088

Table 6.9 shows that all variables had unit root at the level variable. After taking first difference, only LCGR was unit root free. Therefore, all variables were I(1); thus were non-stationary, and integrated for one.

For the ECM, the results for L-R (Appendix D: Cointegration Tests) indicated there were two or less cointegrating relationships (r<=2) among the variables $LVATDBR$, $LCPR$, $LCGR$ and $LVATIMBR$. At r = 2, the coefficient estimation was applied; LCGR and LVATIMBR were found insignificant and restricted to zero, thus deleted. The final estimate of a valid LR cointegrating vector is given in Appendix G: Long Run Cointegration Test. The L-R equilibrium relationship is

$$ECM = LVATDBR - 1.8597\, LCPR \qquad (6.22)$$

Next, the ECM determined the dynamic behaviour of LVATDBR with L-R relationship as error correction component and SR relationship as difference variable relationship. Hendry's general-to-specific validated estimated model is

$$\begin{aligned} DLVATDBR_t = &- 2.1786 + 0.78509\, DLVATDBR_{t-1} - 1.49\, DLCPR_{t-3} \\ &+ 0.41579\, DLVATIMBR_{t-1} - 0.68785\, DLVATIMBR_{t-2} \\ &+ 0.63776\, DLVATIMBR_{t-3} - 0.19758\, ECM_{t-1} \end{aligned} \qquad (6.23)$$

(Adj. $R^2 = 0.76365$)

All estimated coefficients of the specified model were significant, with p-values less than 0.05 (Appendix E: OLS Results). The model's explanatory power is validated at 76 per cent.

Equation 6.23 posits that the change in lagged log of real domestic VAT base at the first quarter ($DLVATDBR_{t-1}$) had a positive effect, while the change in lagged log of real import VAT base at the second quarter ($DLVATIMBR_{t-2}$) and lagged of error correction term (ECM_{t-1}) were likely to have a negative effect on the change in log of real domestic VAT base ($DLVATDBR_t$), as expected. The increase in the real domestic VAT base in the last period led to an expected increase in this period. However, the increase in real import VAT base from the last two quarters, and the subsequent rebates, led to a decrease in real domestic VAT base. ECM validated a L-R equilibrium relationship among the variables in equation (6.23); S-R real domestic VAT base elasticities with respect to lagged of real domestic VAT base at the first quarter, lagged real private consumption, and lagged real import VAT base at the first, second, and third quarters were 0.78509, -1.49, 0.41579, -0.68785 and 0.63776 respectively. The coefficient of error was -0.19758, that is, the previous period's disequilibrium was corrected by 19.8 per cent each quarter.

Import VAT

The import VAT base depends on the value of imported goods (s5.4.4)

$$VATIMB = f(IMG,\ IMGPI) \qquad (5.32)$$

Variables were estimated in real value, except IMGPI, the price index. With natural logarithm applied to variables, the estimate function is

$$LVATIMBR \quad = \quad f\left(LIMGR, LIMGPI\right) \qquad (6.24)$$

where $LVATIMBR$ is the log of real import VAT base

$LIMGR$ is the log of real import of goods

$LIMGPI$ is the log of import goods price index (baht).

The model showed trend (Appendix A: Plot of Variables), and DF and ADF unit root procedures were applied (Table 6.10 and Appendix C: Unit Root Test).

Table 6.10
Import VAT: Unit Root Test Results

Variables	**Level/First Difference**	**DF**		**ADF(4)**	
		Without Trend	**With Trend**	**Without Trend**	**With Trend**
LVATIMBR	Level	-.77177	-1.1142	-2.1070	-2.3235
	First Difference	-5.7021	-5.7554	-2.7774	-2.8409
LIMGR	Level	-.92796	-1.5048	-1.5795	-2.4394
	First Difference	-5.9781	-5.9344	-2.3359	-2.3333
LIMGPI	Level	-1.5083	-2.5137	-1.2950	-2.4991
	First Difference	-6.4181	-6.3853	-3.7730	-3.7679

For level variables
95% critical values for ADF statistic (without trend) = -2.9190
95% critical values for ADF statistic (with trend) = -3.4987

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9202
95% critical values for ADF statistic (with trend) = -3.5005

The table above shows that all variables had unit root at the level variable. After taking first difference, only LIMGPI became unit root free while the other two variables showed weak unit root, thus both remaining variables were also integrated of order one (I[1]). Using JJ procedure in ECM, there was no cointegrating vector among the variables $LVATIMBR$, $LIMGR$ and $LIMGPI$ (see Appendix D: Cointegration Tests).

With a S-R relationship, first difference was applied. A general difference model with four lags was specified using OLS. The estimated model is

$$DLVATIMBR_t = 0.4032\,DLIMGR_t + 0.28114\,DLIMGR_{t-1} - 0.43679\,DLIMGPI_t - 0.28399\,DLIMGPI_{t-2} \quad (6.25)$$

(Adj. R^2 = 0.48384)

With the exception of C, the coefficients were significant at 95 per cent, p-values less than 0.05. There was a low, but acceptable, validity of 48 per cent. The S-R real import VAT base elasticities with respect to real imports of goods, its lag at the first quarter, imported goods price index, and its lag at the second quarter were 0.40320 , 0.28114, -0.43679, and -0.28399 respectively.

The above equation 6.25 suggested that the change in log of real goods imports and lagged log of real goods imports at the first quarter ($DLIMGR_t$, $DLIMGR_{t-1}$) had a positive effect, while the change in log of goods imports price index and lagged log of goods imports price index at the second quarter ($DLIMGPI_t$, $DLIMGPI_{t-2}$) had a negative effect on the change in log of real import VAT base ($DLVATIMBR_t$), as expected. This occurs as increased volumes of imports in current and past quarters led to an increased import VAT base in the current period, as VAT is collected monthly with minimal lag times. On the other hand, an increase in the average prices for imported goods may reduce import volumes which could result in a decline in the taxable import VAT base.

Specific Business Tax

The revenue from loans interest was used as a proxy to estimate SBT revenue. The SBT equations at s5.4.4 are

$$SBT = f(FIR) \quad (5.35)$$

$$FIR = \left(DC_t \left(\frac{MLR_t}{100} \right) \right) \quad (5.36)$$

However, real GDP was inserted into the estimation model as an additional variable to reflect economic performance. As an explanatory variable, GDP transformed equation 5.35 into a regression equation. Since this was a revenue tax from interest, discounting for inflation in SBT and FIR was not required. Natural logarithm was applied, thus the estimate function is

$$LSBT = f(LFIR, LGDPR) \quad (6.26)$$

where $LSBT$ is the log of SBT

$LFIR$ is the log of interest revenues

LGDPR is the log of real GDP (1988 prices)

All variables were smoothed for irregularities for a trend-stationary series, then non-stationarity sought (Appendix A: Plot of Variables). The LGDPR variable was a trended series while LSBT was unidentifiable and LFIR had no trend. DF and ADF unit root procedures were applied for confirmation with results, at the table below (see Appendix C: Unit Root Test).

Table 6.11
SBT: Unit Root Test Results

Variables	**Level/First Difference**	**DF**		**ADF(4)**	
		Without Trend	**With Trend**	**Without Trend**	**With Trend**
LSBT	Level	-0.28560	0.50248	-2.1870	-1.8392
	First Difference	-1.5736	-1.8216	-1.2619	-1.4681
LFIR	Level	-0.74209	0.26745	-2.1482	-1.8866
	First Difference	-1.2048	-1.4885	-1.4355	-1.2239
LGDPR	Level	1.2223	-0.13001	0.3473	-1.6097
	First Difference	-1.7652	-2.0616	-2.5354	-2.7508

For level variables
95% critical values for ADF statistic (without trend) = -2.9241
95% critical values for ADF statistic (with trend) = -3.5066

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9256
95% critical values for ADF statistic (with trend) = -3.5088

Table 6.11 showed all variables were non-stationary. However, from the visual check, LFIR could be a stationary variable (I[0]) while LSBT and LGDPR had unit root at the level variable. LSBT and LGDPR had unit root after taking first difference, which can remove non-stationarity. LSBT and LGDPR were therefore integrated of order 1 (I[1]). The variables were a mix of I(0) and I(1) and ARDL should be applied as the procedure was relevant irrespective of I(0) or I(1). F-statistics (Appendix B: Table F) were therefore used to identify the L-R relationship between variables (s5.6.5), shown below.

Table 6.12
SBT: Long Run Variable Relationships

Dependent Variable	F-statistic	I(0)	I(1)	Result
DLSBT	6.7591	3.793	4.855	Reject H_0
DLGDPR	5.0548	3.793	4.855	Reject H_0
DLFIR	1.0316	3.793	4.855	Reject H_0

Note: the critical value at 95% confident interval and k = 2

H_0: no long-run relationship

In this case, if the F-value fell between the critical values of I(0) and I(1), then H_0 was accepted; there was no L-R relationship between LSBT, LGDPR and LFIR, otherwise H_0 was rejected. With Table 6.12, all F-statistics were outside the critical value of I(0) and I(1); there were valid L-R relationships between LSBT, LGDPR and LFIR. The variables LGDPR and LFIR were the L-R forcing variables that explained the change in LSBT. The estimated model of LR coefficients using the ARDL is

$$\begin{aligned} DLSBT_t = {} & 1.2293\, DLSBT_{t-1} - 0.52659\, DLSBT_{t-2} - 1.0207\, DLGDPR_t \\ & + 1.188\, DLGDPR_{t-3} + 0.27245\, DLFIR_t - 1.4074\, DLFIR_{t-2} \\ & + 1.2885\, DLFIR_{t-3} - 0.002558\, ECM_{t-1} \end{aligned} \quad (6.27)$$

(Adj. R^2 = 0.95932)

All estimated coefficients of the specified model were significant, with p-values less than 0.05 (Appendix E: OLS Results). The model's explanatory power is validated at 96 per cent. Equation 6.27 states that the change in lagged log of specific business tax at the first quarter ($DLSBT_{t-1}$), the change in lagged log of real GDP at the third quarter ($DLGDPR_{t-3}$), the change in log of financial institutions' revenue and its lag at the third quarter ($DLFIR_t$ and $DLFIR_{t-3}$, respectively) had a positive effect on the change in log of SBT ($DLSBT_t$), as expected. An increase in SBT in the last period was likely to be followed by an increase in this period. Further, an increase in real GDP in the past, confirming increased productivity, should be reflected in SBT. Lastly, change in the financial institutions' revenue, past and present, led to increased business activity and thus greater SBT.

A L-R equilibrium was validated in the ECM for the variables in the equation. Short-run SBT elasticities with respect to lagged SBT at the first and second quarters, real GDP and lagged real GDP at the third quarter, financial institution's revenue and lagged financial institution's revenue at the second and third quarters were 1.2293, -0.52659, -1.0207, 1.188, 0.27245, -1.4074, and 1.2885 respectively. The estimated coefficient of the error correction, -0.002558, confirmed that the previous period's disequilibrium was adjusted by 0.26 per cent each quarter.

6.1.5 Estimation Foreign Borrowing

Foreign debt acquisition is difficult to model, as it is determined by a range of factors: budgetary requirements, infrastructure expenditure, and domestic and global economic environments (s5.4.5). Data was therefore taken direct from the Bank of Thailand (2008b). Debt service prediction is difficult due to fluctuating interest rates and principal repayments; however, regulations limit annual debt service to 9 per cent of predicted export value

$$FDS_t \leq 0.09 * EEX_t \quad (5.40)$$

The regulatory annual foreign debt acquisition is capped at $US1 billion. For consistency with this study's periodicity, each quarter's borrowings were assumed equal at one quarter of the cap, $US250 million.

$$FB_t \leq 250 \; million \;\; \$US \quad (6.28)$$

where FB_t is foreign borrowing at time *t*.

6.1.6 Estimation Debt Management

Actual data in lieu of modelling was used to predict domestic borrowings for reasons discussed in s6.1.8 (Bank of Thailand 2008). Annual debt is capped at 20 per cent of budgetary expenditure, or 80 per cent of the approved budgeting on principal payments, whichever limit is first reached (s5.4.5)

$$DB_t + FB_t \leq 0.2BUD_t \quad (5.42)$$

$$DB_t + FB_t \leq 0.8PRINC_t \quad (5.43)$$

Further restrictions on Thailand's debt financing were that public debt must be 50 per cent or less of GDP, and annual debt service must be 15 per cent or less of budget. However, public debt/GDP is an annual function and public debt in this study is a stock variable, thus the function is not applicable. Further, debt service to annual budget restriction was not applicable, as interest rates and repayment schedules were not consistent. The appropriate restriction for this study is equation 5.42, where debt is 20 per cent or less of budget.

6.2 Public Infrastructure: Factor of Production

In this study, a modified production function was applied to explore the impact of public infrastructure on output growth in Thailand (s5.3.2, Nazmi & Ramirez 1997)

$$Y = A\ f\left(L, K_p, K_g\right) \qquad (5.44)$$

However, as appropriate data were not available, a dynamic production function uses percentage growth rates of model variables to modify equation 5.44

$$y = \beta_0 + \beta_1 \frac{\Delta L}{L_{t-1}} + \beta_2 \frac{IP_t}{Y_{t-1}} + \beta_3 \frac{IG_t}{Y_{t-1}} \qquad (5.45)$$

Variables were transformed into real values to discount for inflation. Since this model used growth and ratio denominators, log values were not used

$$GY = f\ (GL, RIPR, RIGR) \qquad (6.29)$$

where GY is output growth $\left(GY_t = \frac{GDPR_t - GDPR_{t-1}}{GDPR_{t-1}} \right)$

GL is growth in labour $\left(GL_t = \frac{L_t - L_{t-1}}{L_{t-1}} \right)$

$RIPR$ is private investment to output $\left(RIPR_t = \frac{IPR_t}{GDPR_{t-1}} \right)$

$RIGR$ is public investment to output $\left(RIGR_t = \frac{IGR_t}{GDPR_{t-1}} \right)$.

In this estimation of GY function, all variables were smoothed to maximise trend. Non-stationarity was established and results were that GY and GL had no trend while RIPR and RIGR were not identified for trend (Appendix A: Plot of Variables). An anomaly in GY occurred with a sharp fall in Q1, 1998 and a dummy variable (D) was introduced where 1998:Q1 was D=1, while other quarters were D=0. DF/ADF unit root was applied and Table 6.13 (see Appendix C: Unit Root Test).

Table 6.13
Public Infrastructure: Unit Root Test Results

Variables	**Level/First Difference**	**DF**		**ADF(4)**	
		Without Trend	**With Trend**	**Without Trend**	**With Trend**
GY	Level	-1.7645	-2.0942	-2.5053	-2.7525
	First Difference	-2.9351	-2.9384	-2.6094	-2.6699
GL	Level	-2.6561	-2.7813	-1.9528	-1.5190
	First Difference	-4.4852	-4.4436	-4.2633	-4.2681
RIPR	Level	-2.8285	-.72317	-2.1798	-1.2585
	First Difference	-1.0787	-1.3798	-1.9310	-2.1086
RIGR	Level	-.27854	-1.5490	-.63931	-2.1956
	First Difference	-2.6908	-2.6474	-2.1920	-2.1180

For level variables
95% critical values for ADF statistic (without trend) = -2.956
95% critical values for ADF statistic (with trend) = -3.5088

For first difference variables
95% critical values for ADF statistic (without trend) = -2.9271
95% critical values for ADF statistic (with trend) = -3.5112

Table 6.13 shows that all variables had unit root at the level variable; only GL was unit root free after taking first difference. First difference removed non-stationarity caused by trend, therefore all variables were I(1) (s5.7.1). ECM was applied using the JJ procedure for a valid LR relationship. The results showed that both maximum Eigen and trace values were equal or less than two cointegrating relationships (r <= 2) amongst variables *GY*, *GL*, *RIPR*, and *RIGR*. The estimates of LR cointegrating vectors are given in Appendix G: Long Run Cointegration Test. The L-R equilibrium relationship is

$$ECM = GY - 2.7758\,GL - 0.10442\,RIPR + 0.10662\,RIGR \qquad (6.30)$$

The ECM shows the dynamic behaviour of the GL, with L-R as the ER component and S-R as the difference variables relationship. Using Hendry’s general-to-specific modelling approach, the estimated was formed.

$$\begin{aligned} DGY_t = &-0.0018 + 0.33679\,DGY_{t-1} - 0.55905\,DGL_{t-3} \\ &+ 0.50852\,DRIPR_{t-1} - 0.44946\,DRIPR_{t-3} \\ &- 0.77197\,DRIGR_{t-2} + 0.5229\,DRIGR_{t-3} \\ &- 0.19712\,ECM_{t-1} - 0.0098173\,D \end{aligned} \qquad (6.31)$$

(Adj. R^2 = 0.85065)

All estimated coefficients of the specified model were significant, with p-values less than 0.05 (Appendix E: OLS Results). The model's explanatory power is validated at 85 per cent.

The change in lagged of real GDP growth at the first quarter (DGY_{t-1}), change in lagged real private investment ratio at the first quarter ($DRIPR_{t-1}$), and change in lagged real government investment ratio at the third quarter ($DRIGR_{t-3}$) had a positive effect on the change in real GDP growth (DGY_t), as expected. An increase in the real GDP from the last period led to an increase in the current real GDP. An increase in real private investment as a function of output from the last period increased private capital, a factor of production, and led to an increase of output. An increase in lagged real public investment as a proportion of output at the third quarter contributed to public capital, facilitated private production and an increase in output. The lagged result also inferred that public investment, an indirect input to private production, reacted later to events than private investment.

The ECM validated a L-R equilibrium among the variables in equation 6.41. The dummy variable (D) confirmed that for Q1, 1998 the change in real GDP growth was lowest. There was an unexpected negative sign for the change in lagged labour growth at the third quarter (DGL_{t-3}), the change in lagged real private investment equation at the third quarter ($DRIPR_{t-3}$), and change in lagged real government investment equation at the second quarter ($DRIGR_{t-2}$).

The negative result for lagged labour growth at the third quarter (DGL_{t-3}) is similar to those from earlier studies (e.g. Khan & Reinhart 1990). The researchers in the citation used population data as a proxy for labour, a factor for error in the variables. In this study, registered labour was used as a proxy for labour; however, there are many unregistered people in the labour force. Registered labour input may not represent an economically active population in this study, and this could lead to the negative result.

Volatility of the data set may account for the negative result for the change in lagged real private investment at the third quarter ($DRIPR_{t-3}$). During the Asian crisis, the government invested to assist private industry, thus overall output growth was not affected to the same extent as real private investment, causing a negative result.

The negative change in lagged real government investment at the second quarter could be due to the crowding out effect (s2.2.3). An increase in public investment increases demand for resources (including production factors such as capital, labour, and finance). This may result in interest rates and labour cost increases, and loss of capital availability, and these factors raise the cost of private investment. In the sequence of events, an increase in the cost of private investment may result in reduction in the level of output (GDP) via a fall in private investment. Hence, an increase in public investment under high productivity conditions could result in negative impact on growth (Aromdee et al. 2005).

The above model, equation 6.31, showed that changes in productivity growth, the S-R real output growth elasticities with respect to lagged real output growth at the first quarter, lagged elasticity of output with respect to labour at the third quarter, lagged marginal productivity of private capital at first and third quarters, and lagged marginal productivity of public capital at the second and third quarters were -0.0018, 0.33679, -0.55905, 0.50852, -0.44946, -0.77197 and 0.5229 respectively. The estimated coefficient of the error correction term was -0.19712, therefore the previous period's disequilibrium was corrected by 19.7 per cent each quarter. The coefficient of the dummy variable was -0.0098, so that in the first quarter of 1998, the change in output growth was 0.98 per cent less than other quarters.

6.3 Model Estimation Results

The supply side model used for this research consists of two parts: the first is revenue generation for investment, and the second is national production (s.5.3). The objective of this structure is to ensure that infrastructure expenditure remains within the fiscal sustainability framework.

The objective of modelling the public revenue generation is to provide an estimation of the funding which could be available for infrastructure investment. Diverse sources of tax and non-tax funds are calculated from identity or estimation equations and these are fully explored in s5.4. Both types of equations are then combined to build the model to estimate the public funding at various times available for the government to invest on infrastructure.

By fully identifying all sources of current revenue available to the Thai government, this model can deliver a more accurate estimate of public revenue than the previous models , which were confined to direct and indirect tax sources (for instance, Tinakorn & Sussangkarn 2001). This study followed the Economic Development Consulting Team's public revenue modelling structure for the Thai Bureau of the Budget (2006), but diverged from the original model to correct for non-stationarity. Therefore, the functional form of this model differs from models that are superficially similar as it has greater reliability. Despite a high variability of quarterly data streams, the overall result of model estimation showed that the explanatory power of the models is within all acceptable limits. The diagnostic statistics (Appendix F: Diagnostic Tests) uniformly showed test results greater than 0.05, confirming that the model all model estimation was free from estimation issues such as serial correlation and heteroscedasticity.

In the second part, the aggregate production function estimates the impact of public infrastructure on economic growth by the inclusion of public capital stock as a factor of production. The linkage between the public finance model and the aggregate production function model is made via the public investment.

Due to a limited availability of consistent public capital stock quarterly time series data for Thailand, the example of Nazmi and Ramirez (1997) was used through application of a dynamic production function that uses percentage growth rates of model variables. The estimation result of public infrastructure as a factor of production is statistically satisfactory with the model's explanatory power of 85 per cent.

The result of this estimation is different from the results of Hulten and Schweb (1991b), Tatom (1993), Holtz-Eakin and Schwartz (1995a), Garcia-Mila et al. (1996), and Ratwongwirun (2000). The studies show little or no influence of infrastructure investment on output growth. However, this estimation shows the important variables in relation to the aggregate production function estimation are that there are both negative and positive outcomes, detected from the change in lagged real government investment at the second and third quarters. If the outcome is positive, then public investment, as a proxy of public infrastructure, has a positive impact on the growth in real GDP. However, when the economy is growing strongly, there may be a short-term negative response from the private sector through a crowding-out effect as the public infrastructure absorbs significant capital resources; the longer term effect at this point of the cycle is that the private sector generates further resources and utilises the new infrastructure to drive growth. With a positive result, an increase in lagged real public investment as a proportion of output at the third quarter contributes to public capital, facilitates private production, and an increase in output. The lagged result also inferred that public investment, an indirect input to private production, reacted later to events than private investment.

If there is a negative result to the production function estimation, then further investment has a reverse effect on the growth in real GDP in both the short and long term. In other words, the greater the amount of public investment, the greater is the effect on economic growth. Timing is paramount for government expenditure. For example, when the economy is at full capacity, large public investment can cause a crowding-out effect that stultifies the economy, as ill-timed public investment can absorb resources past the country's capacity, and GDP falls (Aromdee et al. 2005). Thus, the timing of appropriate infrastructure investment by policymakers during a recession can have the effect of tapping private sector sentiment and driving growth through a crowding-in effect; alternatively, if private investment sentiment is cautious, then public infrastructure investment will have too little effect on perhaps a drawn-out recession. The investment will, however, be available as physical public capital when required, so there is no long term loss.

6.4 Aggregate Production Function

Because the aggregate production function is a crucial part of the model estimation and serves to answer the research question, it is necessary to test the accuracy of the estimated function before combining public revenue generation and the aggregate production function. To illustrate the performance of the estimated aggregate production function, the value of real GDP growth is estimated using the actual value of variables in equation 6.31 in comparison with the actual real GDP growth. This is presented in Figure 6.1: Real GDP Growth, Estimated and Actual:1994-Q3 to 2006-Q2.

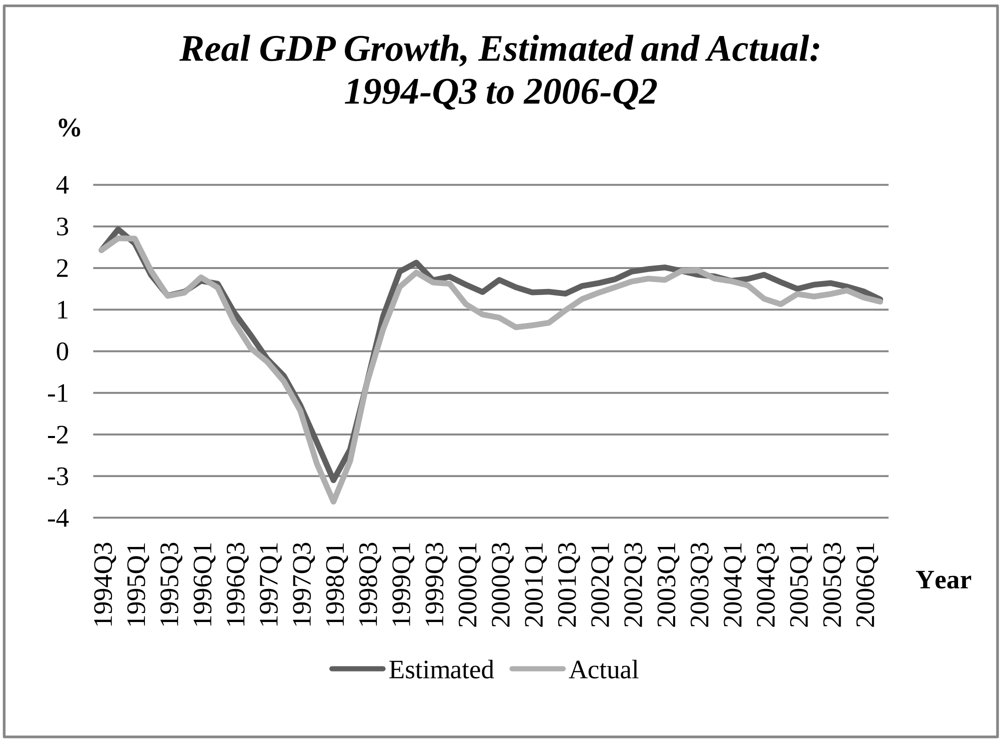

Figure 6.1 *Real GDP Growth, Estimated and Actual:1994-Q3 to 2006-Q2*

Figure 6.1 compares estimated and actual real GDP growth from the third quarter of 1994 to the second quarter of 2006; the estimated model value closely tracks actual value. Real GDP was between 1 and 2 per cent except for the Asian economic crisis, from the fourth quarter 1996 to the third quarter 1998, when Thailand incurred negative growth. The estimation correctly follows this path which indicates that the estimated model can be used as a mean for the actual value prediction.

Further, the estimated real GDP growth was converted into estimated real GDP for comparison with actual real GDP. The comparison diagram is presented in Figure 6.2 Real GDP Estimated and Actual: 1994-Q2 to 2006-Q2.

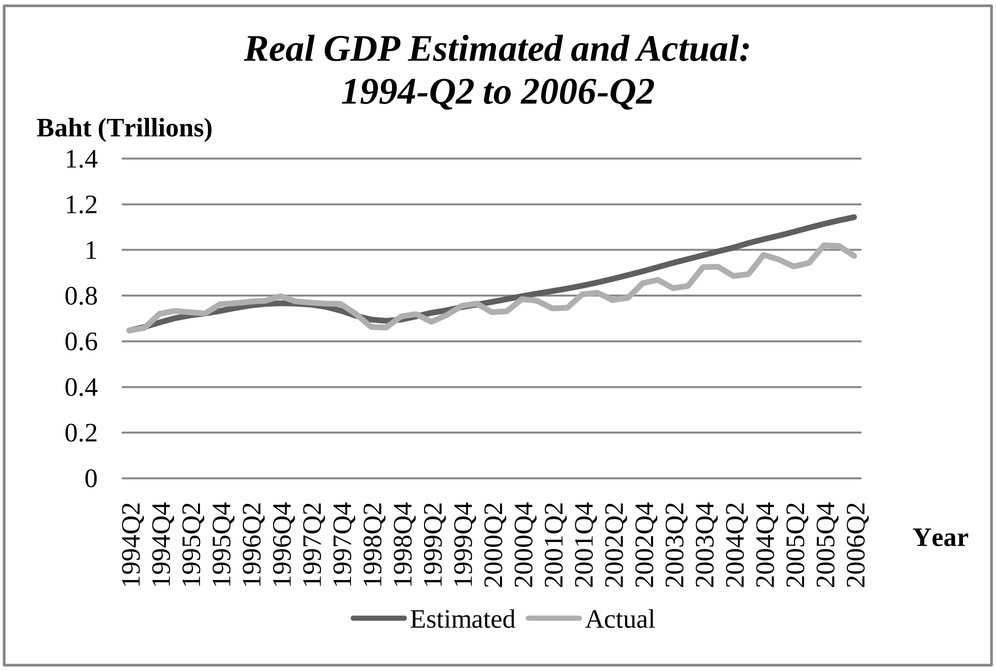

Figure 6.2 *Real GDP Estimated and Actual: 1994-Q2 to 2006-Q2*

Figure 6.2 compares estimated real GDP and actual real GDP from the second quarter 1994 to the second quarter 2006, with good results for the estimation. Real GDP each quarter was between 600 and 800 billion (0.6 and 0.8 trillion) baht between 1994 and 2000, recording a fall within those limits during the economic crisis. GDP trended up after that period. There is a visual disconnect between the estimated and actual GDP from 2001Q1 onward, which could be a result of variability in the quarterly data set. There is an annual cycle visually detected on the actual real GDP from 1994 Q2 to 2006 Q2. The reason is that agricultural products are harvested and sold largely during the fourth quarter of each year. Moreover, manufacturing is stocktaking during the fourth and first quarters of each year. Thus the actual real GDP peaks during the fourth and first quarters of each year. However, the trend lines for both estimated and actual GDP are within statistical probabilities (refer to equation 6.31 s6.2, adjusted R^2 is 0.85065). Hence, the estimated model can explain 85 per cent of variation in the actual real GDP.

6.5 Infrastructure Finance Model for Emerging Economies

Simulations develop scenarios by setting parameters for exogenous variables in a system. The model generated for this study is a recursive simultaneous system and scenarios were developed by working through the generated model (s5.9). Given the objective of the study, public debt, both domestic and foreign borrowings were treated as variables and relevant parameters set. Simulation was carried out as ex ante and ex post scenarios.

Thailand's annual debt restriction at a maximum of 20 per cent of budget permits five borrowing parameters: 20 per cent, 15 per cent, 10 per cent, 5 per cent and zero. Foreign borrowing is restricted to $US250m per quarter; if this amount is exceeded the reminder is allocated to domestic debt of the same quarter.

The estimated financing of public investment scenarios corresponding to government debt parameters were entered as government investment into the estimate production function, to generate real GDP value. Then the estimated real GDP of the current period was entered in the financing public investment equations to estimate the financing for the next period. This sequential estimation followed during both ex ante and ex post simulations.

6.5.1 Ex ante Scenario Simulation

Due to smoothing of variables and taking first difference, the number of observation periods was reduced and the simulation for ex ante scenario was taken from 1994-Q2 to 2006-Q2. Each scenario was conducted separately to obtain the real GDP growth during the observed period. The estimated real GDP growth was then converted into real GDP value. The time paths of the simulated GDP for each scenario were compiled for comparison purposes. Figure 6.3 shows the time paths of real GDP for the five scenarios.

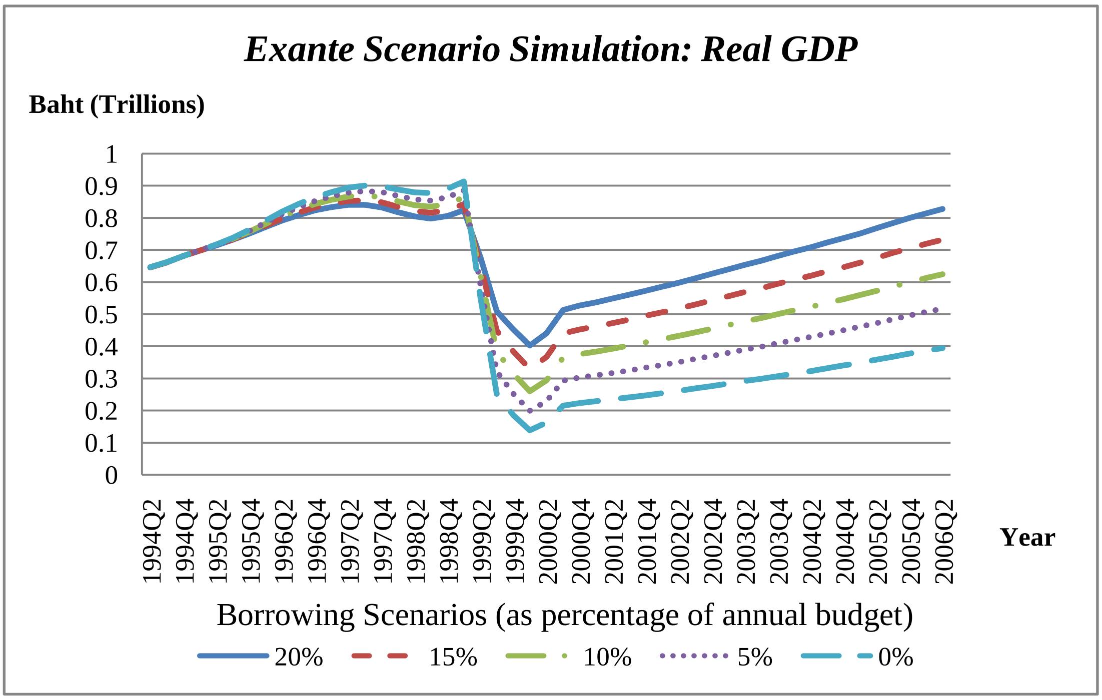

Figure 6.3 *Ex ante Scenario Simulation: Real GDP*

The exante scenario involves the generation of a time-path within the time period used during the analysis to establish consistency in the model. The simulation consists of five scenarios: maximum borrowing (20% of budget), 15 per cent of budget, 10 per cent of budget, 5 per cent of budget, and no borrowing (0). At this stage of the methodology, the model, close to the study's culmination, is termed Infrastructure Finance Model for Emerging Economies (IFMEE). Figure 6.3 shows that in the earlier part of the simulation, 1994-Q2 to 1998-Q4, the time paths of the five scenarios share similar data, with the exception of the government debt variable. Hence, real GDP, government budget, government investment are tracking closely during these iterations which in turn lead to a smaller influence on the next period of real GDP.

There was a distinct fall from 1999 to the first quarter in 2000 in the IFMEE, the aftermath of the economic crisis. The actual crisis occurred in 1997-Q3 but government intervention delayed the full impact of the crisis until 1998 to late 1999, when international investment was withdrawn and the country was in recession. Therefore, the crisis impact period of the scenarios are consistent with the actual experience of the country; however, the scenarios present a greater variation than the actual GDP experience (down to 0.15 trillion baht in the Figure 6.3 simulation, against 0.65 trillion baht in Figure 6.2). The explanation for this anomaly is, as noted, that the Thai government invested heavily in economic stimulation packages to revitalise the economy as soon as possible. As a result, the Figure 6.3 simulation shows the extent that the country may have been in recession, and for a longer period, if there had been no attempts for economic intervention. It should be also noted that the model's iteration process magnifies extreme events.

In the last observed period of IFMEE, 2000-Q2 to 2006-Q2, the economy recovered from the crisis and the increase in real GDP steadied as the model starts accumulating growth in real GDP through government investment. IFMEE clearly show the direct relationship between increases in government investment and rising GDP. Higher real GDP then leads to higher tax and non-tax revenues, resulting in an expanded government budget which in turn allows the government under its fiscal restraint framework to generate more public debt. Government investment thus increases and follows a similar cycle. As a result, the maximum borrowing scenario of 20 per cent has the highest real GDP. It is noted that from the second quarter in 2000, after a rebound from the extreme event, there is a smoothing of growth which is maintained through all five scenarios, including zero infrastructure expenditure. However, the IFMEE is consistent: greater borrowing leads to higher government investment and results in higher real GDP over time.

6.5.2 Ex post Simulation

In the ex post simulation, each of the five scenarios was developed beyond the observation period of 1994-Q2 to 2006-Q2. In this study, simulation projection was extended from 2006-Q2 to 2008-Q4. As the model constructs were based on trend, variables were specified by regressing the time trend. The estimate function is

$$Y = f(T) \qquad (6.32)$$

where Y is an exogenous variable and

T is a time trend variable.

The variables in the ex ante simulation at s6.5.1 were again the basis for Figure 6.4 below.

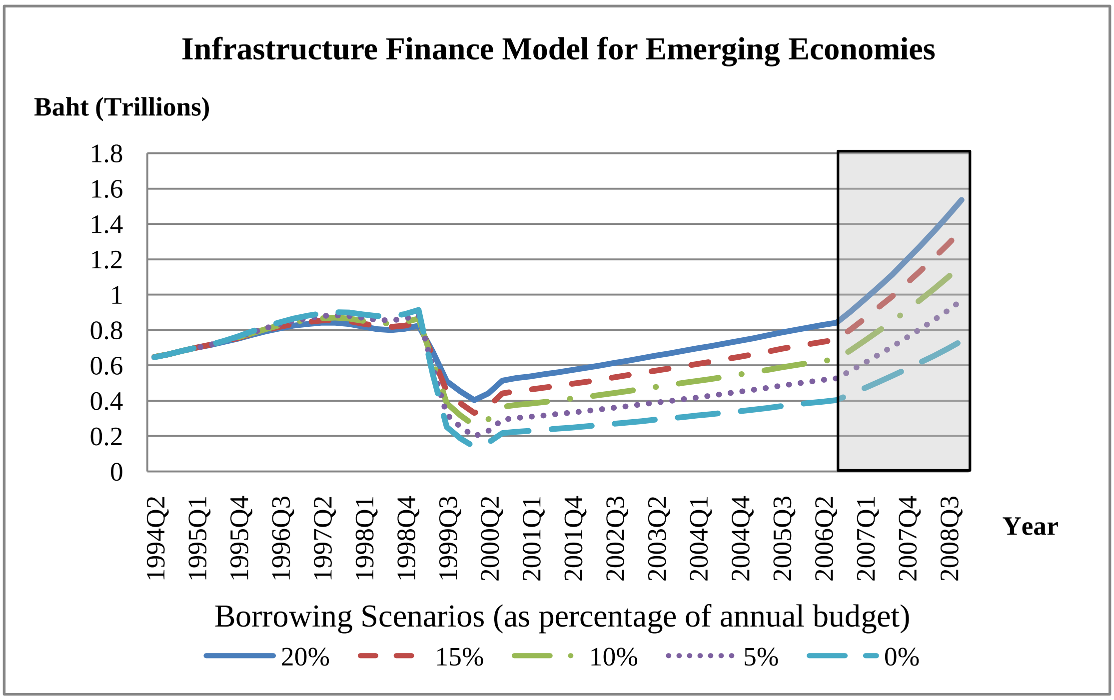

Figure 6.4 *Infrastructure Finance Model for Emerging Economies*

Figure 6.4 shows the comparison of the five scenarios of ex post simulation, the highlighted area from the third quarter of 2006 to the fourth quarter of 2008. After the ex ante period ended in 2006-Q2, the ex post simulation shows a noticeable increase in real GDP for all scenarios, with a steeper upward trend. This change in trend toward greater productivity is assumed to emanate from the acceleration of variables such as the consumer price index (CPI), private investment price index (IPPI) and import goods price index (IMGPI). The first scenario for IFMEE, maximum borrowing of 20 per cent of budget, displays the fastest rate of growth from the higher rates attributed to its inputs, and the remaining scenarios evince slightly lower trends relative to the amount of borrowing and thus the lower rates of inputs.

Government debt is therefore a function of real GDP, although a real growth trend remains, despite zero government borrowing and thus no infrastructure development. The simulation also shows consistency in the model, where 20 per cent borrowing gives the highest real GDP and zero shows the lowest real GDP.

As noted throughout, there is no predictable pattern to government borrowing; nevertheless, IFMEE provides economic modelling in finance management for policymakers. It can therefore be used by the Royal Thai Government to support their decision for financing public infrastructure investment through national or international debt. For growth, the means of generating public debt is of lesser issue than its application. Nevertheless, there are inherent barriers to increasing debt; through the national economic cycle and through extraordinary global events. Further, whilst it has considerable priority in governments' decision-making, GDP growth is not the absolute answer. There are many other public responsibilities such as national health, education and security, which are not measures of GDP. The limitations of a government budget must incorporate the social nature of the current account as well as social and economic infrastructure.

6.6 Discussion

The research questions for this study are twofold: determine first the revenue that the Thai government can raise under its fiscal restraints for infrastructure investment; and use the results of this quantitative research to determine its effects on Thailand's economic growth.

This research, based on the modelling of Thailand's Bureau of the Budget, follows the production function methodology of Aschauer (1989) who found high output elasticities for public infrastructure capital. As noted in the opening chapter, Aschauer's work triggered a largely confirming debate on the relationship between public infrastructure and economic growth performance. However, few studies address the means employed to finance infrastructure and those that mention this aspect do so superficially. This study focuses on economic infrastructure investment, not social infrastructure, to provide a deeper understanding of its effects on the Thai economy and facilitate policymaking.

In this approach, finance is a function of investment, an indicator of economic growth and the investment is subject to the Thai government's fiscal sustainability framework. Thailand relies on taxation for approximately 90 per cent of its revenue, with further sources retained income and debt. However, this revenue is insufficient for the scale of infrastructure development that the government requires (MOF 2005). An endogenous growth model, a partial market, supply side model was selected, where the production function includes public finance infrastructure (chapter 3). This model both analyses the Thai government's capacity to raise finance for public infrastructure under fiscal constraints, and the effects of infrastructure investment on GDP.

6.6.1 Economic Functionality

Thailand's expenditure on infrastructure over the 30-year period of the data averaged some 4.5 per cent, peaking at nearly 9 per cent in 1997 before the Asian financial crisis took effect. Thailand's productivity prior to the crisis was high, reaching 13 per cent in 1988; however, GDP contracted to minus 8 per cent a decade later. Following recovery, GDP generally remained lower at around 4 per cent.

Initially, transport and energy were the government's priorities for infrastructure investment, with communication and social infrastructure secondary to nation-building. Infrastructure investment had varying effects on the country's business sectors. Agricultural productivity varied, benefiting from early water infrastructure to harness monsoonal rains and alleviate the dry season for farmers. Rail, road and port infrastructure, generally in the prosperous central Chao Phraya valley, supported agricultural development mid-century. From a high 17 per cent growth in the late 1980s, manufacturing declined over the decades as competition grew from other emerging economies. The Thai service sector grew at 7 per cent before the Asian crisis and recovered fairly well over the next few years.

Over the decades, Thailand invested in the necessities of water, power and transport to gain competitive advantage for world trade. The country's early competitiveness, where it could produce agriculture products and manufactured goods for export, was adversely impacted by the arrival of new competition from Vietnam; the BRIC countries, Brazil, Russia, India and particularly China. In the later years, Thai focused on its coastal areas of great natural beauty, and the country successfully turned to tourism for regional jobs in the service sector and for foreign revenue; however, this required high investment in transport, airports and roads; and power and social infrastructure.

A country of 65 million people, with improving infrastructure, free enterprise economy and active in seeking foreign investment, Thailand averaged 4 per cent annual real GDP growth after the immediate effects of the economic crisis. From 1997, however, economic growth fell sharply as government decisionmaking was impacted by persistent political crises that stalled infrastructure mega-projects, eroded investor and consumer confidence, and damaged the country's international image. Exports, largely untaxed, were the key economic driver as foreign investment and consumer demand stalled. Continued political uncertainty hampers infrastructure mega-projects such as an extended railway system, a bullet train, new major roads including Thailand's share of the Trans-Asia Highway, and Bangkok's new satellite city (a total of 1.5 trillion baht, following from Table 4.8 at s4.1.7). This situation is further demonstrated by the country's low international competitiveness rating (s4.2.2).

For emerging economies, necessary infrastructure investment at these levels were traditionally the domain of governments, using taxation and perhaps funding from international agencies, however inadequate for global competitiveness. Such economies experience shortage of capital, exacerbated by low incomes, little savings, and therefore low investment and difficulty in raising international finance (Merna & Njiru 2002). With current infrastructure funding from taxation, domestic and foreign debt, and retained income from public enterprises, the Thai government is considering other sources of funding such as public-private partnerships (PPP) and privatisation to support its infrastructure program. However, Figure 4.3 at s.4.3 shows that projects from 2006 to 2011 are primarily using debt finance (47%) and taxation (38%).

Issues of political and financial uncertainty, and low competitiveness exacerbated by the overpowering emergence of Chinese goods across Thailand's export sectors set the environment for this study. It is critical to Thailand's wellbeing that infrastructure investment continues with all resources that can be brought to bear. In this economic climate, this quantitative empirical study can provide a tool for Thailand's decision makers to allow a better understanding of the effect of expenditure on roads, airports, bullet trains, telecommunications (in a country of 52 million mobile phones) and power supplies. These points are discussed below.

6.6.2 Model Application

This chapter introduces and demonstrates the Infrastructure Funding Model for Emerging Economies (IFMEE). The supply side model is divided into two parts; revenue generation for investment (s.6.1) and national production generation (s.6.2). The objective in modelling public revenue generation is to answer the first research question *To what extent can the Thai government raise funds for infrastructure investment under its fiscal constraints?* This finding is then incorporated into the aggregate production function through government investment. The advantage of IFMEE is that it presents public revenue as specific types of taxes to provide accurate estimates of public revenue, which then lead to a precise estimate of aggregate production, or real GDP.

The overall result of model estimation showed that the explanatory power of the model in its manifestations is acceptable. Moreover, with regard to public revenue estimation, IFMEE corrects for non-stationarity in the data set, a factor which enhances reliability, which enhances the original study by the Economic Development Consulting Team (Bureau of the Budget 2006).

In the second part, the aggregate production function is constructed to answer the research question *What is the impact of public infrastructure investment on economic growth in Thailand*? This study estimates the effect of public infrastructure investment on GDP using a modified production function, following the model of Nazmi and Ramirez (1997, s5.4.5).

The estimation result of public infrastructure as a factor of production is statistically satisfactory with the model's explanatory power at 85 per cent. The results are that public infrastructure investment has a mixed effect on output growth. A positive impact is found in the lagged public investment in relation to output at the third quarter, consistent with the findings of Nazmi and Ramirez (1997). Importantly, the finding that infrastructure capital has positive significant effects on economic growth is also consistent with early studies (for instance, Aschauer 1989a, 1989b, 1989c; Easterly & Rebelo 1993; Munnell 1990; Otto & Voss 1994). Replicating these international findings over several decades is a strong confirmation of Aschauer's premise.

Public investment directly stimulates economic growth by increasing national income which in turn encourages private sector investment. Moreover, public investment, especially in infrastructure, creates a better environment for private investors with increased production efficiency and greater return on capital (Aromdee et al. 2005). When compared to private investment, public investment takes longer to have an effect on the economy. This is consistent with the idea that public investment does not directly affect production; however, it facilitates private production, and thus there is a time lag.

The negative impact that occurred at the second quarter, before the third quarter's positive impact, may be caused by the crowding-out effect, which paradoxically precedes a later crowding-in effect. In this situation, the private sector predicts tightening short term economic conditions and curtails resource expenditure until economic circumstances return to its favour; firms again begin buying into the country's resources and raising production. In this situation, public infrastructure investment thus shows a longer lead time to drive growth (Aromdee et al. 2005).

The public revenue generation model was combined with the aggregate production function model to generate public investment scenarios. Within the fiscal constraint framework, the model allows policy makers to simulate the effects on economic growth of different public investment funding components. With five scenarios from maximum borrowing of 20 per cent of budget to zero debt, the ex ante simulation shows that the time paths of the data set, with the exception of debt, converged from 1994-Q2 to 1998-Q4. Hence, the variables of real GDP, budget and public investment form contiguous pathways which display minor effects on the next period of real GDP.

The Asian economic crisis occurred in 1997-Q3, but its impact was delayed with onset from 1998 to late 1999. The simulation scenario shows a greater variability in terms of impact on real GDP than actually occurred; a limitation of the model is that critical events are magnified through iteration. By 2000-Q2 to 2006-Q2, the economy recovered from the crisis and the rate of increase in real GDP steadied, with the model reflecting the government's investments driving growth. Government debt is, as noted, a function of real GDP: greater rates of infrastructure investment lead to higher GDP; higher public income through an expanding economy gains more tax and allows for increased debt levels. This iteration continues until full capacity changes the stage of the economic cycle. As a result, the maximum borrowing scenario of 20 per cent has the highest real GDP.

The ex post simulation shows an increase in real GDP for all scenarios, with a steeper upward slope than the ex ante simulation forecasting a faster growth rate. The first scenario, maximum borrowing of 20 per cent of budget, displays the fastest growth and the remainder evince slightly lower trends relative to the amount of borrowing. Without borrowing, the real GDP can still grow, but at the lowest rate.

6.7 Conclusion.

This quantitative, empirical thesis seeks to offer policy makers an economic model to show the relationships between infrastructure investment and economic growth. The IFMEE is successful in its goal, with the limitation that the iterative process tends to magnify extreme events. A further limitation is that the pattern of infrastructure investment by the Thai government is unpredictable. Nevertheless, IFMEE is a new model expressly grounded in the literature (Aschauer 1989, Nazmi & Ramirez 1997, Aromdee et al. 2005) and on the Bureau of the Budget's model. It incorporates other sources of finance (non-tax) and model testing (stationarity) not previously adopted. IFMEE, with these limitations, offers a new level of accuracy for emerging economies.

This chapter completes the methodology with the estimation results for the equations relating to tax income and other public income available for investment. The supply side model estimation comprises public investment finance and the national production function. Tax collection is denoted through estimable equations, other sources are represented with identity equations. The production function estimates the effect of infrastructure investment on Thailand's GDP. The equations then formed the IFMEE to simulate debt-driven time-paths in ex ante and ex post scenarios. The ex post scenario generates time-path values beyond the analysis and thus provides an economic policy model. Finally, the function of the IFMEE using Thai economic is discussed, and the research questions answered.

The final chapter follows, fulfilling the requirements of the thesis with policy recommendations, acknowledging limitations of the model and suggesting further avenues for research.

Chapter 7 Policy Discussions, Recommendations and Conclusions

As an emerging economy, Thailand encountered mixed fortunes over the past two decades. In company with other mid-sized economies, Thailand modernised, spending heavily on social and capital infrastructure to join the rapidly globalising world economy. The government was successful, building the basics for industry and commerce, and choosing its strengths of a beautiful environment and its hard-working people to adopt resource development, tourism and finance. For this study's economic infrastructure focus, water management, then transport and power claimed priority for Thailand's challenged bureaucracy. The Asian economic crisis, which started in Thailand, was a considerable deterrent to industrial progress, as was political instability in various parts of the diverse nation, and issues with its northern neighbours over time.

Despite these challenges, Thailand prospers. Based largely on trade, it reflects the vicissitudes of the world economies; however, its overall direction is toward greater productivity. The country pays a high price for its emerging economy status, accessing external funding for infrastructure is difficult and the government relies on its internal revenues, largely taxation. However, care must be taken: high taxes are an economic deflator and infrastructure's funding requirements are significant proportions of a country's economy.

This observation, fundamental to the thesis, was emphasised by the 1997 Asian crisis and the current global economic crisis. Other issues are the globalisation of finance and accounting methodologies which to some extent formalise sovereign and capital debt. Further, international central bank cooperation under the advice from the World Bank and the IMF may have money market implications. Whilst of great interest, these matters were peripheral to this analysis and were noted in the text (s2.2.5).

The nature of infrastructure is a conundrum that was the genesis of this research: "What is the impact of public infrastructure investment on economic growth in Thailand?" For a country rich in natural resources and an industrious population the next question is posed: "To what extent can the Thai government raise funds for infrastructure investment under its fiscal constraints?" To answer the latter question first, this quantitative research consists of a model to investigate the maximum public infrastructure funding Thailand can generate under fiscal constraints on government debt, and the results of various levels of borrowing on economic growth. As a safeguard against excessive borrowing, Thailand's public debt is constrained by legislation. For the former question, the model simulates a range of funding scenarios that the government can access for infrastructure investment.

The literature on public finance is largely confined to tax and debt financing, although there is significant debate on the impact of public debt on GDP (Barro1990; Dalamagas 1995; Lin & Sosin 2001; Clements, Bhattacharya & Nguyen 2003). This research widens the debate by introducing other forms of public financing besides tax revenue: domestic and external debt sources and retained income from government enterprises.

A methodology that has to date limited attention by researchers was selected for this study. The recursive Standard Neoclassical Model (SNM) framework was applied to link financing for public infrastructure to economic growth. This is an expanded supply-side model comprising *production function* and *financing public investment,* and facilitating investigation of various types and levels of infrastructure finance. It specifically addresses Thailand's data constraints and improves reliability through stationarity.

This final chapter presents the summary of the thesis. There is an overview of the study, followed by the results of the research. Policy implications of this new approach to economic modelling are offered for consideration. Finally, research limitations and recommendations for future research are discussed and the thesis is finished.

7.1 Study Overview

This thesis comprises seven chapters, divided into three structured sections. The first section draws the parameters of the study through a literature review and, after the methodology, an explanation of the financial and infrastructure environments in Thailand. Next, the methodology for the study is discussed: the model selection, and its estimations and variables explained. Finally, the economic model's equations were adjusted for best fit to meet the circumstances found from the data sources, and the model was completed. Results of the economic modelling are produced as graphs to prove the model as best fit and the data extended for further quarters to assist policy decisions.

The literature review presented in chapter 2 discusses economic growth and identifies linkages between infrastructure investment and growth. As infrastructure requires a large amount of public funding and has a significant impact on the economy, sources of public financing and the effects of different types of public finance on economic growth are explored. Chapter 3 presents support for this research, which, in the literature, applies an endogenous growth format using either a single equation (supply-side) or market model. The single equation model incorporates production, cost and profit functions. Approaches considering finance sources for public infrastructure are discussed; however, the notion of public finance in this study is widened considerably. The recursive Standard Neoclassical Model (SNM) framework was selected to link public infrastructure finance to economic growth. In this model, public infrastructure finance availability in Thailand is determined by calculating

- optimum revenue from taxation without creating distortion within the economy,
- deficit financing from domestic and external sources without detriment to the country's fiscal sustainability, and
- retained income from state-owned enterprises (SOEs).

Chapter 4 discusses the history of Thailand economic and infrastructure development from the first National Economic and Social Development Plan in 1961 to the ninth plan in 2006. The focus for each plan within the prevailing economic conditions, domestic product growth and the development of public infrastructure are discussed. An analysis of Thailand's infrastructure investment, tax and non-tax (including retained income) revenue, and deficit financing from internal and external sources complete the chapter.

In the economic model constructed in chapter 5, a set of identity and behavioural equations are presented to model public revenue generation and the impact of public infrastructure on economic growth. The public revenue generation model in this study, termed Infrastructure Finance Model for Emerging Economies (IFMEE), follows and extends on the rationale of the 2006 model developed by the Economic Development Consulting Team, Bureau of the Budget. One extension of the Bureau's model for this research is that public debt is constrained by regulation. Estimated public infrastructure investment, a proportion of the estimated public revenue, and viewed as a factor of production, represents the production function. After establishing the model structure in Chapter 5, the results of model estimation and simulation are presented in Chapter 6. These results are summarised in the following section.

7.2 Study Results

This study estimates the impact of public infrastructure investment on economic growth using a production function model using Thailand's quarterly time series data, 1993-Q1 to 2006-Q4 (Nazmi & Ramirez 1997). The results indicate that public infrastructure investment has a mixed effect on domestic growth. A positive result is found in lagged public investment as a proportion of GDP at the third quarter, confirming that infrastructure capital has a positive significant effect on economic growth (Aschauer 1989a, 1989b, 1989c; Easterly & Rebelo 1993; Munnell 1990; Otto & Voss 1994; Nazmi and Ramirez (1997).

The findings from this research are that during periods of economic growth, investment through public infrastructure stimulates economic growth by increasing national income. It thus encourages further investment by increasing production efficiency and raising the return on capital (Aromdee et al. 2005). This relates to a crowding-in effect. An inference from the lagged result is that public investment takes longer to react than private investment, as public investment is an indirect element of the production process.

However, a negative impact is found in lagged real government investment at the second quarter. As public investment increases, the demand for resources also increases and, given full capacity for the economy, leads to resource price increases. Increases in the costs of private investment may result in a fall in private investment and thus cause a negative impact on GDP growth (crowding-out effect). Hence, an increase in public investment at the top of the economic cycle could result in negative impacts on growth (Aromdee et al. 2005).

In IFMEE, estimated public revenue as a proxy for public investment is entered into the production function; then estimated GDP is factored into the following period to generate the next public revenue estimation. This process generated simulation scenarios. The ex ante and ex post simulation results show consistency in the estimated model: the maximum annual debt levels of 20 per cent of budget give the highest real GDP, and minimum borrowing of zero, gives the lowest real GDP, although growth in fact continues. The result of the simulation is consistent, increased debt levels lead to increases in GDP.

7.3 IFMEE Explained

The Infrastructure Finance Model for Emerging Economies is not quite the esoteric econometric modelling that it appears. As with all modelling, it has its strengths and weaknesses; the latter included that its accuracy is subject to extreme events which seem to be occurring with greater frequency. Nonetheless, there is a cycle where economic growth leads to a point where stresses in the system, economic, political or natural events, lead to a rapid downturn into recession. No matter where a country lies on this economic cycle, or perhaps an economic wave due to constantly changing inputs from globalisation and technological change; governments must administer to their constituencies through current expenditure and build through capital expenditure. Despite its econometric modelling status, IFMEE can perhaps add more useful real-time information into this unpredictable environment than other more practical responses.

First, noting limitations of economic modelling, over some decades in Thailand IFMEE accurately shows that the private sector quickly (in months) reacts to increased public expenditure on infrastructure related to productivity: water, contamination, power, communications, airports, trains, bridges, ports, wharves, roads, highways and freeways. Such expenditure levels can reach the heights of new cities, where businesses have excellent new opportunities and new resources. However, firms react very differently to this stimulus depending on which part of the economic wave is manifest at the time, and this wave can subside into recession quickly. Because IFMEE reacts quickly as its data include quarterly taxes, findings are that during a period of economic growth, firms initially and temporarily reduce expenditure when infrastructure investment increases; but they quickly re-enter the market to take up the new 'factors of production' within a few months. The ports begin to operate, a section of freeway or a new runway is opened, new mobile phone technology comes online; and time and frustration effects are trimmed off firms' transaction or production costs. Similarly, sometime after that, the government gets a return on its capital investment – high productivity, more taxes, more debt and more infrastructure expenditure.

IFMEE reported mixed results. There are peaks and troughs to the economic wave, which is in constant motion, and rather like isolating a sub-atomic particle; no one knows where it is at a given point of time. IFMEE has perhaps the closest capacity (quarterly data) to find the top of the economic wave – it is the point when no further infrastructure expenditure results in private sector growth. It is, in fact, the reverse of the growth phase which given IFMEE its mixed results. Further resources, that is, capital, labour and inputs, are too expensive to generate profit, so that firms do not invest and growth falls. Government income therefore falls a few months later and reduces capital expenditure, which has a deleterious effect on growth[33].

This 'mixed' result has important consequences for current modelling in emerging economies. It appears that there is a cause-and-effect pattern of private sector perception of public investment which changes with management's view of the current economic conditions, whether to increase resources (capital, labour, inputs) or whether to pause from

[33] Keynes, J. M. 1936/2007 *The General Theory of Employment, Interest and Money*, Macmillan, London, UK

acquisition, or even divest resources. During a recession, or near the bottom of the economic wave, the prices of resources are reduced. Importantly, IFMEE shows that private investment does not occur because firms expect profit to be even lower.

Further, IFMEE was designed as an economic instrument which incorporates a number of 'what if' scenarios for input and output. Its input streams of internal revenues can be minimised, maximised or eliminated from a simulation; similarly, flexible debt can be differentiated to show actual baht outcomes within the regulated fiscal framework. As a policy instrument, IFMEE is summarised below.

7.4 Policy Implications

The Infrastructure Finance Model for Emerging Economies was designed to add to the body of knowledge and as a policy tool for the Royal Thai Government. It is a powerful model.

In the 1997 Asian crisis and in the global recession of 2008 – 2009, Keynesian economics are *de rigueur* for relief, for underpinning the financial system, consumer confidence, house prices, tourism, and regional support.

Of paramount importance in times of recession is the amount and types of revenue available to the government, this determines the extra debt that the government can tolerate. IFMEE has modelled 12 variable estimations for accuracy against the usual four to six in similar iterative models; its recency using quarterly data makes it an accurate predictor of public revenue for Thailand. The high number of variables permits the analysis of each revenue stream. To raise investment revenue, tax structures can be examined with the purpose of yielding further tax revenue with less impact on the majority of taxpayers. For example, the majority of excise tax revenue relies on the six products: petroleum and petroleum products, tobacco, distilled spirits, vehicles, and beverages. There may be a case for restructure of excise items that update other luxury items such as electronic games and new media entertainment which have higher volumes than 'luxury' items from previous years. Further, the quarterly nature of the data facilitates greater liquidity controls for infrastructure management.

Keynes states that capital funds should be spent on capital matters; for a country that requires immediate and substantial expenditure in a notoriously difficult and long term infrastructure sector. Nevertheless, given an accurate knowledge of finances, the Thai government is in a stronger position to make decisions and given that it can predict its revenue, it can estimate its ability to raise capital internally or from abroad.

The immediate crisis over, the enormous expenditures disrupt growth patterns, a noted limitation of IFMEE. Its iterations magnify extreme events, and its predictive powers for future infrastructure investment on baht terms are weakened. However, trend remains. The forward simulations at Figure 6.4 emerging from the destabilisation of the 1997 Asian crisis are evidence that the IFMEE can predict outcomes of public revenue (and infrastructure investment) on the quarterly data. Given a relatively orderly progression of the global economy toward growth from 2009, as a policy instrument IFMEE can provide accurate simulations of financial situations the government can expect. These simulations, run under differing variable revenue streams before final figures are received, can of course achieve statistical validity to predict those with the highest accuracy.

The reason for raising internal revenue is to determine the amount of debt available for infrastructure development. Given the availability of debt, the government can employ Keynesian principles by commencing or accelerating infrastructure expenditure. This raises the question of an optimum expenditure to improve growth without long-tern adverse effects through inflation caused by the economy overheating. The IFMEE provides a range of simulations that can be tailored, as noted, to enhance growth, noting the barriers of private sector sentiment and the effects on resource allocation. The government can use stimulus programs to address these issues, *as the model can predict the responses, in the short and medium term, from the private sector.*

At the time of the study, the results show that the Royal Thai Government can drive the economy forward through financing public infrastructure investment with a balanced budget fiscal regime (without borrowing). The first scenario for IFMEE, maximum borrowing of 20 per cent of budget, displays the fastest rate of growth from the higher rates attributed to its inputs, and the remaining scenarios evince slightly lower trends relative to the amount of borrowing and thus the lower rates of inputs. However, the rate of growth will be lower than in the case of undertaking debt. The promise of higher growth through debt shows that each infrastructure investment should be carefully assessed to determine its effects on the economy. Priority should be given to those public infrastructure investment projects that have a high return.

The nature of government borrowing can be unpredictable and difficult to model, as it is predicated on many factors and diverse environments; nevertheless, IFMEE provides economic modelling in finance management for policymakers. It can therefore be used by the Royal Thai Government to support their decision for financing public infrastructure investment through national or international debt. For growth, the means of generating public debt is of lesser issue than its application. The economic modelling provided in this study has outcome values that should be used in economic planning. The model's simulation result, optimal infrastructure investment accessed through public debt and correlated to GDP, is a useful economic model for policy decisions. Although this study did not investigate accumulation of public debt and its effect on the Thai economy per se, fiscal constraints are in place to permit debt at the levels envisaged in the modelling. The greater the investment, the higher is the aggregate output growth obtained but the government must maintain vigilance regarding rising debt. These factors, including the validity of the model in predicting future GDP at different levels of infrastructure investment, will assist the Thai government in its infrastructure investment planning.

7.5 Research Limitations

There are limitations on this research inherent in all quantitative studies. The use of modelling restricts inputs and the selection of model inevitably shapes outputs. It is noted throughout that quantitative researchers use a variety of models; this study used a model which was considered capable of generating simulations from Thailand's economic data. These are data anticipated to become available over the medium term, whereupon the Infrastructure Finance Model for Emerging Economies can be revisited to test its predictors. For example, an adequate annual time-series data set was not available; as a developing country, economic data are available only from 1993 onward. The annual time-series set used in other studies was not appropriate due to the limited number of Thai observations, and this research employs quarterly time-series data. The quarterly nature of the data, together with the impact of the 1997 crisis, caused noticeable volatility which was removed in many of the variables before they could be used in estimating.

The simulation in this study is carried out only using alternative borrowing limits. It would be preferable if the simulation was also based on probabilistic variations in the equation within the system, such as taxation and retained income. However, this cannot occur due to data limitations and the unpredictable decision making of tax policy.

The effects of improved infrastructure may be of a very long-term character. However, the impact of public infrastructure investment is short term and trailing for the medium term. The role and the intention of the Infrastructure Finance Model for Emerging Economies is to track these effects. For the long term impact an extended annual time series data is required, although not yet available in Thailand. This is particularly noted at s5.4.6 as part of the model's explanation. Extended data will also open up further research possibilities, noted at s7.6.

The irregular nature of the data set had unexpected results for some estimated equation. Due to high variability, several tax data sets were not used in the estimation model: annual personal income tax (PIT3A), half-yearly corporate income tax (CIT1H), import duties (IMDUTI), and excise tax (EXCISET). Therefore another estimation process, Effective Tax Rate, was used for these inputs.

As a quantitative study, this research focused on conventional public financing: budget, domestic borrowing, foreign borrowing, and retained income from state owned enterprises. However, there are newer sources of investment funding, such as public-private partnerships, securitisation and multi-government bonds. These techniques, being fairly new compared to conventional financing, thus have limited statistical data. Also, these new funds sources are not yet a significant part of Thailand's public infrastructure investment. They were omitted from this study for those reasons.

7.6 Recommendations for Further Research

It is clear that the quarterly data used in this study created an issue with variability of the data set, which could be the cause of unexpected results in selected estimated coefficients. In the future, data collection in Thailand will be able to support annual time-series. It would be interesting to pursue a similar study using annual time-series data instead of quarterly data.

Moreover, this thesis focused on Thailand as representative of developing economies. Further work could apply the methodologies developed for this study to a range of other developing countries' economic data to test the results and analysis presented in this thesis. However, the estimation equations should be constructed to fit the specific public finance structure in each country.

Further studies using different conditions for public finance, for example, tax rates or retained public income could add significant insight on the effects of economic growth through public infrastructure investment.

This model did not differentiate the impact between each government investment since we use real government investment as one variable. The impact of public investment on irrigation is the same as investment on mass transportation. This model only concerns the magnitude of public investment. Therefore, further research could differentiate the impact between each type of public investment.

Last but not least, the relationship between public and private investment in Thailand is yet to be proved. It can be argued that private investment is an endogenous variable to output growth. Moreover, from the review of the literature, public investment can *crowd in* private investment. Therefore, further research is necessary to prove the estimation of private investment captures the relationship between output growth and public investment.

7.7 Final

And thus the end to this study. It is a quantitative analysis which draws conclusions and recommendations from the data. It is a comprehensive analysis of Thailand's economic experiences and its ability to profit from its investments in its resources. The exhaustive research defines the nature of funding for public infrastructure to support economic growth, and determines the benefits from further access to debt.

"What is the impact of public infrastructure investment on economic growth in Thailand?" This question is resolved in the affirmative. There is a positive correlated effect from infrastructure investment on growth.

"To what extent can the Thai government raise funds for infrastructure investment under its fiscal constraints?" The government can raise funds from diverse sources. This study determined that debt financing is appropriate for Thailand, at the maximum of 20 per cent of budget. Greater expenditure on infrastructure encourages growth which in turn expands the budget, thus past debt financing is readily serviced

The data issues encountered during this study, such as incomplete datasets and volatility, stem from the fact that the country opened to the world economy just a few decades ago, and its growth in a volatile region is commendable.

As a thesis, this work is the pinnacle of this writer's academic achievements; it also holds the promise of providing an economic model for a maturing economy that could set the pace for other countries in today's volatile world economy.

I offer this work to my supervisors and my examiners, with respect and regard.

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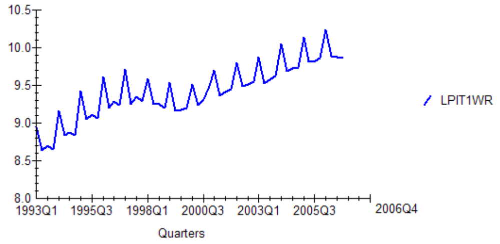
Appendix A: Plot of Variables

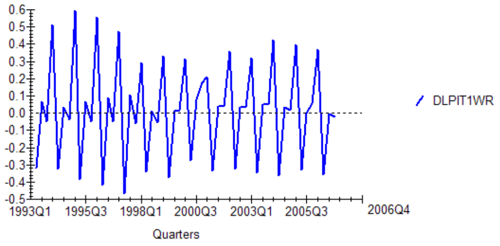
A	Level variable
B	Centre Moving Average of level variable
C	First difference of level variable
D	Centre Moving Average of first difference variable

1. PIT1W

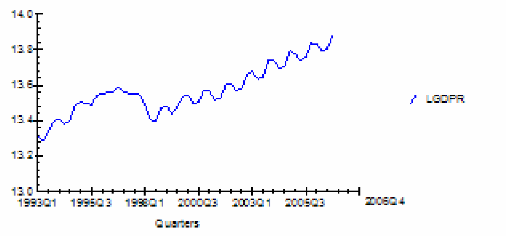
A. LPIT1WR



C. DLPIT1WR



A. LGDPR



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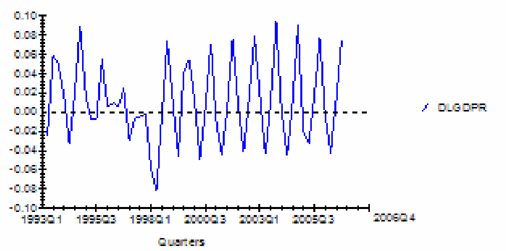
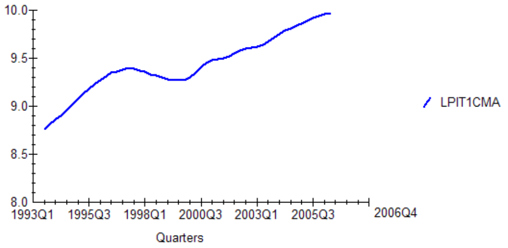
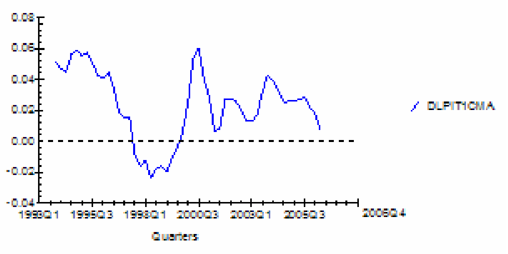


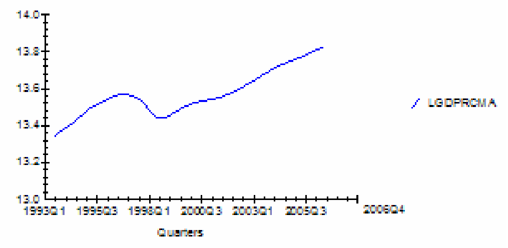
B. LPIT1CMA



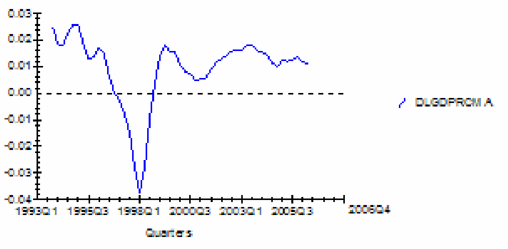
D. DLPIT1CMA



B. LGDPRCMA

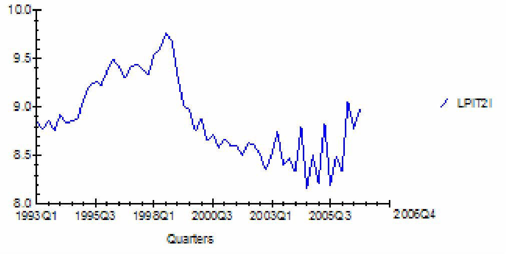


D. DLGDPRCMA



2. PIT2I

A. LPIT2I



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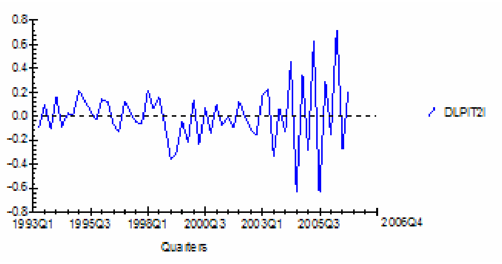

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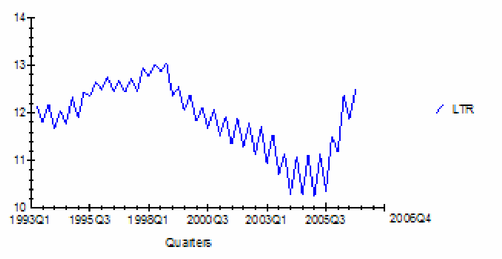
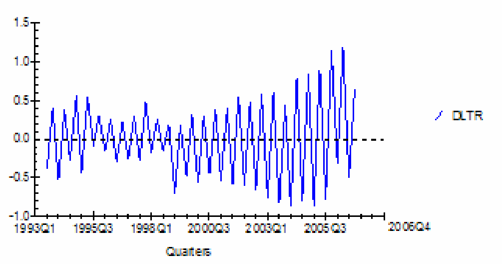
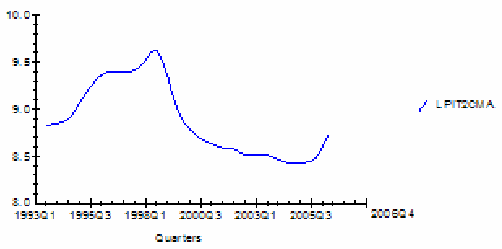


C. DLTR



B. LPIT2CMA



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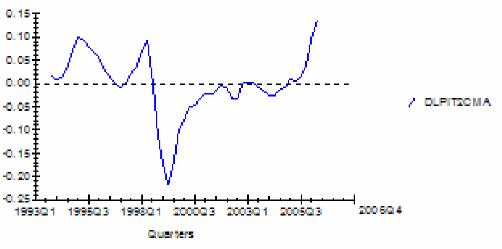

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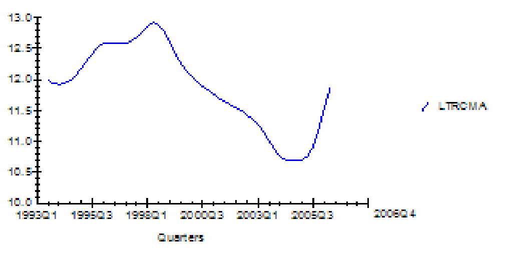

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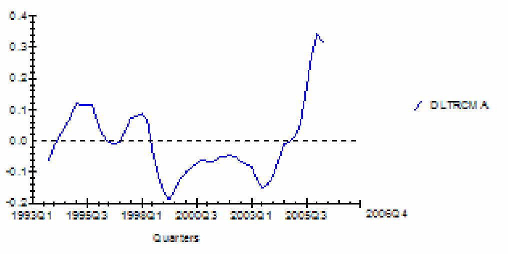
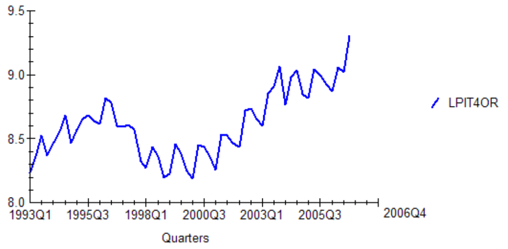
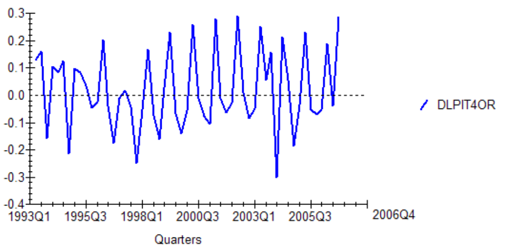


3. PIT4O

A. LPIT4OR



C. DLPIT4OR



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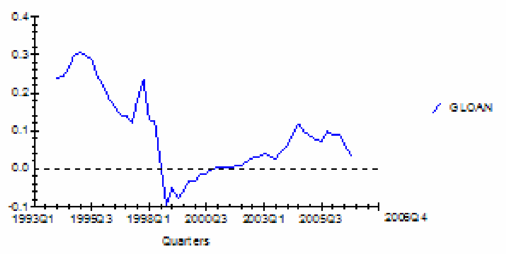

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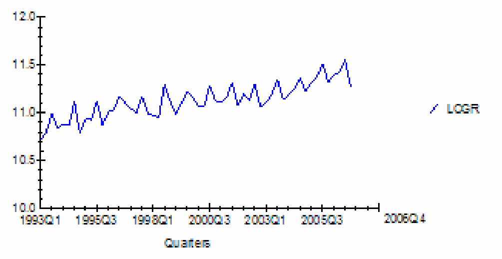
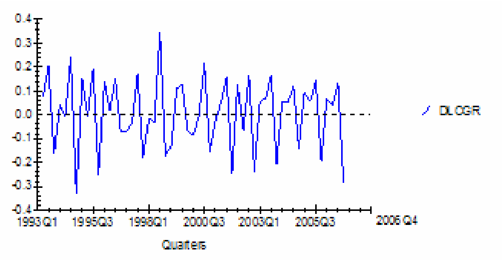
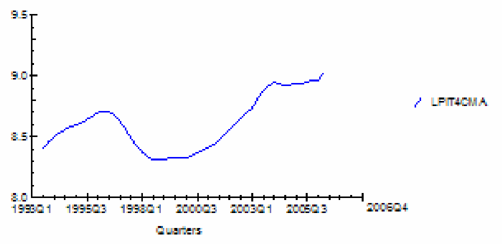


C. DLCGR



B. LPIT4CMA



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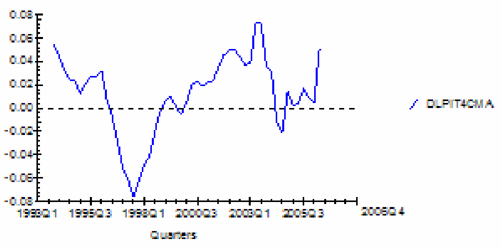
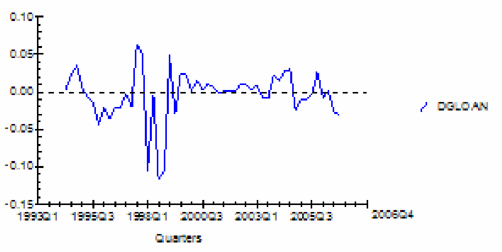


C. DGLOAN



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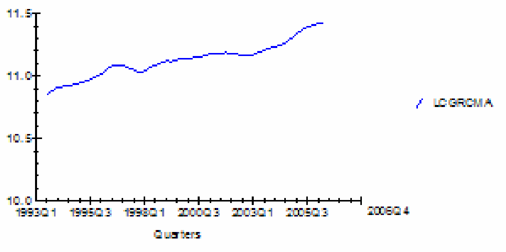

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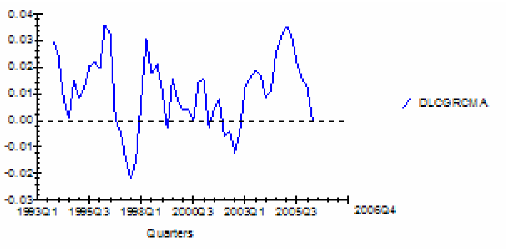
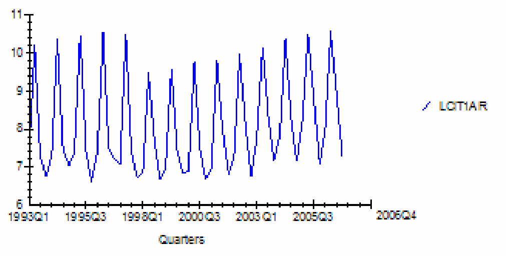


4. CIT1A

A. LCIT1AR



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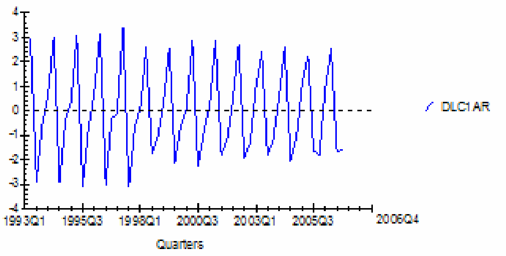

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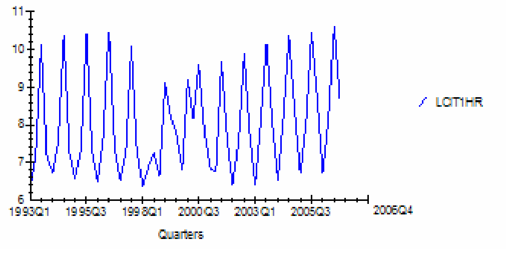

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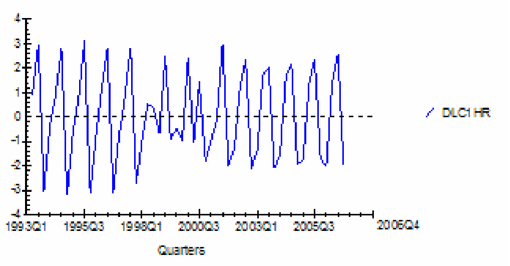

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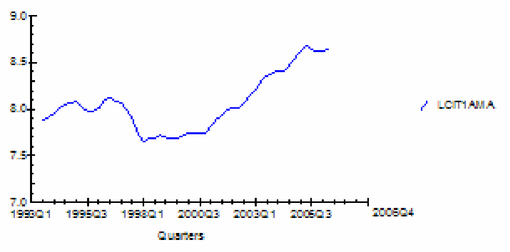

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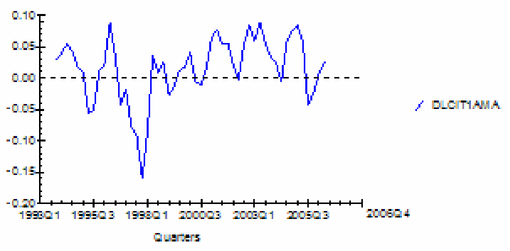

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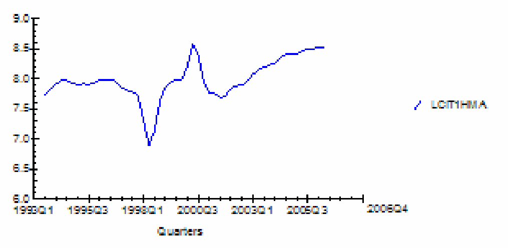

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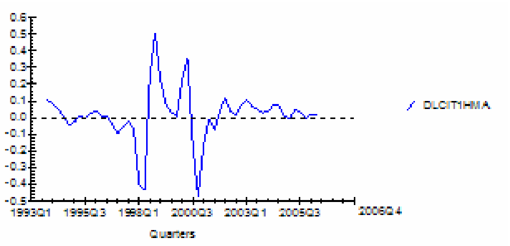
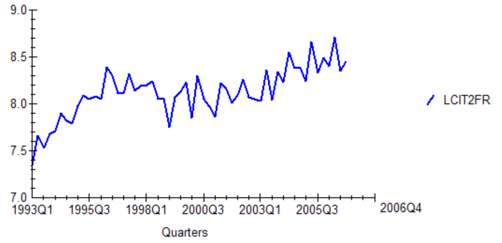


5. CIT2F

A. LCIT2FR



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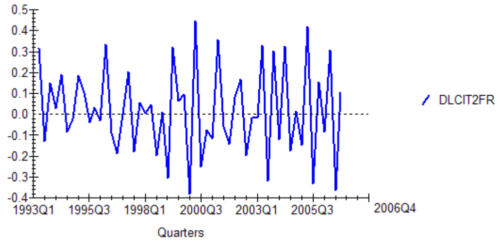

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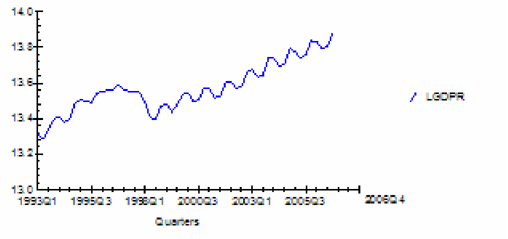
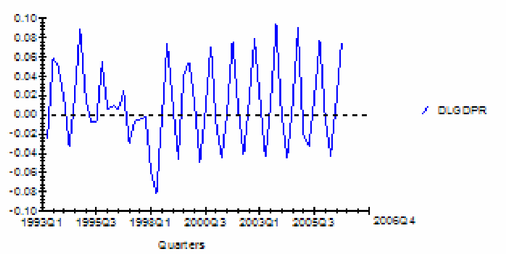
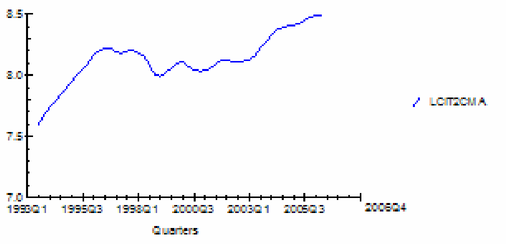


C. DLGDPR



B. LCIT2CMA



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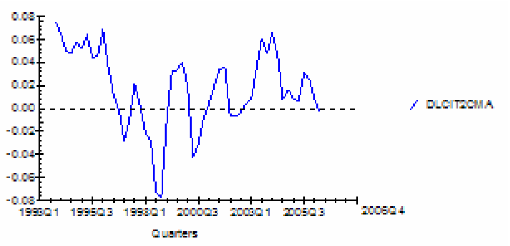

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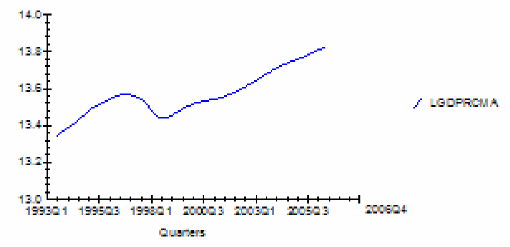

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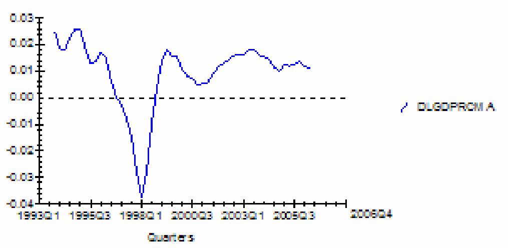
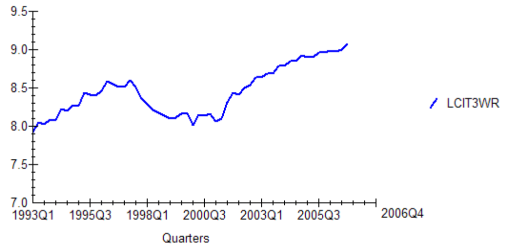
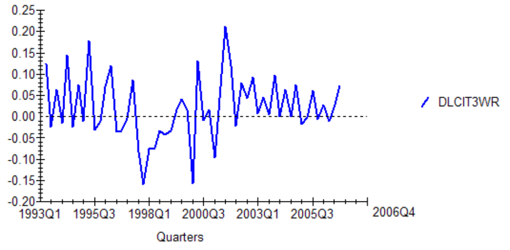


6. CIT3W

A. LCIT3WR



C. DLCIT3WR



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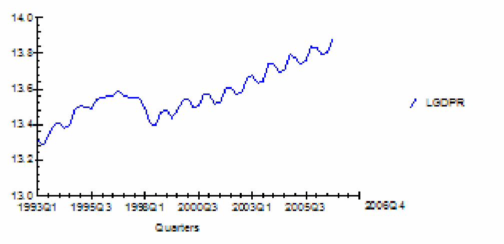
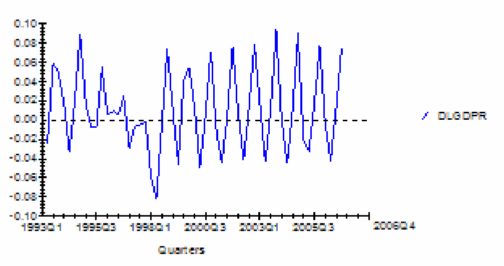
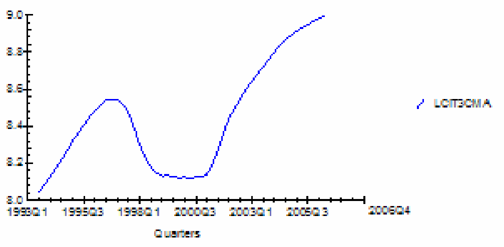


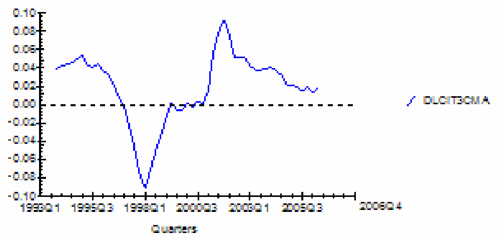
C. DLGDPR



B. LCIT3CMA



D. DLCIT3CMA



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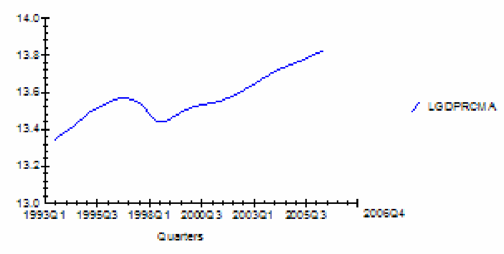

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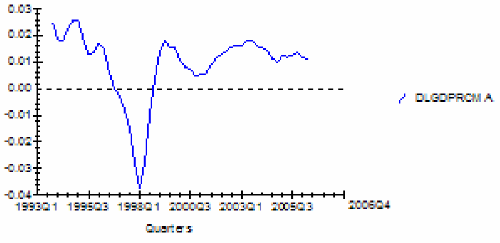

7. CIT4O

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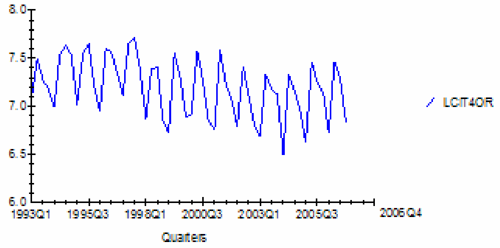
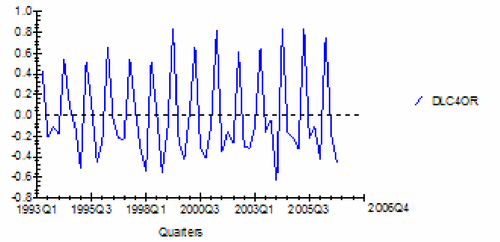
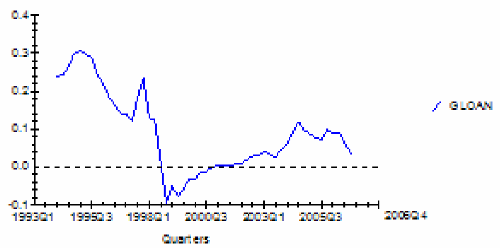


C. DLCIT4OR



A. GLOAN



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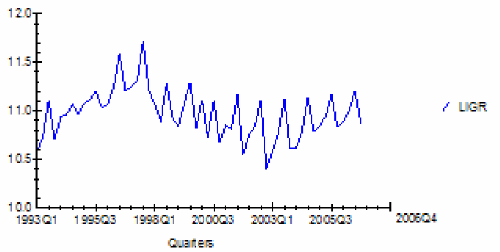
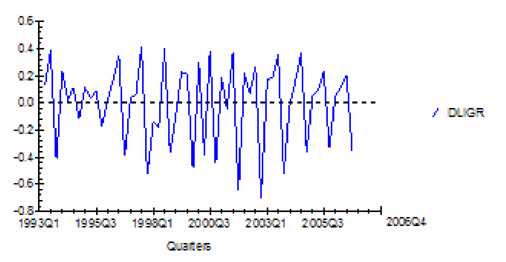


C. DLIGR



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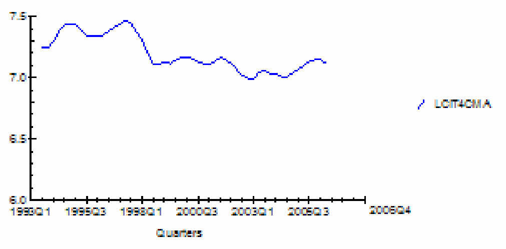

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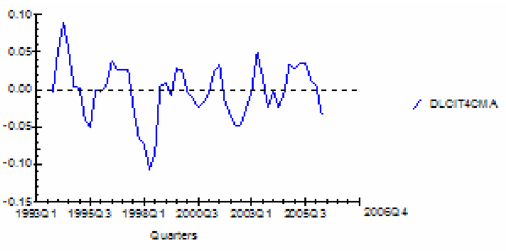
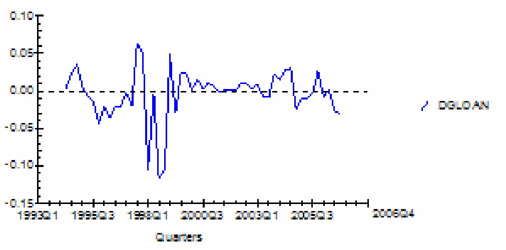


C. DGLOAN



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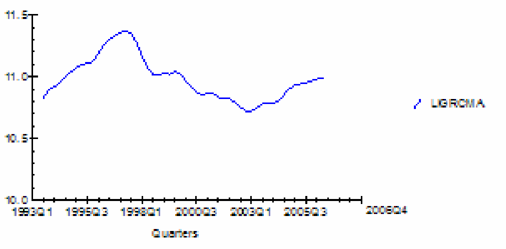

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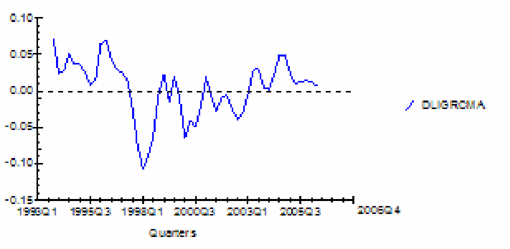

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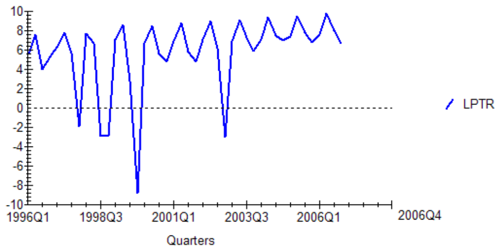

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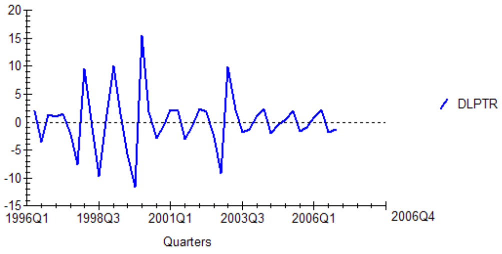
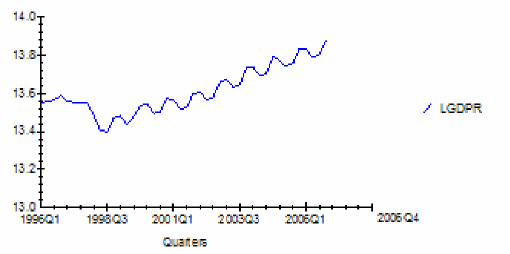


A. LGDPR



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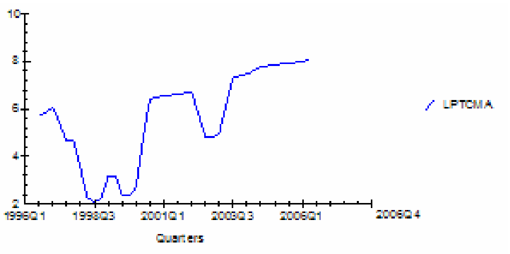

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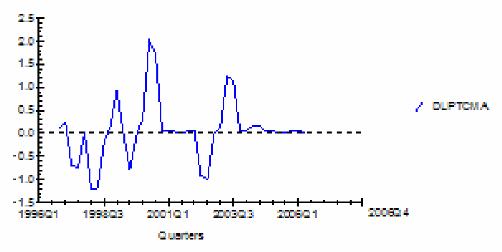

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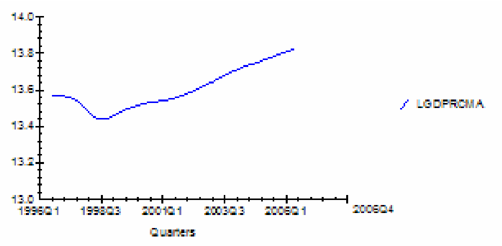
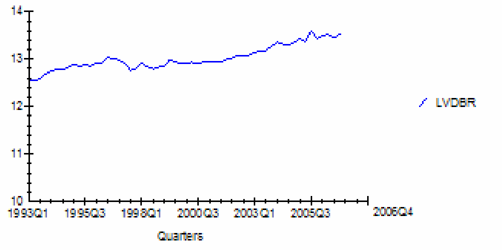
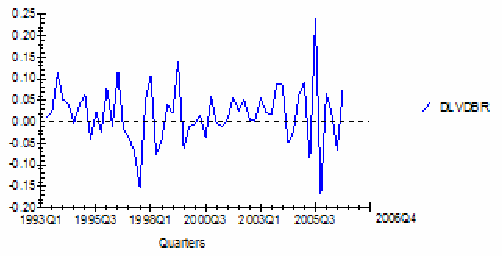


9. VATDB

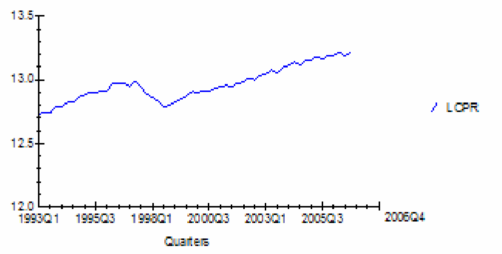
A. LVATDBR



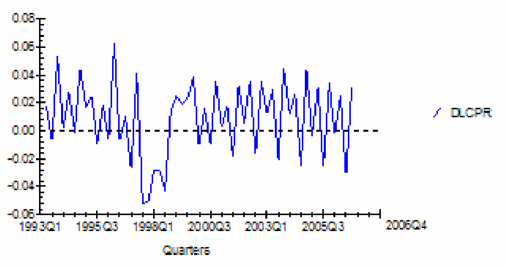
C. DLVATDBR



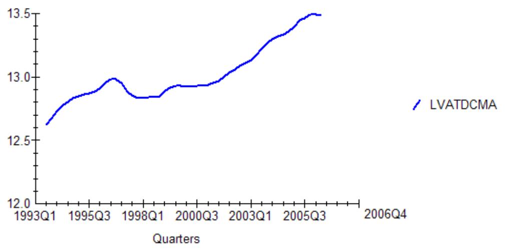
A. LCPR



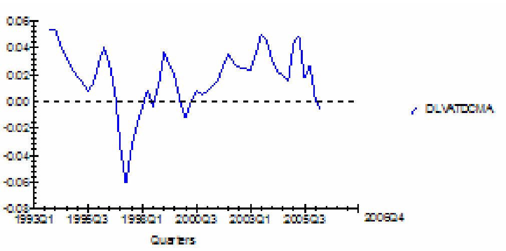
C. DLCPR



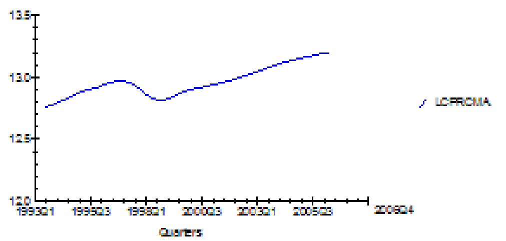
B. LVATDCMA



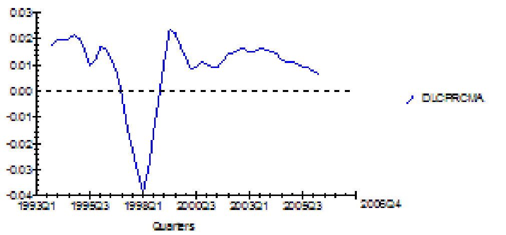
D. DLVATDCMA



B. LCPRCMA



C. DLCPRCMA



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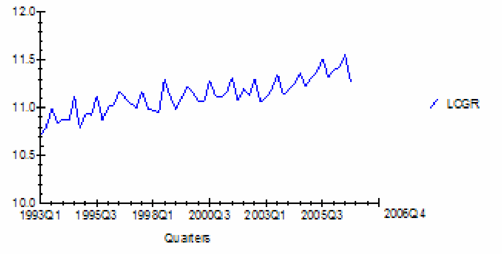
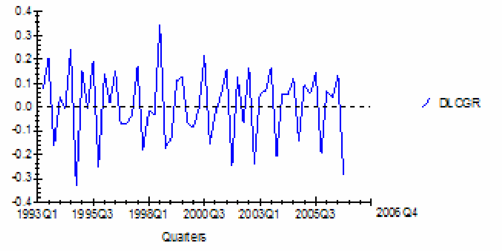
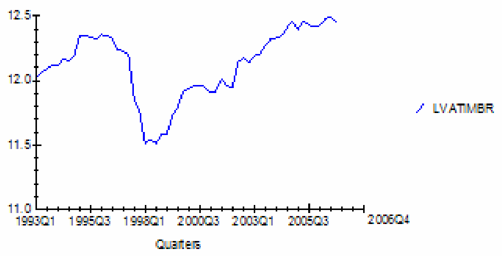


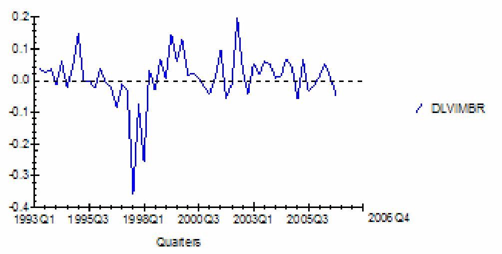
C. DLCGR



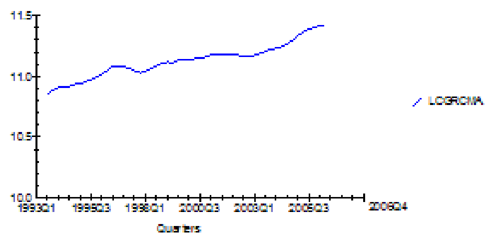
A. LVATIMBR



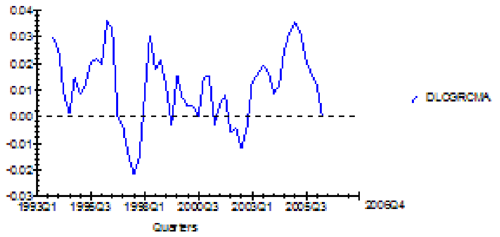
C. DLVATIMBR



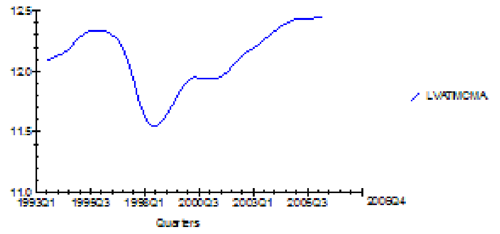
B. LCGRCMA



C. DLCGRCMA



B. LVATIMCMA



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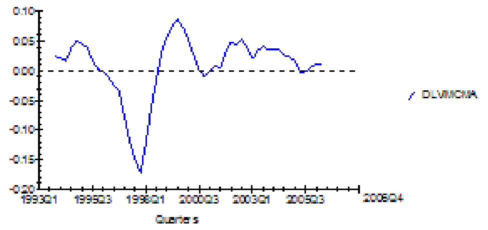

10. VATIMB

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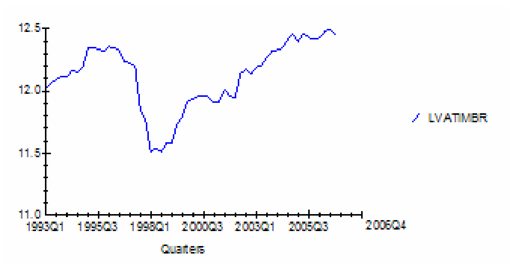

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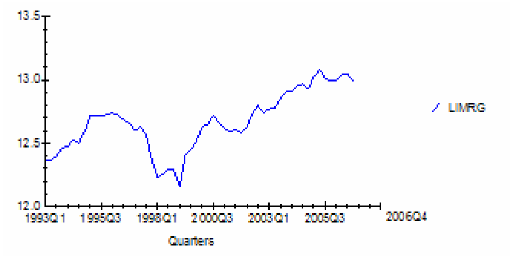
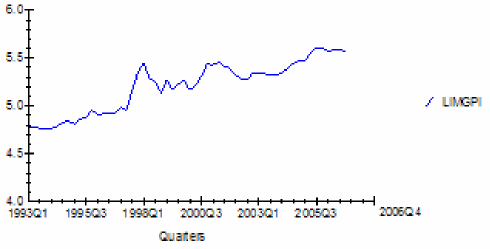
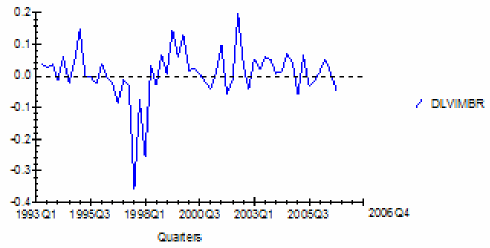


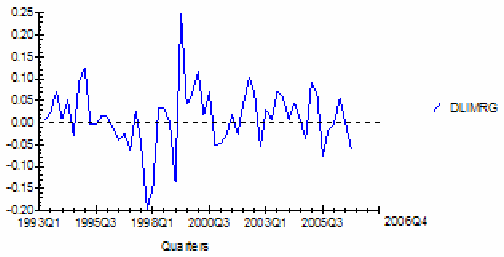
A. LIMGPI



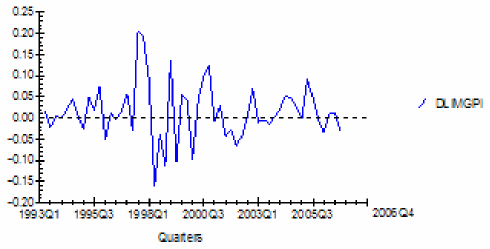
C. DLVATIMBR



C. DLIMGR

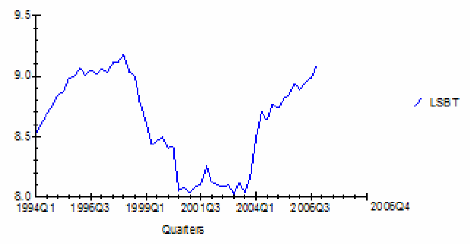


C. DLIMGPI

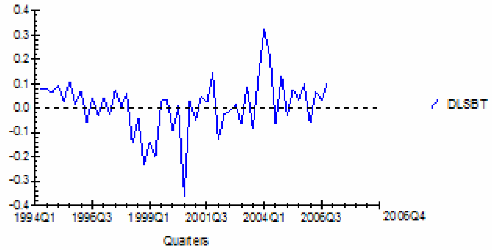


11. SBT

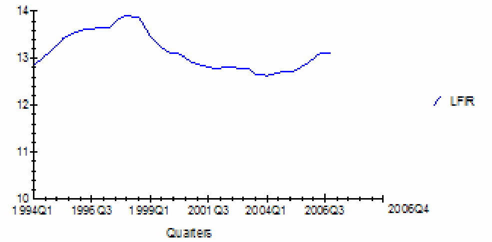
A. LSBT



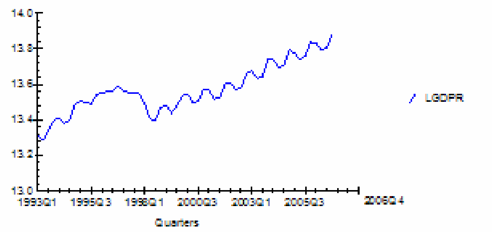
C. DLSBT



A. LFR



A. LGDPR



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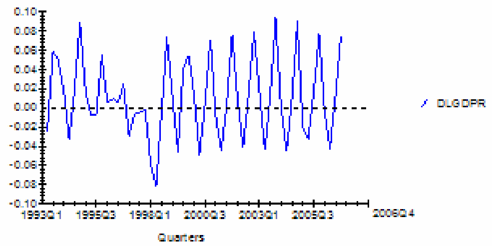
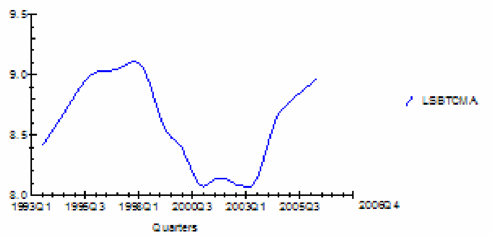
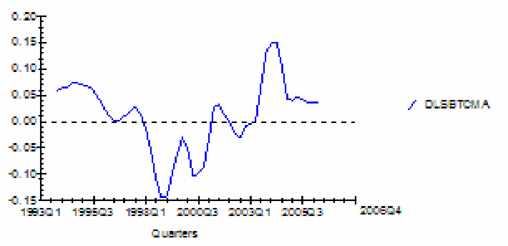


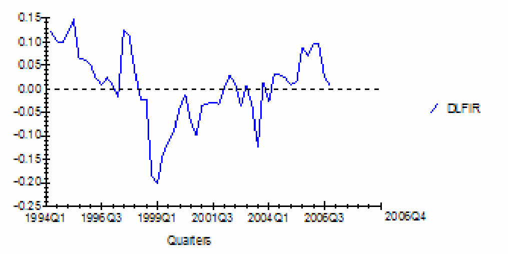
B. LSBTCMA



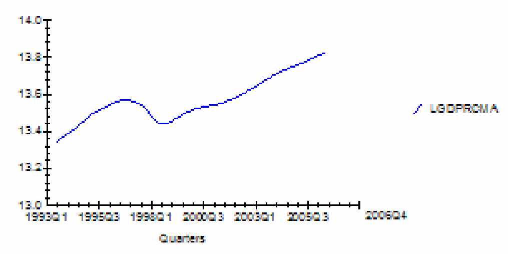
D. DLSBTCMA



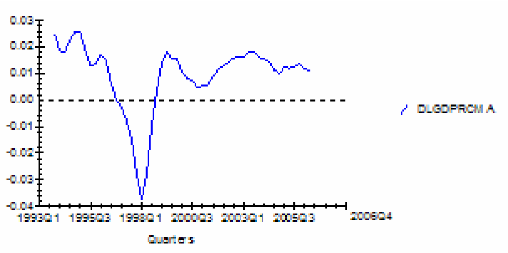
C.DLFR



B. LGDPRCMA

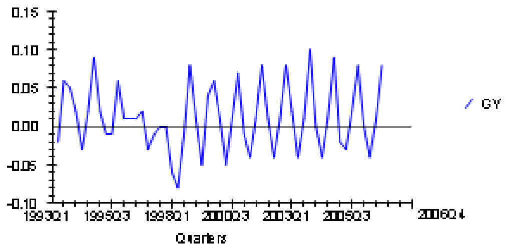


D. DLGDPRCMA

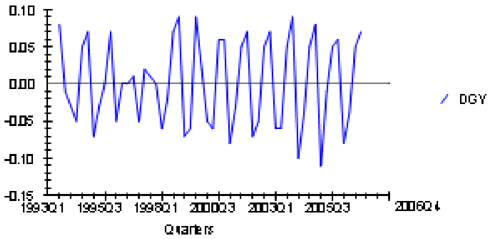


12. GY

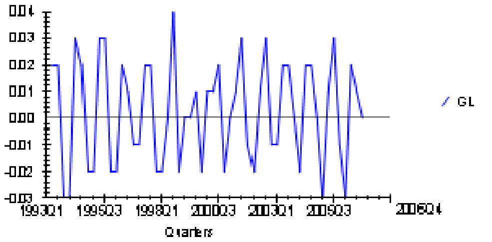
A. GY



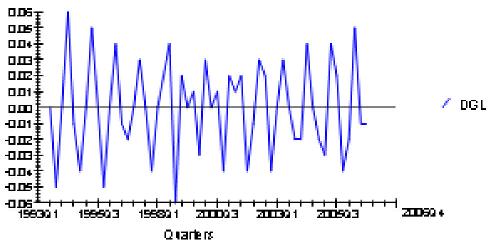
C. DGY



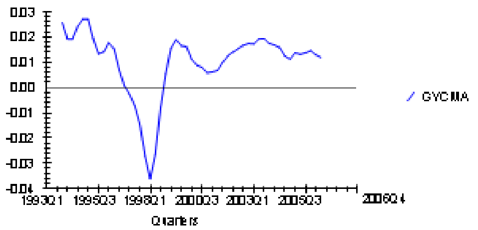
A. GL



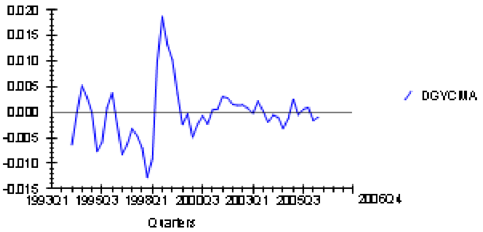
C. DGL



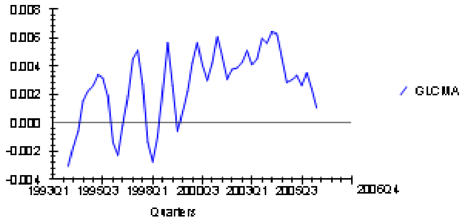
B. GYCMA



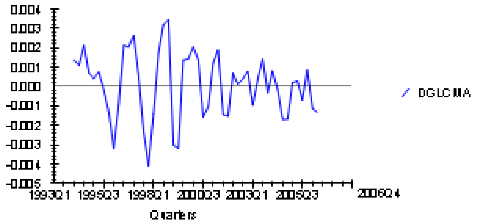
D. DGYCMA



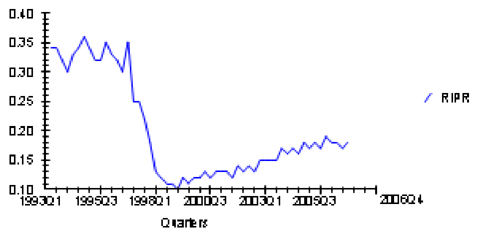
B. GLCMA



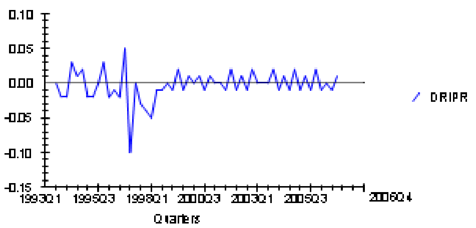
D. DGLCMA



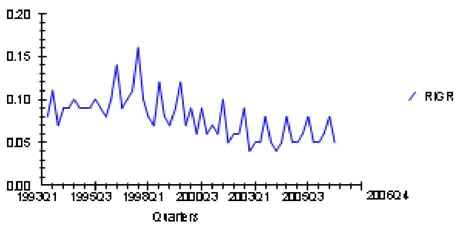
A. RIPR



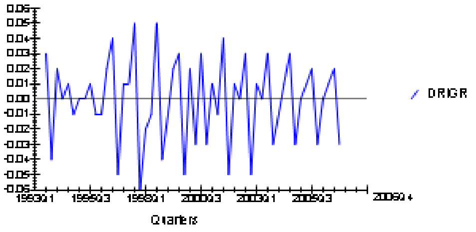
C. DRIPR



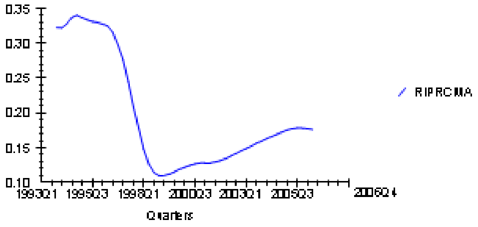
A. RIGR



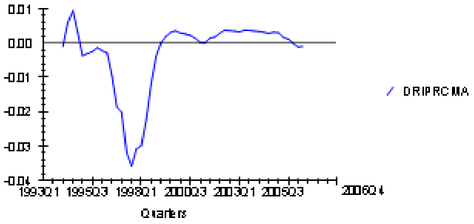
C. DRIGR



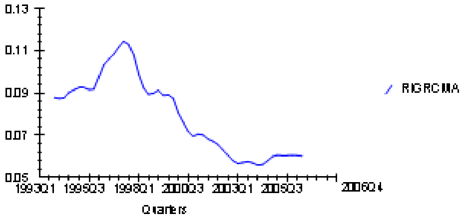
B. RIPRCMA



D. DRIPRCMA



B. RIGRCMA



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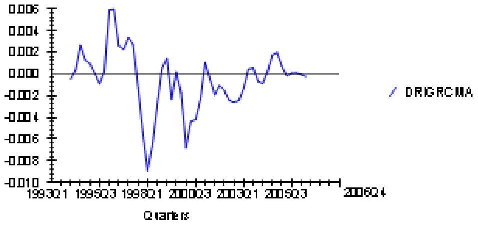

Appendix B: Table F

Table F: Testing the existence of a long-run relationship: critical value bounds of the F statistic

Case II: intercept and no trend

k	90%		95%		97.5%		99%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
0.000	6.597	6.597	8.199	8.199	9.679	9.679	11.935	11.935
1.000	4.042	4.788	4.934	5.764	5.776	6.732	7.057	7.815
2.000	3.182	4.126	3.793	4.855	4.404	5.524	5.288	6.309
3.000	2.711	3.800	3.219	4.378	3.727	4.898	4.385	5.615
4.000	2.425	3.574	2.850	4.049	3.292	4.518	3.817	5.122
5.000	2.262	3.367	2.649	3.805	3.056	4.267	3.516	4.781
6.000	2.141	3.250	2.476	3.646	2.823	4.069	3.267	4.540
7.000	2.035	3.153	2.365	3.553	2.665	3.871	3.027	4.296
8.000	1.956	3.085	2.272	3.447	2.533	3.753	2.848	4.126
9.000	1.899	3.047	2.163	3.349	2.437	3.657	2.716	3.989
10.000	1.840	2.964	2.099	3.270	2.331	3.569	2.607	3.888

Appendix C: Unit Root Test

1. LPIT1WR

```
                      Unit root tests for variable LPIT1WR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -.72629      112.1984      110.1984      108.3482      109.5021
 ADF(1)     -.85877      150.8237      147.8237      145.0484      146.7793
 ADF(2)     -.61516      157.1122      153.1122      149.4119      151.7197
 ADF(3)     -.60601      157.3567      152.3567      147.7314      150.6162
 ADF(4)     -.64320      157.8539      151.8539      146.3035      149.7653
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable LPIT1WR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -1.1387      112.6757      109.6757      106.9005      108.6313
 ADF(1)     -4.0020      157.9305      153.9305      150.2302      152.5380
 ADF(2)     -2.5204      160.2197      155.2197      150.5943      153.4791
 ADF(3)     -2.9380      161.6545      155.6545      150.1040      153.5658
 ADF(4)     -2.7384      161.6560      154.6560      148.1805      152.2193
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable DLPIT1WR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -1.9818      147.0465      145.0465      143.2179      144.3615
 ADF(1)     -2.8299      153.1466      150.1466      147.4036      149.1191
 ADF(2)     -2.4054      153.3489      149.3489      145.6917      147.9789
 ADF(3)     -2.5616      153.8263      148.8263      144.2547      147.1137
 ADF(4)     -1.9906      155.5734      149.5734      144.0875      147.5183
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                    Unit root tests for variable DLPIT1WR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -1.9482      147.1924      144.1924      141.4495      143.1649
 ADF(1)     -2.7851      153.1641      149.1641      145.5068      147.7941
 ADF(2)     -2.3576      153.3745      148.3745      143.8029      146.6619
 ADF(3)     -2.5078      153.8315      147.8315      142.3456      145.7764
 ADF(4)     -1.9094      155.6306      148.6306      142.2304      146.2330
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

Unit root tests for variable LGDPR

The Dickey-Fuller regressions include an intercept but not a trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	1.2223	138.3942	136.3942	134.5441	135.6980
ADF(1)	-.88390	180.0050	177.0050	174.2298	175.9607
ADF(2)	.56158	199.7333	195.7333	192.0330	194.3409
ADF(3)	.18357	203.6201	198.6201	193.9948	196.8796
ADF(4)	.34730	205.2041	199.2041	193.6537	197.1154

95% critical value for the augmented Dickey-Fuller statistic = -2.9241
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LGDPR

The Dickey-Fuller regressions include an intercept and a linear trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-.13001	138.8691	135.8691	133.0938	134.8247
ADF(1)	-3.7312	186.8259	182.8259	179.1256	181.4334
ADF(2)	-1.1209	201.1179	196.1179	191.4926	194.3774
ADF(3)	-2.1020	206.9255	200.9255	195.3751	198.8369
ADF(4)	-1.6097	207.3739	200.3739	193.8984	197.9372

95% critical value for the augmented Dickey-Fuller statistic = -3.5066
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLGDPR

The Dickey-Fuller regressions include an intercept but not a trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.7652	175.6712	173.6712	171.8426	172.9862
ADF(1)	-3.9681	194.9744	191.9744	189.2314	190.9469
ADF(2)	-2.3087	198.7755	194.7755	191.1182	193.4055
ADF(3)	-2.7256	200.3237	195.3237	190.7521	193.6112
ADF(4)	-2.5354	200.3290	194.3290	188.8431	192.2739

95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLGDPR

The Dickey-Fuller regressions include an intercept and a linear trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.0616	176.7331	173.7331	170.9901	172.7055
ADF(1)	-4.2475	196.1647	192.1647	188.5074	190.7947
ADF(2)	-2.5726	199.7521	194.7521	190.1805	193.0395
ADF(3)	-2.9615	201.2778	195.2778	189.7918	193.2227
ADF(4)	-2.7508	201.2970	194.2970	187.8967	191.8994

95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

2. LPIT2I

```
                     Unit root tests for variable LPIT2I
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
       Test Statistic      LL           AIC           SBC           HQC
 DF         -.50076      58.7936       56.7936       54.9434       56.0973
 ADF(1)     -2.8176      98.9239       95.9239       93.1487       94.8796
 ADF(2)     -1.1067     112.6681      108.6681      104.9678      107.2756
 ADF(3)     -1.5576     115.5524      110.5524      105.9270      108.8118
 ADF(4)     -1.6858     115.8662      109.8662      104.3158      107.7776
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion


                    Unit root tests for variable LPIT2I
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
       Test Statistic      LL           AIC           SBC           HQC
 DF         -1.7489      60.4223       57.4223       54.6471       56.3780
 ADF(1)     -3.1310     100.6175       96.6175       92.9172       95.2251
 ADF(2)     -1.5674     113.3770      108.3770      103.7516      106.6364
 ADF(3)     -1.9704     116.5004      110.5004      104.9500      108.4117
 ADF(4)     -2.0599     116.8474      109.8474      103.3719      107.4106
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable DLPIT2I
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
       Test Statistic      LL           AIC           SBC           HQC
 DF         -1.1660      93.0875       91.0875       89.2588       90.4025
 ADF(1)     -3.5311     109.6889      106.6889      103.9459      105.6614
 ADF(2)     -2.2243     111.7468      107.7468      104.0895      106.3767
 ADF(3)     -1.9594     111.7836      106.7836      102.2120      105.0711
 ADF(4)     -1.6551     111.9825      105.9825      100.4966      103.9274
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion


                   Unit root tests for variable DLPIT2I
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
       Test Statistic      LL           AIC           SBC           HQC
 DF         -.90276      94.2900       91.2900       88.5471       90.2625
 ADF(1)     -3.2765     109.8416      105.8416      102.1843      104.4716
 ADF(2)     -1.9466     112.0642      107.0642      102.4925      105.3516
 ADF(3)     -1.6161     112.1547      106.1547      100.6687      104.0996
 ADF(4)     -1.2178     112.5015      105.5015       99.1012      103.1039
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

```
                 Unit root tests for variable LTR
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
       Test Statistic      LL          AIC          SBC          HQC
 DF         -.57377      33.8071      31.8071      29.9569      31.1108
 ADF(1)     -4.0171      92.7654      89.7654      86.9902      88.7211
 ADF(2)     -1.1341     106.1096     102.1096      98.4093     100.7171
 ADF(3)     -1.6400     108.2035     103.2035      98.5782     101.4630
 ADF(4)     -1.6971     108.3402     102.3402      96.7898     100.2516
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable LTR
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
       Test Statistic      LL          AIC          SBC          HQC
 DF         -.71666      33.9353      30.9353      28.1601      29.8910
 ADF(1)     -3.1422      93.5262      89.5262      85.8259      88.1338
 ADF(2)     -1.8542     107.2672     102.2672      97.6419     100.5267
 ADF(3)     -2.1390     109.3301     103.3301      97.7796     101.2414
 ADF(4)     -2.2212     109.5801     102.5801      96.1046     100.1434
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                    Unit root tests for variable DLTR
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
       Test Statistic      LL          AIC          SBC          HQC
 DF          .41599      83.2932      81.2932      79.4646      80.6082
 ADF(1)     -3.1719     102.7775      99.7775      97.0345      98.7500
 ADF(2)     -1.9858     104.1019     100.1019      96.4447      98.7319
 ADF(3)     -1.7874     104.1061      99.1061      94.5345      97.3935
 ADF(4)     -1.4333     104.4278      98.4278      92.9418      96.3727
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                    Unit root tests for variable DLTR
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
       Test Statistic      LL          AIC          SBC          HQC
 DF          .65426      87.1824      84.1824      81.4394      83.1548
 ADF(1)     -2.8889     102.7970      98.7970      95.1397      97.4270
 ADF(2)     -1.5495     104.3056      99.3056      94.7340      97.5931
 ADF(3)     -1.2827     104.3364      98.3364      92.8504      96.2813
 ADF(4)     -.90603     104.7455      97.7455      91.3453      95.3480
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

3. LPIT4OR

```
                      Unit root tests for variable LPIT4OR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF          .99885      93.2526      91.2526      89.4024      90.5564
 ADF(1)     -1.0781     127.9420     124.9420     122.1668     123.8977
 ADF(2)     -.48035     129.0573     125.0573     121.3570     123.6649
 ADF(3)     -.48786     129.0649     124.0649     119.4395     122.3244
 ADF(4)     .053008     131.1456     125.1456     119.5951     123.0569
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable LPIT4OR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF         -.49467      96.4448      93.4448      90.6695      92.4004
 ADF(1)     -2.2003     130.9165     126.9165     123.2162     125.5240
 ADF(2)     -1.5751     131.5160     126.5160     121.8906     124.7754
 ADF(3)     -1.6398     131.6620     125.6620     120.1116     123.5734
 ADF(4)     -1.0249     133.0291     126.0291     119.5535     123.5923
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable DLPIT4OR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF         -1.4924     124.1255     122.1255     120.2969     121.4405
 ADF(1)     -1.8797     125.7086     122.7086     119.9656     121.6811
 ADF(2)     -1.7951     125.7100     121.7100     118.0528     120.3400
 ADF(3)     -2.3488     127.9426     122.9426     118.3710     121.2300
 ADF(4)     -1.5264     131.2534     125.2534     119.7675     123.1983
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion


                    Unit root tests for variable DLPIT4OR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF         -1.9364     125.2846     122.2846     119.5417     121.2571
 ADF(1)     -2.3661     127.1246     123.1246     119.4673     121.7545
 ADF(2)     -2.2813     127.1361     122.1361     117.5645     120.4235
 ADF(3)     -2.8376     129.5466     123.5466     118.0607     121.4916
 ADF(4)     -2.0333     132.8408     125.8408     119.4406     123.4433
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

Unit root tests for variable GLOAN
The Dickey-Fuller regressions include an intercept but not a trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1995Q2 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.4455	94.3020	92.3020	90.4518	91.6057
ADF(1)	-2.4694	94.8544	91.8544	89.0792	90.8101
ADF(2)	-2.5567	95.3067	91.3067	87.6064	89.9142
ADF(3)	-2.7706	96.2296	91.2296	86.6042	89.4890
ADF(4)	-2.2360	103.7678	97.7678	92.2174	95.6791

95% critical value for the augmented Dickey-Fuller statistic = -2.9241
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable GLOAN
The Dickey-Fuller regressions include an intercept and a linear trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1995Q2 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.9857	94.4011	91.4011	88.6259	90.3568
ADF(1)	-2.0920	94.8713	90.8713	87.1710	89.4788
ADF(2)	-2.2354	95.3091	90.3091	85.6837	88.5685
ADF(3)	-2.5446	96.3220	90.3220	84.7715	88.2333
ADF(4)	-1.4580	104.0114	97.0114	90.5358	94.5746

95% critical value for the augmented Dickey-Fuller statistic = -3.5066
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DGLOAN
The Dickey-Fuller regressions include an intercept but not a trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q3 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-5.7513	89.3588	87.3588	85.5301	86.6737
ADF(1)	-3.8887	89.5431	86.5431	83.8002	85.5156
ADF(2)	-2.9486	89.8546	85.8546	82.1974	84.4846
ADF(3)	-4.9545	98.4688	93.4688	88.8972	91.7563
ADF(4)	-3.4035	98.8798	92.8798	87.3939	90.8248

95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DGLOAN
The Dickey-Fuller regressions include an intercept and a linear trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q3 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-5.9146	90.1662	87.1662	84.4232	86.1386
ADF(1)	-4.0517	90.2202	86.2202	82.5629	84.8502
ADF(2)	-3.1118	90.4116	85.4116	80.8400	83.6991
ADF(3)	-5.3601	100.1538	94.1538	88.6679	92.0988
ADF(4)	-3.8060	100.2955	93.2955	86.8953	90.8979

95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LCGR
The Dickey-Fuller regressions include an intercept but not a trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	.49505	135.1583	133.1583	131.3081	132.4621
ADF(1)	-.89835	149.5323	146.5323	143.7571	145.4880
ADF(2)	-.54862	150.7602	146.7602	143.0599	145.3678
ADF(3)	-.50538	150.7918	145.7918	141.1664	144.0512
ADF(4)	-.35740	153.7886	147.7886	142.2381	145.6999

95% critical value for the augmented Dickey-Fuller statistic = -2.9241
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LCGR
The Dickey-Fuller regressions include an intercept and a linear trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-.66055	135.5434	132.5434	129.7682	131.4991
ADF(1)	-3.2486	154.2628	150.2628	146.5626	148.8704
ADF(2)	-2.6685	154.2844	149.2844	144.6590	147.5438
ADF(3)	-2.7865	154.7338	148.7338	143.1834	146.6452
ADF(4)	-2.0130	155.9866	148.9866	142.5111	146.5498

95% critical value for the augmented Dickey-Fuller statistic = -3.5066
LL = Maximized log-likelihood AIC = Akaike Information Criterion

Unit root tests for variable DLCGR
The Dickey-Fuller regressions include an intercept but not a trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.8428	145.9983	143.9983	142.1696	143.3133
ADF(1)	-3.3754	147.6216	144.6216	141.8787	143.5941
ADF(2)	-3.2297	147.7896	143.7896	140.1323	142.4195
ADF(3)	-4.2316	151.2984	146.2984	141.7268	144.5858
ADF(4)	-2.8481	152.5059	146.5059	141.0199	144.4508

95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLCGR
The Dickey-Fuller regressions include an intercept and a linear trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.8181	146.0300	143.0300	140.2871	142.0025
ADF(1)	-3.3650	147.7157	143.7157	140.0585	142.3457
ADF(2)	-3.2281	147.9049	142.9049	138.3333	141.1924
ADF(3)	-4.2149	151.4347	145.4347	139.9488	143.3797
ADF(4)	-2.8714	152.7035	145.7035	139.3032	143.3059

95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

4. LCIT1AR

Unit root tests for variable LCIT1AR
The Dickey-Fuller regressions include an intercept but not a trend

****

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

****

	Test Statistic	LL	AIC	SBC	HQC
DF	.94480	72.4667	70.4667	68.6166	69.7705
ADF(1)	-.51296	85.0931	82.0931	79.3179	81.0487
ADF(2)	-.059613	86.2172	82.2172	78.5170	80.8248
ADF(3)	.10612	86.3406	81.3406	76.7153	79.6001
ADF(4)	.067941	86.3432	80.3432	74.7928	78.2546

****

95% critical value for the augmented Dickey-Fuller statistic = -2.9241
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LCIT1AR
The Dickey-Fuller regressions include an intercept and a linear trend

****

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

****

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.0413	76.6589	73.6589	70.8837	72.6146
ADF(1)	-1.7897	87.8720	83.8720	80.1717	82.4795
ADF(2)	-1.3593	88.9826	83.9826	79.3573	82.2421
ADF(3)	-1.1417	89.1997	83.1997	77.6493	81.1110
ADF(4)	-1.0221	89.2151	82.2151	75.7396	79.7783

****

95% critical value for the augmented Dickey-Fuller statistic = -3.5066
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLCIT1AR
The Dickey-Fuller regressions include an intercept but not a trend

****

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

****

	Test Statistic	LL	AIC	SBC	HQC
DF	-3.0401	82.7182	80.7182	78.8895	80.0332
ADF(1)	-3.4362	83.9181	80.9181	78.1752	79.8906
ADF(2)	-3.2361	84.0360	80.0360	76.3787	78.6659
ADF(3)	-2.8073	84.0423	79.0423	74.4707	77.3298
ADF(4)	-1.7421	87.3048	81.3048	75.8188	79.2497

****

95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLCIT1AR
The Dickey-Fuller regressions include an intercept and a linear trend

****

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

****

	Test Statistic	LL	AIC	SBC	HQC
DF	-3.4162	83.8608	80.8608	78.1179	79.8333
ADF(1)	-3.9694	85.6694	81.6694	78.0121	80.2993
ADF(2)	-3.9014	86.1824	81.1824	76.6108	79.4698
ADF(3)	-3.5679	86.3556	80.3556	74.8696	78.3005
ADF(4)	-2.3922	88.8081	81.8081	75.4078	79.4105

****

95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LCIT1HR
The Dickey-Fuller regressions include an intercept but not a trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.2607	18.9956	16.9956	15.1454	16.2993
ADF(1)	-2.6869	27.2613	24.2613	21.4861	23.2170
ADF(2)	-1.0773	33.9829	29.9829	26.2826	28.5904
ADF(3)	-2.0844	38.7860	33.7860	29.1606	32.0454
ADF(4)	-1.1777	41.0529	35.0529	29.5024	32.9642

95% critical value for the augmented Dickey-Fuller statistic = -2.9241
LL = Maximized log-likelihood   AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion   HQC = Hannan-Quinn Criterion

Unit root tests for variable LCIT1HR
The Dickey-Fuller regressions include an intercept and a linear trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.0719	20.6866	17.6866	14.9114	16.6423
ADF(1)	-3.7023	30.3095	26.3095	22.6092	24.9170
ADF(2)	-1.9654	35.8207	30.8207	26.1953	29.0801
ADF(3)	-3.1210	41.6895	35.6895	30.1391	33.6009
ADF(4)	-2.1218	43.1184	36.1184	29.6429	33.6816

95% critical value for the augmented Dickey-Fuller statistic = -3.5066
LL = Maximized log-likelihood   AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion   HQC = Hannan-Quinn Criterion

Unit root tests for variable DLCIT1HR
The Dickey-Fuller regressions include an intercept but not a trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-4.0581	22.7628	20.7628	18.9341	20.0777
ADF(1)	-6.6321	32.1792	29.1792	26.4363	28.1517
ADF(2)	-3.1825	35.2622	31.2622	27.6049	29.8921
ADF(3)	-4.2299	38.9286	33.9286	29.3570	32.2160
ADF(4)	-2.3558	42.4384	36.4384	30.9525	34.3834

95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood   AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion   HQC = Hannan-Quinn Criterion

Unit root tests for variable DLCIT1HR
The Dickey-Fuller regressions include an intercept and a linear trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-4.0355	22.8411	19.8411	17.0981	18.8135
ADF(1)	-6.6551	32.5403	28.5403	24.8830	27.1703
ADF(2)	-3.1995	35.4229	30.4229	25.8513	28.7103
ADF(3)	-4.2742	39.2570	33.2570	27.7711	31.2019
ADF(4)	-2.4031	42.6268	35.6268	29.2266	33.2293

95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood   AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion   HQC = Hannan-Quinn Criterion

5. LCIT2FR

```
                      Unit root tests for variable LCIT2FR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -.89677       93.9776       91.9776       90.1275       91.2814
 ADF(1)      -1.8425      114.3571      111.3571      108.5818      110.3127
 ADF(2)      -1.3925      117.2911      113.2911      109.5908      111.8987
 ADF(3)      -1.4082      117.6129      112.6129      107.9875      110.8723
 ADF(4)      -1.4142      118.5914      112.5914      107.0409      110.5027
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable LCIT2FR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -1.1138       94.2228       91.2228       88.4476       90.1785
 ADF(1)      -2.7399      116.3964      112.3964      108.6961      111.0039
 ADF(2)      -1.9790      118.3515      113.3515      108.7262      111.6110
 ADF(3)      -2.1414      119.0205      113.0205      107.4701      110.9319
 ADF(4)      -1.9360      119.5939      112.5939      106.1184      110.1571
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable DLCIT2FR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -2.7383      110.1073      108.1073      106.2787      107.4223
 ADF(1)      -3.7189      113.9173      110.9173      108.1744      109.8898
 ADF(2)      -3.0490      114.0658      110.0658      106.4085      108.6958
 ADF(3)      -3.3975      115.2061      110.2061      105.6345      108.4935
 ADF(4)      -2.1144      123.3083      117.3083      111.8224      115.2533
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                    Unit root tests for variable DLCIT2FR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -2.7100      110.1595      107.1595      104.4165      106.1319
 ADF(1)      -3.6736      113.9421      109.9421      106.2848      108.5721
 ADF(2)      -2.9982      114.1017      109.1017      104.5301      107.3892
 ADF(3)      -3.3348      115.2091      109.2091      103.7232      107.1540
 ADF(4)      -2.0044      123.4962      116.4962      110.0960      114.0987
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

```
                      Unit root tests for variable LGDPR
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          1.2223      138.3942      136.3942      134.5441      135.6980
 ADF(1)     -.88390      180.0050      177.0050      174.2298      175.9607
 ADF(2)      .56158      199.7333      195.7333      192.0330      194.3409
 ADF(3)      .18357      203.6201      198.6201      193.9948      196.8796
 ADF(4)      .34730      205.2041      199.2041      193.6537      197.1154
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable LGDPR
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -.13001      138.8691      135.8691      133.0938      134.8247
 ADF(1)     -3.7312      186.8259      182.8259      179.1256      181.4334
 ADF(2)     -1.1209      201.1179      196.1179      191.4926      194.3774
 ADF(3)     -2.1020      206.9255      200.9255      195.3751      198.8369
 ADF(4)     -1.6097      207.3739      200.3739      193.8984      197.9372
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable DLGDPR
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -1.7652      175.6712      173.6712      171.8426      172.9862
 ADF(1)     -3.9681      194.9744      191.9744      189.2314      190.9469
 ADF(2)     -2.3087      198.7755      194.7755      191.1182      193.4055
 ADF(3)     -2.7256      200.3237      195.3237      190.7521      193.6112
 ADF(4)     -2.5354      200.3290      194.3290      188.8431      192.2739
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                    Unit root tests for variable DLGDPR
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -2.0616      176.7331      173.7331      170.9901      172.7055
 ADF(1)     -4.2475      196.1647      192.1647      188.5074      190.7947
 ADF(2)     -2.5726      199.7521      194.7521      190.1805      193.0395
 ADF(3)     -2.9615      201.2778      195.2778      189.7918      193.2227
 ADF(4)     -2.7508      201.2970      194.2970      187.8967      191.8994
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

6. LCIT3WR

```
                     Unit root tests for variable LCIT3WR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          .89779       85.9378       83.9378       82.0877       83.2416
 ADF(1)     -2.3497      139.1483      136.1483      133.3731      135.1040
 ADF(2)     -.59974      148.9337      144.9337      141.2334      143.5412
 ADF(3)     -.75567      149.2066      144.2066      139.5812      142.4660
 ADF(4)     -.65174      149.2244      143.2244      137.6739      141.1357
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                    Unit root tests for variable LCIT3WR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -.21084       87.0598       84.0598       81.2846       83.0155
 ADF(1)     -4.0035      144.2064      140.2064      136.5061      138.8139
 ADF(2)     -1.7546      150.8986      145.8986      141.2732      144.1580
 ADF(3)     -2.0292      151.6216      145.6216      140.0711      143.5329
 ADF(4)     -1.9785      151.6872      144.6872      138.2117      142.2505
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable DLCIT3WR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -1.3211      133.1151      131.1151      129.2864      130.4301
 ADF(1)     -2.5345      145.2771      142.2771      139.5341      141.2496
 ADF(2)     -2.1888      145.4169      141.4169      137.7596      140.0468
 ADF(3)     -2.1905      145.5096      140.5096      135.9380      138.7970
 ADF(4)     -1.7884      146.0674      140.0674      134.5814      138.0123
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                   Unit root tests for variable DLCIT3WR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -1.5462      133.6912      130.6912      127.9483      129.6637
 ADF(1)     -2.7596      146.0263      142.0263      138.3690      140.6563
 ADF(2)     -2.4135      146.1435      141.1435      136.5719      139.4309
 ADF(3)     -2.4234      146.2735      140.2735      134.7876      138.2185
 ADF(4)     -2.0213      146.8045      139.8045      133.4043      137.4070
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

```
                    Unit root tests for variable LGDPR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          1.2223      138.3942      136.3942      134.5441      135.6980
 ADF(1)     -.88390      180.0050      177.0050      174.2298      175.9607
 ADF(2)      .56158      199.7333      195.7333      192.0330      194.3409
 ADF(3)      .18357      203.6201      198.6201      193.9948      196.8796
 ADF(4)      .34730      205.2041      199.2041      193.6537      197.1154
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                    Unit root tests for variable LGDPR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -.13001      138.8691      135.8691      133.0938      134.8247
 ADF(1)     -3.7312      186.8259      182.8259      179.1256      181.4334
 ADF(2)     -1.1209      201.1179      196.1179      191.4926      194.3774
 ADF(3)     -2.1020      206.9255      200.9255      195.3751      198.8369
 ADF(4)     -1.6097      207.3739      200.3739      193.8984      197.9372
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                    Unit root tests for variable DLGDPR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -1.7652      175.6712      173.6712      171.8426      172.9862
 ADF(1)     -3.9681      194.9744      191.9744      189.2314      190.9469
 ADF(2)     -2.3087      198.7755      194.7755      191.1182      193.4055
 ADF(3)     -2.7256      200.3237      195.3237      190.7521      193.6112
 ADF(4)     -2.5354      200.3290      194.3290      188.8431      192.2739
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                   Unit root tests for variable DLGDPR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -2.0616      176.7331      173.7331      170.9901      172.7055
 ADF(1)     -4.2475      196.1647      192.1647      188.5074      190.7947
 ADF(2)     -2.5726      199.7521      194.7521      190.1805      193.0395
 ADF(3)     -2.9615      201.2778      195.2778      189.7918      193.2227
 ADF(4)     -2.7508      201.2970      194.2970      187.8967      191.8994
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

7. LCIT4OR

```
                      Unit root tests for variable LCIT4OR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -1.5700       93.1933       91.1933       89.3432       90.4971
 ADF(1)      -2.4046      107.6535      104.6535      101.8782      103.6091
 ADF(2)      -1.6671      109.9514      105.9514      102.2511      104.5590
 ADF(3)      -1.5713      109.9730      104.9730      100.3476      103.2324
 ADF(4)      -1.0011      118.0786      112.0786      106.5282      109.9899
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable LCIT4OR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -.90642       93.1969       90.1969       87.4217       89.1525
 ADF(1)      -3.5868      111.2099      107.2099      103.5096      105.8175
 ADF(2)      -2.5260      111.9847      106.9847      102.3594      105.2442
 ADF(3)      -2.5114      112.1722      106.1722      100.6217      104.0835
 ADF(4)      -1.1331      118.4523      111.4523      104.9767      109.0155
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable DLCIT4OR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -2.9698      102.4816      100.4816       98.6529       99.7965
 ADF(1)      -3.8863      105.6968      102.6968       99.9538      101.6692
 ADF(2)      -3.6729      105.8564      101.8564       98.1991      100.4863
 ADF(3)      -5.9406      114.7410      109.7410      105.1694      108.0285
 ADF(4)      -3.0396      117.5005      111.5005      106.0146      109.4455
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                    Unit root tests for variable DLCIT4OR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -2.9828      102.6173       99.6173       96.8744       98.5898
 ADF(1)      -3.8820      105.8549      101.8549       98.1977      100.4849
 ADF(2)      -3.6749      106.0035      101.0035       96.4319       99.2910
 ADF(3)      -5.8857      114.8426      108.8426      103.3567      106.7876
 ADF(4)      -3.0213      117.5608      110.5608      104.1606      108.1632
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

Unit root tests for variable GLOAN
The Dickey-Fuller regressions include an intercept but not a trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1995Q2 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.4455	94.3020	92.3020	90.4518	91.6057
ADF(1)	-2.4694	94.8544	91.8544	89.0792	90.8101
ADF(2)	-2.5567	95.3067	91.3067	87.6064	89.9142
ADF(3)	-2.7706	96.2296	91.2296	86.6042	89.4890
ADF(4)	-2.2360	103.7678	97.7678	92.2174	95.6791

95% critical value for the augmented Dickey-Fuller statistic = -2.9241
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable GLOAN
The Dickey-Fuller regressions include an intercept and a linear trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1995Q2 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.9857	94.4011	91.4011	88.6259	90.3568
ADF(1)	-2.0920	94.8713	90.8713	87.1710	89.4788
ADF(2)	-2.2354	95.3091	90.3091	85.6837	88.5685
ADF(3)	-2.5446	96.3220	90.3220	84.7715	88.2333
ADF(4)	-1.4580	104.0114	97.0114	90.5358	94.5746

95% critical value for the augmented Dickey-Fuller statistic = -3.5066
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DGLOAN
The Dickey-Fuller regressions include an intercept but not a trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q3 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-5.7513	89.3588	87.3588	85.5301	86.6737
ADF(1)	-3.8887	89.5431	86.5431	83.8002	85.5156
ADF(2)	-2.9486	89.8546	85.8546	82.1974	84.4846
ADF(3)	-4.9545	98.4688	93.4688	88.8972	91.7563
ADF(4)	-3.4035	98.8798	92.8798	87.3939	90.8248

95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DGLOAN
The Dickey-Fuller regressions include an intercept and a linear trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q3 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-5.9146	90.1662	87.1662	84.4232	86.1386
ADF(1)	-4.0517	90.2202	86.2202	82.5629	84.8502
ADF(2)	-3.1118	90.4116	85.4116	80.8400	83.6991
ADF(3)	-5.3601	100.1538	94.1538	88.6679	92.0988
ADF(4)	-3.8060	100.2955	93.2955	86.8953	90.8979

95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LIGR
The Dickey-Fuller regressions include an intercept but not a trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-.71198	86.9495	84.9495	83.0993	84.2533
ADF(1)	-2.1008	111.0412	108.0412	105.2660	106.9969
ADF(2)	-1.4381	113.3995	109.3995	105.6992	108.0071
ADF(3)	-1.6258	113.9803	108.9803	104.3549	107.2397
ADF(4)	-1.3926	114.3388	108.3388	102.7884	106.2502

95% critical value for the augmented Dickey-Fuller statistic = -2.9241
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LIGR
The Dickey-Fuller regressions include an intercept and a linear trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-.93005	87.1460	84.1460	81.3708	83.1017
ADF(1)	-2.4829	112.0676	108.0676	104.3673	106.6752
ADF(2)	-1.7295	113.9672	108.9672	104.3418	107.2266
ADF(3)	-1.9535	114.7133	108.7133	103.1628	106.6246
ADF(4)	-1.7855	115.0759	108.0759	101.6004	105.6392

95% critical value for the augmented Dickey-Fuller statistic = -3.5066
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLIGR
The Dickey-Fuller regressions include an intercept but not a trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.4650	105.9865	103.9865	102.1578	103.3014
ADF(1)	-3.3121	109.4420	106.4420	103.6990	105.4145
ADF(2)	-2.6542	109.7034	105.7034	102.0461	104.3334
ADF(3)	-2.8706	110.3509	105.3509	100.7793	103.6384
ADF(4)	-2.0858	112.9702	106.9702	101.4843	104.9151

95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLIGR
The Dickey-Fuller regressions include an intercept and a linear trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.4445	106.1104	103.1104	100.3674	102.0828
ADF(1)	-3.2676	109.4796	105.4796	101.8224	104.1096
ADF(2)	-2.6065	109.7545	104.7545	100.1829	103.0420
ADF(3)	-2.8113	110.3758	104.3758	98.8898	102.3207
ADF(4)	-1.9778	113.1596	106.1596	99.7594	103.7621

95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

8. LPTR

```
                      Unit root tests for variable LPTR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 35 observations used in the estimation of all ADF regressions.
 Sample period from 1997Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL            AIC           SBC           HQC
 DF          -.68466     -35.8583      -37.8583      -39.4136      -38.3952
 ADF(1)      -1.6736     -29.3958      -32.3958      -34.7288      -33.2012
 ADF(2)      -1.0590     -28.1079      -32.1079      -35.2186      -33.1817
 ADF(3)      -1.1234     -28.0022      -33.0022      -36.8905      -34.3444
 ADF(4)      -.89223     -27.8397      -33.8397      -38.5057      -35.4504
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9472
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable LPTR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 35 observations used in the estimation of all ADF regressions.
 Sample period from 1997Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL            AIC           SBC           HQC
 DF          -2.3211     -33.1950      -36.1950      -38.5280      -37.0004
 ADF(1)      -3.6757     -24.5247      -28.5247      -31.6354      -29.5985
 ADF(2)      -2.9783     -24.0835      -29.0835      -32.9718      -30.4257
 ADF(3)      -3.1660     -23.4201      -29.4201      -34.0862      -31.0308
 ADF(4)      -2.9340     -23.4180      -30.4180      -35.8617      -32.2972
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5426
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable DLPTR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 34 observations used in the estimation of all ADF regressions.
 Sample period from 1998Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL            AIC           SBC           HQC
 DF          -3.1953     -30.2973      -32.2973      -33.8236      -32.8178
 ADF(1)      -3.8682     -28.3038      -31.3038      -33.5934      -32.0846
 ADF(2)      -3.1245     -28.3022      -32.3022      -35.3550      -33.3433
 ADF(3)      -3.0926     -27.9370      -32.9370      -36.7529      -34.2383
 ADF(4)      -1.7801     -25.1874      -31.1874      -35.7665      -32.7490
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9499
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable DLPTR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 34 observations used in the estimation of all ADF regressions.
 Sample period from 1998Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL            AIC           SBC           HQC
 DF          -3.1615     -30.2517      -33.2517      -35.5413      -34.0325
 ADF(1)      -3.8672     -28.1214      -32.1214      -35.1741      -33.1624
 ADF(2)      -3.1332     -28.1200      -33.1200      -36.9359      -34.4213
 ADF(3)      -3.1336     -27.6545      -33.6545      -38.2336      -35.2161
 ADF(4)      -1.7489     -25.1317      -32.1317      -37.4739      -33.9535
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5468
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

Unit root tests for variable LGDPR

The Dickey-Fuller regressions include an intercept but not a trend

35 observations used in the estimation of all ADF regressions.
Sample period from 1997Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	2.1299	104.3020	102.3020	100.7466	101.7651
ADF(1)	-1.1535	134.4023	131.4023	129.0693	130.5969
ADF(2)	.87560	150.2912	146.2912	143.1805	145.2173
ADF(3)	.14845	152.5823	147.5823	143.6939	146.2400
ADF(4)	.42649	152.9664	146.9664	142.3004	145.3557

95% critical value for the augmented Dickey-Fuller statistic = -2.9472
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LGDPR

The Dickey-Fuller regressions include an intercept and a linear trend

35 observations used in the estimation of all ADF regressions.
Sample period from 1997Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-8.7394	130.3153	127.3153	124.9823	126.5099
ADF(1)	-8.1818	153.8278	149.8278	146.7171	148.7540
ADF(2)	-7.1195	169.3926	164.3926	160.5042	163.0503
ADF(3)	-6.5803	169.4022	163.4022	158.7362	161.7915
ADF(4)	-7.1886	172.6913	165.6913	160.2476	163.8121

95% critical value for the augmented Dickey-Fuller statistic = -3.5426
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

9. LVATDBR

```
                      Unit root tests for variable LVATDBR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          1.9020      114.6484      112.6484      110.7983      111.9522
 ADF(1)     -.42547      134.0226      131.0226      128.2473      129.9782
 ADF(2)      .45419      138.7358      134.7358      131.0355      133.3434
 ADF(3)      .42878      138.7396      133.7396      129.1142      131.9990
 ADF(4)      .51401      138.8460      132.8460      127.2956      130.7573
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable LVATDBR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -.37444      115.7994      112.7994      110.0242      111.7551
 ADF(1)     -2.3483      137.1332      133.1332      129.4329      131.7407
 ADF(2)     -1.2460      140.2766      135.2766      130.6512      133.5360
 ADF(3)     -1.3192      140.4078      134.4078      128.8573      132.3191
 ADF(4)     -1.2330      140.4084      133.4084      126.9329      130.9716
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

```
                      Unit root tests for variable DLVATDBR
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -2.3256      130.6129      128.6129      126.7843      127.9279
 ADF(1)     -3.4252      135.1838      132.1838      129.4409      131.1563
 ADF(2)     -2.9696      135.1947      131.1947      127.5374      129.8247
 ADF(3)     -2.8388      135.2527      130.2527      125.6811      128.5401
 ADF(4)     -1.8367      139.3170      133.3170      127.8311      131.2620
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                    Unit root tests for variable DLVATDBR
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -2.4410      130.9459      127.9459      125.2029      126.9183
 ADF(1)     -3.6887      136.1100      132.1100      128.4527      130.7400
 ADF(2)     -3.2586      136.1100      131.1100      126.5384      129.3975
 ADF(3)     -3.1524      136.2290      130.2290      124.7431      128.1739
 ADF(4)     -2.3420      140.7977      133.7977      127.3975      131.4001
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

```
                       Unit root tests for variable LCGR
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          .49505      135.1583      133.1583      131.3081      132.4621
 ADF(1)     -.89835      149.5323      146.5323      143.7571      145.4880
 ADF(2)     -.54862      150.7602      146.7602      143.0599      145.3678
 ADF(3)     -.50538      150.7918      145.7918      141.1664      144.0512
 ADF(4)     -.35740      153.7886      147.7886      142.2381      145.6999
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable LCGR
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -.66055      135.5434      132.5434      129.7682      131.4991
 ADF(1)     -3.2486      154.2628      150.2628      146.5626      148.8704
 ADF(2)     -2.6685      154.2844      149.2844      144.6590      147.5438
 ADF(3)     -2.7865      154.7338      148.7338      143.1834      146.6452
 ADF(4)     -2.0130      155.9866      148.9866      142.5111      146.5498
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable DLCGR
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -2.8428      145.9983      143.9983      142.1696      143.3133
 ADF(1)     -3.3754      147.6216      144.6216      141.8787      143.5941
 ADF(2)     -3.2297      147.7896      143.7896      140.1323      142.4195
 ADF(3)     -4.2316      151.2984      146.2984      141.7268      144.5858
 ADF(4)     -2.8481      152.5059      146.5059      141.0199      144.4508
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable DLCGR
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -2.8181      146.0300      143.0300      140.2871      142.0025
 ADF(1)     -3.3650      147.7157      143.7157      140.0585      142.3457
 ADF(2)     -3.2281      147.9049      142.9049      138.3333      141.1924
 ADF(3)     -4.2149      151.4347      145.4347      139.9488      143.3797
 ADF(4)     -2.8714      152.7035      145.7035      139.3032      143.3059
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

Unit root tests for variable LCPR

The Dickey-Fuller regressions include an intercept but not a trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	.94696	134.7768	132.7768	130.9267	132.0806
ADF(1)	-1.5122	179.3182	176.3182	173.5430	175.2739
ADF(2)	.23142	203.2266	199.2266	195.5263	197.8341
ADF(3)	-.021074	204.3375	199.3375	194.7121	197.5969
ADF(4)	.22776	205.1952	199.1952	193.6447	197.1065

95% critical value for the augmented Dickey-Fuller statistic = -2.9241
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LCPR

The Dickey-Fuller regressions include an intercept and a linear trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-.43340	135.4975	132.4975	129.7223	131.4532
ADF(1)	-4.4108	187.2130	183.2130	179.5127	181.8206
ADF(2)	-1.2549	204.5691	199.5691	194.9437	197.8285
ADF(3)	-1.7200	206.4203	200.4203	194.8698	198.3316
ADF(4)	-1.3680	206.7723	199.7723	193.2968	197.3355

95% critical value for the augmented Dickey-Fuller statistic = -3.5066
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLCPR

The Dickey-Fuller regressions include an intercept but not a trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.5536	173.9893	171.9893	170.1606	171.3042
ADF(1)	-4.2489	198.7784	195.7784	193.0355	194.7509
ADF(2)	-2.9459	199.7659	195.7659	192.1086	194.3959
ADF(3)	-3.1834	200.5262	195.5262	190.9546	193.8137
ADF(4)	-1.9061	205.0389	199.0389	193.5530	196.9839

95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLCPR

The Dickey-Fuller regressions include an intercept and a linear trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.7250	174.4691	171.4691	168.7261	170.4416
ADF(1)	-4.4507	199.6431	195.6431	191.9858	194.2730
ADF(2)	-3.1430	200.4981	195.4981	190.9265	193.7856
ADF(3)	-3.3892	201.3398	195.3398	189.8539	193.2847
ADF(4)	-2.1139	205.7301	198.7301	192.3299	196.3326

95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LVATIMBR
The Dickey-Fuller regressions include an intercept but not a trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-.12165	69.3988	67.3988	65.5486	66.7025
ADF(1)	-3.8528	120.4976	117.4976	114.7224	116.4533
ADF(2)	-1.1448	135.3864	131.3864	127.6861	129.9940
ADF(3)	-1.1455	135.4124	130.4124	125.7871	128.6719
ADF(4)	-.87461	135.6488	129.6488	124.0983	127.5601

95% critical value for the augmented Dickey-Fuller statistic = -2.9241
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LVATIMBR
The Dickey-Fuller regressions include an intercept and a linear trend

47 observations used in the estimation of all ADF regressions.
Sample period from 1994Q4 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-.74415	71.7233	68.7233	65.9480	67.6789
ADF(1)	-4.3951	122.7543	118.7543	115.0540	117.3619
ADF(2)	-1.7066	137.5644	132.5644	127.9390	130.8238
ADF(3)	-1.6549	137.5719	131.5719	126.0214	129.4832
ADF(4)	-1.3392	137.9529	130.9529	124.4774	128.5162

95% critical value for the augmented Dickey-Fuller statistic = -3.5066
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLVIMBR
The Dickey-Fuller regressions include an intercept but not a trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.4661	111.0270	109.0270	107.1984	108.3420
ADF(1)	-3.7003	131.3263	128.3263	125.5833	127.2988
ADF(2)	-3.2652	131.3389	127.3389	123.6816	125.9689
ADF(3)	-3.3613	131.8554	126.8554	122.2838	125.1429
ADF(4)	-1.9991	135.9831	129.9831	124.4972	127.9281

95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLVIMBR
The Dickey-Fuller regressions include an intercept and a linear trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.7222	111.6475	108.6475	105.9045	107.6199
ADF(1)	-4.0896	132.7749	128.7749	125.1176	127.4049
ADF(2)	-3.7262	132.9225	127.9225	123.3509	126.2099
ADF(3)	-3.9321	133.8557	127.8557	122.3698	125.8006
ADF(4)	-2.4799	137.3022	130.3022	123.9020	127.9047

95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

10. LVATIMBR

```
                      Unit root tests for variable LVATIMBR
      The Dickey-Fuller regressions include an intercept but not a trend
******************************************************************************
 51 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q2 to 2006Q4
******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -.77177       53.4310       51.4310       49.4992       50.6928
 ADF(1)     -1.0956        54.6776       51.6776       48.7799       50.5703
 ADF(2)     -1.7143        57.8350       53.8350       49.9713       52.3585
 ADF(3)     -1.8912        58.2619       53.2619       48.4323       51.4163
 ADF(4)     -2.1070        58.8181       52.8181       47.0227       50.6035
******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9190
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable LVATIMBR
     The Dickey-Fuller regressions include an intercept and a linear trend
******************************************************************************
 51 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q2 to 2006Q4
******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -1.1142        54.1793       51.1793       48.2815       50.0720
 ADF(1)     -1.3628        55.2885       51.2885       47.4248       49.8121
 ADF(2)     -1.9245        58.3853       53.3853       48.5558       51.5398
 ADF(3)     -2.0994        58.8486       52.8486       47.0531       50.6340
 ADF(4)     -2.3235        59.4767       52.4767       45.7153       49.8930
******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.4987
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable DLVATIMBR
      The Dickey-Fuller regressions include an intercept but not a trend
******************************************************************************
 50 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q3 to 2006Q4
******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -5.7021        52.7329       50.7329       48.8209       50.0048
 ADF(1)     -3.2404        54.8760       51.8760       49.0080       50.7839
 ADF(2)     -2.7685        54.9312       50.9312       47.1071       49.4750
 ADF(3)     -2.4206        54.9891       49.9891       45.2091       48.1689
 ADF(4)     -2.7774        56.0915       50.0915       44.3554       47.9071
******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9202
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable DLVATIMBR
     The Dickey-Fuller regressions include an intercept and a linear trend
******************************************************************************
 50 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q3 to 2006Q4
******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -5.7554        53.1378       50.1378       47.2697       49.0456
 ADF(1)     -3.2823        55.0959       51.0959       47.2718       49.6397
 ADF(2)     -2.8166        55.1378       50.1378       45.3578       48.3176
 ADF(3)     -2.4733        55.1854       49.1854       43.4494       47.0011
 ADF(4)     -2.8409        56.3549       49.3549       42.6628       46.8065
******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5005
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

Unit root tests for variable LIMRG

The Dickey-Fuller regressions include an intercept but not a trend

51 observations used in the estimation of all ADF regressions.
Sample period from 1994Q2 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-.92796	62.1843	60.1843	58.2525	59.4461
ADF(1)	-1.1702	62.9550	59.9550	57.0572	58.8477
ADF(2)	-1.1507	62.9602	58.9602	55.0966	57.4838
ADF(3)	-1.3214	63.4623	58.4623	53.6327	56.6168
ADF(4)	-1.5795	64.2954	58.2954	52.4999	56.0808

95% critical value for the augmented Dickey-Fuller statistic = -2.9190
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LIMRG

The Dickey-Fuller regressions include an intercept and a linear trend

51 observations used in the estimation of all ADF regressions.
Sample period from 1994Q2 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.5048	62.9605	59.9605	57.0628	58.8532
ADF(1)	-1.7730	63.9145	59.9145	56.0508	58.4380
ADF(2)	-1.7713	63.9619	58.9619	54.1323	57.1164
ADF(3)	-2.0313	64.7739	58.7739	52.9784	56.5593
ADF(4)	-2.4394	66.1740	59.1740	52.4127	56.5903

95% critical value for the augmented Dickey-Fuller statistic = -3.4987
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLIMRG

The Dickey-Fuller regressions include an intercept but not a trend

50 observations used in the estimation of all ADF regressions.
Sample period from 1994Q3 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-5.9781	60.6883	58.6883	56.7762	57.9602
ADF(1)	-4.6127	60.7160	57.7160	54.8480	56.6238
ADF(2)	-3.4478	60.9688	56.9688	53.1447	55.5125
ADF(3)	-2.6916	61.3774	56.3774	51.5974	54.5571
ADF(4)	-2.3359	61.4634	55.4634	49.7273	53.2790

95% critical value for the augmented Dickey-Fuller statistic = -2.9202
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLIMRG

The Dickey-Fuller regressions include an intercept and a linear trend

50 observations used in the estimation of all ADF regressions.
Sample period from 1994Q3 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-5.9344	60.7591	57.7591	54.8910	56.6669
ADF(1)	-4.5849	60.7941	56.7941	52.9700	55.3378
ADF(2)	-3.4341	61.0411	56.0411	51.2611	54.2209
ADF(3)	-2.6857	61.4427	55.4427	49.7066	53.2583
ADF(4)	-2.3333	61.5242	54.5242	47.8321	51.9758

95% critical value for the augmented Dickey-Fuller statistic = -3.5005
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LIMGPI
The Dickey-Fuller regressions include an intercept but not a trend

51 observations used in the estimation of all ADF regressions.
Sample period from 1994Q2 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.5083	65.6571	63.6571	61.7253	62.9189
ADF(1)	-1.5539	65.8815	62.8815	59.9838	61.7742
ADF(2)	-1.5620	65.9267	61.9267	58.0630	60.4503
ADF(3)	-1.3070	68.1903	63.1903	58.3607	61.3448
ADF(4)	-1.2950	68.1948	62.1948	56.3994	59.9802

95% critical value for the augmented Dickey-Fuller statistic = -2.9190
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable LIMGPI
The Dickey-Fuller regressions include an intercept and a linear trend

51 observations used in the estimation of all ADF regressions.
Sample period from 1994Q2 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.5137	67.8020	64.8020	61.9043	63.6947
ADF(1)	-2.8630	68.8663	64.8663	61.0027	63.3899
ADF(2)	-3.1489	69.7489	64.7489	59.9193	62.9034
ADF(3)	-2.3911	70.4783	64.4783	58.6829	62.2637
ADF(4)	-2.4991	70.8145	63.8145	57.0531	61.2307

95% critical value for the augmented Dickey-Fuller statistic = -3.4987
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLIMGPI
The Dickey-Fuller regressions include an intercept but not a trend

50 observations used in the estimation of all ADF regressions.
Sample period from 1994Q3 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-6.4181	62.8719	60.8719	58.9599	60.1438
ADF(1)	-4.5760	62.8781	59.8781	57.0101	58.7859
ADF(2)	-5.2015	65.4493	61.4493	57.6253	59.9931
ADF(3)	-4.0839	65.4506	60.4506	55.6706	58.6303
ADF(4)	-3.7730	65.6747	59.6747	53.9386	57.4904

95% critical value for the augmented Dickey-Fuller statistic = -2.9202
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DLIMGPI
The Dickey-Fuller regressions include an intercept and a linear trend

50 observations used in the estimation of all ADF regressions.
Sample period from 1994Q3 to 2006Q4

	Test Statistic	LL	AIC	SBC	HQC
DF	-6.3853	63.0027	60.0027	57.1347	58.9106
ADF(1)	-4.5617	63.0068	59.0068	55.1827	57.5506
ADF(2)	-5.1930	65.6357	60.6357	55.8557	58.8155
ADF(3)	-4.0816	65.6372	59.6372	53.9011	57.4529
ADF(4)	-3.7679	65.8609	58.8609	52.1688	56.3125

95% critical value for the augmented Dickey-Fuller statistic = -3.5005
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

11. LSBT

```
Unit root tests for variable LSBT
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -.28560       59.5945       57.5945       55.7443       56.8982
 ADF(1)      -2.9705      105.7788      102.7788      100.0036      101.7345
 ADF(2)      -1.1910      116.6944      112.6944      108.9941      111.3020
 ADF(3)      -2.0455      122.3438      117.3438      112.7184      115.6033
 ADF(4)      -2.1870      122.7100      116.7100      111.1596      114.6214
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable LSBT
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF           .50248       60.9427       57.9427       55.1675       56.8984
 ADF(1)      -2.6841      105.8266      101.8266       98.1263      100.4341
 ADF(2)      -.73770      116.8401      111.8401      107.2148      110.0996
 ADF(3)      -1.6737      122.3452      116.3452      110.7948      114.2566
 ADF(4)      -1.8392      122.7132      115.7132      109.2377      113.2764
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable DLSBT
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -1.5736       98.8536       96.8536       95.0249       96.1686
 ADF(1)      -3.2260      112.9892      109.9892      107.2463      108.9617
 ADF(2)      -1.9222      117.0641      113.0641      109.4068      111.6941
 ADF(3)      -1.8139      117.0686      112.0686      107.4970      110.3561
 ADF(4)      -1.2619      119.9208      113.9208      108.4349      111.8657
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable DLSBT
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -1.8216       99.6856       96.6856       93.9426       95.6580
 ADF(1)      -3.4034      113.7044      109.7044      106.0471      108.3343
 ADF(2)      -2.1137      117.7661      112.7661      108.1945      111.0535
 ADF(3)      -1.9887      117.7823      111.7823      106.2964      109.7272
 ADF(4)      -1.4681      120.9826      113.9826      107.5824      111.5851
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

```
                     Unit root tests for variable LFIR
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q2 to 2006Q4
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -.63281       56.0722       54.0722       52.2220       53.3760
 ADF(1)     -1.6783       76.3052       73.3052       70.5300       72.2608
 ADF(2)     -1.6782       76.3477       72.3477       68.6474       70.9553
 ADF(3)     -1.8119       76.6730       71.6730       67.0476       69.9324
 ADF(4)     -1.4676       77.1634       71.1634       65.6129       69.0747
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable LFIR
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q2 to 2006Q4
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -.67186       56.1428       53.1428       50.3676       52.0985
 ADF(1)     -1.9708       77.0636       73.0636       69.3633       71.6711
 ADF(2)     -2.0096       77.1921       72.1921       67.5668       70.4516
 ADF(3)     -2.1319       77.5936       71.5936       66.0432       69.5050
 ADF(4)     -1.9293       78.1118       71.1118       64.6363       68.6750
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable DLFIR
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q3 to 2006Q4
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -3.1010       73.6104       71.6104       69.7817       70.9254
 ADF(1)     -2.9495       73.6223       70.6223       67.8793       69.5947
 ADF(2)     -2.6933       73.6427       69.6427       65.9854       68.2726
 ADF(3)     -3.0735       74.9806       69.9806       65.4090       68.2680
 ADF(4)     -3.0306       75.1003       69.1003       63.6144       67.0453
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable DLFIR
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q3 to 2006Q4
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -3.1304       74.0886       71.0886       68.3456       70.0610
 ADF(1)     -2.9474       74.0903       70.0903       66.4330       68.7203
 ADF(2)     -2.6393       74.1568       69.1568       64.5852       67.4442
 ADF(3)     -2.9615       75.2331       69.2331       63.7471       67.1780
 ADF(4)     -2.8568       75.2916       68.2916       61.8913       65.8940
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

```
                 Unit root tests for variable LGDPR
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF          1.2223      138.3942     136.3942     134.5441     135.6980
 ADF(1)     -.88390      180.0050     177.0050     174.2298     175.9607
 ADF(2)      .56158      199.7333     195.7333     192.0330     194.3409
 ADF(3)      .18357      203.6201     198.6201     193.9948     196.8796
 ADF(4)      .34730      205.2041     199.2041     193.6537     197.1154
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9241
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                 Unit root tests for variable LGDPR
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 47 observations used in the estimation of all ADF regressions.
 Sample period from 1994Q4 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF         -.13001      138.8691     135.8691     133.0938     134.8247
 ADF(1)     -3.7312      186.8259     182.8259     179.1256     181.4334
 ADF(2)     -1.1209      201.1179     196.1179     191.4926     194.3774
 ADF(3)     -2.1020      206.9255     200.9255     195.3751     198.8369
 ADF(4)     -1.6097      207.3739     200.3739     193.8984     197.9372
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5066
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                 Unit root tests for variable DLGDPR
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF         -1.7652      175.6712     173.6712     171.8426     172.9862
 ADF(1)     -3.9681      194.9744     191.9744     189.2314     190.9469
 ADF(2)     -2.3087      198.7755     194.7755     191.1182     193.4055
 ADF(3)     -2.7256      200.3237     195.3237     190.7521     193.6112
 ADF(4)     -2.5354      200.3290     194.3290     188.8431     192.2739
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                 Unit root tests for variable DLGDPR
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF         -2.0616      176.7331     173.7331     170.9901     172.7055
 ADF(1)     -4.2475      196.1647     192.1647     188.5074     190.7947
 ADF(2)     -2.5726      199.7521     194.7521     190.1805     193.0395
 ADF(3)     -2.9615      201.2778     195.2778     189.7918     193.2227
 ADF(4)     -2.7508      201.2970     194.2970     187.8967     191.8994
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

12. GY

```
Unit root tests for variable GY
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF          -1.7645      175.9416     173.9416     172.1130     173.2566
 ADF(1)      -3.8854      194.6700     191.6700     188.9270     190.6424
 ADF(2)      -2.3120      198.1128     194.1128     190.4555     192.7427
 ADF(3)      -2.6995      199.5052     194.5052     189.9336     192.7927
 ADF(4)      -2.5053      199.5142     193.5142     188.0283     191.4591
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable GY
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF          -2.0942      177.0892     174.0892     171.3462     173.0617
 ADF(1)      -4.1976      195.9585     191.9585     188.3012     190.5884
 ADF(2)      -2.6035      199.1507     194.1507     189.5791     192.4381
 ADF(3)      -2.9660      200.5371     194.5371     189.0512     192.4820
 ADF(4)      -2.7525      200.5632     193.5632     187.1629     191.1656
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

Unit root tests for variable DGY
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 45 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q2 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF          -2.9351      183.2719     181.2719     179.4653     180.5984
 ADF(1)      -4.7582      190.6172     187.6172     184.9072     186.6070
 ADF(2)      -3.3471      190.9965     186.9965     183.3832     185.6495
 ADF(3)      -3.3524      191.4035     186.4035     181.8868     184.7197
 ADF(4)      -2.6094      191.7058     185.7058     180.2858     183.6853
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9271
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                      Unit root tests for variable DGY
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 45 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q2 to 2006Q2
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF          -2.9384      183.3701     180.3701     177.6601     179.3598
 ADF(1)      -4.7839      190.8964     186.8964     183.2830     185.5494
 ADF(2)      -3.3889      191.2462     186.2462     181.7296     184.5625
 ADF(3)      -3.4167      191.7288     185.7288     180.3088     183.7083
 ADF(4)      -2.6699      191.9537     184.9537     178.6304     182.5964
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5112
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

```
                              Unit root tests for variable GL
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -2.6561      230.8544      228.8544      227.0257      228.1694
 ADF(1)      -4.7016      240.0961      237.0961      234.3532      236.0686
 ADF(2)      -2.7131      243.4549      239.4549      235.7976      238.0848
 ADF(3)      -2.3933      243.5586      238.5586      233.9870      236.8460
 ADF(4)      -1.9528      247.2342      241.2342      235.7483      239.1791
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9256
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable GL
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 46 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q1 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -2.7813      231.3209      228.3209      225.5779      227.2934
 ADF(1)      -5.6644      243.6587      239.6587      236.0014      238.2886
 ADF(2)      -3.1282      244.8646      239.8646      235.2930      238.1521
 ADF(3)      -2.7853      244.9544      238.9544      233.4685      236.8994
 ADF(4)      -1.5190      247.3740      240.3740      233.9738      237.9765
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5088
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                              Unit root tests for variable DGL
     The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 45 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q2 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -4.4852      225.0570      223.0570      221.2503      222.3835
 ADF(1)      -7.1614      234.4963      231.4963      228.7863      230.4860
 ADF(2)      -5.8429      235.3334      231.3334      227.7201      229.9864
 ADF(3)      -7.1313      241.0328      236.0328      231.5161      234.3490
 ADF(4)      -4.2633      241.7119      235.7119      230.2919      233.6914
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9271
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion

                     Unit root tests for variable DGL
    The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 45 observations used in the estimation of all ADF regressions.
 Sample period from 1995Q2 to 2006Q2
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF          -4.4436      225.0987      222.0987      219.3887      221.0885
 ADF(1)      -7.0977      234.5794      230.5794      226.9661      229.2324
 ADF(2)      -5.8173      235.4992      230.4992      225.9825      228.8154
 ADF(3)      -7.1762      241.5157      235.5157      230.0957      233.4952
 ADF(4)      -4.2681      241.9908      234.9908      228.6675      232.6336
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.5112
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```

Unit root tests for variable RIPR

The Dickey-Fuller regressions include an intercept but not a trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.8285	147.1449	145.1449	143.3163	144.4599
ADF(1)	-4.3871	201.9982	198.9982	196.2553	197.9707
ADF(2)	-2.3522	208.6263	204.6263	200.9690	203.2563
ADF(3)	-2.2269	208.7659	203.7659	199.1943	202.0534
ADF(4)	-2.1798	209.8216	203.8216	198.3357	201.7665

95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood   AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion   HQC = Hannan-Quinn Criterion

Unit root tests for variable RIPR

The Dickey-Fuller regressions include an intercept and a linear trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-.72317	150.8308	147.8308	145.0879	146.8033
ADF(1)	-4.2273	202.7031	198.7031	195.0458	197.3331
ADF(2)	-1.9206	208.6468	203.6468	199.0752	201.9343
ADF(3)	-1.6633	208.7669	202.7669	197.2810	200.7118
ADF(4)	-1.2585	209.9264	202.9264	196.5262	200.5289

95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood   AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion   HQC = Hannan-Quinn Criterion

Unit root tests for variable DRIPR

The Dickey-Fuller regressions include an intercept but not a trend

45 observations used in the estimation of all ADF regressions.
Sample period from 1995Q2 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.0787	190.4020	188.4020	186.5954	187.7285
ADF(1)	-2.1533	201.2120	198.2120	195.5020	197.2017
ADF(2)	-2.4146	201.9362	197.9362	194.3229	196.5892
ADF(3)	-2.9225	203.5462	198.5462	194.0296	196.8625
ADF(4)	-1.9310	206.0559	200.0559	194.6359	198.0353

95% critical value for the augmented Dickey-Fuller statistic = -2.9271
LL = Maximized log-likelihood   AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion   HQC = Hannan-Quinn Criterion

Unit root tests for variable DRIPR

The Dickey-Fuller regressions include an intercept and a linear trend

45 observations used in the estimation of all ADF regressions.
Sample period from 1995Q2 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.3798	190.8155	187.8155	185.1055	186.8052
ADF(1)	-2.3840	201.8031	197.8031	194.1898	196.4561
ADF(2)	-2.6386	202.5969	197.5969	193.0802	195.9131
ADF(3)	-3.2649	204.6830	198.6830	193.2630	196.6625
ADF(4)	-2.1086	206.5550	199.5550	193.2317	197.1978

95% critical value for the augmented Dickey-Fuller statistic = -3.5112
LL = Maximized log-likelihood   AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion   HQC = Hannan-Quinn Criterion

Unit root tests for variable RIGR
The Dickey-Fuller regressions include an intercept but not a trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-.27854	204.0446	202.0446	200.2160	201.3596
ADF(1)	-1.2690	221.6232	218.6232	215.8802	217.5956
ADF(2)	-.71377	224.8492	220.8492	217.1919	219.4792
ADF(3)	-.83371	225.1765	220.1765	215.6049	218.4639
ADF(4)	-.63931	225.6399	219.6399	214.1540	217.5848

95% critical value for the augmented Dickey-Fuller statistic = -2.9256
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable RIGR
The Dickey-Fuller regressions include an intercept and a linear trend

46 observations used in the estimation of all ADF regressions.
Sample period from 1995Q1 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-1.5490	205.3708	202.3708	199.6279	201.3433
ADF(1)	-2.8833	224.9315	220.9315	217.2742	219.5614
ADF(2)	-2.2276	227.2446	222.2446	217.6730	220.5320
ADF(3)	-2.4126	227.9433	221.9433	216.4573	219.8882
ADF(4)	-2.1956	228.1524	221.1524	214.7522	218.7549

95% critical value for the augmented Dickey-Fuller statistic = -3.5088
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DRIGR
The Dickey-Fuller regressions include an intercept but not a trend

45 observations used in the estimation of all ADF regressions.
Sample period from 1995Q2 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.6908	215.4906	213.4906	211.6839	212.8171
ADF(1)	-3.7241	219.3298	216.3298	213.6198	215.3196
ADF(2)	-2.9158	219.5938	215.5938	211.9805	214.2468
ADF(3)	-3.1057	220.2341	215.2341	210.7174	213.5503
ADF(4)	-2.1920	221.5421	215.5421	210.1221	213.5216

95% critical value for the augmented Dickey-Fuller statistic = -2.9271
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DRIGR
The Dickey-Fuller regressions include an intercept and a linear trend

45 observations used in the estimation of all ADF regressions.
Sample period from 1995Q2 to 2006Q2

	Test Statistic	LL	AIC	SBC	HQC
DF	-2.6474	215.4917	212.4917	209.7817	211.4814
ADF(1)	-3.6789	219.3462	215.3462	211.7328	213.9992
ADF(2)	-2.8595	219.5978	214.5978	210.0812	212.9140
ADF(3)	-3.0525	220.2545	214.2545	208.8346	212.2340
ADF(4)	-2.1180	221.5422	214.5422	208.2189	212.1849

95% critical value for the augmented Dickey-Fuller statistic = -3.5112
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Appendix D: Cointegration Tests

1. LPIT1WR

```
              Cointegration with unrestricted intercepts and no trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LPIT1WR        LGDPR
 List of eigenvalues in descending order:
.12290    .062726
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1         6.2946           14.8800                12.9800
 r<= 1      r = 2         3.1094            8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).
```

```
      Cointegration with unrestricted intercepts and no trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LPIT1WR        LGDPR
 List of eigenvalues in descending order:
.12290    .062726
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1         9.4040           17.8600                15.7500
 r<= 1      r = 2         3.1094            8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).
```

```
      Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LPIT1WR        LGDPR
 List of eigenvalues in descending order:
.12290    .062726
*******************************************************************************
 Rank      Maximized LL        AIC            SBC            HQC
 r = 0       378.4108       364.4108       351.3124       359.4609
 r = 1       381.5581       364.5581       348.6529       358.5475
 r = 2       383.1128       365.1128       348.2720       358.7487
*******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

2. LPIT2I

```
Cointegration with unrestricted intercepts and no trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LPIT2I        LTR
 List of eigenvalues in descending order:
.16517    .013756
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1         8.6655           14.8800                12.9800
 r<= 1      r = 2         .66489            8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

      Cointegration with unrestricted intercepts and no trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LPIT2I        LTR
 List of eigenvalues in descending order:
.16517    .013756
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1         9.3304           17.8600                15.7500
 r<= 1      r = 2         .66489            8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

      Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LPIT2I        LTR
 List of eigenvalues in descending order:
.16517    .013756
*******************************************************************************
 Rank      Maximized LL        AIC            SBC            HQC
 r = 0       241.9759       227.9759       214.8775       223.0260
 r = 1       246.3087       229.3087       213.4035       223.2981
 r = 2       246.6411       228.6411       211.8003       222.2769
*******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

3. LPIT4OR

Cointegration with unrestricted intercepts and no trends in the VAR
Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
****
46 observations from 1995Q1 to 2006Q2. Order of VAR = 4.
List of variables included in the cointegrating vector:
LPIT4OR LCGR GLOAN
List of I(0) variables included in the VAR:
D
List of eigenvalues in descending order:
.49015 .39675 .045007
****

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	30.9876	21.1200	19.0200
r<= 1	r = 2	23.2495	14.8800	12.9800
r<= 2	r = 3	2.1184	8.0700	6.5000

****
Use the above table to determine r (the number of cointegrating vectors).

Cointegration with unrestricted intercepts and no trends in the VAR
Cointegration LR Test Based on Trace of the Stochastic Matrix
****
46 observations from 1995Q1 to 2006Q2. Order of VAR = 4.
List of variables included in the cointegrating vector:
LPIT4OR LCGR GLOAN
List of I(0) variables included in the VAR:
D
List of eigenvalues in descending order:
.49015 .39675 .045007
****

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	56.3555	31.5400	28.7800
r<= 1	r>= 2	25.3679	17.8600	15.7500
r<= 2	r = 3	2.1184	8.0700	6.5000

****
Use the above table to determine r (the number of cointegrating vectors).

Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
****
46 observations from 1995Q1 to 2006Q2. Order of VAR = 4.
List of variables included in the cointegrating vector:
LPIT4OR LCGR GLOAN
List of I(0) variables included in the VAR:
D
List of eigenvalues in descending order:
.49015 .39675 .045007
****

Rank	Maximized LL	AIC	SBC	HQC
r = 0	392.6384	359.6384	329.4658	348.3356
r = 1	408.1322	370.1322	335.3880	357.1168
r = 2	419.7570	378.7570	341.2698	364.7141
r = 3	420.8162	378.8162	340.4147	364.4308

****
AIC = Akaike Information Criterion SBC = Schwarz Bayesian Criterion
HQC = Hannan-Quinn Criterion

4. LCIT1AR

```
Cointegration with unrestricted intercepts and no trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT1AR        LCIT1HR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.32177    .038317
******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1        18.6369           14.8800                12.9800
 r<= 1      r = 2         1.8754            8.0700                 6.5000
******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).
```

```
      Cointegration with unrestricted intercepts and no trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT1AR        LCIT1HR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.32177    .038317
******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1        20.5123           17.8600                15.7500
 r<= 1      r = 2         1.8754            8.0700                 6.5000
******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).
```

```
      Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT1AR        LCIT1HR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.32177    .038317
******************************************************************************
 Rank      Maximized LL        AIC           SBC           HQC
 r = 0       136.7141        120.7141      105.7445      115.0570
 r = 1       146.0325        127.0325      109.2561      120.3148
 r = 2       146.9702        126.9702      108.2582      119.8989
******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

5. LCIT2FR

```
Cointegration with unrestricted intercepts and no trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT2FR        LGDPR
 List of eigenvalues in descending order:
.22075   .0026808
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1        11.9722           14.8800                12.9800
 r<= 1      r = 2         .12885            8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

      Cointegration with unrestricted intercepts and no trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT2FR        LGDPR
 List of eigenvalues in descending order:
.22075   .0026808
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1        12.1011           17.8600                15.7500
 r<= 1      r = 2         .12885            8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

      Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT2FR        LGDPR
 List of eigenvalues in descending order:
.22075   .0026808
*******************************************************************************
 Rank      Maximized LL        AIC             SBC             HQC
 r = 0       335.5007        321.5007        308.4023        316.5508
 r = 1       341.4868        324.4868        308.5816        318.4762
 r = 2       341.5513        323.5513        306.7105        317.1871
*******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

6. LCIT3WR

```
Cointegration with unrestricted intercepts and no trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT3WR        LGDPR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.19660    .010612
******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1        10.5074           14.8800                12.9800
 r<= 1      r = 2         .51211            8.0700                 6.5000
******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).
```

```
      Cointegration with unrestricted intercepts and no trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT3WR        LGDPR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.19660    .010612
******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1        11.0195           17.8600                15.7500
 r<= 1      r = 2         .51211            8.0700                 6.5000
******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).
```

```
      Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT3WR        LGDPR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.19660    .010612
******************************************************************************
 Rank      Maximized LL        AIC             SBC             HQC
 r = 0       372.7504        356.7504        341.7808        351.0934
 r = 1       378.0041        359.0041        341.2277        352.2864
 r = 2       378.2602        358.2602        339.5482        351.1889
******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

7. LCIT4OR

```
Cointegration with unrestricted intercepts and no trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
*******************************************************************************
 46 observations from 1995Q1 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT4OR        LIGR         GLOAN
 List of eigenvalues in descending order:
.47763     .27358     .13032
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1        29.8716           21.1200                19.0200
 r<= 1      r = 2        14.7029           14.8800                12.9800
 r<= 2      r = 3         6.4230            8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

      Cointegration with unrestricted intercepts and no trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
*******************************************************************************
 46 observations from 1995Q1 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT4OR        LIGR         GLOAN
 List of eigenvalues in descending order:
.47763     .27358     .13032
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1        50.9976           31.5400                28.7800
 r<= 1      r>= 2        21.1260           17.8600                15.7500
 r<= 2      r = 3         6.4230            8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).


      Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
*******************************************************************************
 46 observations from 1995Q1 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LCIT4OR        LIGR         GLOAN
 List of eigenvalues in descending order:
.47763     .27358     .13032
*******************************************************************************
 Rank      Maximized LL        AIC            SBC            HQC
 r = 0       331.9911        301.9911       274.5614       291.7158
 r = 1       346.9269        311.9269       279.9256       299.9390
 r = 2       354.2783        316.2783       281.5341       303.2630
 r = 3       357.4899        318.4899       282.8313       305.1320
*******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

8. LPTR

```
Cointegration with unrestricted intercepts and no trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
*******************************************************************************
 40 observations from 1997Q1 to 2006Q4. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LPTR           LGDPR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.28370    .034729
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1        13.3460           14.8800               12.9800
 r<= 1      r = 2         1.4139            8.0700                6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

      Cointegration with unrestricted intercepts and no trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
*******************************************************************************
 40 observations from 1997Q1 to 2006Q4. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LPTR           LGDPR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.28370    .034729
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1        14.7599           17.8600               15.7500
 r<= 1      r = 2         1.4139            8.0700                6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

      Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
*******************************************************************************
 40 observations from 1997Q1 to 2006Q4. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LPTR           LGDPR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.28370    .034729
*******************************************************************************
 Rank      Maximized LL        AIC            SBC            HQC
 r = 0       10.2571         -5.7429       -19.2540       -10.6281
 r = 1       16.9301         -2.0699       -18.1143        -7.8711
 r = 2       17.6370         -2.3630       -19.2518        -8.4694
*******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

9. LVATDBR

```
Cointegration with unrestricted intercepts and no trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LVATDBR        LCPR         LCGR         LVATIMBR
 List of eigenvalues in descending order:
.58486     .40752     .21092   .6397E-3
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1        42.1989           27.4200                24.9900
 r<= 1      r = 2        25.1248           21.1200                19.0200
 r<= 2      r = 3        11.3705           14.8800                12.9800
 r<= 3      r = 4        .030715            8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

      Cointegration with unrestricted intercepts and no trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LVATDBR        LCPR         LCGR         LVATIMBR
 List of eigenvalues in descending order:
.58486     .40752     .21092   .6397E-3
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1        78.7249           48.8800                45.7000
 r<= 1      r>= 2        36.5260           31.5400                28.7800
 r<= 2      r>= 3        11.4012           17.8600                15.7500
 r<= 3      r = 4        .030715            8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

      Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
*******************************************************************************
 48 observations from 1994Q3 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LVATDBR        LCPR         LCGR         LVATIMBR
 List of eigenvalues in descending order:
.58486     .40752     .21092   .6397E-3
*******************************************************************************
 Rank      Maximized LL        AIC            SBC            HQC
 r = 0       697.8069       645.8069       597.1557       627.4215
 r = 1       718.9064       659.9064       604.7059       639.0460
 r = 2       731.4688       667.4688       607.5903       644.8406
 r = 3       737.1540       670.1540       607.4688       646.4652
 r = 4       737.1694       669.1694       605.5485       645.1270
*******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

10. LVATIMBR

```
Cointegration with unrestricted intercepts and restricted trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
*******************************************************************************
 52 observations from 1994Q1 to 2006Q4. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LVATIMBR        LIMRG           LIMGPI          Trend
 List of eigenvalues in descending order:
.35037     .24594    .091548      .0000
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1        22.4307           25.4200                23.1000
 r<= 1      r = 2        14.6791           19.2200                17.1800
 r<= 2      r = 3         4.9927           12.3900                10.5500
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

  Cointegration with unrestricted intercepts and restricted trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
*******************************************************************************
 52 observations from 1994Q1 to 2006Q4. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LVATIMBR        LIMRG           LIMGPI          Trend
 List of eigenvalues in descending order:
.35037     .24594    .091548      .0000
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1        42.1024           42.3400                39.3400
 r<= 1      r>= 2        19.6717           25.7700                23.0800
 r<= 2      r = 3         4.9927           12.3900                10.5500
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

  Cointegration with unrestricted intercepts and restricted trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
*******************************************************************************
 52 observations from 1994Q1 to 2006Q4. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 LVATIMBR        LIMRG           LIMGPI          Trend
 List of eigenvalues in descending order:
.35037     .24594    .091548      .0000
*******************************************************************************
 Rank      Maximized LL        AIC             SBC             HQC
 r = 0       244.4189        214.4189        185.1502        203.1980
 r = 1       255.6342        219.6342        184.5118        206.1691
 r = 2       262.9738        222.9738        183.9489        208.0126
 r = 3       265.4701        223.4701        182.4940        207.7608
*******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

11. LSBT

Cointegration with unrestricted intercepts and no trends in the VAR
Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

46 observations from 1995Q1 to 2006Q2. Order of VAR = 4.
List of variables included in the cointegrating vector:
LSBT LFIR LGDPR
List of eigenvalues in descending order:
.45630 .15812 .038697

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	28.0305	21.1200	19.0200
r<= 1	r = 2	7.9174	14.8800	12.9800
r<= 2	r = 3	1.8154	8.0700	6.5000

Use the above table to determine r (the number of cointegrating vectors).

Cointegration with unrestricted intercepts and no trends in the VAR
Cointegration LR Test Based on Trace of the Stochastic Matrix

46 observations from 1995Q1 to 2006Q2. Order of VAR = 4.
List of variables included in the cointegrating vector:
LSBT LFIR LGDPR
List of eigenvalues in descending order:
.45630 .15812 .038697

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	37.7633	31.5400	28.7800
r<= 1	r>= 2	9.7327	17.8600	15.7500
r<= 2	r = 3	1.8154	8.0700	6.5000

Use the above table to determine r (the number of cointegrating vectors).

Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria

46 observations from 1995Q1 to 2006Q2. Order of VAR = 4.
List of variables included in the cointegrating vector:
LSBT LFIR LGDPR
List of eigenvalues in descending order:
.45630 .15812 .038697

Rank	Maximized LL	AIC	SBC	HQC
r = 0	410.5688	380.5688	353.1392	370.2935
r = 1	424.5841	389.5841	357.5828	377.5962
r = 2	428.5427	390.5427	355.7985	377.5274
r = 3	429.4504	390.4504	354.7919	377.0925

AIC = Akaike Information Criterion SBC = Schwarz Bayesian Criterion
HQC = Hannan-Quinn Criterion

12. GY

```
Cointegration with unrestricted intercepts and no trends in the VAR
   Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix
*******************************************************************************
 47 observations from 1994Q4 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 GY           GL           RIPR         RIGR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.57217     .38850     .12014    .054689
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r = 1        39.9046          27.4200                24.9900
 r<= 1      r = 2        23.1169          21.1200                19.0200
 r<= 2      r = 3         6.0156          14.8800                12.9800
 r<= 3      r = 4         2.6433           8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

      Cointegration with unrestricted intercepts and no trends in the VAR
          Cointegration LR Test Based on Trace of the Stochastic Matrix
*******************************************************************************
 47 observations from 1994Q4 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 GY           GL           RIPR         RIGR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.57217     .38850     .12014    .054689
*******************************************************************************
 Null    Alternative    Statistic     95% Critical Value     90% Critical Value
 r = 0      r>= 1        71.6804          48.8800                45.7000
 r<= 1      r>= 2        31.7758          31.5400                28.7800
 r<= 2      r>= 3         8.6589          17.8600                15.7500
 r<= 3      r = 4         2.6433           8.0700                 6.5000
*******************************************************************************
 Use the above table to determine r (the number of cointegrating vectors).

      Cointegration with unrestricted intercepts and no trends in the VAR
Choice of the Number of Cointegrating Relations Using Model Selection Criteria
*******************************************************************************
 47 observations from 1994Q4 to 2006Q2. Order of VAR = 4.
 List of variables included in the cointegrating vector:
 GY           GL           RIPR         RIGR
 List of I(0) variables included in the VAR:
 D
 List of eigenvalues in descending order:
.57217     .38850     .12014    .054689
*******************************************************************************
 Rank      Maximized LL        AIC            SBC            HQC
 r = 0       949.6074       893.6074       841.8033       874.1132
 r = 1       969.5597       906.5597       848.2801       884.6287
 r = 2       981.1181       913.1181       850.2131       889.4466
 r = 3       984.1260       913.1260       847.4457       888.4100
 r = 4       985.4476       913.4476       846.8423       888.3836
*******************************************************************************
 AIC = Akaike Information Criterion    SBC = Schwarz Bayesian Criterion
 HQC = Hannan-Quinn Criterion
```

Appendix E: OLS Results

1. Withholding PIT

Regressor	Coefficient	P-value
C	0.0035583	0.045
DLPIT1WR(-1)	1.1338	0
DLPIT1WR(-2)	-0.50097	0
DLGDPR(-3)	0.47732	0.002

2. PIT on Interest

Regressor	Coefficient	P-value
C	0.8513E-6	0.100
DLPIT2I(-1)	1.2641	0
DLPIT2I(-2)	-0.60887	0
DLTR	0.15916	0

3. Other PIT

Regressor	Coefficient	P-value
C	-0.391360	0
DLPIT4OR(-1)	0.820380	0
DLCGR(-3)	-0.400830	0.011
ECM(-1)	-0.074996	0
D	-0.026062	0.001

4. Annual CIT

Regressor	Coefficient	P-value
C	-0.0063941	0.678
DLCIT1AR(-1)	0.58710	0
DLCIT1AR(-3)	-0.38556	0.005
ECM(-1)	-0.044042	0.047
D	-0.046302	0.005

5. CIT Service Sector and Repatriated Foreign Profits

Regressor	Coefficient	P-value
C	-4.8471	0.028
DLCIT2FR(-1)	-0.56232	0.003
DLCIT2FR(-2)	-0.052689	0.690
DLGDPR(-2)	1.5652	0.008
DLGDPR(-3)	1.3316	0.016
ECM(-1)	-0.43369	0.028

6. Withholding CIT

Regressor	Coefficient	P-value
C	-0.0001123	0.93674
DLCIT3WR(-1)	1.3573	0
DLCIT3WR(-2)	-0.54066	0
DLGDPR	0.36637	0.056

7. Other CIT

Regressor	Coefficient	P-value
C	-1.0964	0
DLCIT4OR(-1)	-0.35037	0.026
DLCIT4OR(-2)	-0.36279	0.004
DLCIT4OR(-3)	-0.27060	0.025
DGLOAN(-1)	1.1601	0.032
ECM(-1)	-0.67814	0
D2	0.43186	0.001
D3	0.42696	0.002

8. Petroleum Tax

Regressor	Coefficient	P-value
C	-0.0099250	0.977
DLPTR(-1)	-0.62358	0
DLPTR(-2)	-0.73906	0
DLPTR(-3)	-0.29356	0.058
DLGDPR(-2	28.0173	0.012

9. Domestic VAT

Regressor	Coefficient	P-value
C	-2.1786	0
DLVATDBR(-1)	.78509	0
DLCPR(-3)	-1.4900	0
DLVIMBR(-1)	.41579	0.003
DLVIMBR(-2)	-.68785	0.001
DLVIMBR(-3)	.63776	0
ECM(-1)	-.19758	0

10. Imported VAT

Regressor	Coefficient	P-value
C	0.0097233	0.314
DLIMGR	0.40320	0.012
DLIMGR(-1)	0.28114	0.035
DLIMGPI	-0.43679	0.009
DLIMGPI(-2)	-0.28399	0.036

11. SBT

Regressor	Coefficient	P-value
DLSBT(-1)	1.2293	0
DLSBT(-2)	-0.52659	0
DLGDPR	-1.0207	0.003
DLGDPR(-3)	1.1880	0
DLFIR	0.27245	0.011
DLFIR(-2)	-1.4074	0
DLFIR(-3)	1.2885	0
ECM(-1)	-0.002558	0

12. Public Infrastructure

Regressor	Coefficient	P-value
DGY(-1)	.33679	0.002
DGL(-3)	-.55905	0.005
DRIPR(-1)	.50852	0
DRIPR(-3)	-.44946	0
DRIGR(-2)	-.77197	0
DRIGR(-3)	.52290	0.016
ECM(-1)	-.19712	0
D	-.009817	0.001

Appendix F: Diagnostic Tests

Variable	Diagnostic Tests	P-value of Chi-square	P-value of F-statistic
1. LPIT1WR	Serial Correlation	0.100	0.123
	Heteroscedasticity	0.442	0.452
2. LPIT2I	Serial Correlation	0.098	0.121
	Heteroscedasticity	0.473	0.484
3. LPIT4OR	Serial Correlation	0.050	0.060
	Heteroscedasticity	0.719	0.726
4. LCIT1AR	Serial Correlation	0.181	0.233
	Heteroscedasticity	0.656	0.664
5. LCIT2FR	Serial Correlation	0.069	0.097
	Heteroscedasticity	0.187	0.194
6. LCIT3WR	Serial Correlation	0.139	0.171
	Heteroscedasticity	0.522	0.532
7. LCIT4OR	Serial Correlation	0.295	0.420
	Heteroscedasticity	0.182	0.189
8. LPTR	Serial Correlation	0.313	0.399
	Heteroscedasticity	0.965	0.966
9. LVATDBR	Serial Correlation	0.091	0.139
	Heteroscedasticity	0.596	0.605
10. LVATIMBR	Serial Correlation	0.156	0.198
	Heteroscedasticity	0.091	0.095
11. LSBT	Serial Correlation	0.062	0.110
	Heteroscedasticity	0.430	0.441
12. GY	Serial Correlation	0.397	0.530
	Heteroscedasticity	0.175	0.182

Note: 1. Use Lagrange multiplier test of residual serial correlation

2. Heteroscedasticity test based on the regression of squared residuals on squared fitted values

Appendix G: Long Run Cointegration Tests

1. *Other PIT*

Regressor	Coefficient	Standard Error
LPIT4OR	1.0000	*NONE*
LCGR	-1.2652	0.17963
GLOAN	0	*NONE*

2. *Annual CIT*

Regressor	Coefficient	Standard Error
LCIT1AR	1.0000	*NONE*
LCIT1HR	-1.1003	0.23841

3. *CIT Service Sector and Repatriated Foreign Profits*

Regressor	Coefficient	Standard Error
LCIT2FR	1.0000	*NONE*
LGDPR	-1.4226	0.11993

4. *Other CIT*

Regressor	Coefficient	Standard Error
LCIT4OR	1.0000	*NONE*
LIGIR	-0.7700	0.13447
GLOAN	0	*NONE*

5. *Domestic VAT*

Regressor	Coefficient	Standard Error
LVATDBR	1.0000	*NONE*
LCPR	-1.8597	0.058560
LCGR	0	*NONE*
LVATIMBR	0	*NONE*

6. *Public Infrastructure*

Regressor	Coefficient	Standard Error
GY	1.0000	*NONE*
GL	-2.7758	1.3592
RIPR	-.10442	.022962
RIGR	.10662	.091362