RELATIONSHIP BETWEEN GDP AND SOCIAL AND ECONOMIC INFRASTRUCTURE IN SRI LANKA - A STATISTICAL APPROACH

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Degree of Master of Science in Business Statistics

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DECLARATION OF THE CANDIDATE

I hereby declare this project report is the product of my own and is based on a research that I performed independently without the participation of any other person or authority. The references made to other researches here have been acknowledged appropriately with due appreciation. The sources of data and information external to the dissertation and the research have been acknowledged appropriately. Also the substance in this research has never been submitted for any other degree, anywhere else. I hereby give my consent to making this available by photocopy for inter-library loans, and for the title and summary of the dissertation to be made available for use by other institutions of learning.

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W.A.P.S.Perera (128958B)

DECLARATION OF THE SUPERVISOR

I have supervised and accepted this thesis for the submission of the degree.

Signature: Date:

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Abstract

The objective of this study is to evaluate the infrastructure development of Sri Lanka with respect to selected variables over the recent past and try to find the relationship between infrastructure development and Gross Domestic Product (GDP) at current market prices during the period from 1989 to 2014. The study keeps a special focused on selected components of infrastructure development namely; Government expenditure on education, health, petroleum and electricity consumption and also number of vessels arrived by applying multivariate time series techniques to develop a short-term and long-term relationship between GDP and other variables. Vector Error Correction Models (VECM) found that there is a short run equilibrium relationship among all the variables considered; Government expenditure on education, health, petroleum and electricity consumption and number of vessels arrived at 95% confidence level. The model was statistically validated and found that the errors having white noise. Furthermore, it was found that causality is running from GDP to petroleum expenditure and there is a one way causal relationship exists between electricity consumption and number of vessels arrived, electricity consumption, expenditure on health and education. However, the short term impact from the number of vessels arrived is low compared that with other variables. The Johnson's co-integrating test confirmed that there is no long run equilibrium among selected variables. These results can be used by policy makers to understand more clearly the nature of the problem of infrastructure development and to set more focused targets and come up with more strategic planning's to reach the economic goals. Due to short term relationship, it is recommend that to carry out such studies at regular intervals before firm decisions are taken.

Key words : Co-integration, Error Correction, Granger causality, Gross Domestic Product, Infrastructure development

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LIST OF ABBREVIATIONS

Abbreviation	**Description**
ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
ECM	Error Correction Model
EDU	Government Expenditure on Education
EFA	Education For All
ELEC	Electricity Consumption
EU	European Union
GDP	Gross Domestic Product
GNP	Gross National Product
HCE	Health Care Expenditure
HDR	Human Development Report
HEALTH	Government Expenditure on Health Services
HQ	Hannan and Quin
ILO	International Labour Organization
MDGs	Millennium Development Goals
OLS	Ordinary Least Squares
PETRO	Petroleum Expenditure on Local Consumption
PP	Philip Perron
SAARCSTAT	South Asian Association for Regional Cooperation Statistics
SDI	Social Development Index
SIC	Schwarz Information Criterion
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
VA	Number of Vessels Arrived
VAR	Vector Auto Regressive
VECM	Vector Error Correction Model

CHAPTER ONE

INTRODUCTION

1.1 Background

Infrastructure, in general, defines as a set of facilities through which goods and services are provided to the public. Its installations do not produce goods and services directly but provide inputs for all other socio-economic activities. Infrastructure is the stock of basic facilities and capital equipment needed for the functioning of a country or area; the term to refer collectively to the roads, bridges, rail lines, and similar public works that are required for an industrial economy, or a portion of it, to function (Sirinivasu and Rao, 2013).

Infrastructure is a basic essential service that should be put in place to enable development to occur. Socio-economic development can be facilitated and accelerated by the presence of social and economic infrastructures. If these facilities and services are not in place, development will be very difficult and in fact can be likened to a very scarce commodity that can only be secured at a very high price and cost. The provision and development of infrastructure has been the subject of much theoretical analysis and empirical studies. Better management of economic infrastructure would have positive output, income and employment effects on the economy. Moreover, it will impact directly on the poor, thus reducing poverty (Ayansola, 2015). Gross Domestic Product is commonly used as an indicator of the economic health of a country, as well as to gauge a country's standard of living. Development of social infrastructure of a country is vital for strengthening the human capital base resulting in productivity improvements and innovations which would drive the economic growth (Central Bank, 2011).

World Development Report (1994) has shown that a one percent increase in the stock of infrastructure is associated with a one percent increase in the Gross Domestic Product across all countries and as countries develop, infrastructure must adapt to support changing pattern of demand, as the shares of power, roads, and telecommunications in the total stock of infrastructure increase. As the economy develops, an increasing proportion of the country would need to be opened up by the construction of roads, there would be increased demand for power supply for industrial and domestic consumption, and telecommunications facilities. Studies have therefore found that poor countries record low stock of infrastructure (World Development Report, 1994).

According to a report by European Commission, good quality infrastructure is a key ingredient for sustainable development. All countries need efficient transport, sanitation, energy and communications systems if they are to prosper and provide a decent standard of living for their populations. Unfortunately, many developing countries possess poor infrastructure, which hampers their growth and ability to trade in the global economy (European Commission, 2010).

Sri Lanka has progressively improved in human development over the years and is ranked 73 in the category of High Human Development Country in the Human Development Report (HDR) 2014 released by the United Nations Development Programme (UNDP) . The average HDI value for the Asia region, at 0.588, is below the world average of 0.702 and only Sri Lanka in the South Asian region is above the average. The report has considered Sri Lanka's favorable social indicators of literacy, life expectancy and year of schooling to place the country in the High Human Development group (Human Development Report, 2014).

Infrastructure investment is one of the main preconditions for enabling developing countries to accelerate or sustain the pace of their development and achieve the Millennium Development Goals (MDGs) set by the United Nations in 2000. Furthermore, the future investment needs of developing countries in infrastructure far exceed the amount being spent by the governments, the private sector and other stakeholders, resulting in a significant financing gap. According to a World Bank estimate, on average, developing countries currently invest annually 3-4% of their

GDP in infrastructure; yet they would need to invest an estimated 7-9% to achieve broader economic growth and poverty reduction goals (UNCTAD, 2008).

Sri Lanka's government infrastructure investment was 5.2% and 4.5% of GDP in 2013 and 2014 respectively (Central Bank, 2014). It is far below the investment rate of 7-9% recommended by the World Bank to achieve broader economic growth and poverty reduction objectives. However, in Sri Lankan economy, the private sector plays an important role in the provision of economic and social infrastructure. The private sector has been visibly engaged in the provision of services such as education, health, communication, passenger and goods transportation and power generation on a standalone basis or as Public-Private- Partnerships of different models. These private sector experiences could be useful in institutional reform, particularly in transforming the loss making public corporations into viable institutions and lessening the fiscal burden while improving the efficiency and transparency of infrastructure service delivery (Central Bank, 2014). In my study only the government sector contribution has been considered.

By a developing country standard, Sri Lanka has better developed infrastructure such as roads, education, health facilities and telecommunication. The investment by government of Sri Lanka for both economic and social infrastructure has been increasing over the years (Fig. 1.1).

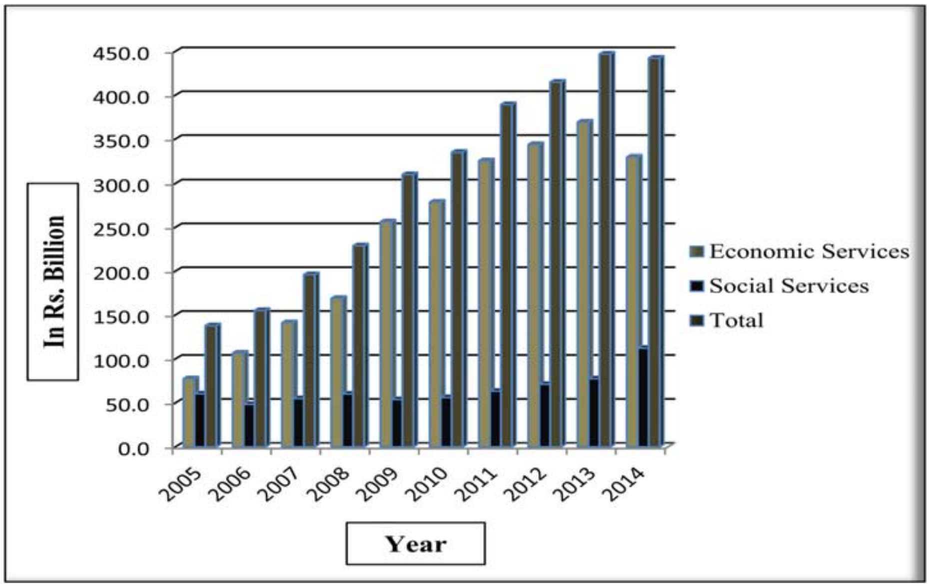


Fig.1.1: Government Investment in Infrastructure for Last 10 Years

Source : 2014, Annual Report of Central Bank

In Sri Lanka the private sector also continues to play a significant role in strengthening the economic infrastructure of the country, particularly in relation to the telecommunication and transportation sectors while contributing to enhance social infrastructure such as education, health and housing. The current pace of infrastructure development in sectors such as urban development and transportation provide numerous opportunities for the private sector to participate and share their expertise. The economic efficiency and long term sustainability of those projects may also be improved through private sector participation in the subsequent maintenance and operation of such projects following the initial capital outlay made by the government. Such forms of Public-Private Partnerships are essential to catalyze economic development and to create an investor friendly environment in the country (Central Bank, 2012).

1.2 Gross Domestic Product (GDP)

GDP is the market value of all officially recognized final goods and services produced within a country in a year or other given period of time. GDP is the sum of gross value added of all resident producer units within the economic borders of a country (DCS, 2015). GDP can be calculated in three (3) ways. The three approaches are,

1. Income Approach - Add up labor income, rental income, interest income and profits to come up with the total value produced within an economy.
2. Expenditure Approach - Add up private consumption, private investment, government purchases, and net exports to come up with total value produced.
3. Production Approach - Calculate the value of all outputs, determine the intermediate consumption, and then subtract the two to determine net value.

The most common approach to measuring and quantifying GDP is the expenditure approach and the department of Census and Statistics of Sri Lanka also uses the same method.

$GDP = C + I + G + (X - M)$ where,

C = Private Consumption, I = Gross Investment, G = Government Spending,
X = Exports and M = Imports

1.3 Government Expenditure on Education

The role of education as a social infrastructure and as a stimulant of growth and development can be enhanced only if it is qualitatively provided. Qualitative education is a major determinant of the stock of human capital. A less developing economy needs professionals in all sectors to accelerate the growth and development of such sectors. At the 9th meeting of the high level group on Education for all (EFA) held in Addis Ababa, 2010, the ministers of education called upon national governments to reinforce their determination to increase the level of domestic spending to education to at least six percent of GNP and/or twenty percent of public expenditure. In fact, UNESCO recommends a minimum of fifteen percent of government expenditures on education (Singh, 2010).

According to the South Asian Association for Regional Cooperation Statistics (SAARCSTAT,2014), The Sri Lanka's population has a literacy rate of 95%, higher than that is expected for a third world country; it has the second highest literacy rate in South Asia and overall, one of the highest literacy rates in Asia. Education plays a major part in the life and culture of the country (SAARCSTAT, 2014).

Sri Lanka ranks at 82 out of 149 countries in the Knowledge Economy Index prepared by the World Bank (2009). The knowledge economy is one that creates, disseminates and uses knowledge to enhance growth and development in a country. A successful knowledge economy is characterized by close links between science and technology, greater importance placed on innovation for economic growth and competitiveness, increased significance of education, greater investment in research & development, information technology, and education (Central Bank, 2010). The private sector participation is very high in Sri Lankan educational sector. However in my study, only government expenditure in education has been considered.

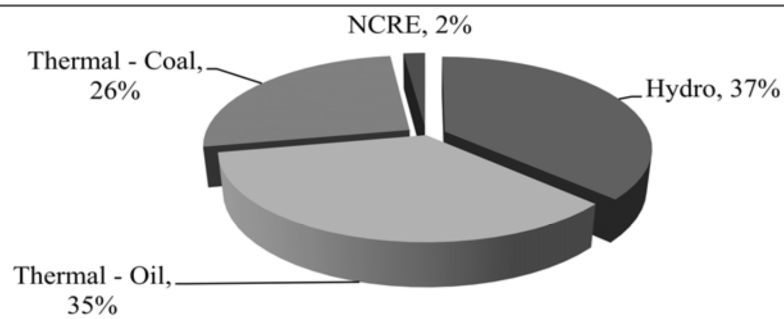
1.4 Government Expenditure on Health Services

Sri Lankan government provides free universal healthcare. Sri Lanka is a one of the few countries in the world with free healthcare and education, both of which have been national priorities for decades. The success of Sri Lanka's health sector is largely due to its effective public delivery system, which provides both preventive and curative care at low cost. Government-provided healthcare is free for all citizens and accounts for almost all preventive care and most in-patient treatment. Both the Government and Private sector have been rapidly building and improving infrastructure, quality of services and human capital base in the healthcare sector.

Sri Lanka has an impressive record of health care provision, with model accomplishments in health outcomes compared to similar developing countries. Over the decades, since independence, the Government of Sri Lanka has played a remarkable role in the health system, provision, financing, and regulation of health care across the country. Successes of these initiatives have been reflected in the impressive health outcomes associated with good maternal and child health, low levels of communicable diseases and long life-expectancy (Bandara, 2011).

1.5 Electricity Consumption

Electricity is a vital component which serves as a salient feature to satisfy the need of infrastructure development. The largest contribution to electricity generation in the Sri Lanka power systems comes from hydro power. The thermal power generating by oil & coal, also give a higher contribution to the electricity generation. The electricity generation by source in 2014 is given in figure 1.2.



NCRE - Non Conventional Renewable Energy (Solar, Dendro, Biomass, Wind)

Source : Statistical Digest – 2014, CEB

Fig. 1.2: Power Generation by Source –2014

Heavy dependence on imported energy sources, such as coal, has the potential to plunge Sri Lanka into acute energy insecurity related issues. Besides, fossil fuel based power, most importantly coal power, come with great global warming potential. Capital for such mega electricity generation projects must be secured through loans from foreign sources, the repayment of which could heavily burden the future generation (Rajaratnam, 2010). According to the Ministry of Power and Renewable Energy, Sri Lanka has reached the national electrification ratio of 94% (Powemin, 2015).

Annual electricity consumption of Sri Lanka can be divided into four major sectors namely domestic & religious, industrial, general purpose and hotel & street lighting. In the study, total annual consumption of those four sectors has been considered.

1.6 Petroleum Expenditure

Sri Lanka imports 100% of her crude oil requirements at present. In addition the country imports 50% of her petroleum products requirements. Eighty per cent of Sri Lanka's requirements of crude oil comes from Iran and is said to be the quality most suited for the oil refinery at Sapugaskande. The balance is imported from Saudi Arabia. Over the last 15 years or so, the demand for petroleum products has risen rapidly. Crude oil is refined to produce a wide array of petroleum products, including heating oils (gasoline, diesel) and jet fuels; lubricants; asphalt; ethane, propane, and butane; and many other products used for their energy or chemical content. (petroleum, 2016). Sri Lanka exports a few quantities of her petroleum products. In my study, only the expenditure of local petroleum consumption has been considered.

1.7 Number of Vessels Arrived

Sri Lanka being an island nation there are only two ways available for its exports to leave the country in search of their foreign markets. That is either as sea cargo or as air cargo. Due to the costly nature of air cargo services, shipping is the best mode of transport available for majority of Sri Lankan exporters. Hence the development of port sector infrastructure is very important to gain the foreign exchange to the economy. It creates direct and indirect labour market (Nadeesha and Silva, 2013). In the study it has been used the annual total number of vessels arrived to the four ports in Sri Lanka namely Colombo, Hambantota, Trincomalee and Galle.

1.8 Objectives of the study

In view of the above, the objectives in this study are,

- To develop a model for relationship of GDP and selected factors of economic and social infrastructure namely electricity consumption, petroleum expenditure, government expenditure on education, government expenditure of health and total number of vessels arrived.
- To derive some recognition based on short term and long term relationship based on the relationship obtained.

1.9 Organization Structure of the Thesis

The thesis is organized as follows. Chapter one presents introduction and objectives of the study. Chapter two briefly reviews the theoretical and empirical literature related to this study. Chapter three presents materials and methods which have been used for the study. Chapter four brings out the results and discussions and the last chapter five presents the conclusion.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter focuses to give an idea about the literature related to infrastructure development and GDP in Sri Lanka and other countries. Furthermore, this find out infrastructure development and GDP emerged a serious debate and resulted in various conclusions.

2.2 Related Studies in Sri Lanka

Previous statistical analysis of Sri Lankan infrastructure investment is extremely limited. Kesavarajah, (2010) tried to examine the causality between public expenditure and economic growth in Sri Lanka using time series annual data over the period of 1977 - 2009. This study keeps a special focused on various selected components of public expenditure by applying a multivariate co-integration and vector error correction modeling (VECM) techniques. The empirical evidence has suggest in long run, public expenditure on education, agriculture health and transport and communication have positive and statistically significant effect on economic growth while defense expenditure shows a negative but a statistically significant effect on economic growth. Furthermore, Granger causality analysis has confirmed that there is a unidirectional causality running from education expenditure to economic growth, defense expenditure to economic growth, and agriculture expenditure to economic growth, which supports the existence of Keynesian hypothesis in Sri Lanka. Analysis also indicates that existence of bidirectional causality between health expenditure and economic growth, transport and communication expenditure and economic growth. Therefore, the findings of this study provide an important implication to policy makers to improve the efficiency of public expenditure by reallocating among sectors in a growth context.

Herath (2010) examined a relationship between public expenditure and economic growth in Sri Lanka for the period 1959 to 2003. The study found government expenditure has a positive effect on economic growth. Further this study suggests that openness is beneficial for Sri Lanka as it increases economic growth.

Rajaratnam (2010) investigated the existence and direction of Granger causality between electricity consumption and economic growth in Sri Lanka, proxies by gross domestic product (GDP), using annual data covering the period 1971 to 2007. The results of the augmented Dickey-Fuller, GLS-detrended Dickey-Fuller and Phillips-Perron tests has shown that the natural logarithms of both the times series are individually I(1). The autoregressive distributed lag bounds testing approach to co-integration used in this study revealed that the two time series are co-integrated. The estimated long-run equilibrium relationship has shown that 1% growth in GDP induces 1.45% growth in electricity consumption, and any deviation from the long-run equilibrium following a short-run disturbance is corrected within 17 months. Granger causality test results revealed unidirectional causality running from economic growth to electricity consumption without any feedback effect. The results have shown that the economic growth of Sri Lanka is not dependent on electricity consumption.

2.3 Related Studies in Other Countries

Herranz-Loncan (2007) analyzed the impact of infrastructure investment on Spanish economic growth between 1850 and 1935. Using new infrastructure data and VAR techniques, he shows that the growth impact of local-scope infrastructure investment was positive, but returns to investment in large nation-wide networks were not significantly different from zero. He provides two complementary explanations for the latter result. On the one hand, public intervention and the application of non-efficiency investment criteria were very intense in large network construction while on the other hand, returns to new investment in large networks might have decreased dramatically once the basic links were constructed.

By applying pair wise Granger causality tests between economic growth, economic infrastructure investment, and employment in South Africa for the period 1960-2009 using bivariate vector auto regression (VAR) model with and without a structural break, Kumo (2012) studied that there is a strong causality between economic infrastructure investment and GDP growth that runs in both directions implying that economic infrastructure investment drives the long term economic growth in South Africa while improved growth feeds back into more public infrastructure investments. He also found a strong two way causal relationship between economic infrastructure investment and public sector employment reflecting the role of such investments on job creation through construction, maintenance and the actual operational activities, while increased employment could in turn contribute to further infrastructure investments indirectly through higher aggregate demand and economic growth. Further, there was a strong unidirectional causal link between economic growth and public sector employment that runs from the former to the latter; and a strong one way causal link between private sector employment and economic growth that runs from the former to the latter.

Among the limited research in this area, Canning and Pedroni (1999) conducted Granger causality test between investments in three types of economic infrastructure i.e., kilometers of paved road, kilowatts of electricity generating capacity, and number of telephones based on data from a panel of 67 countries for the period 1960-1990. They found strong evidence in favour of causality running in both directions between each of the three infrastructure variables and GDP among a significant number of the countries investigated.

Sirinivasu and Rao (2013), tried to establish a relationship between infrastructure and economic growth using growth theories and empirical evidences. Finally they found that there is a strong relationship between infrastructure and economic growth. Furthermore they found a fact that there is a strong relationship between infrastructure services availability and poverty alleviation using 16 major states data of India. The states which higher infrastructure services availability have low head count ratio of poverty and the status which have lower infrastructure services availability have high poverty levels.

Ben-Haj (2014) tried to examine a causal relationship between economic growth and social development In Saudi Arabia between 1980 and 2011. For those statistical and econometric techniques such as unit root test, co integration and Granger Engels causality through Vector Error Correction Model (VECM) were applied. Based on the aggregation of several indicators he has calculated a single social composite index, known as Social Development Index (SDI) for a given year t as shown below.

$$SDI_t = \sum_{i=1}^{n} \frac{x_{it} - x_{mini}}{x_{maxi} - x_{mini}} * 100 \qquad (1)$$

Where x_{it} is the value of the i^{th} variable in year t.
x_{mini} is the minimum value of variable i over time.
x_{maxi} is the maximum value of variable i over time.

Thus, each variable that enters the index is normalized to be between 0 and 100. The results have been showed that there is significant long run causality from social development to economic growth. This indicates that trickle-up hypothesis is more active dominantly and that development strategies in Saudi Arabia have succeeded to reach significant social development enough to cause economic growth in the long run.

Loayza and Odawara (2010), analyzed the situation, trends and effects of infrastructure in Egypt by using pooled data set of cross-country observations for 150 countries using the latest available data of each indicator. As for the measures of infrastructure assets, they selected different indicators in stock and quality of services from four major infrastructure sectors: transport, telecommunications, electricity, and water and sanitation. The analysis provided in this study suggested that a permanent increase in infrastructure expenditures has a gradually rising effect on per capita

GDP growth. Using data for 78 countries for the period 1960-2005, this study confirmed the result on the beneficial growth impact of infrastructure in telecommunication, transport, and power generation. This impact is found to be larger if infrastructure development does not involve an increase in government burden on the economy. Moreover, using Egypt specific data, the study found a positive and significant link between infrastructure expenditures and infrastructure development. Based on these results, this study concluded that improving infrastructure in Egypt will have a beneficial effect on economic growth and that, in turn, improving infrastructure will require a combination of larger infrastructure expenditures and more efficient investment.

Zhike and Huiming (2014) tried to search a relationship between per capita healthcare expenditure (HCE) and per capita GDP for 42 African countries over the period 1995 – 2009 using a semi parametric panel data analysis. They found that infant mortality rate per 1000 live births has a negative effect on per capita HCE, while the proportion of the population aged 65 was statistically insignificant in African countries. Furthermore they found that the income elasticity is not constant but varies with income level, and healthcare is a necessity rather than a luxury for African countries.

Shaista, Abida and Butt (2010) examined the long run relationship between Social expenditure and economic growth in Asian developing countries including Sri Lanka. According to the analysis the study concludes that expenditure in infrastructure, education and health plays an important role in promoting economic growth in all the selected Asian countries.

Applying a multivariate stochastic co-integration method to US data, Lau and Sin (1997) have found that the evidence is unfavorable to the endogenous economic growth model with public infrastructure. They also have investigated that the estimated elasticity of output with respect to public capital is 0.11, smaller than typical values obtained in single equation regression studies. On the other hand, if the share of capital income is taken to be one third, then the spillover effect due to private capital is positive but may be as low as 0.10.

The importance of investment in infrastructure to the socio-economic advancement of a nation cannot be overemphasized. Insufficient or poor infrastructure limits citizen's access to markets, as well as livelihood opportunities and services such as clean water, education, health, transport and communication. According to an ILO report, although infrastructure development is not identified as a direct Millennium Development Goal (MDG) target or indicator, without it many of the targets will not be met and that sustainable infrastructure is not only an essential part in improving the livelihoods of the poor; it also provides opportunities for creating jobs during development, operation and maintenance (ILO, 2010).

Bhat & Jain (2004) analyzed the time-series behavior of private health expenditure and GDP to understand whether there was long-term equilibrium relationship between these two variables and estimate income elasticity of private health expenditure. The study used co-integration analysis with structural breaks and estimated these relationships using fully modified ordinary least squares (FM OLS) method. The findings suggest that income elasticity of private health expenditures is 1.95 indicating that for every one per cent increase in per capita income the private health expenditure has gone up by 1.95 per cent. The private health expenditure was 2.4 per cent of GDP in 1960 and this has risen to 5.8 per cent in 2003. In nominal terms it has grown at the rate of 11.3 per cent since 1960 and during 1990's the growth rate is 18 per cent per annum. The study discusses four reasons for this high growth experience. These are: (i) financing mechanisms including provider payment system, (ii) demographic trends and epidemiological transition, (iii) production function of private health services delivery system, and (iv) dwindling financing support to public health system.

Dritsakis (2004) tried to search the relationship between health care expenditures of GDP and the ratio of health services prices index to the GDP prices index for the member countries of European Union (EU) using annual data. Hence used variables showed unit root, co integration analysis was applied as suggested by Engel-Granger and Johansen and Juselious as well in order to induce a long-run equilibrium relationship between the used variables. Furthermore, the results suggested that there is a positive relationship between health care expenditure and GDP, but also between the ratio of health services price index, to the GDP price index. Then the error correction model methodology was applied in order to estimate the short-run and the long-run relationships. The selected vectors gave the error correction terms, which in most member-countries of EU proved to be statistically significant at 0.05% significance level during their importation in short run dynamic equations. Finally, it was proved that health care must be regarded as a luxury in member-countries of EU.

Jamil (2010) studied the relationship among electricity consumption, its price and real GDP at the aggregate and sectoral level in Pakistan using annual data for the period 1960-2008. The study finds the presence of unidirectional causality from real economic activity to electricity consumption. In particular, growth in output in commercial, manufacturing and agricultural sectors tend to increase electricity consumption, while in residential sector, growth in private expenditures is the cause of rising electricity consumption. The study concludes that electricity production and management needs to be better integrated with overall economic planning exercises.
For India, Ghosh (2002) and for Australia, Narayan and Smyth (2005) found causality running from economic growth to electricity consumption.

According to a case study of Ireland, Dennya and Nyamdasha (2010) investigated that the existence of bi-directional Granger causality between economic growth and electricity consumption growths at a disaggregate level while there is unidirectional Granger causality running from economic growth to total electricity consumption at an aggregate level.

Asafu-Adjaye (2000) studied the relationship among energy consumption, energy prices and GDP for India, Indonesia, Philippines and Thailand using co-integration and error correction (EC) methods and found bidirectional causality between GDP and energy consumption for Thailand and Philippines, and unidirectional causality running from energy to income for India and Indonesia.

In a summary of the literature on the causal relationship between energy consumption, including oil consumption, and economic growth, there are a number of evidences to support bidirectional or unidirectional causality between energy consumption and economic growth. Recently, Yang (2000) investigated the causal relationship between real gross domestic product (GDP) and several disaggregate categories of energy consumption, including coal, oil, natural gas, and electricity, and found that there is unidirectional causality running from economic growth to oil consumption in Taiwan without any feedback effect.

Aktas and Yilmaz (2008) tried to examine the short- and long-run causality between oil consumption and Gross National Product for Turkey using annual data covering the period of 1970-2004. As economic growth and oil consumption variables used in empirical analysis was same order of integration, they employed Granger causality test. The study found that existence of bidirectional Granger causality between oil consumption and economic growth in the short and long run.

Stern (2000) analyzed causality between GDP and energy use, labour, capital input and time trend in to US macro economy using a multivariate co-integration approach. The time trend was added to capture the exogenous effect of new technology. Stern measured energy input differently using a quality adjusted index. He argued, this would take into account the effect of energy quality on energy consumption. He also used divisia aggregation index of energy content in energy aggregate final energy consumption of coal, natural gas, petroleum and electricity power and bio fuels and found there is co-integration between GDP, capital, labour and energy. He concluded that, with a dynamic multivariate co-integration analysis approach, energy is significant in the Granger Causality sense, in explaining GDP.

Fatai, Oxley and Scrimgeour (2001) showed that energy conservation policies do not have significant impacts on real GDP growth in industrialized countries such as New

Zealand and Australia compared to some developing economics by using GDP and various disaggregated energy data (coal, natural gas, electricity, oil) for period of 1960-1999 annual data. They also have found evidence of unidirectional link from real GDP to aggregate final energy consumption and unidirectional link from real GDP to industrial and commercial energy consumption in New Zealand as well as in Australia. They also identified unidirectional link from energy to income for India and Indonesia and a bidirectional link in Thailand and the Philippines.

Bhusal (2010) examined the short and long run causality between oil consumption and GDP for Nepal using annual data covering the period of 1975 to 2009. Granger causality test was employed to analyze the relationship between economic growth and oil consumption variables with same order of integration. In this study, using ADF test and Johanson maximum likelihood test he has found that there exists bi-directional Granger causality between oil consumption and economic growth in the short and long run.

Magazzino (2014) tried to assess the empirical evidence of the nexus between GDP and energy consumption for Italy during the period 1970 – 2009, using a time series approach. A Co-integration relationship has found among two variables and also found there was a there was a long run bidirectional causal relationship between the two series. According to the results he concluded that energy is a limiting factor to GDP growth in Italy. Furthermore they suggested the energy conservation policy of Italy should be formulated and implemented wisely.

2.4 Summary

Theoretical and empirical literature suggests the existence of positive & negative relationships between variables of infrastructure investment such as oil consumption, electricity consumption, education expenditure, health expenditure, Kilometers of paved roads, number of telephones used and economic growth in different countries. The review also helps to identify the research methodologies that have been used by various researches. The mostly used methodology for such studies was Johansen's Co-integration method with a Vector Error Correction model (VECM) approach.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Data Source

The secondary data for the period of 25 years of annual GDP from Annual Reports of National Accounts of Sri Lanka (1989 – 2014) Published by the Department of Census and Statistics have been used. The secondary data for the period of 25 years of economic infrastructure data from reports of Economic and Social Statistics of Sri Lanka (1989 - 2014) published by the Central Bank of Sri Lanka also have been used.

3.2 Used Variables

3.2.1 Gross Domestic Product (GDP)

The annual Gross Domestic Product at current market price in thousand million rupees

3.2.2 Government Expenditure on Education (EDU)

The annual total government expenditure for the education sector including higher education sector in '000 million rupees

3.2.3 Government Expenditure on Health Services (HEALTH)

The annual total government expenditure for the health sector in '000 million rupees

3.2.4 Electricity Consumption (ELEC)

The annual total sales by Ceylon Electricity Board in '000 GWh

3.2.5 Petroleum expenditure (PETRO)

The annual petroleum expenditure on local consumption in '000 million rupees

3.2.6 Number of Vessels Arrived (VA)

The annual total number of vessels arrived to the Sri Lankan ports

3.3 Methods of Data Analysis

It is expected to develop a statistical model for GDP and to find a long run or short run relationship among the explanatory variables of infrastructure investment namely electricity consumption, petroleum consumption, government expenditure on education and government expenditure on health using Johanson Co-integration analysis method in time-series and Vector Error Correction Model (VECM) approach.

3.3.1 Model Specification

The GDP model estimated in this study can be expressed in equation (2) and can represent this function in a mathematical linear model as shown in equation (3).

$$GDP = f(EDU, HEALTH, ELEC, PETRO, VA) \quad \textbf{(2)}$$

$$GDP_t = \beta_1+\beta_2*EDU_t+\beta_3*HEALTH_t+\beta_4*ELEC_t+\beta_5*PETRO_t+\beta_6*VA_t+ U_t \quad \textbf{(3)}$$

As in general most of economic variables are homoscedasticity in variance. Log transformation is used to reduce the heteroscedasticity. Thus equation (3) can be expressed in a log-linear form, as shown in (4).

$$lgGDP_t = \beta_1+\beta_2*lgEDU_t+\beta_3*lgHEALTH_t+\beta_4*lgELEC_t+\beta_5*lgPETRO_t+\beta_6*lgVA_t+U_t \quad \textbf{(4)}$$

Where; β_i (i = 1, 2, 3, 4,5, 6) are the coefficients in the equations

3.3.2 Testing for Stationary - Unit Root Test

To have a meaningful understanding of the relationship between two or more economic variables using VAR methodology, the time series data should satisfy some stationary properties. Hence any time series analysis should start by checking the order of integration of each variable. The augmented dickey fuller (ADF) and Philip Perron (PP) tests are used to examine the presence of unit roots in the data series.

3.3.2.1 Augmented Dickey-Fuller Test (ADF Test)

The general form of augmented dickey fuller (ADF) (1979) test can be written as follows.

$$\Delta X_t = a + b_t + pX_{t-1} + \Sigma\ \Delta X_{t-1} + U_t \qquad (5)$$

Where,

X_t = Individual time series,

ΔX_t = First difference of the series X_t

Here, $\Delta X_t = X_t - X_{t-1}$

K = Lag order

t = Linear time trend

U_t = Serially uncorrelated random term with zero means and constant variance

A = Constant

The above ADF test suggest that a time series has unit root if p-values is not significantly different from zero, and it is stationary if p-values is significantly different from zero. This test will be used to test whether a series follows a random walk without a drift $y_t = \phi_1 y_{t-1} + e_t$ or a random walk with a drift $y_t = \phi_0 + \phi_1 y_{t-1} + e_t$. Then the hypothesis tested under ADF test is:

$H_0 : \phi = 1$ (has a unit root) vs $H_1 : \phi < 1$ (has root outside unit circle)

If the unit root is present then $\phi = 1$ and so the model would be non-stationary in this case. The regression model can be written a

$$y_t - y_{t-1} = \nabla y_t = (\phi_1 - 1)\nabla y_{t-1} + e_t = \delta y_{t-1} + e_t \qquad (6)$$

Where $\delta = (\rho - 1)$ and ∇ is the first difference operator.

Unit roots can be tested by running the above regression. Hypothesis is given below.

Null hypothesis: H_0: $\delta = 0$ (Non stationary, Unit root exist)

Alternate hypothesis: H_1 : $\delta \neq 0$ (Stationary)

If $\delta = 0$, then $\rho = 1$, which implies that the series is non-stationary. If the series is non-stationary, the first difference of the series is tested for unit roots. If the series becomes Stationary after first differencing, the first difference series can be used in regression model (Dickey-Fuller, 1989).

3.3.2.2 Philip Perron Test

Philip Perron (PP) test under Bartlett Kernel and newly west bandwidth were conducted to test the stationary of the series. Phillips and Perron (1988) tests for unit roots are a modification and generalization of DF's procedures. While DF tests assume that the residuals are statistically independent (white noise) with constant variance, Phillips-Perron (PP) tests consider less restriction on the distribution of the disturbance term (Enders, 2004). Phillips-Perron tests undertake non-parametric correction to account for autocorrelation present in higher AR order models. The tests assume that the expected value of the error term is equal to zero, but PP does not require that the error term be serially uncorrelated. The critical values of PP tests are similar to those given for DF tests (Phillips and Perron, 1988).

3.3.3 Johansen Co-integration Test

Co-integration is an econometric property of time series variables. If two or more series are themselves non-stationary, but a linear combination of them is stationary, then the series are said to be co-integrated. A series of co-integration tests is carried out to examine whether there exists a long run relationship among the variables. The statistical test is carried out using Johansen co-integrated test (Johansen, 1991) which allows to test whether more than one co-integrating relationship exists or not.

Hypothesis :

H_0 = Đ = 0 (co-integration does not exists)

H_1 = Đ < 0 (co-integration exist)

This method requires that variables entering the co-integration relationship to be integrated of the same order and yields two likelihood statistics known as trace and maximum Eigen value statistics which are given by;

λ_{trace} (r) = -T Σ ln(1 – λ_i) (7)

λ_{max} (r, r+1) = -T ln(1 – λ_{r+1}) (8)

Where,

T = Number of observation

i = i^{th} eigen value λ_i

r = 0, 1, 2, …….,n-1

The trace statistic tests the null hypothesis of at most r co-integration relations against the alternative of more than r co-integrating relations.

3.3.4 Determination of Lag Length for VAR Model

The lag length for the VAR model may be determined using model selection criteria. The general approach is to fit VAR models with orders m = 0, ... , p_{max} and choose the value of m which minimizes some model selection criteria (Lutkepohl, 2005).

The three most commonly used information criteria for selecting the lag order are the Akaike information criterion (AIC) (Akaike, 1974), Schwarz information criterion (SIC) (Schwarz, 1978), Hannan-Quin information criteria (HQ) (Hannan, and Quinn, 1979). Thus, among the three criteria AIC always suggests the largest order, SIC chooses the smallest order and HQ is between. Of course, this does not preclude the possibility that all three criteria agree in their choice of VAR order. The HQ and SIC criteria are both consistent, that is, the order estimated with these criteria converges in probability or almost surely to the true VAR order p under quit general conditions, if p_{max} exceeds the true order. These criteria mainly indicate the goodness of fit of alternatives (models) so they should be used as complements to the LR test. The LR test (Sequential modified LR test statistic) should be used as a primary determinant of how many lags to include (Peiris, 2012). The likelihood ratio test statistics is given by,

$LR = (T - m)(\ln|\Sigma_r| - \ln|\Sigma_u|) \sim \chi^2_{(q)}$ and under H_0 $LR \sim \chi^2_{(q)}$, (9)

If the LR statistics < critical value, reject the null hypothesis of the restricted system.

3.3.5 Long-Run Relationship

A rough long-run relationship can be determined by the co-integration test and then this relationship can be utilized to develop a refined dynamic model which can have a focus on long-run aspect such as the two VECM of a usual VAR in Johansen test (Engle and Granger, 1987).

3.3.6 Granger Causality Test

Correlation does not necessarily imply causation in any meaningful sense of that word (Johansen, 1990). The econometric graveyard is full of magnificent correlations, which are simply spurious or meaningless. Interesting examples include a positive correlation between teachers' salaries and the consumption of alcohol and a superb positive correlation between the death rate in the United Kingdom and the proportion of marriages solemnized in the church of England and so economists claim that correlations which are less, in spite of significance, obviously meaningless. The Granger (1969) approach to the question is to find of whether causes is to see how much of the current values can be explained by past values and then to see whether adding lagged values can improve the model.

It is important to note that the statement "Granger causes" does not imply that is the effect or the result of Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term (Johansen, 1988). When you select the Granger Causality view in Eviews, you will first see a dialog box asking for the number of lags to use in the test regressions. In general, it is better to use more rather than fewer lags, since the theory is couched in terms of the relevance of all past information. Thus it is advised to pick a lag length that corresponds to reasonable beliefs about the longest time over which one of the variables could help predict the other (Juselius, 2006).

A question that frequently arises in time series analysis is whether or not one economic variable can help to forecast another economic variable. One way to address this question was proposed by Granger (1969) and popularized by Sims (1972). Testing causality, in the Granger sense, involves using *F*-tests to test whether lagged information on a variable Y provides any statistically significant information about a variable X in the presence of lagged X. If not, then Y does not Granger-cause X (Engle, and Granger, 1987).

3.3.7 Vector Error Correction Model (VECM)

An error correction model is a dynamical system with the characteristics that the deviation of the current state from its long-run relationship will be fed into its short-run dynamics. This is not a model that corrects the error in another model. Error Correction Models (ECMs) are a category of multiple time series models that directly estimate the speed at which a dependent variable Y returns to equilibrium after a change in an independent variable X. ECMs are a theoretically-driven approach useful for estimating both short term and long term effects of one time series on another (Engle, and Granger, 1987). This is generally developed, if the variables are co-integrated after Johansen co-integration test. This is known as restricted vector autoregressive (VAR) model.

3.3.8 Vector Auto Regression Model (VAR)

VAR is an econometric model used to capture the linear interdependencies among multiple time series. VAR models generalize the univariate auto regression (AR) models by allowing for more than one evolving variable. All variables in a VAR are treated symmetrically in a structural sense (although the estimated quantitative response coefficients will not in general be the same); each variable has an equation explaining its evolution based on its own lags and the lags of the other model variables.

VAR model estimates and describe the relationships and dynamics of a set of endogenous variables. For a set of n time series variables $Y_t = (Y_{1t}, Y_{2t}, \ldots\ldots, Y_{mt})^T$ a VAR model of order p (VAR(p)) can be written as;

$$Y_t = A_0 + A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + A_p T_{t-p} + \varepsilon_t \quad (10)$$

Where,

P = Number of lags to be considered in the system

In matrix form two variables VAR (1) is written as;

$$y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \epsilon_{2t} \end{bmatrix}$$

Thus,

$$y_{1t} = a_{10} + a_{11}\, y_{1t-1} + a_{12}\, y_{2t-1} + \varepsilon_{1t} \quad (11)$$

$$y_{2t} = a_{20} + a_{21}\, y_{1t-1} + a_{22}\, y_{2t-1} + \varepsilon_{2t} \quad (12)$$

This is generally used, when the variables are not co-integrated after Johansen co-integration test and this is known as unrestricted vector autoregressive (VAR) model. (Peris, 2012)

3.3.9 Wald Test

The Wald Test reports two test statistics, the F-Statistic and the Chi^2 Statistic, both based on an estimation of the unrestricted regression (i.e., without imposing the coefficient restrictions in the null hypothesis) and measuring how close the unrestricted estimation results are to the restricted estimation results. If the restrictions are true (i.e., all coefficients are equal to zero), unrestricted estimations should be close to restricted estimations. If the probability is less than the significance level being tested (e.g., 5%), the null hypothesis that all independent variable coefficients are jointly equal to zero is rejected (EViews User's Guide, p 329-332).

3.3.10 Breusch-Godfrey Serial Correlation LM Test

The null hypothesis of the Breusch-Godfrey Test is that there is no serial correlation up to the specified number of lags. The Breusch-Godfrey Test regresses the residuals on the original regressors and lagged residuals up to the specified lag order. The number of observations multiplied by R^2 is the Breusch-Godfrey Test statistic (EViews User's Guide, p 338).

3.3.11 ARCH LM Test

An uncorrelated time series can still be serially dependent due to a dynamic conditional variance process. A time series exhibiting conditional heteroscedasticity or autocorrelation in the squared series is said to have autoregressive conditional heteroscedastic (ARCH) effects. Engle's ARCH test is a Lagrange multiplier test to assess the significance of ARCH effects. The test statistic for Engle's ARCH test is the usual F statistic for the regression on the squared residuals. Under the null hypothesis, the F statistic follows a χ^2 distribution with m degrees of freedom. A large critical value indicates rejection of the null hypothesis in favor of the alternative (Engle, 1982).

3.3.12 White Heteroscedasticity Test

The White Test is a test for heteroskedasticity in OLS residuals. The null hypothesis of the White Test is that there is no heteroskedasticity. The test statistic is computed by an auxiliary regression of the squared residuals on all possible cross products of the regressors. The number of observations times the R^2 from the test regression is used to compute the White Test statistic (EViews User's Guide, p 340).

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Descriptive Statistics

The important descriptive statistics for the six variables and their distribution were obtained for empirical investigation.

Table 4.1 Descriptive Statistics of Variables

Variable	Mean	SD	Variance	Min	Max	Skewness	Kurtosis	Correlation
GDP	2750.6	2795.1	7812727.9	251.9	9785.0	1.273	0.586	
EDU	57.9	51.1	2608.9	8.1	190.0	1.074	0.235	0.989
HEALTH	41.0	39.0	1524.8	4.6	138.4	1.056	0.127	0.998
PETRO	165.7	198.2	39265.8	6.1	609.2	1.175	0.076	0.978
ELEC	6.1	2.7	7.5	2.4	11.0	0.369	-1.175	0.944
VA	4.1	0.4	0.2	2.8	4.8	-1.172	2.068	0.373

Results of Table 4.1 indicate the mean GDP of the series during 1989 to 2014 is 2750.6. Minimum (251.9) and maximum (9785.0) values of GDP were in 1989 and 2014 respectively. It can be seen that the variance of the GDP is exceptionally high. The variance of electricity consumption and the variance of number of vessels arrived are very low. The correlations between GDP and the five variables namely EDU, HEALTH, PETRO, ELEC and VA were found as 0.989, 0.998, 0.978, 0.944 and 0.373.

4.2 Temporal Variation of Variables

The Time series plots for GDP, government expenditure on education, government expenditure on Health, electricity consumption, petroleum expenditure and vessels arrived are shown in Figures 4.1 – 4.6 respectively.

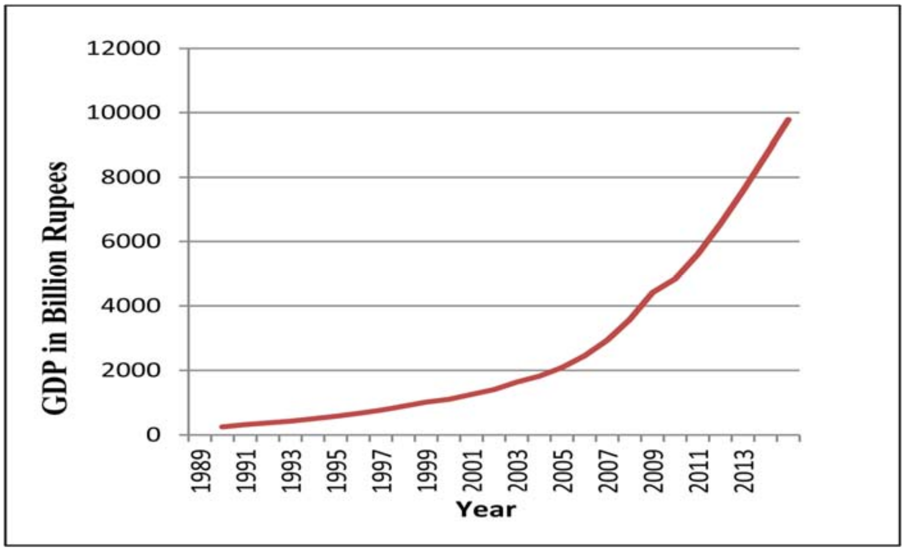


Figure 4.1: Time Series Plot for GDP

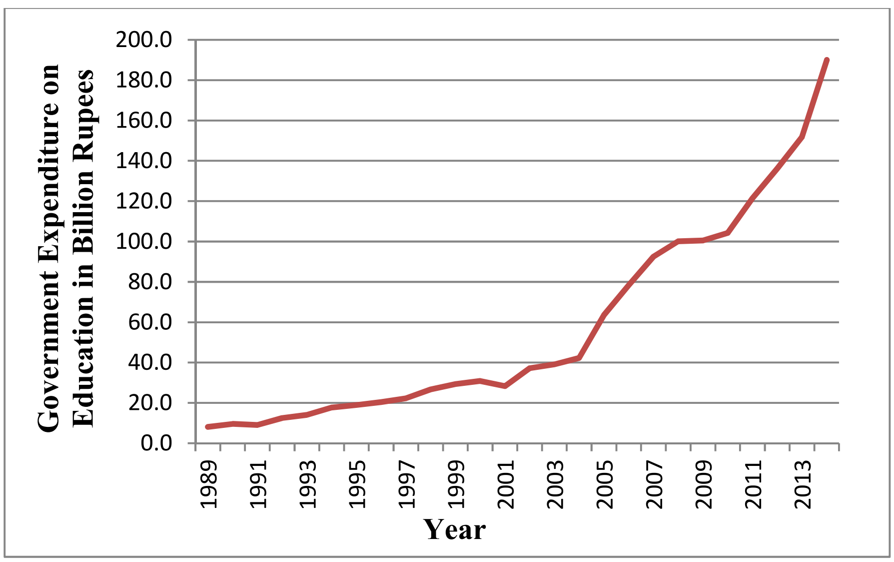


Figure 4.2 : Time Series Plot for Government Expenditure on Education in Billion Rupees

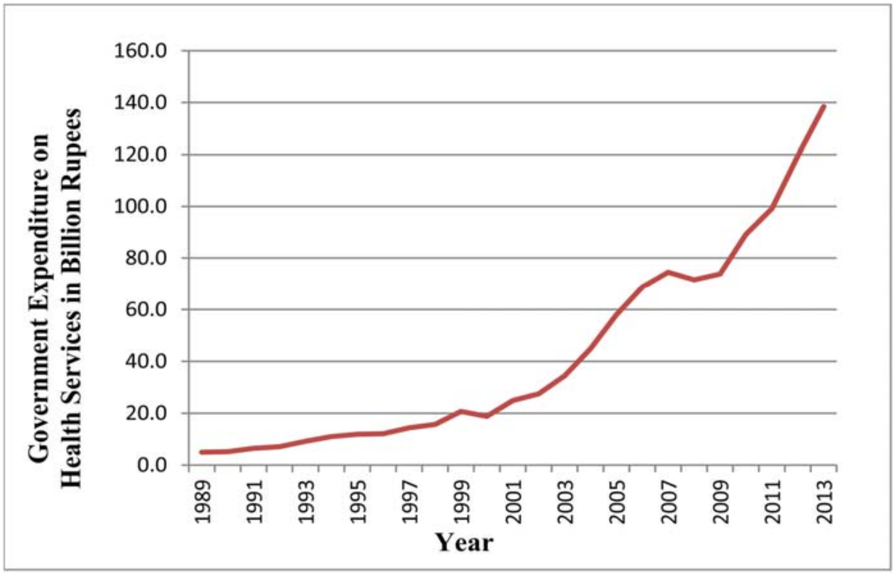


Figure 4.3 : Time Series Plot for Government Expenditure on Health Services in Billion Rupees

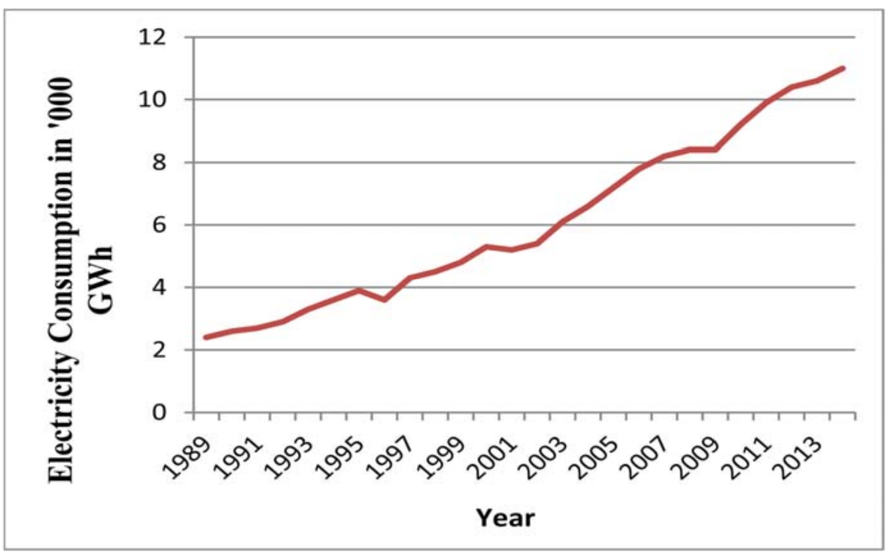


Figure 4.4 : Time Series Plot for Electricity Consumption in '000 GWh

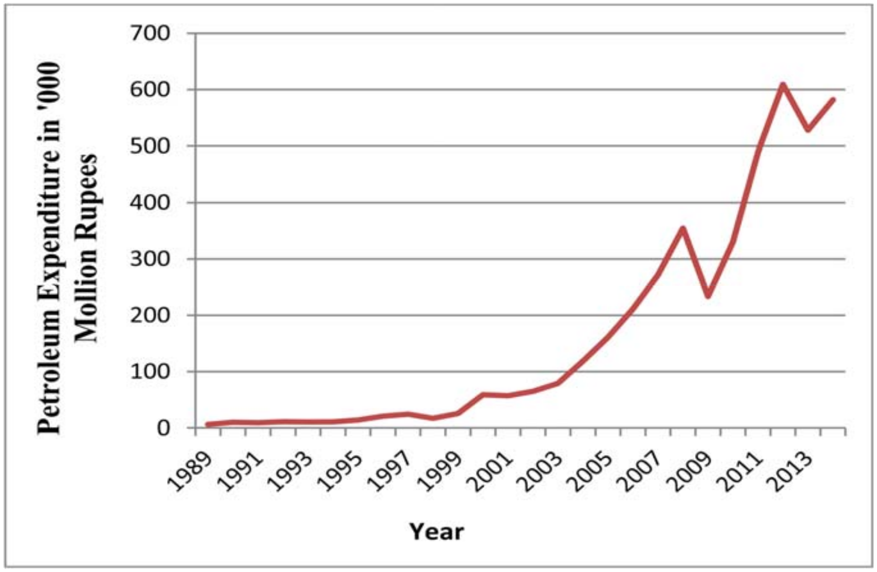


Figure 4.5 : Time Series Plot for Petroleum Expenditure on Local Consumption in '000 Million Rupees

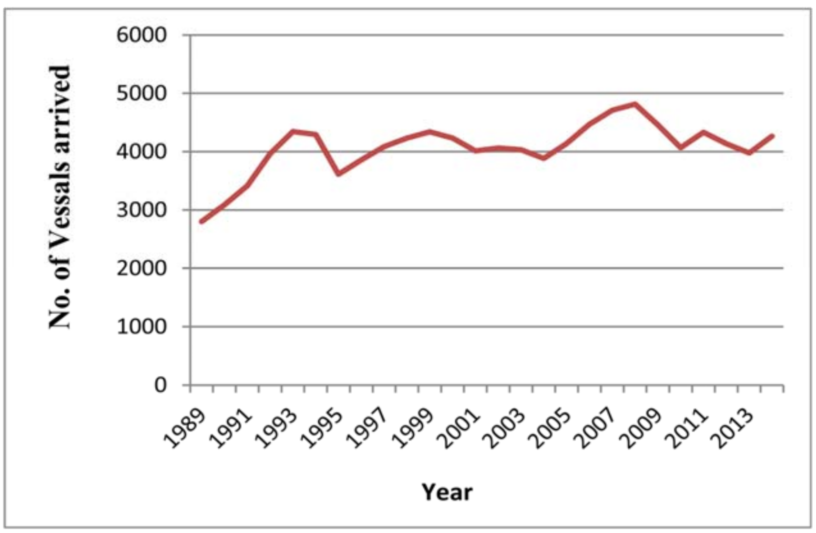


Figure 4.6 : Time Series Plot for Number of Vessels Arrived

The above graphs of GDP, government expenditure on education, government expenditure on health services, electricity consumption and petroleum expenditure indicate upward trend with higher increasing rate over the years while the number of vessels arrived over time indicates a natural fluctuation between 3000 and 5000 with an exponential low value in 1989. It clearly seems that all the variables are non-stationary.

4.3 Check the Series for Stationary

In order to avoid the possibility of biased results due to existence of unit roots in each variable, unit root test was carried out using augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test. Results are shown in table 4.2.

Table 4.2: Results of Augmented Dickey-Fuller and Phillips-Perron Tests

Series	ADF		Phillips-Perron	
	Test Statistic	P - Value	Test Statistic	P - Value
GDP	5.9272	1.0000	5.7638	1.0000
EDU	1.4596	0.9999	1.4596	0.9999
ELEC	-1.8120	0.6684	-1.6057	0.7616
HEALTH	1.1268	0.9998	0.7945	0.9995
PETRO	1.4890	0.9999	-1.1141	0.9063
VA	-4.0630	0.0201	-3.0217	0.1463
Critical Value (1%)	-4.3743			
Critical Value (5%)	-3.6032			
Critical Value (10%)	-3.2381			

Results in Table 4.2 clearly indicate that the respective P values of variables are greater than the significance levels $\alpha = 0.01, 0.05$ and 0.1. Therefore all the series are non-stationary. As all the series showed upward trend, log transformation is applied for the all series as variance stabilization measure.

4.4 Check the Log Series for Stationary

ADF test and Phillips-Perron test were applied to verify the stationary of the log transformation series and results are shown in Table 4.3.

Table 4.3 : Results of Augmented Dickey-Fuller and P-P Tests for Log Series

Series	ADF		Phillips-Perron	
	Test Statistic	P - Value	Test Statistic	P - Value
LGDP	-1.9945	0.5760	-2.2426	0.4475
LEDU	-2.6080	0.2800	-2.6523	0.2626
LELEC	-3.0734	0.1339	-3.0572	0.1377
LHEALTH	-3.1873	0.1114	-2.6905	0.2483
LPETRO	-2.7075	0.2420	-2.6024	0.2822
LTD	-2.3582	0.3899	-1.6493	0.7433
LVA	-4.1295	0.0175	-3.5155	0.0594
Critical Value (1%)	-4.3743			
Critical Value (5%)	-3.6032			
Critical Value (10%)	-3.2380			

According to the results of Augmented Dicky-Fuller and Phillips-Perron tests in Table 4.3, it can be confirmed that log series of all the variables are non stationary at 5% significance level as corresponding p-values of all variables are greater than 0.05. The first difference of each series was considered.

4.5 : Stationary of Log Series

For Granger Causality tests, it is necessary that all series should be stationary at the same level. Then the 1st differences of the log Series were checked for stationary. Time series plots for log transformation of GDP, EDU, HEALTH, ELEC, PETRO and VA are shown in Figure 4.7 – 4.12 respectively.

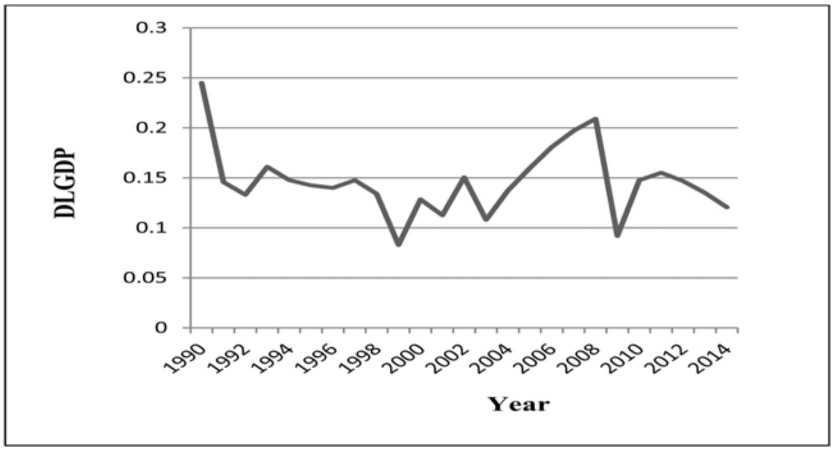


Figure 4.7 : Time Series Plot for 1st Difference Series of Log Series of the GDP

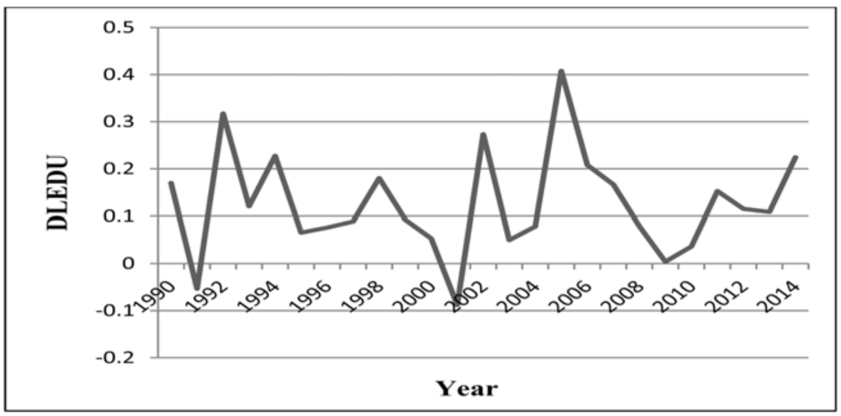


Figure 4.8 : Time Series Plot for 1st Difference Series of Log Series of Government Expenditure on Education

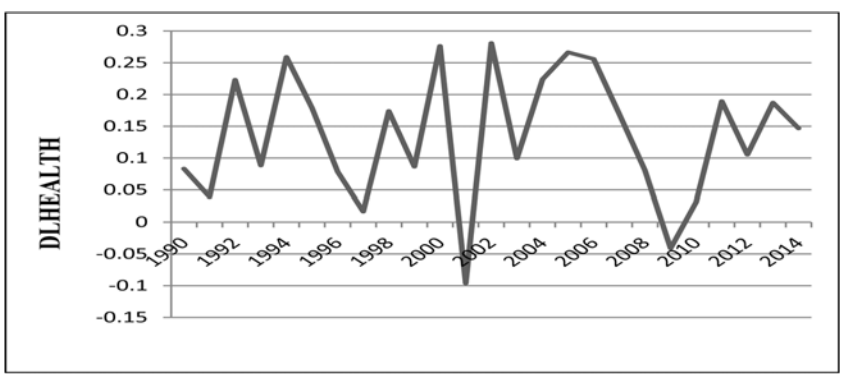


Figure 4.9 : Time Series Plot for 1st Difference Series of Log Series of Government Expenditure on Health Services

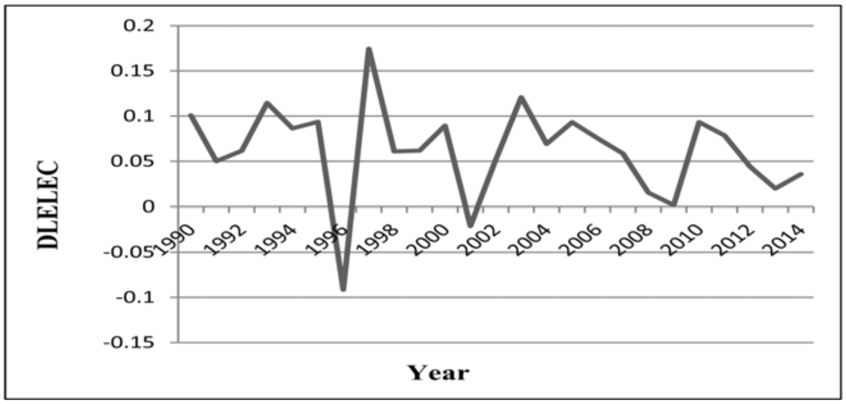


Figure 4.10 : Time Series Plot for 1st Difference Series of Log Series of Electricity Consumption

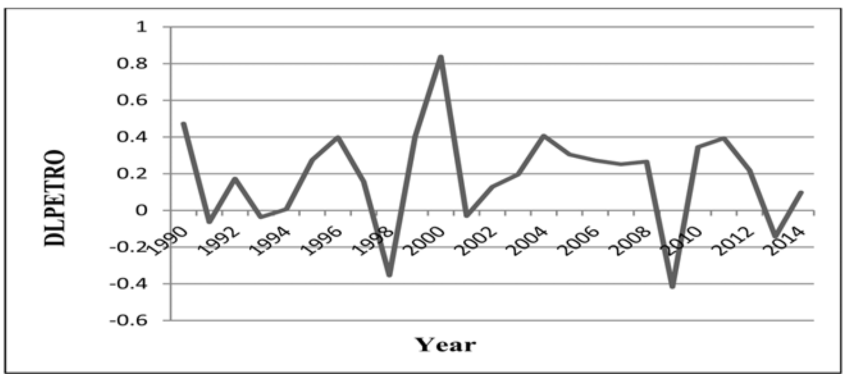


Figure 4.11 : Time Series Plot for 1st Difference Series of Log Series of Petroleum Expenditure

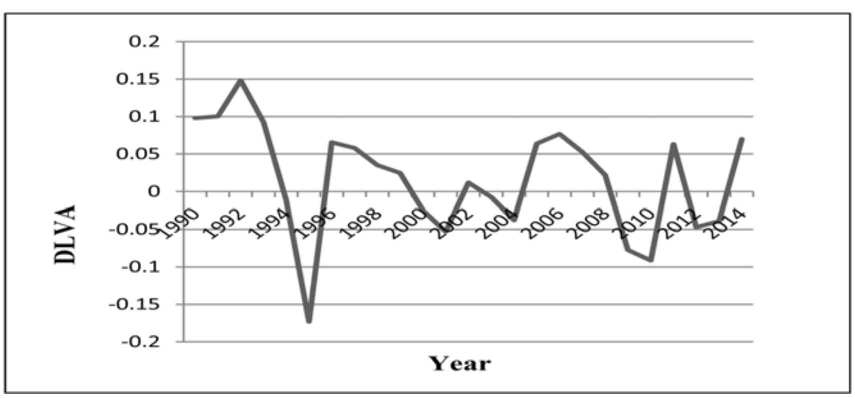


Figure 4.12 : Time Series Plot for 1st Difference Series of Log Series of Number of Vessels Arrived

Table 4.4 : Results of Augmented Dickey-Fuller and P - P Tests for 1st Difference Series of Log Series

Series	ADF		Phillips-Perron	
	Test Statistic	P - Value	Test Statistic	P - Value
DLGDP	-4.7756	0.0044	-4.7592	0.0045
DLEDU	-5.3125	0.0013	-5.3125	0.0013
DLELEC	-6.4864	0.0001	-10.9911	0.0000
DLHEALTH	-5.4817	0.0009	-5.4503	0.0010
DLPETRO	-5.3450	0.0014	-7.7755	0.0000
DLVA	-3.6051	0.0507	-3.3619	0.0805
Critical Value (1%)	-4.3943			
Critical Value (5%)	-3.6122			
Critical Value (10%)	-3.2431			

Results in Augmented Dicky Fuller and Phillips-Perron tests indicate that the 1st difference of log series of GDP (DLGDP), DLEDU, DLELEC, DLHEALTH and DLPETRO are stationary at 5% significance level (p-value<0.05) and DLVA is stationary at 10% level (p-value<0.001). As can be seen in the Table 4.4 null hypothesis that the series contain a unit root can be rejected at 1%, 5% and 10% significance level. Because, both P-values are less than the significance levels, it can be concluded that both series are stationary at its 1st difference suggesting that these series are integrated of order one, I(1).

4.6 Long Run Equilibrium

Since the series are integrated in same order I(1), it is required to estimate the long run equilibrium relationship between the log series. Hence the simple linear regression was carried out taking LGDP as the response variable and LEDU, LHEALTH, LELEC, LPETRO, LVA as explanatory variables to check the stationary of error series of the above regression model. The results of the simple linear regression model are presented in table 4.5.

Table 4.5 : Results of the Estimated Simple Linear Regression model

Variable	Co-efficient	P-value
Dependent Variable: LGDP		
LEDU	1.019630	0.0040
LHEALTH	-0.524136	0.1851
LELEC	1.118130	0.0105
LPETRO	0.123926	0.2075
LVA	-0.450837	0.0722
Constant	3.557935	0.0000
R-Squared	0.994095	
Adjusted R-Square	0.992619	
DW Statistic	1.378336	
Sum squared resid	0.176958	
S.E. of regression	0.094063	
F-statistic	673.3973	

The results confirm that two parameters (LEDU and LELEC) are statistically significant at 5% level and LVA is significant at 10% level. It can be seen that the R^2 statistic is very high (99%) and it is almost equal to adjusted R^2 (99%). However Durbin-Watson statistics is not close to two (1.38) confirming errors are not randomly distributed. Results of residual analysis are shown in Table 4.6. The residual equation is as follows.

Error = LGDP - 1.019630 * LEDU + 0.524136 * LHEALTH - 1.118130 * LELEC - 0.123926 * LPETRO + 0.450837 * LVA - 3.557935 (13)

Table 4.6 : Test the Randomness of Residuals

Test	T- Statistic	P-value
ADF	-6.206944	0.0002
Phillips - Perron	-6.299353	0.0002

Critical value (1%)	-4.394309
Critical value (5%)	-3.612199
Critical value (10%)	-3.243079

According to the results in Table 4.6, null hypothesis, H_0 : first difference of residuals has a unit root is rejected at 5% significance level as P-value of the test statistic is 0.0002 (Table 4.6). Thus it can be concluded that the residual series is stationary at its first difference. Once a unit root has been confirmed for the residuals, it is necessary to test for the existence of a long-run equilibrium relationship among the observed sets of variables.

4.7 Selection of Optimal Lag Length

A major requirement in conducting Johansen co-integration tests and estimation of a VECM system is the choice of an optimal lag length. In this study, the optimal lag length choice was made by examining the lag structure in an unrestricted VAR using lag order selection criteria. Minimum value of Akaike Information Criterion(AIC), Schwarz Information Criterion(SIC) and Hannan-Quinnin Information Criterion(HQ) were considered to select the optimal lag length.

Table 4.7 Results of Lag Order Selection

Lag	AIC	SC	HQ
0	-8.282598	-7.988084	-8.204463
1	-15.66513*	-13.60354*	-15.11819*
2	-15.38992	-11.56124	-14.37417

* indicates lag order selected by the criterion.

Results in Table 4.7 indicate that minimum value of Akaike Information Criterion(AIC), Schwarz Information Criterion(SIC) and Hannan-Quinnin Information Criterion(HQ) indicators were obtained at Lag 1. Therefore it can be concluded that the optimal lag order is 1 for Johansen co-integration model. However, to apply Johansen co-integration test, variables should be non stationary at level and to be stationary at the first differences of each series.

4.8 Evidence from Granger Causality Test

The next analysis is to test for causality between GDP and selected components of infrastructure development in the long run. Table 4.8 reports the results of the causality tests between variables DLGDP, DLEDU, DLELEC, DLHEALTH, DLPETRO and DLVA.

Table 4.8 : Pair wise Granger Causality Test

Null Hypothesis	F-Statistic	Probability	Decision
DLEDU does not Granger Cause DLGDP	0.69447	0.41403	Do not Reject
DLGDP does not Granger Cause DLEDU	0.42588	0.52110	Do not Reject
DLELEC does not Granger Cause DLGDP	0.04458	0.83481	Do not Reject
DLGDP does not Granger Cause DLELEC	0.73482	0.40100	Do not Reject
DLHEALTH does not Granger Cause DLGDP	0.03967	0.84405	Do not Reject
DLGDP does not Granger Cause DLHEALTH	1.83633	0.18978	Do not Reject
DLPETRO does not Granger Cause DLGDP	0.40239	0.53271	Do not Reject
DLGDP does not Granger Cause DLPETRO	7.32512*	0.01322	Reject
DLVA does not Granger Cause DLGDP	0.29637	0.59190	Do not Reject
DLGDP does not Granger Cause DLVA	0.36048	0.55466	Do not Reject
DLELEC does not Granger Cause DLEDU	0.01685	0.89796	Do not Reject
DLEDU does not Granger Cause DLELEC	2.40370**	0.09359	Reject
DLHEALTH does not Granger Cause DLEDU	0.01196	0.91396	Do not Reject
DLEDU does not Granger Cause DLHEALTH	0.43761	0.51547	Do not Reject
DLPETRO does not Granger Cause DLEDU	1.71593	0.20437	Do not Reject
DLEDU does not Granger Cause DLPETRO	3.0E-05	0.99566	Do not Reject
DLVA does not Granger Cause DLEDU	0.34964	0.56063	Do not Reject

Table 4.8 (Contd.) : Pair wise Granger Causality Test

DLEDU does not Granger Cause DLVA	0.19242	0.66539	Do not Reject
DLHEALTH does not Granger Cause DLELEC	0.00074	0.97850	Do not Reject
DLELEC does not Granger Cause DLHEALTH	2.06395**	0.06555	Reject
DLPETRO does not Granger Cause DLELEC	0.52114	0.47832	Do not Reject
DLELEC does not Granger Cause DLPETRO	0.01935	0.89069	Do not Reject
DLVA does not Granger Cause DLELEC	7.26910*	0.01353	Reject
DLELEC does not Granger Cause DLVA	0.00266	0.95938	Do not Reject
DLPETRO does not Granger Cause DLHEALTH	0.71036	0.40882	Do not Reject
DLHEALTH does not Granger Cause DLPETRO	0.42829	0.51993	Do not Reject
DLVA does not Granger Cause DLHEALTH	0.03292	0.85776	Do not Reject
DLHEALTH does not Granger Cause DLVA	0.12864	0.72342	Do not Reject
DLVA does not Granger Cause DLPETRO	1.64007	0.21428	Do not Reject
DLPETRO does not Granger Cause DLVA	0.11364	0.73938	Do not Reject

Note : *, ** denotes rejection of the hypothesis at the 0.05 and 0.10 level

The results of Table 4.8 indicate that the null hypothesis of DLGDP does not granger cause DLEDU, DLELEC, DLHEALTH and DLVA do not reject at 1%, 5% and 10% level of significance. Further the causality test also indicate that the causality is running from GDP to petroleum expenditure and there is a one way causal relationship exists between electricity consumption and vessels arrived, electricity consumption and health expenditure, education expenditure and electricity consumption.

4.9 Estimation of the Johansen Co-integration Model

Since all variables are integrated of order one to test for co-integration, Johansen Co-integration test was applied at the predetermined lag 1 to estimate the long run equilibrium relationship among the variables. In this test, trace statistics (Table 4.9) and maximum eigenvalue statistics (Table 4.10) were compared with the corresponding critical values. Co-integration test for log transformation series of GDP, EDU, HEALTH, ELEC, PETRO and VA are shown in Table 4.10.

Table 4.9 : Results of Trace Test for Log Series

Unrestricted Co-integration Rank Test(Trace)				
Number of Co-integrating Equation	Trace test			
	Eigenvalue	Statistic	Critical Value (5%)	P-value
None *	0.766941	105.4293	95.75366	0.0091
At most 1 *	0.666873	70.47417	69.81889	0.0443
At most 2	0.599185	44.09261	47.85613	0.1080
At most 3	0.403569	22.15047	29.79707	0.2902
At most 4	0.329178	9.747450	15.49471	0.3007
At most 5	0.006869	0.165419	3.841466	0.6842

Trace test indicates 2 co integrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Table 4.10 : Results of Maximum Eigenvalue Test for Log Series

Unrestricted Co-integration Rank Test (Maximum Eigen Test)				
Number of Co-integrating Equation	Maximum Eigenvalue Test			
	Eigenvalue	Statistic	Critical Value (5%)	P-value
None	0.766941	34.95517	40.07757	0.1688
At most 1	0.666873	26.38156	33.87687	0.2980
At most 2	0.599185	21.94214	27.58434	0.2234
At most 3	0.403569	12.40302	21.13162	0.5084
At most 4	0.329178	9.582031	14.26460	0.2409
At most 5	0.006869	0.165419	3.841466	0.6842

Results in Table 4.9 indicate that trace statistics is greater than critical value at 5% level only for the 1st two eigenvalues, confirming H_0 is rejected at 5% significant level. Thus there is no co-integration among the series. However results in maximum eigenvalue test (Table 4.10) also confirm the above results. Results of both tests did not show the same results, it cannot indicate that there exists a long run relationship among the variables. That is all variables do not move together. Co-integration test for original series of GDP, EDU, HEALTH, ELEC, PETRO and VA are shown in table 4.11 and 4.12.

Table 4.11 : Results of Trace Test for Original Series

Unrestricted Co-integration Rank Test(Trace)				
Number of Co-integrating Equation	Trace test			
	Eigenvalue	Statistic	Critical Value (5%)	P-value
None *	0.960795	77.73457	40.07757	0.0000
At most 1 *	0.797538	38.33287	33.87687	0.0137
At most 2	0.612083	22.72715	27.58434	0.1854
At most 3	0.528603	18.04932	21.13162	0.1280
At most 4	0.328454	9.556160	14.26460	0.2427
At most 5	0.115965	2.958204	3.841466	0.0854

Trace test indicates 2 co integrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

Table 4.12 : Results of Maximum Eigen value Test for Original Series

Unrestricted Co-integration Rank Test (Maximum Eigen Test)				
Number of Co-integrating Equation	Maximum Eigen value Test			
	Eigen value	Statistic	Critical Value (5%)	P-value
None *	0.960795	169.3583	95.75366	0.0000
At most 1 *	0.797538	91.62371	69.81889	0.0004
At most 2 *	0.612083	53.29084	47.85613	0.0142
At most 3 *	0.528603	30.56369	29.79707	0.0407
At most 4	0.328454	12.51436	15.49471	0.1339
At most 5	0.115965	2.958204	3.841466	0.0854

Trace test indicates 4 co integrating eqn(s) at the 0.05 level

When the original series of GDP, EDU, HEALTH, ELEC, PETRO and VA were considered trace statistics (Table 4.11) is greater than critical value at 5% level only up to at most 1, confirming H_0 is rejected at 5% significant level. Maximum Eigen value statistics (Table 4.12) is greater than critical value at 5% level up to at most 3. Hence it can be concluded that Trace Statistics Test indicates 2 co-integration equations and Maximum Eigen value Test indicates 4 co-integration equations. Therefore it implied that there exists a long run equilibrium relationship among the variables. Hence vector error correction model can be applied to the variables.

4.10 Estimation of Vector Error Correction Model

To determine the short run relationship among the series, Vector Error Correction Model (VECM) was applied. Table 4.13 presents the results of the VECM.

Table 4.13 : Co-integrating Results for Error Correction Model

Co-integrating Eq:	CointEq1
LGDP(-1)	1.000000
LEDU(-1)	-1.625490
	(0.17917)
	[-9.07239]
LELEC(-1)	-0.396536
	(0.31957)
	[-1.24086]
LHEALTH(-1)	1.254101
	(0.24940)
	[5.02838]
LPETRO(-1)	-0.464711
	(0.06943)
	[-6.69359]
LVA(-1)	0.074109
	(0.12868)
	[0.57592]
C	-2.967272

Coefficient estimated of the VEC model is presented in Table 4.13 and Table 4.14. Table 4.13 contains the detail of the co-integration vector which is derived by normalizing the GDP. The long run equation is given as follows:

GDP(-1) = - 2.967272 - 1.625490 * LEDU(-1) - 0.396536 * LELEC(-1) + 1.254101 * LHEALTH(-1) - 0.464711 * LPETRO(-1) + 0.074109 * LVA(-1) (14)

Table 4.14 : Coefficients of the Error Correction Terms

Error Correction	D(LGDP)	D(LEDU)	D(LELEC)	D(LHEALTH)	D(LPETRO)	D(LVA)
CointEq1	-0.164100	0.563439	0.330977	0.251726	0.267324	0.469706
	(0.11060)	(0.43575)	(0.13161)	(0.38137)	(0.96259)	(0.27666)
	[-1.48372]	[1.29302]	[2.51482]	[0.66006]	[0.27771]	[1.69776]
D(LGDP(-1))	-0.135769	0.235158	-0.300816	-0.823789	-3.666937	0.816858
	(0.23985)	(0.94498)	(0.28541)	(0.82704)	(2.08749)	(0.59997)
	[-0.56606]	[0.24885]	[-1.05397]	[-0.99607]	[-1.75663]	[1.36149]
D(LEDU(-1))	-0.002416	0.001655	0.432183	0.348663	0.500942	0.243483
	(0.12312)	(0.48507)	(0.14651)	(0.42453)	(1.07154)	(0.30798)
	[-0.01962]	[0.00341]	[2.94992]	[0.82129]	[0.46750]	[0.79059]
D(LELEC (-1))	-0.045109	0.337090	-0.208405	0.744075	0.013422	0.108434
	(0.12936)	(0.50967)	(0.15394)	(0.44606)	(1.12587)	(0.32359)
	[-0.34871]	[0.66139]	[-1.35385]	[1.66812]	[0.01192]	[0.33509]
D(LHEALTH(-1))	0.013326	-0.114064	-0.364430	-0.456349	0.160607	-0.312814
	(0.12052)	(0.47486)	(0.14342)	(0.41559)	(1.04897)	(0.30149)
	[0.11056]	[-0.24021]	[-2.54098]	[-1.09808]	[0.15311]	[-1.03756]
D(LPETRO (-1))	-0.008290	-0.019882	0.066831	0.006982	0.058320	0.107713
	(0.03423)	(0.13487)	(0.04073)	(0.11803)	(0.29793)	(0.08563)
	[-0.24217]	[-0.14742]	[1.64066]	[0.05915]	[0.19575]	[1.25792]

Table 4.14 (Contd.) : Coefficients of the Error Correction Terms

D(LVA(-1))	-0.039917	0.503594	0.441816	0.190937	-0.489063	0.390090
	(0.10783)	(0.42485)	(0.12832)	(0.37183)	(0.93851)	(0.26974)
	[-0.37017]	[1.18534]	[3.44314]	[0.51351]	[-0.52111]	[1.44617]
C	0.165733	0.080226	0.095127	0.228523	0.623427	-0.126801
	(0.03843)	(0.15142)	(0.04573)	(0.13252)	(0.33450)	(0.09614)
	[4.31222]	[0.52981]	[2.07999]	[1.72439]	[1.86376]	[-1.31892]
R-squared	0.228738	0.231225	0.670710	0.292149	0.323822	0.243704
Adj. R-sq	-0.108689	-0.105115	0.526646	-0.017536	0.027994	-0.087175
Sum sq. resids	0.014623	0.226988	0.020706	0.173864	1.107663	0.091500
S.E. equation	0.030231	0.119108	0.035974	0.104242	0.263114	0.075623
F-statistic	0.677889	0.687474	4.655636	0.943376	1.094628	0.736536

Table 4.14 contains the coefficients of the error correction terms (cointEq1) for the co-integration vector. These coefficients are called the adjustment coefficients. This measures the short-run adjustments of the deviations of the endogenous variables from their long- run values. Thus, using the error correction term as another independent variable in the restricted VAR model the following Vector Error Correction Model can be recommended.

D(LGDP) = -0.164100*(LGDP(-1) - 1.625490* LEDU(-1) - 0.396536* LELEC(-1) + 1.254101* LHEALTH(-1) - 0.464711 * LPETRO(-1) + 0.074109* LVA(-1) - 2.967272) - 0.135769 * D(LGDP(-1)) - 0.002416 * D(LEDU(-1)) - 0.045109 * D(LELEC(-1)) + 0.013326 * D(LHEALTH(-1)) - 0.008290 * D(LPETRO(-1)) - 0.039917 * D(LVA(-1)) + 0.165733 (15)

4.11 Check Long Run and Short Run Causality

D(LGDP) = C(1) * (LGDP(-1) - 0.4647108895 * LPETRO(-1) - 0.396535763 * LELEC(-1) - 1.625490413 * LEDU(-1) + 1.254100559 * LHEALTH(-1) + 0.07410918997 * LVA(-1) - 2.967271861) + C(2) * D(LGDP(-1)) + C(3) * D(LPETRO(-1)) + C(4) * D(LELEC(-1)) + C(5) * D(LEDU(-1)) + C(6) * D(LHEALTH(-1)) + C(7) * D(LVA(-1)) + C(8) (16)

Table 4.15 : Error Correction Terms to Determine Long Run Causality

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.164100	0.110600	-1.483725	0.1573
C(2)	-0.135769	0.239848	-0.566063	0.5792
C(3)	-0.008290	0.034231	-0.242172	0.8117
C(4)	-0.045109	0.129361	-0.348706	0.7319
C(5)	-0.002416	0.123118	-0.019622	0.9846
C(6)	0.013326	0.120525	0.110565	0.9133
C(7)	-0.039917	0.107833	-0.370170	0.7161
C(8)	0.165733	0.038433	4.312216	0.0005

According to the results of Table 4.15, Error Correction term (C(1)) is statistically not significant at 1%, 5% and 10% significance level indicating that independent variables have no long run causality on dependant variable.

Table 4.16 : Error Correction Terms to Determine Short Run Causality (Wald Test)

Test Statistics	Value	Probability
F-statistic	3.564984	0.0195
Chi-square	21.38990	0.0016

A result of Table 4.16 indicates that Chi-square value is significant (p value < 0.05) thus H_0 is rejected. It means all the coefficients of independent variables jointly influence on dependant variable. There is a short run causality on dependant variable.

4.12 Model Checking

In order to ascertain whether the model provides an appropriate representation, a test for misspecification should be performed.

Table 4.17 : Test of Residual Autocorrelation

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. | . |</td><td>. | . |</td><td>1</td><td>0.050</td><td>0.050</td><td>0.0688</td><td>0.793</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>2</td><td>0.012</td><td>0.009</td><td>0.0727</td><td>0.964</td></tr>
<tr><td>. |* . |</td><td>. |* . |</td><td>3</td><td>0.153</td><td>0.153</td><td>0.7703</td><td>0.857</td></tr>
<tr><td>.**| . |</td><td>.**| . |</td><td>4</td><td>-0.284</td><td>-0.307</td><td>3.2802</td><td>0.512</td></tr>
<tr><td>.**| . |</td><td>. *| . |</td><td>5</td><td>-0.190</td><td>-0.170</td><td>4.4631</td><td>0.485</td></tr>
<tr><td>.**| . |</td><td>.**| . |</td><td>6</td><td>-0.220</td><td>-0.253</td><td>6.1369</td><td>0.408</td></tr>
</table>

Table 4.17 represents the results of the correlogram of Q statistic test for VEC model. These tests are used to test the overall significance of the residual autocorrelations. According to the table 4.17, it can be concluded that there is no obvious residual autocorrelation problem hence all p-values are larger than 0.05 significance level.

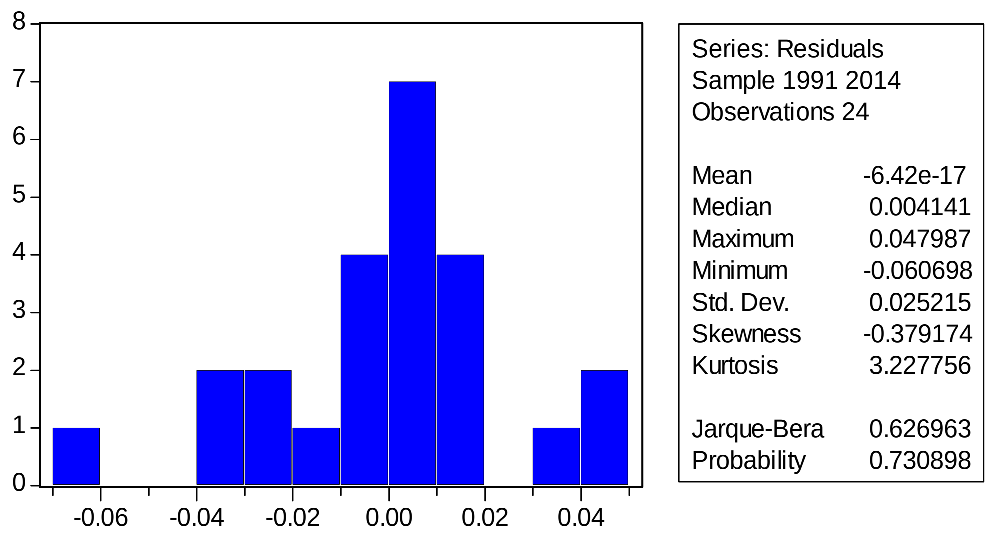


Figure 4.13 : Normality Test

According to the results of Normality test, Jarque-Bera value is 0.626963 and p-value >0.05 (0.730898) confirming the normality of residual distribution at 5% significance level.

Table 4.18: Test of Serial Correlation

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	6.967700	Probability	0.007940
Obs*R-squared	11.97225	Probability	0.002513

Results of Table 4.18 indicate that P value is less than 5%, indicating that H_0 is rejected. Thus it can be concluded that this model has any serial correlation.

Table 4.19: ARCH LM Test

F-statistic	0.701168	Probability	0.508394
Obs*R-squared	1.512149	Probability	0.469506

Results of Table 4.19 indicate that fitted model does not have any ARCH effect since P value is greater than 0.05.

Table 4.20 : White Heteroscedasticity Test

F-statistic	1.324887	Probability	0.235178
Obs*R-squared	23.96411	Probability	0.243963

Results of table 4.20 indicate that residuals are not heteroscedasticity ($p > 0.05$) confirming that fitted model has homoxedasticity.

CHAPTER FIVE

CONCLUTIONS AND RECOMMENDATIONS

5.1 Conclusions

This study examined the causality between GDP and infrastructure development in Sri Lanka over the period 1989 to 2014. The five components considered in the model for infrastructure development on annual basis are Government expenditure on education (EDU), government expenditure on health services (HEALTH), electricity consumption (ELEC), petroleum expenditure (PETRO) and number of vessels arrived (VA). All variables studied were non stationary in ordinary form. Log transformation was used to reduce the variance heteroscedasticity. The Augmented Dicky-Fuller and Phillips-Perron used in the tests confirmed that the 1st difference of log series were stationary and the analyses was carried out for log series. All three information criteria: Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinnin Information Criterion (HQ) confirmed that the optimal lag order is 1 for Johansen co-integration model.

The analysis indicated that the existence of a short run equilibrium relationship among selected variables. The causality is running from GDP to petroleum expenditure and there is a one way causal relationship exists between electricity consumption and number of vessels arrived, electricity consumption and health expenditure, education expenditure and electricity consumption. The identified short-term relationship is:

D(LGDP) = -0.164100*(LGDP(-1) - 1.625490* LEDU(-1)- 0.396536* LELEC(-1) + 1.254101* LHEALTH(-1) - 0.464711 * LPETRO(-1) + 0.074109* LVA(-1) - 2.967272) - 0.135769 * D(LGDP(-1)) - 0.002416 * D(LEDU(-1)) - 0.045109 * D(LELEC(-1)) + 0.013326 * D(LHEALTH(-1)) - 0.008290 * D(LPETRO(-1)) - 0.039917 * D(LVA(-1)) + 0.165733. (15)

It was found that error series of the above model satisfied all statistical requirements which confirmed that the fitted model is statistically valid. The test reveals that the existence of a positive and significant short term relationship between Government expenditure on health and GDP at 95% confidence level. But a negative and significant short term relationship was found between GPD and expenditure on education (EDU), electricity consumption (ELEC) and petroleum expenditure (PETRO). The short term impact from the number of vessels arrived (VA) is relative small compared with other variables.

The Johnson's co-integrating test confirmed that there is no long run equilibrium among selected variables. Results derived in this study have more practical implications for Government policy planners, researchers and intellectuals in the field of study.

5.2 Recommendations

It is recommended to carrying out this type tests and studies at a regular intervals prior to firm decisions are taken due to short term relationship could be expected. Also, it is recommended to use different economic variables as well.

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