Chapter 1- Introduction

1.1 Introduction

Construction is one of the major contributors for National Economy in any country. In another words, it accounts for a sizable proportion in Gross Domestic Product (GDP) and Gross National Product (GNP). Therefore, this analysis was undertaken to determine the relationship between national economy and construction activities in all segments in Sri Lanka mainly categorized as residential buildings, non-residential buildings and others. These categories cover all types of construction activities in the country including hotels, housing complexes, hospitals, trade centers, towers, schools, other buildings, urban infrastructure including water supply, sewerage and drainage. Also it comprises construction of roads, railways, highways, ports, airports; power & oil storing systems; irrigation, recreation facilities and agriculture systems and telecommunications etc. that indicates input - output flux of national fiscals.

As per the definition of United Nations (UN) construction is "an economic activity directed to the creation, renovation, repair or extension of fixed assets in the form of buildings, land improvements of an engineering nature and other such engineering constructions as roads, bridges, dams and so forth". It is a process that consists of the building or assembling of infrastructure in the fields of architecture and civil engineering. Construction industry involves a broad range of stakeholders and provides substantial employment opportunities to unskilled, semi-skilled and skilled labor markets. It supplements the foreign revenue derived from trade in construction material and engineering services. Further, it has strong linkages with other sectors which positively contribute towards the national income.

Construction activities in Sri Lanka has shown fairly upward trend year-on year since 1990. However, after the end of 30 year prolonged war in 2009, construction industry has shown a steep development with an average of 13.0% increase from 2009 to 2013. This has been accelerated specially due to reconstruction activities undertaken in North and East parts of the country and many other development projects carried out around the island. The trend for real GDP and construction sector GDP fluctuation is shown in figure 1 below.

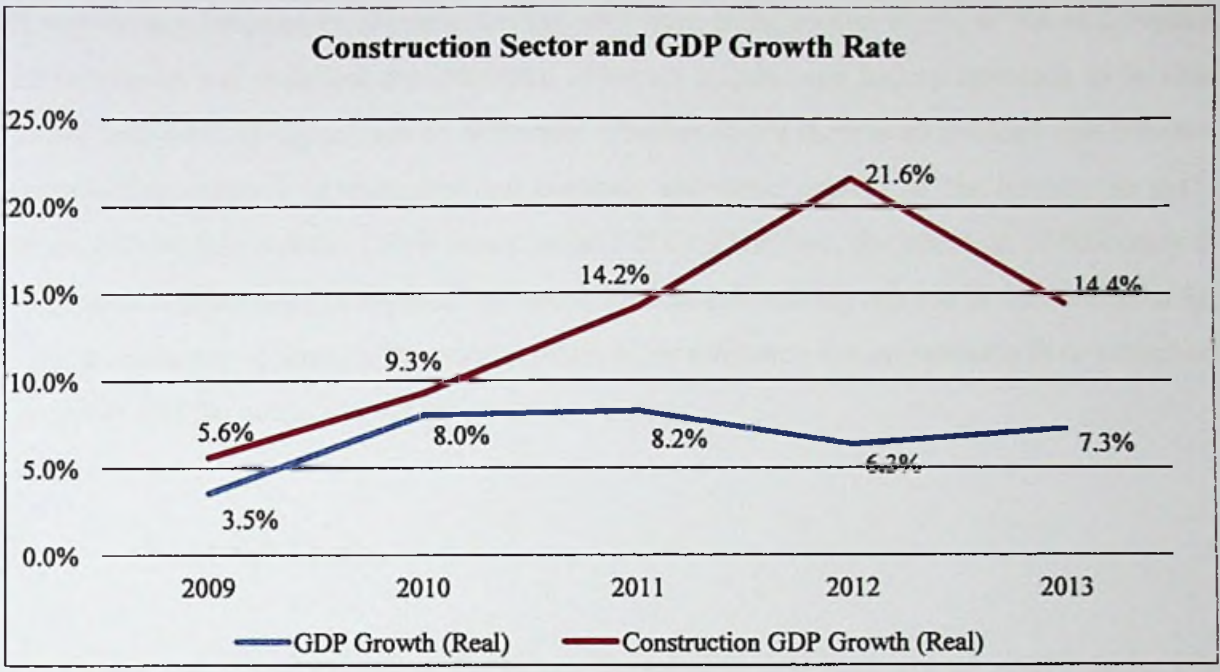


Figure 1 - Construction Sector and overall GDP Growth Rate (Source : CBSL Annual Report 2013)

As shown in Table 1.1 below, construction sector has contributed 8.1% to the overall GDP (real) in 2012 and 8.7% in 2013. Similarly, construction subsector has contributed 26.7% towards 'Industry Sector' in 2012 and subsequently 27.8% in 2013.

Table 1 - Comparison of construction sector in terms of GDP and Industry Sector (Source : CBSL Annual Report 2013)

Year	**GDP (Real)** (Rs. Mn)	**Industry Sector (Real)** (Rs. Mn)	**Construction GDP (Real)** (Rs. Mn)	**Construction as % of GDP**	**Construction as % of Industry Sector**
2009	2,449,214	701,129	162,790	6.6%	23.2%
2010	2,645,542	760,334	177,912	6.7%	23.4%
2011	2,863,715	838,932	203,204	7.1%	24.2%
2012	3,045,288	925,152	247,091	8.1%	26.7%
2013	3,266,099	1,016,886	282,742	8.7%	27.8%

However, by looking at just the row figures it may be difficult to get a clear understanding of if any money invested in construction industry may bring profits or not at the end. Hence, entrepreneurs and investors are interested to have a reliable and logical approach to be used in the decision making process to determine whether or not there is an obvious link between construction industry investments and constant economic growth of the country to get a feeling about the returns of their investments (ROI). Therefore, the intention of this study is to provide a mathematical approach to assist the decision making process in the context of Sri Lankan economy to identify the correct relationships between the investments in construction activities and the economic indicators of the country.

1.2 About Sri Lanka

Sri Lanka is an island located in the Indian Ocean with total land area of 65,610 squire kilo meters and 20.3 million of population with a distribution of 47.4% male and 52.6% female in gender (2012 census). Further, Sri Lanka has recorded 1% of population growth rate (2011). Sri Lanka is strategically located at the cross roads of major shipping routes connecting South Asia, Far East and the Pacific with Europe and the Americas next to the fast growing Indian sub-continent with close proximity to Southeast Asia and the Middle East.

As per the Socio Economic Indicators published by Central Bank of Sri Lanka (2013) Ethnic diversity of the country has been reported as Sinhalese – 74.9%, Sri Lankan Tamils – 11.2%, Indian Tamils – 4.2%, Moors – 9.2%, and Other – 0.5% (2012 census) with overall literacy rate (Aged 15 years and above, 2010) 91.9%. (Male – 93.2% and Female - 90.8%) Also the life expectancy (2011) has been reported as average of 74.9 years in total population.

Labor force as a percentage to the population has been recorded as 48.2% in the country (exclude Northern and Eastern provinces, 2011) whilst Unemployment percentage out of total labor force has been recorded as 4.2% with the same conditions. Per capita income has been recorded as USD 2,805 (LKR 310,124) in 2011 and this is an increase of 15.73% compared to 2010 and 14.65% compared to 2009.

Sri Lanka is rich with natural resources such as graphite, apatite, limestone, dolomite, mica, quartz, calcite, silica sand, gems, mineral sands, clay, hydropower and phosphates. Certain minerals such as Graphite and Silica (mostly monazite) and few verities of gems are mainly exported as row materials with no purification or processing. The Government has emanated the State policy under 'Mahinda Chinthana' vision to develop Sri Lanka as one major hub in the South Asian region consist with five sub components such as Maritime, Aviation, Commercial & Tourism, Knowledge and Energy. This is called 'five-hub concept' in government strategy plans. However, still the main economic revenue of the country is generated through tourism, apparel & textile, tea, rubber & coconut exports and other agricultural products such as rice production. Further, Sri Lanka receives significant remittance through work force deployed in foreign countries for employment.

Most of third world countries are facing the problem of racing funds to improve their capital expenditures. As a developing country, Sri Lanka is also facing for the same issue in terms of inadequacy funds to improve infrastructure facilities in the country. Nevertheless, it's a challenge to meet global standards and to par with global economic trends specially to attract investors from the outside the country. Therefore, developing of traveling and transportation facilities, aviation, ports, telecommunication, information technology and uninterrupted power solutions are essential and high priority.

1.3 Sri Lankan Economy and Outlook

As per Central Bank Statistics for past five years (2009 -2013), Sri Lanka has gained average of 6.7% growth in real GDP. Further, it was noted a sustainable growth trajectory throughout the period and has achieved 7.3% growth in 2013 compared to 6.3% in 2012. (Refer Table 1.2). This has been supported by growth of all sectors including improved earnings from merchandises, service exports and workers' remittances received in to the country. It was also noted the inflation (Colombo Consumers' Price Index, Department of Census and Statistics, Base 2006/07=100) remained at a single digit level for the fifth consecutive year, recording 6.9 in December 2013 whereas 7.6 in December 2012. Latest reports indicate that this has been further reduced to 5.6 in April 2014. Year-on-year headline inflation too has moved on a decelerating path since March 2013 with the improvements in supply conditions. Continuation of this trend will help to reduce wage pressures in the economy and also to raise investor confidence in the long run.

Further, as per World Economic Outlook by IMF (April, 2014) it is noted that, Sri Lanka has made a remarkable progress in comparison to the emerging and developing markets in the Asian continent.

Table 2 – World GDP - Real (Source : World Economic Outlook by IMF (April, 2014))

	Average 1996–2005	2009	2010	2011	2012	2013
Advanced Economies	**2.9**	**-2.7**	**1.8**	**1.4**	**1.2**	**1.0**
United States	3.9	-3.0	1.5	1.8	2.4	1.6
United Kingdom	3.9	-4.8	1.2	-0.6	1.4	1.6
Germany	0.7	-1.6	1.8	2.9	0.4	0.6
France	2.2	-1.4	1.6	1.0	-0.1	0.3
Japan	0.8	-2.3	2.0	0.7	2.2	2.1
Emerging and Developing						
Asia	7.1	7.7	9.7	7.9	6.7	6.5
Bangladesh	5.4	5.9	6.4	6.5	6.1	5.8
Bhutan	6.9	5.7	9.3	10.1	6.5	5
China	9.2	9.2	10.4	9.3	7.7	7.7
India	6.4	8.5	10.3	6.6	4.7	4.4
Indonesia	2.6	4.6	6.2	6.5	6.3	5.8
Sri Lanka	4.3	3.5	8	8.2	6.3	7.3

All sectors of the economy has contributed positively towards the steady growth of DGP and backed by favorable climate conditions prevailed during the year 2013. As a result, GDP in nominal terms has been grew by 14.5% to LKR 8,674 billion (USD 67 billion) in 2013 compared to 15.8% of growth amounting LKR 7,582 billion (USD 59.4 billion) in 2012. This has helped to raise GDP per capita from USD 2,923 in 2012 to USD 3,280 in 2013 by recognizing Sri Lanka as the second highest country for GDP per capita among the SARRC members after Maldives.

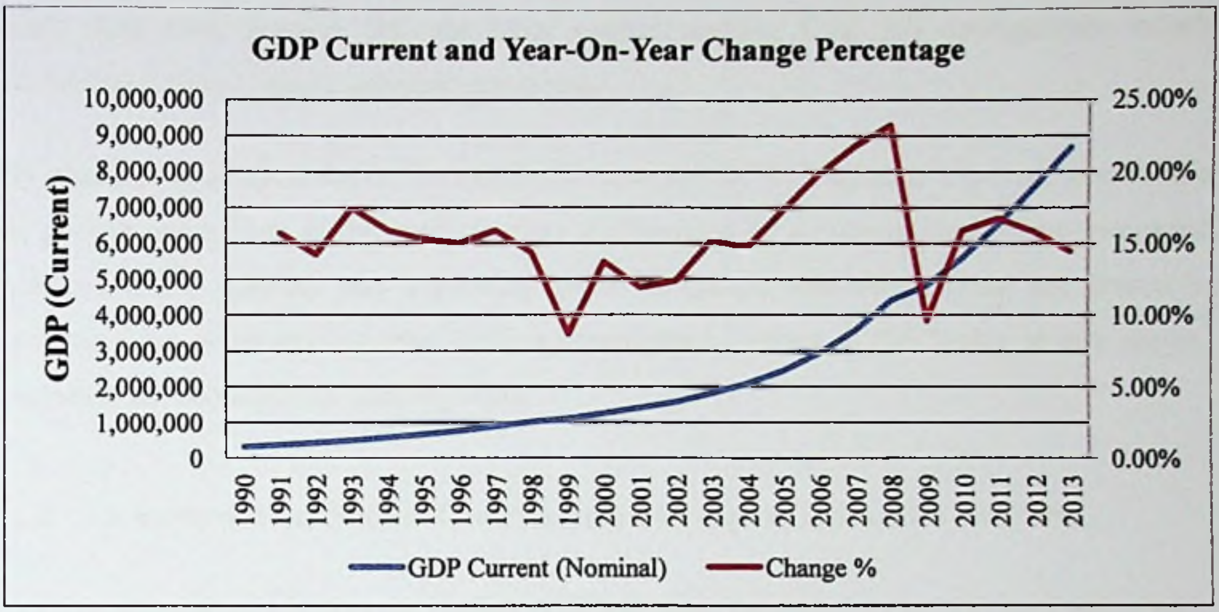


Figure 2 – GDP Current and Year-On-Year Change % (Source : CBSL)

In terms of expenditure, GDP growth supports increasing of consumption as well as investments in the country. Also it was noted interest rates have been reduced from double digit levels to single digit levels by the end of year 2013. This will lead to a positive move of the economy as relatively low interest rates will help to increase resources for investment activities in the future with the expansion in credit growth. Credit to both Industry and Services sectors have been increased by LKR 201.1 billion in 2013. The Central Bank policy introduced in 2013 has resulted to increase declarations of credit obtained from commercial banks in Sri Lanka. Further, it has helped to boost the access to the domestic and global capital markets by the private sector in 2013.

As per the preliminary findings of the Household Income and Expenditure Survey (HIES) for 2012/13, population below the Poverty Line ratio has been declined to 6.5% from 8.9% in 2009/2010. This is also a positive trend that indicates the development of Sri Lanka in terms of investor confidence. Further, it was noted that new reforms have been new introduced to simplify the tax system while reducing its inefficiencies and leakages. This will help reducing tax evasion and increase state revenue.

As per the CBSL economic indicators, it is observed an increase of labour force by 4.1% in 2013 compared to the previous year. Further, it was noted that labour force participation rate (LFPR) also has increased to 53.8% in 2013 compared to 52.6% in 2012. Although, unemployment rate has recorded high in 2013 this would have been resulted by increased entry from rural females into the labor market seeking local job opportunities which attributing 6.6% of female unemployment rate.

By considering all facts above, in overall, the economy of Sri Lankan is expected to continue its growth momentum in the medium term underpinned by increased investment, improved macroeconomic stability and improving global economic conditions. These are favorable indicators for entrepreneurs who look opportunities to invest in Sri Lanka in any sector, including the construction sector as well.

1.4 Construction Sector Contribution to Gross Domestic Product

The construction sector share to overall GDP has been improved steadily since 1990. CBSL statistics indicates 13% of average growth (in real terms) in Construction Sector during the past five years (2009 -2013). Further, it was noted the Construction Sector GDP in real terms has achieved 282.7 billion (USD 2.2 billion) in 2013 in comparison to LKR 247 billion (USD 1.9 billion) in 2012. Whilst the highest growth rate of 21.6% recorded in 2012, still the sector has maintained 14.4% of growth in 2013. (Refer figure 1)

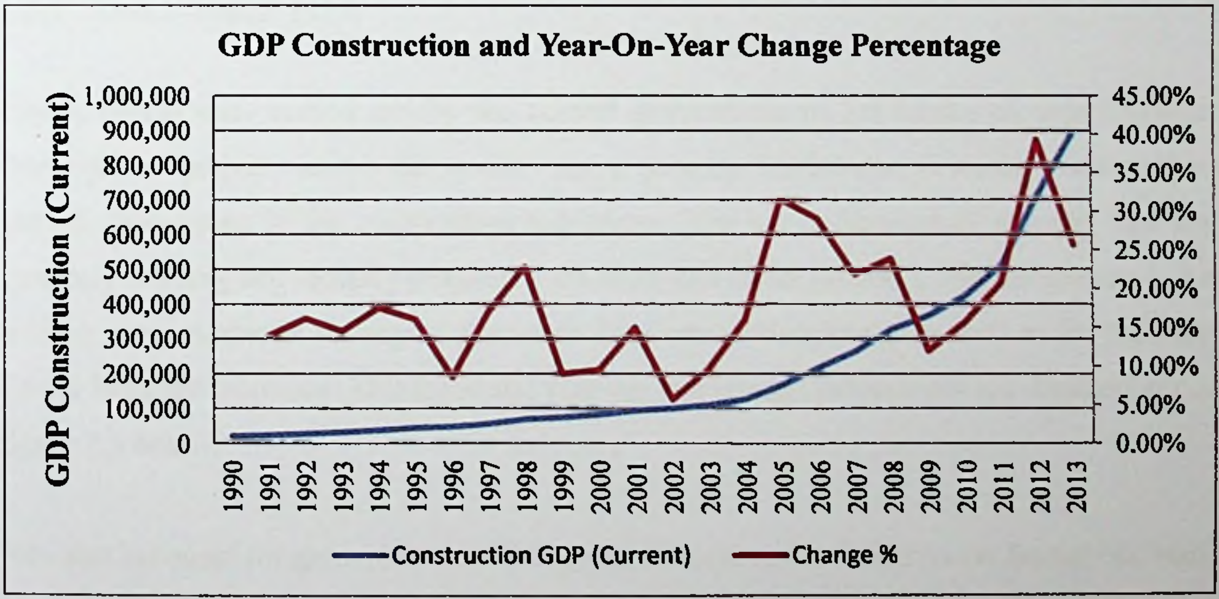


Figure 3 – GDP Construction (Current) and Year-On-Year Change % (Source : CBSL Annual Report 2013)

As a result of robust construction and manufacturing activities initiated in Sri Lanka, the Industry Sector recorded a growth rate of 9.9%, from LKR 925 million in 2012 to LKR 1 billion in 2013. Industry Sector share also has been increased from 30.4% in 2012 to 31.1%

in 2013 from overall GDP contribution perspective. Similarly, Construction Sector has grown by 14.4% during 2013 as described above providing 8.7% share to the overall GDP. Construction Sector share to the overall GDP in 2012 was 8.1% in 2012 and 7.1% in 2011.

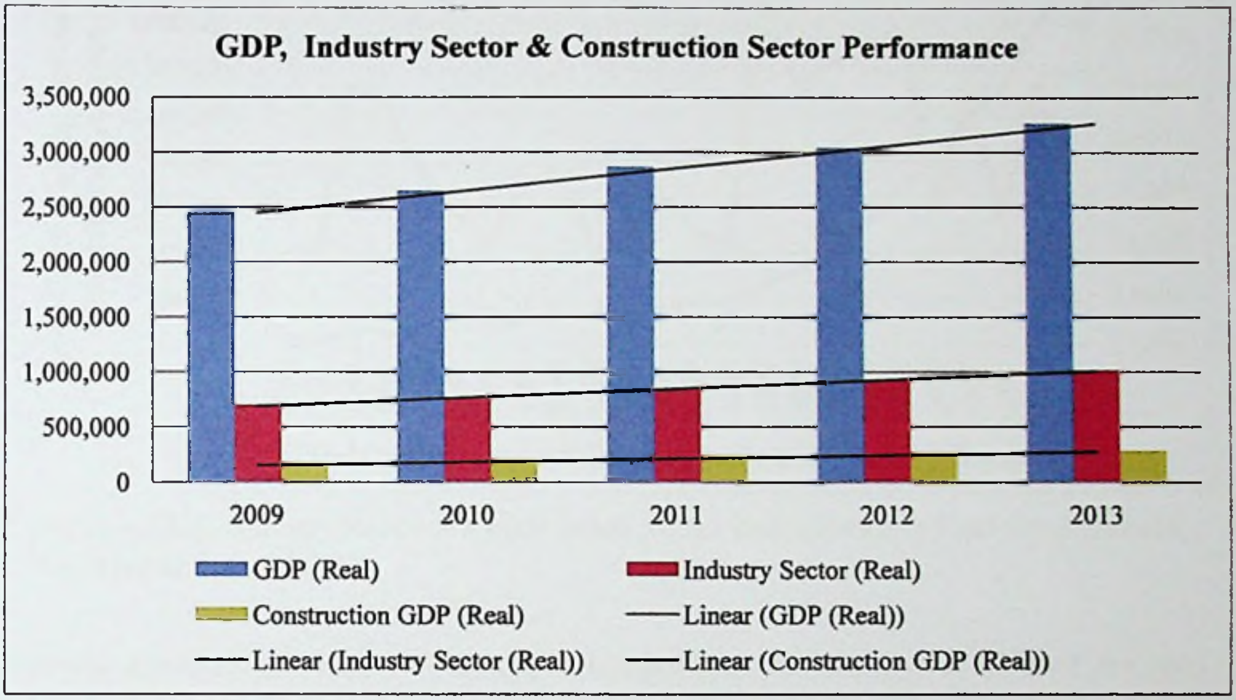


Figure 4 – GDP, Industry Sector & Construction Sector Performance in Real terms (Source : CBSL Annual Report 2013)

Heavy investments carried out by the current government of Sri Lanka on infrastructure development projects across the country have strongly contributed towards a sustainable growth momentum in the construction sub sector. The key infrastructure projects that are currently ongoing and recently completed are described under section 1.5 in the chapter 1. As a result gross domestic fix capital formation for Construction Sector as well as for Industry Sector has been increased. This trend and year-on-year change percentages are depicted in the figure 1.5 below.

National accounts for gross domestic fix capital formation for Construction Sector has been measured in three main areas comprising residential building, non-residential building and other activities such as construction of roads, railways, highways, ports, airports; power & oil storing systems; irrigation, recreation facilities and agriculture systems, telecommunications etc.

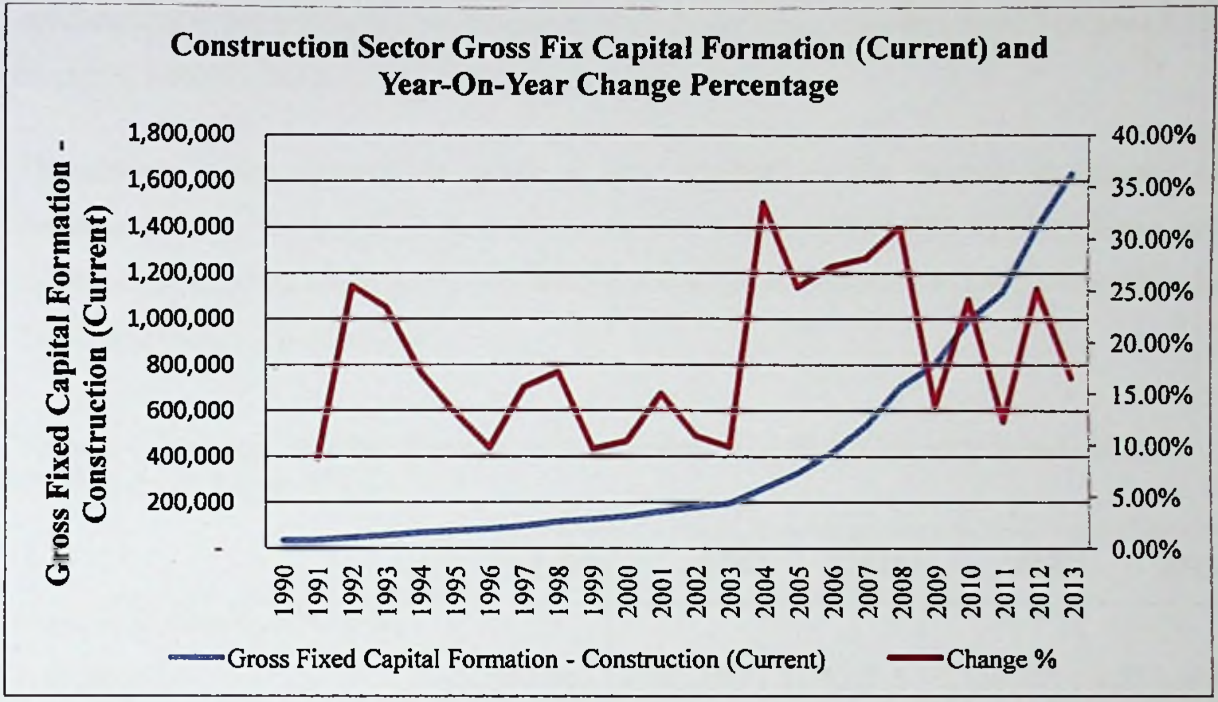


Figure 5 – GDP, Industry Sector & Construction Sector Performance in Real terms (Source : CBSL Annual Report 2013)

Building construction is one of the major components attributing over 52% of the total investments within the construction industry during last five years. (Refer Table 3 below). Therefore, this has a significant contribution to the sub sector especially in the areas such as condominiums, mega hotel projects and housing units, etc.

With the introduction of Public-Private Partnerships (PPPs) program for the development, financing, & operation of infrastructure, private sector got Immense potential to get involve with construction and development projects mainly in residential and non-residential buildings as well as other sectors such as transportation, energy, education, housing, health, etc. Also the figures indicate the private sector contribution in housing development projects attributed to 9.1% and 16.6% for the overall construction sector by commercial banks while the public sector was also involved in housing development projects, highways, rail roads and transport sector development projects such as phase two of the Southern Expressway, the Colombo – Katunayake Expressway, the Colombo Outer Circular Highway Project and the Northern Railway Project as well as port development projects. Those have been contributed towards sustaining growth momentum in this sub sector. Furthermore, Private sector participation remains significant in the areas such as water supply, drainage and other construction activities inclusive telecommunication, power and energy sectors. Meantime the public investment on economic and social infrastructure development activities have attributed LKR 447 billion (5.2% of overall GDP) in 2013 in comparison to 415 billion (5.5% of overall GDP) in 2012.

The growth in the construction sector is also reflected by the increase in imports of investment goods and building materials. In 2012 it was recorded LKR 157.4 million spent on importing building materials to Sri Lanka and it has been increased to LKR 175 million in 2013 reflecting 11.2% of growth.

Table 3 – Comparison of construction sector in terms of GDP and Industry Sector (Source : CBSL Annual Report 2013)

	2009	2010	2011	2012	2013
Gross Domestic Fixed Capital Formation	1,147,440	1,452,002	1,772,515	2,189,805	2,536,648
Construction	802,445	996,190	1,118,634	1,400,370	1,631,404
Construction Sector as a % of GFCF	69.9%	68.6%	63.1%	63.9%	64.3%
Residential Buildings	318,944	420,673	433,167	527,478	595,585
Non Residential Buildings	148,426	217,776	200,398	256,673	261,023
Building Sector as a % of Construction GFCF	58.2%	64.1%	56.6%	56.0%	52.5%
Other	335,075	357,741	485,069	616,219	774,796

As per the all construction cost index formulated by the Institute of Construction Training and Development (ICTAD), the total cost of construction activities has been increased by 12.2% in 2012 whereas it had decreased to 7.2% in 2013. This reflects the price increases of raw materials and labor in the industry. These price hikes are invariably link to the supply and demand in the industry. In another words, the rise in labor costs in the construction sub sector reflects the lack of labor to meet the demand arising from the expansion in the industry and the increase of cost links to an increase in demand. This issue has to overcome with the introduction of project management concepts to enhance efficiency and productivity and using the technology to automate the areas where need no human intervention.

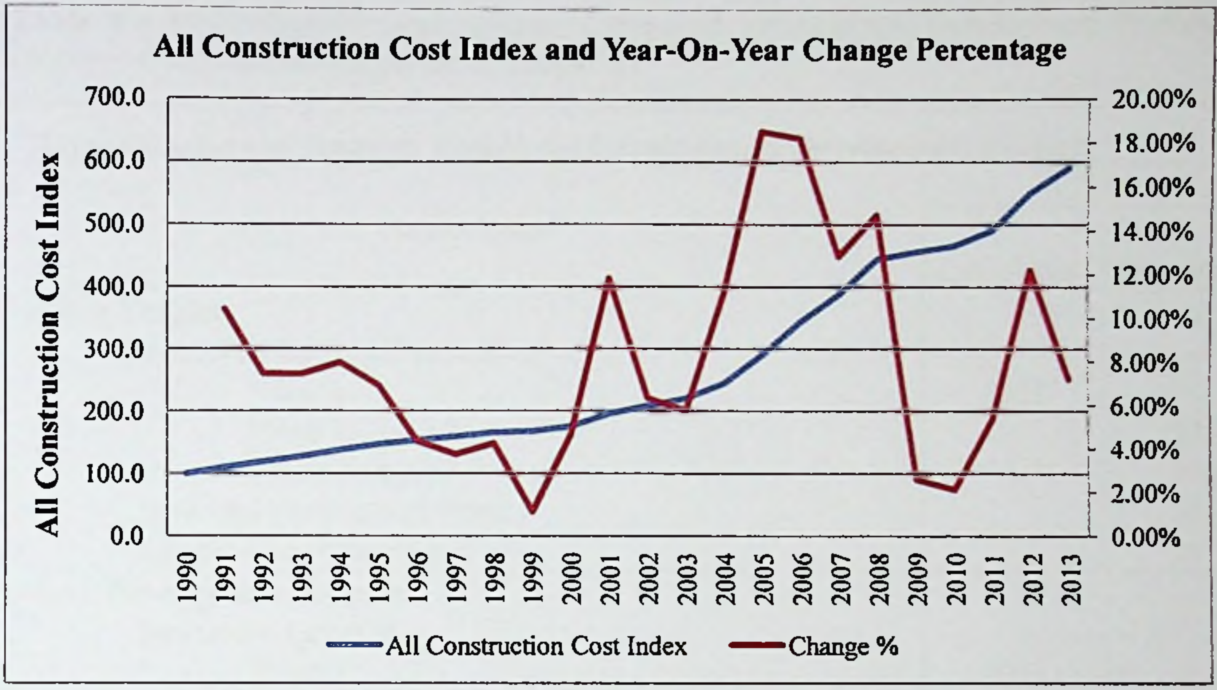


Figure 6 – All Construction cost index and change Percentages (Source : ICTAD Publications)

1.5 Recent infrastructure development projects undertaken by the Government of Sri Lanka

The year 2013 was a booming year on all types of construction activities invested and initiated by both public and private sectors. It was observed the completion and continuation of many key projects in terms of improving physical infrastructure in the country. Whilst Table 1.4 below indicates a summary of massive public investments carried out by the current Government of Sri Lanka. Private sector got opportunity to join with government projects through Public-Private Partnerships Program. Also the private sector invested heavily specially in the areas like real estate projects.

Table 4 – Major Ongoing And Recently Completed Infrastructure Development Projects (Source : CBSL Annual Report 2013, Chapter 3)

Major Ongoing and Recently Completed Infrastructure Development Projects		
Project Name	Year	
	Completed	To be Completed
Power Projects		
Norochcholai Coal Power Plant		
Phase I	2011	
Phase II : Unit 2		2014
Phase II : Unit 3		2014
Uma Oya Hydropower Plant		2015
Sampur Coal Power Plant		2017
Road Development Projects		
Southern Expressway		
Phase I	2011	
Phase II	2014	
Colombo-Katunayake Expressway	2013	
Outer Circular Highway		
Phase I	2014	
Phase II		2015
Phase III		2017
Railway Development Projects		
Northern Railway Line Reconstruction Project		
Medawachchiya - Madu	2013	
Madu - Thaleimannar		2014
Omanthai - Pallai	2014	
Pallai - Kankasenthurai		2014
Signalling and Telecommunication System		2015
Matara-Kataragama Railway Line Project		
Phase I : Matara-Beliatta		2016
Port Development Projects		
Colombo South Harbour Project		
South Container Terminal	2013	
East Container Terminal		2014
MagamRuhunupuraMahindaRajapaksa Port		
Phase I	2010	
Phase II		2015
Oluvil Port Development Project	2013	
Airport Development Projects		
MattalaRajapaksa International Airport - Phase I	2013	
Bandaranaike International Airport Expansion Project		2017

The share of Foreign Direct Investments (FDIs) in infrastructure development activities attributed 56.5% from total FDIs to the country in 2013. Those have been mainly invested in the sectors such as telephone and telecommunication networks, housing and property development and ports and container terminals. In addition to the mega projects described below, government investments on infrastructure developments have been further expanded to several urban development initiatives among many of the major cities in the island with the aim of enhancing life quality of public. Countrywide township development projects and Colombo city beautification project aided the recreational and wellbeing of community. Further, those have helped to attract tourist attention and promoting Sri Lanka as an up market tourist destination. Meanwhile, many small scale projects also have been carried out with the scope of enhancing and facilitating rural livelihood. These projects included rural road developments and carpeting projects, electrification projects, irrigation projects and community based water supply projects, etc.

1.5.1 Power and Energy Projects

The government has invested in developing of power & energy projects as described below.

- **Norochcholai Coal Power Project** -The construction of first phase of this Power Plant (300 MW) was completed at the end of 2010 and with an investment of USD 450 million loan obtained from China. This was added to the national grid by end of March 2011. The second and third phases (600 MW) are due completing before the end of 2014 with another investment of USD 891 million.

- **Uma Oya Hydropower Plant** –The estimated cost of this project is USD 529 which mainly funded by the Government of Iran through Export and Development Bank as a loan. This is expected to connect to the national grid in 2015 with the output of 120 MW to the generation system with 230GWh of annual energy generation.

- **Sampur Coal Power Plant** - Phase I of this project had estimated USD 300 million and USD 200 million has been financed by the Indian government in 2010. It is expected to generate 500 MW of electricity to the national grid in 2017 from this project.

- **Upper Kotmale Hydro Power Plant** – Construction of the Upper Kotmale Hydro Power Plant incurred a cost of USD 475 million with the assistance from Japan International

Cooperation Agency (JICA).This power plan provides 150 MW output capacity using two turbines each can generate 75 MW.

1.5.2 Road Development Projects

The government strategies are in placed (National Road Master Plan) to construct highways and bridges at both national and provincial levels. Further, large investments can be seen on widening of roads, introduction of flyovers, reconstruction of bridges, etc. with the aim of increasing mobility in freight and passenger transportation through land network and reduction of traffic congestion and fuel costs.

- **Southern Expressway** –The Southern Highway (Southern Expressway) project has cost USD 741.1 million and it is a 126km-long express highway running from Colombo to Matara on the south coast. Further, it is the longest expressway out of the proposed expressway networks with 100 km/h constant speed until the end of the journey. This highway consists with 4-lane capacity. The first section (Phase I) from Kottawa to Pinnaduwa (Galle) was completed in November 2011 and the second section (Phase II) from Pinnaduwa (Galle) to Godagama (Matara) was opened to public in March 2014.

- **Colombo-Katunayake Expressway** – This is an investment of USD 292 million from Exim Bank in China. This Expressway is 25km-long with 4-lane capacity. It links the capital Colombo with Bandaranaike International Airportin Katunayake and further extended up to Negombo city. This was opened to the public since October 2013.

- **Outer Circular Highway (OCH)** –This is located in the Colombo Metropolitan Region and passes through two administrative districts, namely Colombo and Gampaha. This Highway runs around 20 km away from the City center of Colombo, connecting radial routes and has a total length of 29.2 km. The northern end of the highway is located at Kerawalapitiya on Colombo - Katunayake Expressway and the southern end in located at Kottawa.

  The expressway is implemented in three phases as given below;

  Phase 1 - Section from Kottawa to Kaduwela - 11km (opened for public since March 2014 with the financial assistance from Japan.)

Phase 2 - Section from Kaduwela to Kadawatha - 8.9km (commenced in May 2014 and due completion by 2015.)

Phase 3 - Section from Kadawatha to Kerawalapitiya - 9.3km (Due completion by 2017.)

- **Colombo - Kandy Highway** - This is an alternative Highway between Colombo and central hill capital of Kandy with 98km-long. This is connected to the Outer Circular Highway at Kadawatha and run up to Katugastota. Field surveys have been completed and design and land acquisitions are in progress.

  Phase 1 - Kadawatha to Ambepussa 48.2 km (will be commencing in 2015 with the Chinese assistance. This is expected to have 4 lanes track with provision for 6 lanes in future. Expected cost would be USD 1 billion.)

  Phase 2 - Ambepussa to Katugastota 50.7 km (This is expected to have 2 lanes track with provision for 4 lanes in future.)

1.5.3 Railway Development Projects

Following railway projects are currently under way. These are extensions to the existing railway lines with the state mission to expand the national rail network.

- **Northern Railway Line** - The Northern Railway Line in Sri Lanka before terminating at the railway station call Kankasanthurai at the Northern Province and it stretch was 339km-long. After the end of war in 2009, Sri Lankan government initiated reconstructing of Northern Railway Line from Vavuniya to Omanthai by Sri Lankan military and Omanthai to Pallai by IRCON International. (Total 96 km-long in length)Reconstructed Northern Railway Line from Kilinochchi to Pallai (30 km) was opened to the public in March 2014. The re-constructed railway line from Omanthai to Kilinochchi (62 km) was commissioned and opened to the public in September 2013. Reconstruction of Omantei to Palei Railway Line was cost USD 185.49 million which was supported by Indian government.

- **Matara-Kataragama Railway Line Project** - The extension of the new railway line from Matara to Kataragama will be carried out in three phases. Estimated length of this

Railway Line is a 114.5 kilo-meters. Once the project is completed the trains will travel at a speed of 120 kilo-meters per hour.

Phase 1 - from Matara to Beliatta, (This stretch is 26.75 km-long, single line rail track and has been commenced construction on October 2013. Chinese government has granted a USD278 million loan for this phase)

Phase 2 - from Beliatta to Hambantota(48km-long)

Phase 3 -from Hambantota to Kataragama.(39.5km-long)

1.5.4 Ports Development Projects

The Sri Lankan government is capitalizing on the island's strategic location to promote it as an economic hub in South Asia region and to cater the increasing demand of services in the international shipping industry. Therefore, developing of ports and maritime also one of the key priorities in government agenda in terms of expand the capacity and improve the efficiency of existing ports through modernization and construction of new ports in strategic locations.

- **Colombo Port Expansion Project (CPEP)** – This Project was initiated in 2006 to cater for increasing demands of services in the international shipping industry. After completing of this project, Colombo port will gain the strength to handle large cargo ships that carry more than 8,000 containers. This project is jointly financed the USD 300 million from Asian Development Bank (ADB) and USD 200 million from the Sri Lanka Ports Authority (SLPA). This entire infrastructural development project is called "Colombo Port Expansion Project (CPEP)"

    i. **South Port Expansion Project and Container Terminal**- The Colombo South Harbour is situated west to the existing port of Colombo comprising an area of approximately 600 hectares. The harbour will be served by a new two-way channel with a depth of 20m and a width of 570m. The harbour has 3 terminals each having 1,200m length and facilities to accommodate 3 berths alongside with capacity of 2.4 million TEUs per annum. The project was intended to increase the capacity of the Colombo Port by 160% upon completion. The small boat harbour at the end of secondary breakwater has 400m length of quay wall and the construction work of this breakwater has been completed. The breakwater cost over USD 400 million and USD 300 million has been funded by Asian Development Bank (ADB).

ii. **East Container Terminal** - The Terminal is being developed as a twenty-first century facility to serve international shipping requirements. The construction work has been undertaken by Colombo International Container Terminals Ltd., (CICT) in December 2011 with an envisaged investment of USD 500 million, including the installation of the latest state of the art terminal equipment. It is so far the single largest foreign direct investment in Sri Lanka by a private entity. The Port of Colombo with a current capacity of over 4.5 million TEUs has embarked on a large infrastructure development programme to increase the total capacity of the Port of Colombo by another 7.2 million TEUs in three separate phases.

- **Hambantota (MagamRuhunupura - MahindaRajapaksa) Port–** This is located in the Southern Province and about 10 km away from the new Mattala Rajapakse International Airport with an initial investment of USD 450 million. The total project will occupy an area of 4,000 acres (16km²) and expected to accommodate 33 vessels at time. The constructions are underway for Phase I with room for three further terminals in the coming years.

Phase I – The total estimated project cost is USD 361 million and 85% from that to be funded by the government of China. The construction was carried out in 43 hectares of land. The main construction work in Phase I was commenced in 2008. The port is expected initially to function as a service and industrial port accommodating vessels up to 100,000 DWT and later be developed to handle transshipment cargo.

Phase II - This has planned to construct an additional quay approximately 2500 meters long to accommodate four 100,000t and two 10,000t wharf berths. Phase II of the port is underway at an estimated cost of USD 800 million. The port is ideally located to serve the main East-West shipping lane connecting Europe and the Middle-east with South East Asia.

Phase III – This phase has planned to construct of a container oil terminal of 300m long and 17m depth, four 100,000 DWT container berths, one 100,000 DWT oil wharf and two 30,000 DWT feeder berths. With the completion of the phase, the port will facilitate around 33 ships at a given time provide services such as bunkering facilities, ship repair, ship building and general shipping services while, 'Raw Raw' services for importing and re-exporting.

- **Oluvil Port Development Project** – Oluvil port is located in east coast of Sri Lanka and proposed project comprises the construction of a commercial port and a basin for fishing crafts. The port is to be built on an open shore and will be spread along 1.4 km of the coastline. The commercial port will comprise 330 meters of quay with a water depth of 8 meters enabling 5000 ton ships while the fishing port will comprise 200 meters of quay with a water depth of 3 meters. Construction work of this project commenced in 2008 with the funds granted through a loan by the Ministry of Foreign Affairs of Denmark. (DANIDA) Oluvil port is expected to provide more convenient and cost effective access to and from the southeastern region for goods and cargo originating on the west coast.

1.5.5 Airport Development Projects

The government of Sri Lanka expects two million tourist arrivals by 2016. Development of infrastructure at the airports is highly important to meet this objective as well as to increase international passengers and international aircraft movements. Also it is a key to support the overall economic development of Sri Lanka. Therefore, the Government has decided to implement Bandaranaike International Airport Development Project – Phase 2 and to construct of second International airport at Mattala.

- **Expansion of Bandaranayake International Airport Development Project, Phase II** – By keeping a mile stone, aircraft movements through Bandaranayake International Airport (BIA) has passed the mark of 52,000 in and out of Sri Lanka in 2013 showing a 7.1%increase compared to the previous 2012, in the history of the country's civil aviation. Furthermore, the total number of passenger moments in and out of Sri Lanka in 2013 has been recorded as 7,328,798 with 3,621,822 passengers arriving and 3,690, 047 departing using the BIA. Ministry of Civil and Aviation estimates that more than 8 million international passengers will move through the country by 2015. Therefore, a project is under way to expand the Bandaranayake International Airport (BIA) with adding a new transit area, construction of new baggage-reclaim area, aircraft parking apron, taxiway, multi storied car park and widening of the existing runway. The agreements have been signed in 21012 with the Government of Japan (GOJ) to funded USD 346 million for this project as a way of long term loan and this project is expected to be completed in 2017.

- **Development of second International airport at Mattala** – The growth in air service sector in South Asian Region has created more opportunities for Sri Lanka to capture overflying aircrafts and to provide them vast range of services. Therefore, the government of Sri Lanka decided to construct the country's 2nd International Airport, Mattala Rajapaksa International Airport serving the city of Hambantota in southern province, Sri Lanka with the aim of enabling international trade, tourism, vocational training and employment in addition to above. Features of this new airport include a 4,000m-long, 75m-wide runway and two taxi ways, as well as a 5,000m² cargo facilities. The airport can also house the world's largest commercial aircraft such as Airbus A380. Upon completion the full project, the new airport will gain the capability to handle one million passengers a year, 30,000 aircraft movements and 45,000tons of cargo.

  Phase I – China's Export-Import Bank came forward to fund the phase I of this project by granting a USD 210 million loan. Construction work for 1st phase commenced in November 2009 and it was completed and opened on 18th March 2013. That included one runway, aerodrome facilities, Passenger and Cargo Terminals and a taxi way along with basic infrastructure such as access roads, accommodation for officials, fuel farm, sewerage treatment plant, water supply facilities, meteorological building, fire building, catering facility and a car park.

  Phase II - This stage will include a full length parallel Taxi way, a flying school, an airport hotel and recreational facilities along with 20 parking bays for Aircrafts and 15 aero bridges. It will increase an additional five million passenger capacity once implemented in 2015.

1.5.6 Water supply and irrigation projects

The government has initiated many water supply and irrigation projects around the country to augment urban water supply, boost agriculture activities by improving irrigation systems, reservoirs and water resources management.

As per the central bank annual report in 2013, National Water Supply and Drainage Board (NWS&DB) has managed to increase pipe borne water to 44.3% in 2013 in comparison to 43.5 % in 2012 through several new projects carried out in various districts such as Colombo, Gampaha, Kandy, Galle, Ampara, Kurunegala and Jaffna. During the year, the government has spent 26.4 billion rupees for the implementation of water supply and sewerage projects. Meanwhile, two major projects launched namely Kelani River Right Bank and the towns North of Colombo-Stage II, are aiming to provide benefits over 1.25 million consumers in Colombo and Gampaha districts. Also it should be essentially stated that some of the large scale water supply projects have been carried out particularly in the North province in association with the Emergency North Recovery Project (ENRP) in 2013. These water supply projects included Nadunkerny, Vidathalathiv, Thevanpiddy, Adampan, Valvatithurai, Maruthankerny, Pandiyankulam, Mallavi and Oddusudan benefiting 51,220 people in 60 Grama Niladhari divisions. Japan has granted USD 8.31 million for Kilinochchi Water Supply Scheme.

Work on several major irrigation projects has been commissioned and continuing. A large number of irrigation schemes including Rambakan Oya, abandoned Moragahakanda, Uma Oya and Deduru Oya are currently in progress.

In addition to above, following projects such as Yan Oya Project, Morana Reservoir, Ellewewa Reservoir, Digili Oya Reservoir, Kalugal Oya Reservoir, Kubukkan Oya Reservoir, Talpitigala Reservoir, Lower Malwathuoya Multi sector Development Project, Redeemaliyadda Integrated Development, Wilakandiya, Kaudulla Stage 2 & NWP canal, Weli Oya Integrated Development Project, Weheragala, Kirindi Oya, Heda Oya and Uda Walawe left bank also have been commenced or completed in terms of new capacity creation. These projects will facilitate cultivation activities specially in the abandon lands and domestic water supply.

1.5.7 Telecommunication Infrastructure Development projects

Private sector telecommunication companies in Sri Lanka has been invested in spectrum for 4G mobile broadband to support the expansion of modern mobile broadband technology and 4G services in the commercial environment. Further, the Government has focused in developing of a high speed national fiber backbone network to facilitate the requirements of high speed connectivity throughout the country.

Sri Lanka is connected to the South East Asia-Middle East-West Europe 4 (SEA-ME-WE 4) project, the submarine cable system approximately 20,000 km long connecting 17 countries from Europe to the Middle East and South East Asia. The total project cost has been estimated to be over USD 500 million. The project is aimed to significantly increasing the bandwidth and global connectivity of users and to provide a bandwidth capacity of 1.28 terabits per second, with a 25 year guaranteed lifespan for the technology.

1.6 Construction related bodies in Sri Lanka

There are two main accredited and apex bodies in Sri Lanka established to look after various aspects of Construction Industry and to assist Government Policies. Objectives of these bodies are:

- Recommend strategies for the development of the Construction Industry.
- Facilitating business partnerships linkages between Construction Industry stakeholders.
- Regulate registration and grading of Construction Contractors.
- Promote professionalism and coordinate activities of professional bodies.
- Promote /Facilitate export of construction industrial services.
- Provide advisory services.
- Provision of information& publications.
- Assist in the provision of training facilities.
- Conduction of Seminars and Construction Industry Exhibitions.
- Promote /Undertake research on matters related to the Construction Industry.
- Promote Quality Assurance and productivity solutions.

The Institute of Construction Training & Development (ICTAD) –This institute was set up by the Government of Sri Lanka to develop and promote the domestic Construction Industry, Contractors, Professionals, Work Force, etc to create a reliable and globally competitive construction industry for Sri Lanka.

Chamber of Construction Industry Sri Lanka (CCI) –This is the apex body of the construction industry that servicing the SME (small and medium sized enterprises) sector by facilitation, training of all types of craftsmen associated to the industry. Further it has a primary objective to focus on national interest and facilitating the development of the construction industry.

There are few big main construction companies in Sri Lanka. Some of them are owned by the government and rests of majority are belonging to private sector. The main State-owned construction companies are:

- **State Engineering Corporation of Sri Lanka (SEC)** – Established in 1962 and functioning under the Ministry of Construction & Engineering Services of Sri Lanka. Only government construction organization certified with ISO 9001:2008. As the premier engineering organization in Sri Lanka, State Engineering Corporation is engaged in the following discipline of Engineering such as Engineering Design, Construction. Manufacturing, Fabrication, Project Management and Information Management.

- **Central Engineering Consultancy Bureau (CECB)** -Leading, Highly Diversified, Multidisciplinary Engineering Consultancy and Construction Organization established in 1973 under the Ministry of Irrigation and Water Management. Currently CECB is engaged in four core business segments including Water Resources Development, Buildings, Water Supply and Sanitation and Transportation (Roads, Bridges, Railways, Tunnels, Ports and Airports)

- **State Development and Construction Corporation (SD&CC)**–This was established in 1971 as a State organization under the State Industrial Corporation to undertake heavy civil engineering construction works. SD&CC is now under the purview of Ministry of Construction, Engineering Services, Housing and Common Amenities.

This Corporation plays a major role in the development of Sri Lanka, specially in the up-liftment of Infrastructure Construction. Further, it has undertaken various major engineering projects in the fields of Construction such as bridges, roads, highways, dams, irrigation determent schemes, hydro power tunnels and power houses, water supply and treatment works, multi storied buildings.

Below are few big private sector construction and engineering services companies currently operating in Sri Lanka.

- Access Engineering PLC.
- ICC -International Construction Consortium (Pvt) Ltd.
- Maga Engineering (Pvt) Ltd.
- Nawaloka Construction Company (Pvt) Ltd.
- Sanken Construction (Pvt) Ltd.
- Tudawe Brothers (Pvt) Ltd.

1.7 Objectives of the Study

The objective of this study is to identify mathematical relationships between construction industry outputs and the national economy or vice versa. It is expected to identify any short term and long term associations between the chosen variables. Such model can be used as a very helpful tool by entrepreneurs who are interested to invest money in construction industry in Sri Lanka.

1.8 Scope of the Study

This study may help in economic policy development standpoint to evaluate the structures of government policies, their effectiveness as well as direct and indirect impact to the social wellbeing in the country. It is focused on causality relationships between the developments of construction activities and the GDP Growth in Sri Lanka. Empirical data of economic indicators and construction index were used to determine the Granger Causality Test for the period of 1990 to 2013. It was checked the associations between national economic statistics and construction activates taken place in the country to identify unidirectional and bidirectional relationships among the variables as well as short term and long term relationships.

This statistical hypothesis test was used to find the correlation between them. Therefore, it was tested on following relationships to determine the association between each of them.

- National Economy and Construction Activates of Sri Lanka does not have a causal relationship.
- National Economy has a unidirectional relationship towards Construction Activates in Sri Lanka. (Unidirectional - X to Y)
- Construction Activates has a unidirectional relationship towards National Economy in Sri Lanka. (Unidirectional - Y to X)
- National Economy causes Construction Activates and the same time Construction Activates also causes National Economy in Sri Lanka. (Bidirectional- X causes Y whilst Y causes X)

1.9 Significance of the Study

Many researchers have attempted to assess the relationship between the construction outputs and national economy both in developing and developed countries. They have used many different variables to determine association between national economy and construction sector. However, majority of researchers have assessed the relationships merely based on Granger Causality Test whilst some of them have used simple models to elaborate causality relationships further.

Hence, this study attempts to construct a model using statistical approach specially to find more accurate and specific relationships among national economy and construction sector outputs. This will help for entrepreneurs to determine the return of their investment in the construction industry both in short and long run.

There are two main statistical tests were used in this dissertation namely Ganger Causality test and Vector Auto Regression model and assumption tests to validate Cointegration issues.

1.10 Limitations of the Study

The following can be considered as the limitations of this study.

- Since some of the variables are only available on annual basis (i.e. - Gross Fixed Capital Formation for construction sector) the annual data was used for this study. However, if more frequent data (i.e. – daily, monthly, and quarterly) could be obtained, the output would have been more precise and qualitative.

- The base year used to calculate GDP has been changed time to time. Hence GDP current (nominal) was selected to eliminate the time value of money based on the index calculation. As a result current value has been selected for rest of all applicable variables.

- Data from 1990 to 2013 has been used in the study due to lack of historical data beyond 1990 in certain variables. (i.e. - Gross Fixed Capital Formation for construction sector)

1.11 Organization of the Dissertation

This dissertation is comprised with five main chapters. The first Chapter describes a comprehensive introduction into this research. Also it provides in detail view about the country level and construction sector economic indicators and how those have been moved over a period of time. Also this chapter describes recent key infrastructure projects initiated and undertaken by the government of Sri Lanka. The second chapter includes the review and discussion of the literature. Also it contains an overview of construction sector main accredited and apex bodies in Sri Lanka. The third chapter explains the methodology to the study, theoretical concepts and their applications that is implemented in this study. The fourth chapter presents a comprehensive description of the analysis using the theories described above. The derived models are explained in there. Finally, the conclusion is included in chapter five. Also it describes recommendation and future work in to the study.

Chapter 2 - Literature Review

2.1 Introduction

Many researchers have studied the relationship between construction activities and economic fiscals in the history. Also it was noted that, many of them have used various multivariate theories and tested the causality relationship among the variables to build a connection among construction industry and its activities as a subsector which can be used to describe the trends of national economy. The studies have been carried out with the empirical data of developed countries as well as developing countries using various measures of construction output and national economic statistics. This chapter is mainly intended to study about previous researches which had been carried out in relation to this topic. Further, it will explain the key differences among various studies with respect to geographical locations and the identified patters of relationships among different variables.

2.2 Literature Review

It was noted that the previous studies for the construction industry is driven back to 1940s (i.e. - Simon, 1944; Phillip Report, 1950; Emmerson, 1962; Banwell, 1964; Great Britain, EDC for Building, 1967; Wood, 1975). After 1960s, most of the studies have begun focusing on contribution by construction and building industry towards economic development activities. (i.e. - Bowley, 1966; Higgin G. and Jessop N. K., 1963 and 1965; Hillebrandt, 1974, 1984, 1985). Subsequently, it has been paid more focus on theory building in the construction industry emphasizing more into theoretical framework to assist economic concepts.(i.e. - Edmonds, 1979;Ball M., 1988; Wells, 1986; Miles, D. & Neale R. H., 1991; Ofori G, 1993, 1994). Some of the other researchers have introduced systems ideas. These ideas included thought processes such;

- Interrelatedness of human elements and technological imperatives within organizations (Tavistock, 1966).
- Napier (1970) discussed about Swedish construction industry enhancements through correlations with power, status, learning, boundaries, goal evaluation, innovation, and group values, etc.
- Ofori (1980) identified eight factors for construction industry development in developing countries. These factors included Economic growth and stability,

Government recognition, Indigenous environment, Planning and resources, Development planning and policies, Codes and procedures, Use of local materials, Education and training, Appropriate technologies, and Incentives for local contractors.

- Fox (1989) developed a causal model of 50 factors to explain the development of Hong Kong's construction industry.
- Al-Omari (1992) considered the statistical technique of factor analysis deriving six key factors from a case study in Abu Dhabi. These factors included External environment, Indigenous environment, Development planning & policies, Planning prerequisites & measurement tools, Implementation strategies and Working environment.
- Tassios (1993) expressed that the ratio between structural components cost and the finishing components cost, reflect the level of construction development comparing both developing and developed countries.

Some of the scholars have discussed certain important ideas and have been presented detail description through research papers. Those were used to gain a better understanding about;

- Our prime objective. This means to determine whether construction industry supports national economy or vice versa.
- Where does Sri Lanka stand in comparison to other developing countries within the region or outside the region.

A significant role of the construction industry in the national economy has been highlighted by Duccio Turin (1969). He has based on cross section of data from developing countries as well as industrial countries. His focus was to build a relationship between the output of the construction industry and the Gross Domestic product (GDP) and particularly the per capita measures of each. He argued about a positive relationship between construction output and economic growth. Furthermore, he showed as economies grow construction output grows at a faster rate, assuming a higher proportion of GDP particularly in developing countries. Turin (1969) suggested that this may be due to much of the construction work take place in the developing countries and these countries need importing of construction materials and skills. In the same token, capital formation accounts for a significantly lower proportion of GDP in most developing countries in comparison to developed countries. He explained this trend as higher income countries are more willing and able to invest in fix capital formation.

Following the same view point the World Bank report (1984) indicated in general, construction activities tend to increase with the increase of a country's resource base and level off only after a high degree of economic development has been achieved. Among countries that are members of the Organisation for Economic Co-operation and Development, the average share of construction during the 1970s ranged between 7 percent and 8percent of the GDP.

Subsequently, this point has been endorsed by few other scholars. Hillebrandt (1985) expressed that construction in any country is a complex sector of the economy, which involves a broad range of stakeholders and has wide ranging linkages with other areas of activity such as manufacturing and the use of materials, energy, finance, labor and equipment.

Similarly, Wells (1986) analyzed the statistical data of a large number of countries and demonstrated a positive relationship between GDP per capita and the three separate measures of construction's contributions namely, value-added by construction as a percentage of GDP, gross construction output as a percentage of GDP and construction employment as a percentage of total Economically Active Population. He has noted that all three contributions of construction increase with the increase of income. Further he has observed that the annual increase of both GDP per capita and value-added in construction per capita of rich countries is substantially higher than that of poor countries. So, he has concluded in the countries where construction demand is small, rational planning and production of basic construction materials appropriate for the size of the construction market is essential for development of the construction industry.

Bon (1992) discussed the changing role of the construction sector at the various stages of economic development. He studied the construction activity since World War II in Finland, Ireland, Italy, Japan, the UK, and the USA. The data underlying his analysis spans a 50-year period and appears to place special emphasis on Europe. He argued that construction follows the bell-shaped pattern of development or an inverted U-shaped relationship. The Bon curve (Figure 2.1) claims that a relationship between the share of construction in output and economic development.

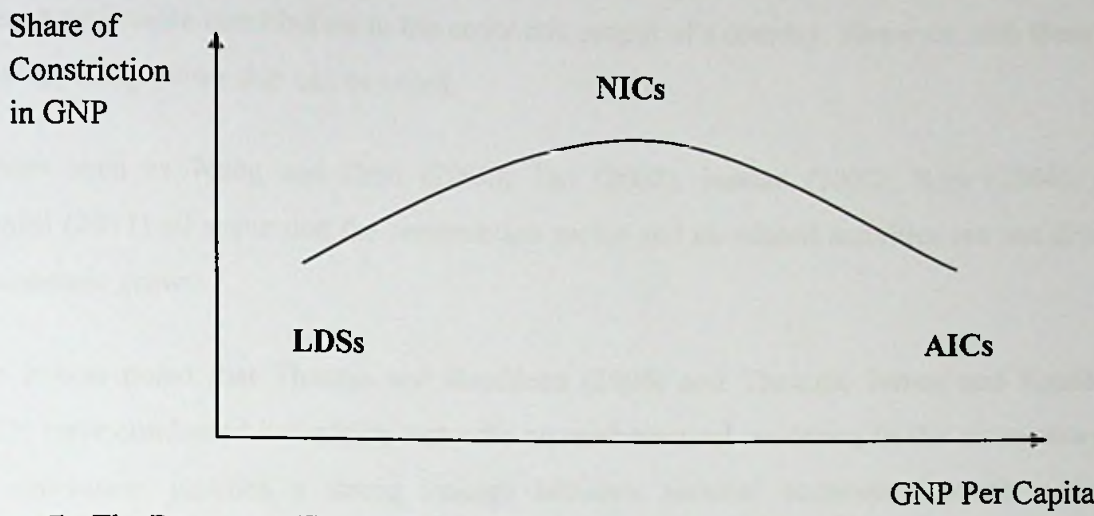


Figure 7 - The Bon curve (Source: Bon 1992)

The inverted U-shaped relationship presented by Bon (1992) is very different from the S-shaped relationship found by Turin (1978).Turin's analysis was mainly focused on developing countries. Bon's 1992 argument concerns the entire path from LDC (least developed countries) to NIC (newly industrialised countries) to AIC (advanced industrial countries) status. The share of construction in total output first increases and then decreases with economic development, this is called the inverted U-shaped relationship.

Ofori (1993) enhanced his previous views in 1980 and suggested that construction industry development as 'the deliberate and managed process to improve the capacity and effectiveness of the construction industry to meet the national economic demand for building and civil engineering products, and to support sustained national economic and social development objectives.' In another hand he introduced that the following components: human resource development; materials development; technology development; corporate development; development of documentation and procedures; institution building; and development of operating environment of the industry.

Jin et al. (2003) found a non-linear relationship between the shares of construction output in GDP with the GDP per capita. Jin used the statistics across 34 countries and regions to analyses this.

In addition to above many studies on construction economics (Wells 1986; Field and Ofori 1988; Bon and Pietroforte 1990; Green 1997; Hillebrandt 2000; Lean 2001; Rameezdeen 2007; Anaman and Amponsah, 2007; Myers 2008; Dlamini 2011) emphasize the important role of the construction sector in national economic growth. They all argue that construction makes a noticeable contribution to the economic output of a country. However, still there are some opposing views also can be noted.

Authors such as Wang and Zhou (2000), Tan (2002), Hassan (2002), Kim (2004), and Dlamini (2011) all argue that the construction sector and its related activities are not drivers of economic growth.

Also it was noted that Thanuja and Raufdeen (2006) and Thanuja, James and Raufdeen (2013) have conducted a causality test with no mathematical modeling in the same area and the conclusion justifies a strong linkage between national economic growth and the construction industry activities.

Chapter 3 - Methodology

3.1 Introduction

This chapter describes the data and the methodology used in this study and the impact of the growth of the construction sector to the national economy.

3.2 Selection of Data

In this empirical analysis it is used basic set of variables consists of both national economy fiscals and construction sector annual figures from 1990 to 2013. Whilst National Economy Fiscals included variables such as Nominal Gross Domestic Product (GDP) and Balance of Trade (BOT); Construction Sector variables included Construction Gross Domestic Products (CGDP), Gross Fixed Capital Formation for Construction Sector (CGFCF) and All Construction Cost Index (ACINDEX). All the variables are expressed in natural logarithms so that they may be considered elasticity of the relevant variables. Annual observations of GDP, BOT, CGDP, CGFCF were extracted from data published by the Central Bank of Sri Lanka on the annual reports and All Construction Cost Index (ACINDEX) was extracted from The Institute of Construction Training & Development (ICTAD) bulletins.

3.3 Granger Causality

Clive J Granger (1969) introduced the Granger causality tests to analyze the effect of one time series on another one. He thought out of the box and said that 'regressions' does not only show 'correlations' but if certain tests are performed on them they may reveal information about causality. The idea of Granger causality is that a variable X Granger-courses variable Y can be better predicted using the histories of both X and Y than it can be predicted using the history of Y alone. This is shown if the expectation of Y given the history of X is different from the unconditional expectation of Y. It was then widely used in economics.

3.3.1 Definition of Granger Causality

We say that x_t is Granger causal for y_t with respect to F_t if the variance of the optimal linear predictor of y_{t+h} based on F_t has smaller variance than the optimal linear predictor of y_{t+h} based on z_t, z_{t-i}... for any h. In other word x_t is Granger causal for y_t if x_t helps predict y_t at some stage in the future.

Often you will have that x_t Granger causes y_t and y_t Granger causes x_t. In this case we talk about a feedback system. Most economists will interpret a feedback system as simply showing that the variables are related (or rather they do not interpret the feedback system).

Sometimes econometricians use the shorter terms "causes" as shorthand for "Granger causes". You should notice, however, that Granger causality is not causality in a deep sense of the word. It just talks about linear prediction, and it only has "teeth" if one thing happens before another. (In other words if we only find Granger causality in one direction). In economics you may often have that all variables in the economy react to some un-modeled factor and if the response of x_t and y_t is staggered in time you will see Granger causality even though the real causality is different. There is nothing we can do about that (unless you can experiment with the economy) Granger causality measures whether one thing happens before another thing and helps predict it and nothing else. Of course we all secretly hope that it partly catches some "real" causality in the process. In any event, you should try and use the full term Granger causality if is not obvious what you are referring to.

The definition of Granger causality did not mention anything about possible instantaneous correlation between x_t and y_t. If the innovation to y_t and the innovation to x_t are correlated we say there is instantaneous causality. You will usually (or at least often) find instantaneous correlation between two time series, but since the causality (in the "real" sense) can go either way, one usually does not test for instantaneous correlation. However, if you do find Granger causality in only one direction you may feel that the case for "real" causality is stronger if there is no instantaneous causality, because then the innovations to each series can be thought of as actually being generated from this particular series rather than part of some vector innovations to the vector system. Of course, if your data is sampled with a long sampling period, for example annually, then you would have to explain why one variable would only cause the other after such a long lag (you may have a story for that or you may not, depending on your application).

Granger causality is particularly easy to deal with in VAR models. Assume that our data can be described by the model,

$$\begin{pmatrix} y_t \\ z_t \\ x_t \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \end{pmatrix} + \begin{pmatrix} A^1_{11} A^1_{12} A^1_{13} \\ A^1_{21} A^1_{22} A^1_{23} \\ A^1_{31} A^1_{32} A^1_{33} \end{pmatrix} \begin{pmatrix} y_{t-1} \\ z_{t-1} \\ x_{t-1} \end{pmatrix} + \dots\dots\dots + \begin{pmatrix} A^K_{11} A^K_{12} A^K_{13} \\ A^K_{21} A^K_{22} A^K_{23} \\ A^K_{31} A^K_{32} A^K_{33} \end{pmatrix} \begin{pmatrix} y_{t-k} \\ z_{t-k} \\ x_{t-k} \end{pmatrix} + \begin{pmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \end{pmatrix} + \Sigma$$

Also assume that,

$$\Sigma_u = \begin{bmatrix} \Sigma_{11} \Sigma_{12} \Sigma_{13} \\ \Sigma^1_{12} \Sigma_{22} \Sigma^1_{23} \\ \Sigma^i_{13} \Sigma^i_{23} \Sigma_{33} \end{bmatrix}.$$

This model is a totally general VAR-model - only the data vectors has been partitioned in 3sub-vectors - the y_t and the x_t vectors between which can be tested for causality and the z_t vector(That could be empty) which we condition on.

In this model it is clear that x_t does not Granger cause y_t with respect to the information set generated by z_t if either $A^i_{13} = 0$; and $A^i_{23} = 0$; i = 1,……,k or $A^i_{13} = 0$; and $A^i_{12} = 0$; i = 1,…k. Note that this is the way you will test for Granger causality. Usually you will use the VAR approach if you have an econometric hypothesis of interest that states that x_t Granger causes y_t but y_t does not Granger cause x_t.

3.3.2 Limitations of Granger Causality

Granger causality is not necessarily true causality. If both *X* and *Y*are driven by a common third process with different lags, one might still accept the alternative hypothesis of Granger causality. Yet, manipulation of one of the variables would not change the other. Indeed, the Granger test is designed to handle pairs of variables, and may produce misleading results when the true relationship involves three or more variables. A similar test involving more variables can be applied with vector auto regression.

3.4 Vector Auto Regression (VAR) Analysis

The vector autoregression (VAR) model is one of the most successful, flexible, and easy to use models for the analysis of multivariate time series. It is a natural extension of the univariate autoregressive model to dynamic multivariate time series. A way to summarize the dynamics of macroeconomic data is to make use of Vector Auto Regressions. The VAR model has proven to be especially useful for describing the dynamic behavior of economic and financial time series and for forecasting. Therefore, VAR models have become increasingly popular in recent decades. They are estimated to provide empirical evidence on the response of macroeconomic variables to various exogenous impulses in order to discriminate between alternative theoretical models of the economy. It often provides superior forecasts to those from univariate time series models and elaborate theory-based simultaneous equations models. Forecasts from VAR models are quite flexible because they can be made conditional on the potential future paths of specified variables in the model.

In addition to data description and forecasting, the VAR model is also used for structural inference and policy analysis. In structural analysis, certain assumptions about the causal structure of the data under investigation are imposed, and the resulting causal impacts of unexpected shocks or innovations to specified variables on the variables in the model are summarized. These causal impacts are usually summarized with impulse response functions and forecast error variance decompositions. This simple framework provides a systematic way to capture rich dynamics in multiple time series, and the statistical toolkit that came with VARs was easy to use and to interpret.

In addition to measuring the broad correlation in the variables of a system, VAR helps us to measure the lead-lag relationships. VAR is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables. The VAR approach side steps the need for structural modeling by modeling every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system. The estimated VARs are used to calculate the percentages of each endogenous variable that can be explained by innovations in each of the explanatory variables and provides information about the relative importance of each random innovation to the variable in the VAR. The mathematical form of a VAR is

$$Y_t = A_1 Y_{t-1} + \cdots \ldots + A_p Y_{t-p} + \beta X_t + \varepsilon_t$$

Where Y_t is a k vector of endogenous variables, X_t is a d vector of exogenous variables, A_1, ..., A_p and β are matrices of coefficients to be estimated, and εt is a vector of innovations that may vary contemporaneously.

3.5 Multiple Regression and Assumptions

Multiple regression is most effect at identifying relationship between a dependent variable and a combination of independent variables when its underlying assumptions are satisfied. In another words, it relies upon certain assumptions about the variables used in the analysis. When these assumptions are not met the results may not be trustworthy.

These assumptions include

- The errors are normally distributed
- The mean of the errors is zero
- Errors have a constant variance
- The model errors are independent

Each metrics variables are normally distributed, the relationships between metric variables are linear, and the relationship between metric and dichotomous variables is homoscedastic. Failing to satisfy the assumptions does not mean that our answer is wrong. It means that our solution may under-report the strength of the relationships.

Outliers can distort the regression results. When an outlier is included in the analysis, it pulls the regression line towards itself. This can result in a solution that is more accurate for the outlier, but less accurate for all of the other cases in the data set. It shall be checked for univariate outliers on the dependent variable and multivariate outliers on the independent variables. The problems of satisfying assumptions and detecting outliers are intertwined. For example, if a case has a value on the dependent variable that is an outlier, it will affect the skew, and hence, the normality of the distribution. Removing an outlier may improve the distribution of a variable. Transforming a variable may reduce the likelihood that the value for a case will be characterized as an outlier.

The order in which we check assumptions and detect outliers will affect our results because we may get a different subset of cases in the final analysis. In order to maximize the number of cases available to the analysis, it shall be evaluated assumptions first. It shall be substituted any transformations of variable that enable us to satisfy the assumptions. It shall be used any transformed variables that are required in our analysis to detect outliers.

3.6 Least Squares Method (LSM)

The Least Squares Methods (LSM) is one of the very popular techniques in statistics due to following reasons.

- Most common estimators can be casted within this framework. (i.e – the mean of a distribution is the value that minimizes the sum of squared deviations of the scores.
- This method has recognized as very tractable as when the error is independent of an estimated quantity, it can add the squared error and the squared estimated quantity.
- Mathematical tools and algorithms are involved in LSM (derivatives, Eigen composition, singular value decomposition) have been well studied for a relatively long time.

The Method of Least Squares is a procedure to determine the best fit line to data; the proof uses simple calculus and linear algebra. The basic problem is to find the best fit straight line $y = ax + b$ given that, for $n \in \{1, \dots\dots, N\}$, the pairs $(x_n ; y_n)$ are observed. The method easily generalizes to finding the best fit of the form;

$y = a_1 f_1(x) + \dots\dots\dots + c_k f_k(x)$;

it is not necessary for the functions f_k to be linearly in x – all that is needed is that y is to be a linear combination of these functions.

Given data $\{(x_1; y_1), \dots\dots, (x_N; y_N)\}$, we may define the error associated to saying $y = ax + b$ by

$$E(a, b) = \sum_{n=1}^{N} (Y_n - (ax_n + b))^2$$

This is just N times the variance of the data set $\{y_1 - (ax_1 + b), \ldots\ldots, y_n - (ax_N + b)\}$. It makes no difference whether or not we study the variance or N times the variance as our error, and note that the error is a function of two variables.

The goal is to find values of a and b that minimize the error. In multivariable calculus we learn that this requires us to find the values of (a; b) such that,

$$\frac{\partial E}{\partial a} = 0, \qquad \frac{\partial E}{\partial b} = 0$$

Therefore the final solution can be drawn as,

$$\hat{b} = \frac{S_{xy}}{S_{xx}}$$

$$\hat{a} = \bar{y} - \hat{b}\bar{x}$$

It is not necessary to worry about boundary points: as |a| and |b| become large, the fit will clearly get worse and worse. Thus it was not necessary to check on the boundary.

3.7 Preliminary Analysis

Both graphical representations as well as descriptive statistics were comprehensively employed in examining the data properties.

Variables are depicted using scatter plots and line graphs which is useful in identifying characteristics of the series, detecting possible outliers, observations that could be used in the modeling process such as determining the probable transformation to make the series stationary etc.

A comprehensive descriptive level analysis is carried out under Chapter 4 for all the variables selected, in order to identify the patterns and special characteristics of the series. The summary measures included measures of central tendency such as arithmetic mean, median and mode and measures of dispersion such as variance, standard deviation and range which are widely known. Further, measures of distribution shape including skewness and kurtosis which is normally a concern in most of the economic data series is also considered.

3.8 Skewness

Skewness is a measure of asymmetry of the distribution of a series around its arithmetic mean and computed by the formula,

$$S = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{y_i - \bar{y}}{\hat{\sigma}}\right)^3$$

Where $\hat{\sigma}$ is an estimator for the standard deviation and n is the sample size.
The skewness of a symmetric distribution, such as the normal distribution, is zero. A positive value implies positive skewness of the distribution and a negative value implies negative skewness of the distribution.

3.9 Kurtosis

Kurtosis measures how sharply peaked the distribution is (peaked ness or flatness of the distribution) of a series and calculated as,

$$K = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{y_i - \bar{y}}{\hat{\sigma}}\right)^4$$

Where $\hat{\sigma}$ an estimator for the standard deviation and n is is the sample size. The kurtosis of the normal distribution is 3. If the kurtosis exceeds 3, the distribution is peaked (leptokurtic) relative to the normal; if the kurtosis is less than 3, the distribution is flat (platykurtic) relative to Normal distribution.

3.10 Cointegration

If two or more series are themselves non-stationary, but a linear combination of them is stationary, then the series are said to be cointegrated. That is if they share a common stochastic drift.

Not concerning about co-integration may cause spurious or nonsense regressions in time series in modeling. This is where the usual procedure for testing hypotheses concerning the relationship between non-stationary variables was to run ordinary least squares regressions on data which had initially been differenced is incorrect if the non-stationary variables are cointegrated.

Let $Y_t = (y_{1t}, \ldots, y_{nt})'$ denote an $(n \times 1)$ vector of I(1) time series.

Y_t is cointegrated if there exists an $(n \times 1)$ vector $\beta = (\beta_1, \ldots, \beta_n)'$ such that

$\beta_0 Y_t = \beta_1 y_{1t} + \cdots + \beta_n y_{nt} \sim I(0)$

The intuition is that I(1) time series with a long-run equilibrium relationship cannot drift too far apart from the equilibrium because economic forces will act to restore the equilibrium relationship. Here the individual series are first-order integrated that is I(1) but some cointegrating vector of coefficients exists to form a stationary linear combination of them. Therefore I such cases Error Correction Models recommended when it comes to the modeling process.

3.11 Detecting Cointegration - Johansen Cointegration Test

Johansen Co-integration test is a technique for testing cointegration of several time series. This test permits more than one cointegrating relationship.

It was selected a VAP (p)

$$y_t = \mu + A_1 y_{t-1} + \ldots\ldots + A_p y_{t-p} + \varepsilon_t$$

Where y_t is an *n* x 1 vector of variables that are integrated of order one commonly denoted I(1) and ε_t is an *n* x 1 vector of innovations. This vector auto regression can be re-written as ,

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{i=1}^{p-1} \tau_i \Delta y_{t-1} + \varepsilon_t$$

Where,

$$\Pi = \sum_{i=1}^{p} A_i = I \text{ And } \tau_i = \sum_{j=i+1}^{p} A_j .$$

If the coefficient matrix Π has reduced rank $r < n$, then there exist *n* x *r* matrices α and β each with rank *r* such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is stationary. *R* is the number of co-integrating relationships, the elements of α are known as the adjustment parameters in the vector error correction model and each column of β is a co-integrating vector .It can be shown that for a given *r*, the maximum likelihood estimator of β defines the combination of y_{t-1} that yields the *r* largest canonical correlations of Δy_t with y_{t-1} after correcting for lagged differences and deterministic variables when present. Johansen theory proposes two different likelihood ratio tests of the significance of these canonical correlations and thereby the reduced rank of the Π matrix.

3.12 Trace Test

H_0 : Cointegration rank is less than or equal to r

H_0 : There is m cointegrating relations" (i.e., the series are stationary)

Where r = 0, 1, . . . , m − 1.

Where $J_{trace} = T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_1)$

Where T = sample size and $\hat{\lambda}_1$ is the largest canonical correlation.

Maximum Eigen value statistic test

H_0 : Number of cointegration vectors equal to r

H_0 : Number of cointegration vectors equal to r + 1

where

$\lambda_{max} = -T ln(1 - \hat{\lambda}_{r+1})$x x

The tests also produce maximum likelihood estimates of the parameters in a vector error-correction (VEC) model of the cointegrated series.

3.13 Selection of the lag length

The optimum lag length is arrived by considering the VAR lag order selection criteria of the lag structure. The available criterias are

- Sequential modified LR test statistic
- Final prediction error
- Akaike information criterion

The Akaike Information Criterion (AIC) is used in model selection processes and smaller values are preferred. It is computed as,

$$AIC = -2\frac{l}{n} + \frac{2k}{n}$$

Where ***l*** is the Log likelihood and k is the number of parameters in the model and n is the sample size.

- Schwarz information criterion

This is an alternative to the Akaike Information Criterion that imposes a larger penalty for additional coefficients. It is calculated as,

$$SC = -2\frac{l}{n} + \frac{k\log(n)}{n}$$

Smaller values are preferred in this criterion also.

- Hannan-Quinn information criterion

$$HQ = -2\frac{l}{n} + \frac{2k\log(\log(n))}{n}$$

This criterion also imposes another penalty function for unimportant inclusions to the model. Commonly selected lag by the available techniques is considered as the best possible lag of the model while taking more emphasis on Akaike information criterion, Schwarz information criterion and Hannan-Quinn information criterion which are widely employed.

Chapter 4 - Analysis of Data

4.1 Introduction

In this chapter the methodology elaborated in chapter 3 is implemented to the selected variables described under notation section. Gross Domestic Product (GDP) and Balance of Trade (BOT) have been selected to reflect the national economic statistics whilst Construction Sector of Gross Domestic Product (CGDP), Gross Fixed Capital Formation for Construction Sector (CGFCF) and All Construction Cost Index (ACINDEX) have been selected to reflect construction outputs. In order to understand the characteristics of the variables the graphical as well as summary measures were studied at first. Then the series was tested to determine whether the assumptions are met and the given regressions are explained our objective reflecting any unidirectional bidirectional relationship between construction outputs and national economic statistics. A keen attention was paid to safeguard the characteristics and real behavior of row data. Hence, transformations deemed unnecessary as it results to compromise the details and smoothness of variables particularly used in this analysis. Then the residual tests were tested for unit root, serial correlation, heteroscedasticity and multivariate normality to validate the model. Finally, the conclusion was arrived based on the test results.

It was obtained a sample consist of 24 data elements from year 1990 to 2013. The information such as CGFCF is only published annually. Hence, for higher accuracy and reliability, the study was based on published annual data by the respective national authorities during the mentioned period above. Observations of GDP, BOT, CGDP, CGFCF were extracted from data published by the Central Bank of Sri Lanka on the annual reports from 2009 – 2013 and All Construction Cost Index (ACINDEX) was extracted from The Institute of Construction Training & Development (ICTAD) bulletins.

4.2 Notation

Let,

- Gross Domestic Product (Nominal) – Abbr : GDP
- Construction Sector of Gross Domestic Product (Nominal) – Abbr : CGDP
- Balance of Trade - Abbr : BOT

- Gross Fixed Capital Formation for Construction Sector - Abbr : CGFCF
- All Construction Cost Index - Abbr: ACINDEX

4.3 Graphical Representation of the Variables

Plot of each series was checked separately to identify the trend. E-views have been used to plot the graphs.

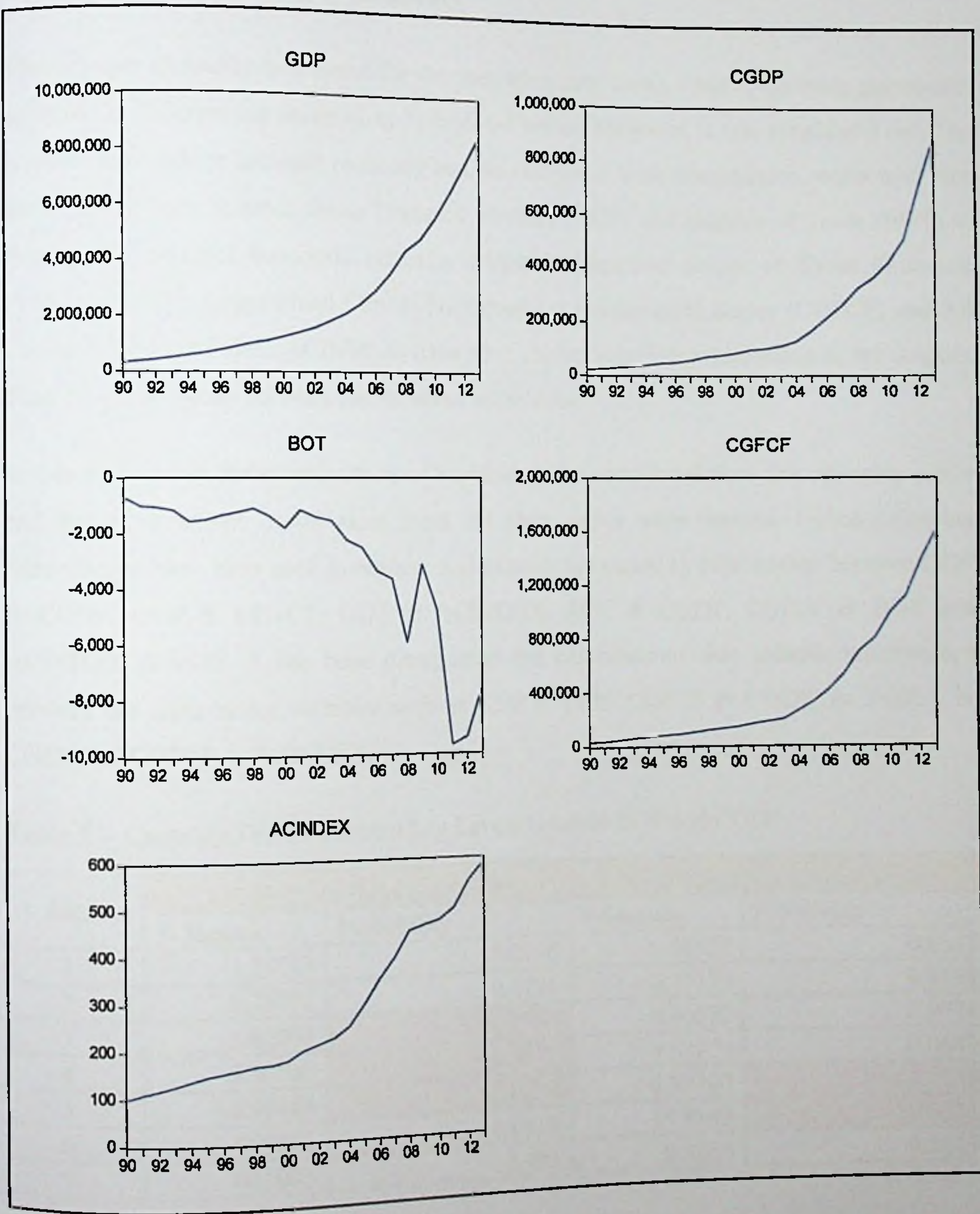


Figure 8 – Time series line plots of the variables

When observing the scattered plots of the variables, all of them are fairly concentrated along with their trends indicating possible consistence in variance except BOT.

4.4 Testing for Ganger Causality

The Granger Causality was tested for the following data series. Null Hypothesis test results appeared in different lag levels (1 to 7) depicted below. However, it was considered only the combinations where national economy can be compared with construction sector and vice versa. It has been selected Gross Domestic Product (GDP) and Balance of Trade (BOT) to express the national economic statistics whilst Construction Sector of Gross Domestic Product (CGDP), Gross Fixed Capital Formation for Construction Sector (CGFCF) and All Construction Cost Index (ACINDEX) have been chosen to reflect construction sector outputs. Then the associations between the variables were tested

In this study, only the combinations of variables were considered from the opposing sector and the combinations of variables from the same sector were omitted. Hence following relationships have been used to analyse and express the causality relationship between GDP & CGDP, GDP & CGFCF, GDP & ACINDEX, BOT & CGDP, CGFCF & BOT and ACINDEX & BOT. It has been disregarded the combinations that indicate relationships between the same sector variables such as GDP & BOT, CGFCF & CGDP, ACINDEX & CGDP and CGFCF & ACINDEX.

Table 5 – Causality Test in different Lag Levels between GDP and CGDP

Lag	CGDP Does Not Cause GDP		GDP Does Not Cause CGDP	
	F-Statistic	Probability	F-Statistic	Probability
1	1.23513	0.2796	0.04527	0.8337
2	0.76871	0.4791	0.05222	0.9493
3	5.82095	0.0085	0.06522	0.9774
4	5.20869	0.0133	3.03779	0.0649
5	4.97484	0.0229	4.98107	0.0228
6	4.83161	0.0524	19.9189	0.0024
7	10.1035	0.093	8.3356	0.1113

It was noted no causal relationship exists in any direction between 1st and 2nd lags of CGDP and GDP. However there is a unidirectional relationship from CGDP to GDP in lag 3 and lag 4. Also it was noted a bidirectional relationship between GDP and CGDP in lag 5. There is an unidirectional relationship from GDP to CGDP in lag 6. However, there is no recent relationship observed that variables GDP or CGDP depend on resent past data (lag 1 or 2) Therefore this was not examined this further as it would not able to identify any short term relationship between these two variables to forecast any trend.

Table 6 – Causality Test in different Lag Levels between GDP and CGFCF

Lag	CGFCF Does Not Cause GDP		GDP Does Not Cause CGFCF	
	F-Statistic	Probability	F-Statistic	Probability
1	1.32122	0.2639	6.71212	0.0175
2	0.61141	0.5541	4.20032	0.0329
3	0.92367	0.4549	1.68143	0.2165
4	1.72011	0.2154	1.88107	0.184
5	5.43141	0.0179	2.38259	0.1319
6	7.09323	0.0242	3.07376	0.1192
7	17.4166	0.0554	5.06661	0.1747

It was noted no causal relationship exists among first four lag levels from CGFCF to GDP. Although, there is a unidirectional relationship from CGDP to GDP in lag 5 and 6, still this was not examined further as it would not able to identify any long or short term relationship from CGFCF to GDP in causality. However there was a unidirectional relationship from GDP to CGFCF both in lag 1 and 2. Hence, we examined this relationship further.

Table 7 – Causality Test in different Lag Levels between GDP and CGFCF

Lag	ACINDEX Does Not Cause GDP		GDP Does Not Cause ACINDEX	
	F-Statistic	Probability	F-Statistic	Probability
1	1.77796	0.1974	0.00771	0.9309
2	0.87748	0.4338	0.25375	0.7788
3	3.93906	0.0314	0.53632	0.665
4	4.76458	0.0178	4.30823	0.0244
5	3.16916	0.0717	3.22285	0.069
6	3.34224	0.1033	1.42001	0.3587
7	17.6715	0.0546	17.3099	0.0557

Although, there is a unidirectional relationship from ACCINDEX to GDP in lag 3 & 4 and unidirectional relationship from GDP to ACCINDEX in lag 4, still this was not examined further as it would not able to identify any long or short term relationship among these two variables.

Table 8 – Causality Test in different Lag Levels between BOT and CGDP

Lag	BOT Does Not Cause CGDP		CGDP Does Not Cause BOT	
	F-Statistic	Probability	F-Statistic	Probability
1	14.5153	0.0011	7.99639	0.0104
2	6.20009	0.0095	19.158	0.00004
3	6.80489	0.0046	3.07867	0.0621
4	3.57876	0.042	1.25566	0.3442
5	4.32161	0.0334	1.86712	0.2061
6	3.42797	0.0988	1.2015	0.4295
7	7.59064	0.1213	2.37194	0.3284

Table 4.4 indicates productive and meaningful bi-directional causal relationship from BOT to CGDP and CGDP to BOT. At the outset this indicates that there would be a relationship among variables BOT and CGDP in short run. Hence, it was tested further to understand long term relationship.

Table 9 – Causality Test in different Lag Levels between CGFCF and BOT

Lag	CGFCF Does Not Cause BOT		BOT Does Not Cause CGFCF	
	F-Statistic	Probability	F-Statistic	Probability
1	16.6491	0.0006	0.88755	0.3574
2	24.5656	0.00001	0.5615	0.5806
3	5.20794	0.0127	4.43729	0.0217
4	1.75006	0.2091	2.63759	0.0914
5	2.75479	0.0978	3.48346	0.0574
6	3.6645	0.0878	4.31271	0.0651
7	3.92563	0.218	9.44205	0.0991

There is a positive short term unidirectional relationship from CGFCF to BOT in lag 1 to 3. This was investigated further to understand any mathematical long term relationship. Although there is a unidirectional relationship from BOT to CGFCF in lag 3, this was not examined further as it would not able to identify any long or short term relationship here.

Table 10 – Causality Test in different Lag Levels between ACINDEX and BOT

Lag	ACINDEX Does Not Cause BOT		BOT Does Not Cause ACINDEX	
	F-Statistic	Probability	F-Statistic	Probability
1	9.13246	0.0067	0.66854	0.4232
2	11.7564	0.0006	1.53437	0.244
3	1.7717	0.1987	3.29993	0.0518
4	0.32062	0.8584	2.14952	0.1424
5	0.74817	0.6097	1.9292	0.1949

6	0.43009	0.8332	0.64395	0.6981
7	4.11901	0.2092	0.98016	0.5915

A short term unidirectional causal relationship exists between ACINDEX and BOT in lag 1 and 2. No causal relationship can be noted vice versa from BOT to ACINDEX.

4.5 Summary Measures of the variables

Table 11 – Summary Measures

	GDP	CGDP	BOT	CGFCF	ACINDEX
Mean	2559349.	201638.3	-2930.529	401720.9	268.9344
Median	1494642.	97730.50	-1548.650	170657.0	202.4125
Maximum	8673870.	894683.0	-702.5000	1631404.	590.4250
Minimum	321784.0	21541.00	-9710.000	35239.00	100.0000
Std. Dev.	2456862.	231775.7	2666.122	464442.0	154.9524
Skewness	1.164400	1.667581	-1.531855	1.382934	0.748164
Kurtosis	3.186333	5.006492	4.114979	3.740262	2.116075
Jarque-Bera	5.458027	15.14931	10.62950	8.198015	3.020321
Probability	0.065284	0.000513	0.004919	0.016589	0.220875

As the values of the variable are in different scales it is less meaningful in comparing summary measures of the variables.

When considering the shape of the distributions, according to the Jarque-Bera statistics all the variables do not look normally distributed.

H_0: Distribution is Normally Distributed

H_1: Distribution is not Normally Distributed

Reject the null hypothesis when probability is less than 0.05 at 5% significance.

Further, skewnesses of the variable distributions are almost close to zero indicating their all the variables are normally distributed.

4.6 Vector Autoregression Estimates

We tested Vector Autoregression Estimates for different lag levels in each variable to build a relationship equation explaining its evolution based on its own lags and the lags of the other model variables.

Since at 5% significance level, the value of the test statistics are greater than 0.05 we do not reject the null hypothesis.

4.6.1 VAR Estimate - Lag 1

Table 12 - VAR Estimate (Lag 1)

Vector Autoregression Estimates
Date: 05/16/14 Time: 20:04
Sample (adjusted): 1991 2013
Included observations: 23 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	GDP	CGDP	BOT	CGFCF	ACINDEX
GDP(-1)	1.203189	0.067967	-0.002142	0.073310	4.85E-05
	(0.19856)	(0.02606)	(0.00176)	(0.05711)	(2.6E-05)
	[6.05965]	[2.60788]	[-1.21774]	[1.28365]	[1.86845]
CGDP(-1)	-0.106635	1.002809	0.037204	0.004218	5.96E-05
	(1.35102)	(0.17733)	(0.01197)	(0.38859)	(0.00018)
	[-0.07893]	[5.65501]	[3.10777]	[0.01085]	[0.33741]
BOT(-1)	21.71853	-11.67808	-0.029640	-7.584921	-0.004714
	(27.7583)	(3.64348)	(0.24596)	(7.98397)	(0.00363)
	[0.78242]	[-3.20520]	[-0.12051]	[-0.95002]	[-1.29996]
CGFCF(-1)	-0.236662	-0.131513	-0.016547	0.748119	-0.000268
	(0.89407)	(0.11735)	(0.00792)	(0.25716)	(0.00012)
	[-0.26470]	[-1.12065]	[-2.08870]	[2.90919]	[-2.29825]
ACINDEX(-1)	446.6763	-515.4916	12.50492	-3.093559	0.932789
	(1200.99)	(157.638)	(10.6418)	(345.434)	(0.15690)
	[0.37192]	[-3.27009]	[1.17507]	[-0.00896]	[5.94524]
C	-56824.98	26978.38	-2000.654	-31637.81	-2.283689
	(111546.)	(14641.3)	(988.401)	(32083.6)	(14.5724)
	[-0.50943]	[1.84262]	[-2.02413]	[-0.98611]	[-0.15671]
R-squared	0.998616	0.997348	0.908264	0.996826	0.993958
Adj. R-squared	0.998208	0.996568	0.881283	0.995893	0.992181

Sum sq. resids	1.85E+11	3.19E+09	14522620	1.53E+10	3156.763
S.E. equation	104308.7	13691.30	924.2682	30001.79	13.62688
F-statistic	2452.551	1278.758	33.66288	1067.827	559.3125
Log likelihood	-294.9269	-248.2232	-186.2264	-266.2666	-89.23638
Akaike AIC	26.16756	22.10637	16.71534	23.67536	8.281425
Schwarz SC	26.46377	22.40258	17.01156	23.97158	8.577640
Mean dependent	2656634.	209468.7	-3027.400	417654.9	276.2793
S.D. dependent	2464360.	233716.4	2682.509	468124.8	154.1039

Determinant resid covariance (dof adj.)	7.54E+32
Determinant resid covariance	1.66E+32
Log likelihood	-1016.375
Akaike information criterion	90.98915
Schwarz criterion	92.47023

It is noted AIC (Akaike information criterion) in lag 1 is 90.99 and SIC (Schwarz information criterion) is 92.47. It shall be chosen the lag length that minimizes AIC and SIC for the VAR model. Therefore it was tested the second lag length of the VAR (Vector Autoregression) model and then test the correlations of residuals.

4.6.2 VAR Estimate - Lag 2

Table 13 - VAR Estimate (Lag 2)

Vector Autoregression Estimates
Date: 05/16/14 Time: 20:10
Sample (adjusted): 1992 2013
Included observations: 22 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	GDP	CGDP	BOT	CGFCF	ACINDEX
GDP(-1)	1.376091	0.103286	-0.008117	0.254942	0.000107
	(1.09535)	(0.12471)	(0.00851)	(0.24380)	(0.00013)
	[1.25630]	[0.82819]	[-0.95398]	[1.04570]	[0.80656]
GDP(-2)	-0.453766	-0.029637	0.008920	-0.201886	-2.57E-05
	(0.95884)	(0.10917)	(0.00745)	(0.21342)	(0.00012)
	[-0.47325]	[-0.27148]	[1.19761]	[-0.94598]	[-0.22098]
CGDP(-1)	4.881203	1.516740	-0.027805	-0.060623	3.84E-05
	(5.58953)	(0.63641)	(0.04342)	(1.24410)	(0.00068)
	[0.87328]	[2.38329]	[-0.64036]	[-0.04873]	[0.05657]
CGDP(-2)	-6.036992	-1.829311	0.068175	-1.429155	-0.000952
	(9.04052)	(1.02932)	(0.07023)	(2.01221)	(0.00110)

	[-0.66777]	[-1.77720]	[0.97076]	[-0.71024]	[-0.86669]
BOT(-1)	108.7569	-0.851401	-1.090161	13.94529	0.006624
	(79.5529)	(9.05764)	(0.61798)	(17.7067)	(0.00967)
	[1.36710]	[-0.09400]	[-1.76406]	[0.78757]	[0.68532]
BOT(-2)	76.57792	1.632175	-0.856162	-16.75054	0.001844
	(84.0353)	(9.56799)	(0.65280)	(18.7043)	(0.01021)
	[0.91126]	[0.17059]	[-1.31151]	[-0.89554]	[0.18064]
CGFCF(-1)	-2.529798	-0.356966	0.007776	0.010963	-0.000235
	(1.92839)	(0.21956)	(0.01498)	(0.42921)	(0.00023)
	[-1.31187]	[-1.62583]	[0.51908]	[0.02554]	[-1.00227]
CGFCF(-2)	4.549544	0.731724	-0.041732	1.545865	0.000329
	(2.60046)	(0.29608)	(0.02020)	(0.57880)	(0.00032)
	[1.74952]	[2.47137]	[-2.06587]	[2.67080]	[1.04251]
ACINDEX(-1)	3791.441	-242.0887	6.443437	686.6023	1.379196
	(5031.06)	(572.820)	(39.0824)	(1119.80)	(0.61128)
	[0.75361]	[-0.42263]	[0.16487]	[0.61315]	[2.25625]
ACINDEX(-2)	-2090.701	-87.12927	-6.415008	-691.1034	-0.704977
	(6771.39)	(770.969)	(52.6016)	(1507.16)	(0.82273)
	[-0.30876]	[-0.11301]	[-0.12195]	[-0.45855]	[-0.85687]
C	-16759.30	26474.00	-2716.995	-20001.55	32.10987
	(323555.)	(36838.9)	(2513.45)	(72015.9)	(39.3122)
	[-0.05180]	[0.71864]	[-1.08098]	[-0.27774]	[0.81679]
R-squared	0.998950	0.998504	0.947266	0.998573	0.995976
Adj. R-squared	0.997995	0.997144	0.899326	0.997275	0.992318
Sum sq. resids	1.35E+11	1.74E+09	8121025.	6.67E+09	1986.678
S.E. equation	110608.3	12593.50	859.2293	24618.86	13.43901
F-statistic	1046.393	734.0740	19.75935	769.5173	272.2499
Log likelihood	-279.0945	-231.2926	-172.2248	-246.0399	-80.75159
Akaike AIC	26.37223	22.02660	16.65680	23.36727	8.341054
Schwarz SC	26.91775	22.57212	17.20232	23.91279	8.886575
Mean dependent	2760466.	217874.7	-3119.686	434899.7	283.8193
S.D. dependent	2470322.	235630.7	2708.007	471604.3	153.3265

Determinant resid covariance (dof adj.)	1.98E+31
Determinant resid covariance	6.18E+29
Log likelihood	-910.6413
Akaike information criterion	87.78557
Schwarz criterion	90.51318

Subsequent lag length indicates a minimization of AIC to 87.78 and SIC to 90.51. Therefore lag 2 is a better modification. However, it was checked the third lag length also to determine the optimal level.

4.6.3 VAR Estimate - Lag 3

Table 14 - VAR Estimate (Lag 3)

Vector Autoregression Estimates
Date: 05/16/14 Time: 20:11
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	GDP	CGDP	BOT	CGFCF	ACINDEX
GDP(-1)	3.479916 (1.04949) [3.31582]	0.481880 (0.13531) [3.56140]	-0.020749 (0.01162) [-1.78615]	0.568011 (0.17954) [3.16378]	0.000313 (0.00012) [2.58861]
GDP(-2)	-2.795751 (0.72258) [-3.86910]	-0.296971 (0.09316) [-3.18776]	0.026988 (0.00800) [3.37431]	-0.463770 (0.12361) [-3.75181]	-0.000346 (8.3E-05) [-4.16299]
GDP(-3)	2.220802 (0.65113) [3.41070]	0.203470 (0.08395) [2.42377]	-0.016464 (0.00721) [-2.28429]	0.212530 (0.11139) [1.90801]	0.000328 (7.5E-05) [4.37848]
CGDP(-1)	-14.71995 (5.63501) [-2.61223]	-1.172407 (0.72650) [-1.61377]	0.108677 (0.06237) [1.74236]	-2.752454 (0.96398) [-2.85530]	-0.001998 (0.00065) [-3.07882]
CGDP(-2)	18.40258 (9.38165) [1.96155]	1.890045 (1.20954) [1.56261]	-0.136078 (0.10384) [-1.31039]	1.905485 (1.60492) [1.18728]	0.002025 (0.00108) [1.87482]
CGDP(-3)	-31.87847 (9.39991) [-3.39136]	-4.836822 (1.21190) [-3.99112]	0.227706 (0.10405) [2.18849]	-5.622572 (1.60804) [-3.49654]	-0.003503 (0.00108) [-3.23658]
BOT(-1)	94.46554 (59.1817) [1.59620]	4.698371 (7.63008) [0.61577]	-1.223029 (0.65508) [-1.86700]	22.51751 (10.1242) [2.22413]	0.004236 (0.00681) [0.62171]
BOT(-2)	-199.6260 (84.6043) [-2.35953]	-31.60142 (10.9077) [-2.89716]	0.979886 (0.93648) [1.04635]	-39.11709 (14.4732) [-2.70272]	-0.031011 (0.00974) [-3.18353]
BOT(-3)	58.58385	-4.726645	-0.928631	41.10457	0.014354

	(91.7097)	(11.8238)	(1.01513)	(15.6888)	(0.01056)
	[0.63880]	[-0.39976]	[-0.91479]	[2.62000]	[1.35941]
CGFCF(-1)	1.637064	0.114167	-0.027313	1.094410	0.000416
	(1.38149)	(0.17811)	(0.01529)	(0.23633)	(0.00016)
	[1.18500]	[0.64099]	[-1.78615]	[4.63084]	[2.61845]
CGFCF(-2)	0.691693	0.403583	-0.015273	0.488031	-0.000133
	(1.54640)	(0.19937)	(0.01712)	(0.26454)	(0.00018)
	[0.44729]	[2.02427]	[-0.89228]	[1.84481]	[-0.74670]
CGFCF(-3)	2.529342	0.116545	-0.012543	0.993829	-7.81E-05
	(3.01340)	(0.38851)	(0.03336)	(0.51550)	(0.00035)
	[0.83937]	[0.29998]	[-0.37603]	[1.92789]	[-0.22509]
ACINDEX(-1)	-5538.957	-1627.047	48.54597	-1332.166	0.106009
	(5148.39)	(663.763)	(56.9872)	(880.734)	(0.59277)
	[-1.07586]	[-2.45125]	[0.85188]	[-1.51256]	[0.17884]
ACINDEX(-2)	44.00800	-715.5223	16.83539	797.4952	-0.234959
	(8190.13)	(1055.92)	(90.6560)	(1401.08)	(0.94299)
	[0.00537]	[-0.67763]	[0.18571]	[0.56920]	[-0.24916]
ACINDEX(-3)	-2793.643	38.12013	-11.34743	-587.3804	-0.172266
	(4485.93)	(578.354)	(49.6544)	(767.407)	(0.51650)
	[-0.62276]	[0.06591]	[-0.22853]	[-0.76541]	[-0.33353]
C	702294.7	179380.2	-7302.263	115130.0	105.7062
	(462760.)	(59662.0)	(5122.26)	(79164.3)	(53.2809)
	[1.51762]	[3.00661]	[-1.42559]	[1.45432]	[1.98394]
R-squared	0.999890	0.999801	0.988952	0.999913	0.999616
Adj. R-squared	0.999560	0.999206	0.955808	0.999650	0.998463
Sum sq. resids	1.35E+10	2.24E+08	1651538.	3.94E+08	178.6931
S.E. equation	51922.24	6694.144	574.7239	8882.331	5.978179
F-statistic	3027.443	1678.373	29.83821	3813.817	867.2633
Log likelihood	-242.7369	-199.7181	-148.1610	-205.6575	-52.27976
Akaike AIC	24.64161	20.54458	15.63438	21.11024	6.502834
Schwarz SC	25.43743	21.34041	16.43021	21.90607	7.298661
Mean dependent	2871665.	226893.3	-3218.500	453323.3	291.6857
S.D. dependent	2474264.	237527.1	2733.938	475068.8	152.4960

Determinant resid covariance (dof adj.)	1.20E+26
Determinant resid covariance	9.21E+22
Log likelihood	-704.1970
Akaike information criterion	74.68543
Schwarz criterion	78.66457

It was noted that the relative quality of Akaike (AIC – 74.68) and Schwarz (SIC – 78.66) values in the third lag level. Those have been minimized and optimized compared to first two lag values.

4.7 Proposed Models

Based on the values obtained through the above VAR models, the following relations ships were identified. However these relationships to be tested further against model assumptions.

Model 1 -

$$GDP = 3.31582\ \mathrm{GDP}(-1) - 3.86910\ \mathrm{GDP}(-2) + 3.41070\ \mathrm{GDP}(-3) - 2.61223\ \mathrm{CGDP}(-1) + 1.96155\ \mathrm{CGDP}(-2) - 3.39136\ \mathrm{CGDP}(-3) - 2.35953\ \mathrm{BOT}(-2)$$

Model 2 -

$$CGDP = 3.56140\ \mathrm{GDP}(-1) - 3.18776\ \mathrm{GDP}(-2) - 2.42377\ \mathrm{GDP}(-3) - 3.99112\ \mathrm{CGDP}(-3) - 2.89716\ \mathrm{BOT}(-2) + 2.02427\ \mathrm{CGFCF}(-2) - 2.45125\ \mathrm{ACINDEX}(-1) + \mathrm{C}$$

Here, $C = 3.00661$

Model 3 -

$$BOT = 3.37431\ \mathrm{GDP}(-2) - 2.28429\ \mathrm{GDP}(-3) + 2.18849\ \mathrm{CGDP}(-3)$$

Model 4 -

$$CGFCF = 3.16378\ \mathrm{GDP}(-1) - 3.75181\ \mathrm{GDP}(-2) - 2.85530\ \mathrm{CGDP}(-1) - 3.49654\ \mathrm{CGDP}(-3) + 2.22413\ \mathrm{BOT}(-1) - 2.70272\ \mathrm{BOT}(-2) + 2.62000\ \mathrm{BOT}(-3) + 4.63084\ \mathrm{CGFCF}(-1)$$

Model 5 -

$$ACINDEX = 2.58861\ \mathrm{GDP}(-1) - 4.16299\ \mathrm{GDP}(-2) + 4.37848\ \mathrm{GDP}(-3) + 3.07882\ \mathrm{CGDP}(-1) - 3.23658\ \mathrm{CGDP}(-3) - 3.18353\ \mathrm{BOT}(-2) + 2.61845\ \mathrm{CGFCF}(-1) + \mathrm{C}$$

Here, $C = 1.98394$

4.8 Testing of assumptions

Series of tests were undertaken to determine whether above mentioned multiple regressions violate one or more of multiple linear regression assumptions. When these assumptions are not met the results may not be trustworthy. Some of the key assumption were tested as below.

- Variables are Normally distributed.
- Assumption of a Linear Relationship between the Independent and Dependent Variable(s).
- Variables are measured without error (Reliably)
- Assumption of Homoscedasticity

4.8.1 Model 1

In model 1, we noted the GDP has the following relationship.

$$\begin{aligned} GDP = {} & 3.31582\ \mathrm{GDP}(-1) - 3.86910\ \mathrm{GDP}(-2) + 3.41070\ \mathrm{GDP}(-3) \\ & - 2.61223\ \mathrm{CGDP}(-1) + 1.96155\ \mathrm{CGDP}(-2) - 3.39136\ \mathrm{CGDP}(-3) \\ & - 2.35953\ \mathrm{BOT}(-2) \end{aligned}$$

It shows the current year GDP is linked to the previous year GDP, CGDP and BOT.

Further analysis was undertaken. Since at 5% significance level, the value of the test statistics are greater than 0.05, we do not reject the null hypothesis.

<u>**Model 1.1 –**</u>

It was used a lagged regression model to test the significance of the lagged variables identified in the VAR model 1.

Table 15 - Least Squares estimate for Model 1 (1st Iteration)

Dependent Variable: GDP
Method: Least Squares
Date: 06/12/14 Time: 16:21
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-124026.8	86033.50	-1.441611	0.1731

GDP(-1)	1.314008	0.364276	3.607174	0.0032
GDP(-2)	-1.232275	0.748251	-1.646874	0.1235
GDP(-3)	1.677201	0.556039	3.016337	0.0099
CGDP(-1)	-3.598568	2.497096	-1.441101	0.1732
CGDP(-2)	11.49616	4.543061	2.530487	0.0251
CGDP(-3)	-15.26034	4.067904	-3.751400	0.0024
BOT(-2)	-68.99373	78.24270	-0.881791	0.3939

R-squared	0.999292	Mean dependent var	2871665.
Adjusted R-squared	0.998911	S.D. dependent var	2474264.
S.E. of regression	81649.53	Akaike info criterion	25.74059
Sum squared resid	8.67E+10	Schwarz criterion	26.13850
Log likelihood	-262.2762	Hannan-Quinn criter.	25.82695
F-statistic	2621.857	Durbin-Watson stat	2.281746
Prob(F-statistic)	0.000000		

The following variables were noted as significant during the lagged regression model 1.1. GDP(-1), GDP(-3), CGDP(-2) and CGDP(-3).

Model 1.2 -

Based on the output, of model 1.1, GDP was regressed again with GDP(-1) GDP(-3) CGDP(-2) and CGDP(-3)

Table 16 - Least Squares estimate for Model 1.1 (2nd Iteration)

Dependent Variable: GDP
Method: Least Squares
Date: 06/12/14 Time: 16:25
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	0.847234	0.185404	4.569668	0.0003
GDP(-3)	0.716986	0.279047	2.569405	0.0199
CGDP(-2)	4.955498	2.919302	1.697494	0.1078
CGDP(-3)	-9.960046	3.716558	-2.679911	0.0158

R-squared	0.998872	Mean dependent var	2871665.
Adjusted R-squared	0.998673	S.D. dependent var	2474264.
S.E. of regression	90142.58	Akaike info criterion	25.82582
Sum squared resid	1.38E+11	Schwarz criterion	26.02477
Log likelihood	-267.1711	Hannan-Quinn criter.	25.86899
Durbin-Watson stat	1.884926		

The following variables were noted as significant from model 1.2. GDP(-1), GDP(-3), and CGDP(-3).

Model 1.3 -

Based on the output, of model 1.2, GDP was regressed again with GDP(-1) GDP(-3) and CGDP(-3)

Table 17 - Least Squares estimate for Model 1.2 (3rd Iteration)

Dependent Variable: GDP
Method: Least Squares
Date: 06/12/14 Time: 16:30
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	1.065655	0.140287	7.596239	0.0000
GDP(-3)	0.453002	0.243504	1.860347	0.0793
CGDP(-3)	-4.515170	1.972940	-2.288548	0.0344

R-squared	0.998681	Mean dependent var	2871665.
Adjusted R-squared	0.998534	S.D. dependent var	2474264.
S.E. of regression	94736.68	Akaike info criterion	25.88715
Sum squared resid	1.62E+11	Schwarz criterion	26.03637
Log likelihood	-268.8151	Hannan-Quinn criter.	25.91954
Durbin-Watson stat	2.017691		

The following variables were noted as significant from model 1.3. GDP(-1) and CGDP(-3).

Model 1.4 -

Based on the output, of model 1.3, GDP was regressed again with GDP(-1) and CGDP(-3).

Table 18 - Least Squares estimate for Model 1.3 (4th Iteration)

Dependent Variable: GDP
Method: Least Squares
Date: 06/29/14 Time: 15:55
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	1.276242	0.088068	14.49149	0.0000
CGDP(-3)	-2.210864	1.632085	-1.354626	0.1914

R-squared	0.998427	Mean dependent var	2871665.

Adjusted R-squared	0.998344	S.D. dependent var	2474264.
S.E. of regression	100685.1	Akaike info criterion	25.96778
Sum squared resid	1.93E+11	Schwarz criterion	26.06725
Log likelihood	-270.6616	Hannan-Quinn criter.	25.98937
Durbin-Watson stat	2.296031		

At the end it has been received a relationship between GDP and GDP lag 1 which is the previous year. This concluded that the current GDP depend only on the previous year GDP and does not have a relationship with any other construction output parameters. Hence, this relationship was disregarded.

4.8.2 Model 2

In model 2, it was noted that the CGDP has the following relationship.

$$CGDP = 3.56140\,\mathrm{GDP}(-1) - 3.18776\,\mathrm{GDP}(-2) - 2.42377\,\mathrm{GDP}(-3) - 3.99112\,\mathrm{CGDP}(-3) - 2.89716\,\mathrm{BOT}(-2) + 2.02427\,\mathrm{CGFCF}(-2) - 2.45125\,\mathrm{ACINDEX}(-1) + \mathrm{C}$$

Further analysis was undertaken. Since at 5% significance level, the value of the test statistics are greater than 0.05, we do not reject the null hypothesis.

Model 2.1 -

Based on the output, of VAR model 2, CGDP was regressed again with GDP(-1), GDP(-2), GDP(-3), CGDP(-3), BOT(-2), CGFCF(-2) and ACINDEX(-1).

Table 19 - Least Squares estimate for Model 2 (1st Iteration)

Dependent Variable: CGDP
Method: Least Squares
Date: 06/12/14 Time: 16:13
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	102707.5	9925.878	10.34744	0.0000
GDP(-1)	0.323930	0.017682	18.32022	0.0000
GDP(-2)	-0.217260	0.031069	-6.992929	0.0000
GDP(-3)	0.177691	0.029970	5.928900	0.0000
CGDP(-3)	-3.087483	0.285563	-10.81191	0.0000
BOT(-2)	-21.91222	2.114318	-10.36373	0.0000

CGFCF(-2)	0.542623	0.069937	7.758750	0.0000
ACINDEX(-1)	-1360.750	101.7535	-13.37301	0.0000

R-squared	0.999602	Mean dependent var	226893.3
Adjusted R-squared	0.999387	S.D. dependent var	237527.1
S.E. of regression	5880.578	Akaike info criterion	20.47903
Sum squared resid	4.50E+08	Schwarz criterion	20.87694
Log likelihood	-207.0298	Hannan-Quinn criter.	20.56539
F-statistic	4659.563	Durbin-Watson stat	3.016022
Prob(F-statistic)	0.000000		

All the variables concluded as significant. Therefore the assumption test was undertaken.

Testing of Stationarity of the model residuals with Augmented Dickey-Fuller test

H_0 : Residuals are non-stationary (There is a unit root)

H_1 : Residuals are stationary (There is no unit root)

Table 20 - Augmented Dickey-Fuller test for model 2.1

Null Hypothesis: RES2 has a unit root
Exogenous: None
Lag Length: 1 (Automatic based on SIC, MAXLAG=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.387454	0.0000
Test critical values:	1% level	-2.692358	
	5% level	-1.960171	
	10% level	-1.607051	

*MacKinnon (1996) one-sided p-values.
Warning: Probabilities and critical values calculated for 20 observations
and may not be accurate for a sample size of 19

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES2)
Method: Least Squares
Date: 06/29/14 Time: 16:35
Sample (adjusted): 1995 2013
Included observations: 19 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES2(-1)	-2.296711	0.359566	-6.387454	0.0000
D(RES2(-1))	0.519505	0.206786	2.512285	0.0224

R-squared	0.821985	Mean dependent var	-15.34085

Adjusted R-squared	0.811514	S.D. dependent var	8676.206
S.E. of regression	3766.777	Akaike info criterion	19.40513
Sum squared resid	2.41E+08	Schwarz criterion	19.50454
Log likelihood	-182.3487	Hannan-Quinn criter.	19.42195
Durbin-Watson stat	1.967183		

P value < 0.05 we reject H_0

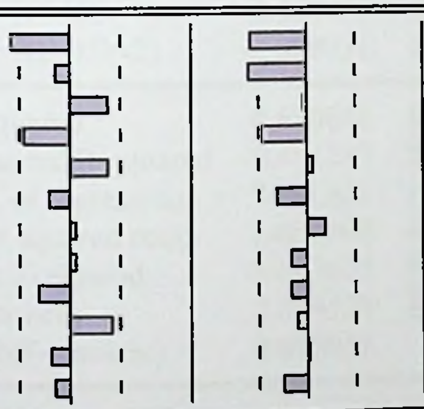
Since at 5% significance level, the p-value of the Augmented Dickey-Fuller test statistic (0.0000) is less than 0.05 we reject the null hypothesis. Therefore, the residuals are stationary.

Serial Correlation - Correlogram of Residuals (Q statistics)

H_0 : No serial correlation exists in residuals

H_1 : There exists serial correlation in residuals

Date: 06/12/14 Time: 16:18
Sample: 1993 2013
Included observations: 21



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.510	-0.510	6.2703	0.012
		2	-0.123	-0.516	6.6534	0.036
		3	0.333	-0.047	9.6245	0.022
		4	-0.392	-0.404	13.997	0.007
		5	0.333	0.045	17.348	0.004
		6	-0.180	-0.272	18.390	0.005
		7	0.057	0.159	18.503	0.010
		8	0.060	-0.148	18.635	0.017
		9	-0.273	-0.154	21.642	0.010
		10	0.355	-0.086	27.179	0.002
		11	-0.166	0.022	28.512	0.003
		12	-0.121	-0.223	29.292	0.004

Figure 9 - Correlogram of Residuals for model 2.1

Since some of the p-values are less than 0.05 it was concluded that there exists serial correlation between residuals.

Breusch-Godfrey Serial Correlation LM Test

H_0 : No serial correlation exists in residuals

H_1 : There exists serial correlation in residuals

Table 21 - Breusch-Godfrey Serial Correlation LM Test for model 2.1

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	11.20109	Prob. F(2,11)	0.0022
Obs*R-squared	14.08428	Prob. Chi-Square(2)	0.0009

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 06/12/14 Time: 16:21
Sample: 1993 2013
Included observations: 21
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2869.090	6252.025	0.458906	0.6552
GDP(-1)	0.013343	0.013172	1.012991	0.3328
GDP(-2)	0.016753	0.024809	0.675262	0.5135
GDP(-3)	-0.046913	0.021945	-2.137717	0.0558
CGDP(-3)	0.253073	0.190368	1.329385	0.2106
BOT(-2)	0.433999	1.338486	0.324246	0.7518
CGFCF(-2)	-0.037874	0.044632	-0.848583	0.4142
ACINDEX(-1)	-19.70464	63.85451	-0.308586	0.7634
RESID(-1)	-1.121400	0.243080	-4.613288	0.0007
RESID(-2)	-0.808731	0.283000	-2.857701	0.0156

R-squared	0.670680	Mean dependent var	-1.46E-10
Adjusted R-squared	0.401237	S.D. dependent var	4741.073
S.E. of regression	3668.633	Akaike info criterion	19.55878
Sum squared resid	1.48E+08	Schwarz criterion	20.05617
Log likelihood	-195.3672	Hannan-Quinn criter.	19.66673
F-statistic	2.489130	Durbin-Watson stat	1.693209
Prob(F-statistic)	0.078051		

Since at 5% significance level, the p-value of the Breusch-Godfrey Serial Correlation LM Test: statistic (0.0022) is lesser than 0.05 the null hypothesis was rejected.

That means this relationship has serial correlation among residuals. Therefore, this was not investigated further.

4.8.3 Model 3

In model 3, it was noted that the BOT has the following relationship.

$$BOT = 3.37431\, GDP(-2) - 2.28429\, GDP(-3) + 2.18849\, CGDP(-3)$$

Further analysis was undertaken. Since at 5% significance level, the value of the test statistics are greater than 0.05, we do not reject the null hypothesis.

Model 3.1 -

Based on the output, of VAR model 3, BOT was regressed with GDP(-2), GDP(-3) and CGDP(-3).

Table 22 - Least Squares estimate for Model 3 (1st Iteration)

Dependent Variable: BOT
Method: Least Squares
Date: 05/16/14 Time: 20:22
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-125.8388	428.0259	-0.293998	0.7723
GDP(-2)	0.005463	0.002124	2.572653	0.0198
GDP(-3)	-0.008555	0.003181	-2.689744	0.0155
CGDP(-3)	0.007538	0.026119	0.288601	0.7764

R-squared	0.898872	Mean dependent var	-3218.500
Adjusted R-squared	0.881026	S.D. dependent var	2733.938
S.E. of regression	943.0050	Akaike info criterion	16.70566
Sum squared resid	15117393	Schwarz criterion	16.90462
Log likelihood	-171.4095	Hannan-Quinn criter.	16.74884
F-statistic	50.36816	Durbin-Watson stat	1.780255
Prob(F-statistic)	0.000000		

The following variables were noted as significant during the lagged regression model 3.1. GDP(-2) and GDP(-3).

Model 3.2 -

Based on the output, of model 3.1, BOT was regressed with GDP(-2) and GDP(-3)

Table 23 - Least Squares estimate for Model 3.1 (2nd Iteration)

Dependent Variable: BOT
Method: Least Squares
Date: 06/12/14 Time: 15:44
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-2)	0.005543	0.002034	2.724796	0.0134
GDP(-3)	-0.008140	0.002368	-3.438068	0.0028

R-squared	0.895906	Mean dependent var	-3218.500
Adjusted R-squared	0.890428	S.D. dependent var	2733.938
S.E. of regression	904.9805	Akaike info criterion	16.54410
Sum squared resid	15560803	Schwarz criterion	16.64357
Log likelihood	-171.7130	Hannan-Quinn criter.	16.56569
Durbin-Watson stat	1.752762		

It was identified that both the variables were significant.

Testing of Stationarity of the model residuals with Augmented Dickey-Fuller test

H_0 : Residuals are non-stationary (There is a unit root)

H_1 : Residuals are stationary (There is no unit root)

Table 24 - Augmented Dickey-Fuller test for model 3.2

Null Hypothesis: RES has a unit root
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.883453	0.0005
Test critical values:	1% level	-2.685718	
	5% level	-1.959071	
	10% level	-1.607456	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES)
Method: Least Squares
Date: 06/12/14 Time: 15:49
Sample (adjusted): 1994 2013
Included observations: 20 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES(-1)	-0.980821	0.252564	-3.883453	0.0010

R-squared	0.436910	Mean dependent var	116.4395
Adjusted R-squared	0.436910	S.D. dependent var	1192.150

S.E. of regression	894.5817	Akaike info criterion	16.47930
Sum squared resid	15205251	Schwarz criterion	16.52908
Log likelihood	-163.7930	Hannan-Quinn criter.	16.48902
Durbin-Watson stat	1.817203		

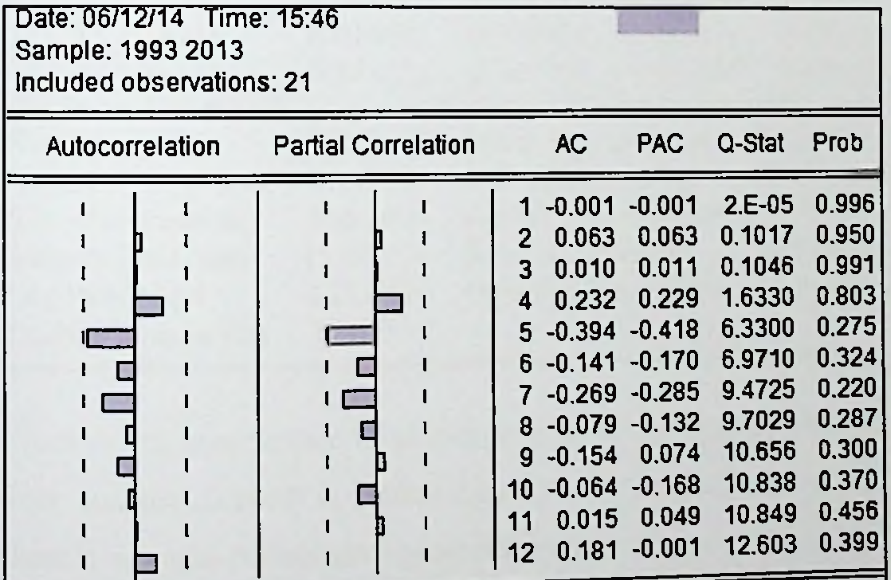
P value < 0.05 we reject H_0

Since at 5% significance level, the p-value of the Augmented Dickey-Fuller test statistic (0.0005) is less than 0.05 we reject the null hypothesis. Therefore, the residuals are stationary.

Serial Correlation – Correlogram of Residuals (Q statistics)

H_0 : No serial correlation exists in residuals

H_1 : There exists serial correlation in residuals


Date: 06/12/14 Time: 15:46
Sample: 1993 2013
Included observations: 21

	AC	PAC	Q-Stat	Prob
1	-0.001	-0.001	2.E-05	0.996
2	0.063	0.063	0.1017	0.950
3	0.010	0.011	0.1046	0.991
4	0.232	0.229	1.6330	0.803
5	-0.394	-0.418	6.3300	0.275
6	-0.141	-0.170	6.9710	0.324
7	-0.269	-0.285	9.4725	0.220
8	-0.079	-0.132	9.7029	0.287
9	-0.154	0.074	10.656	0.300
10	-0.064	-0.168	10.838	0.370
11	0.015	0.049	10.849	0.456
12	0.181	-0.001	12.603	0.399

Figure 10 - Correlogram of Residuals for model 3.2

As per the correlogram no spike could be observed lay beyond the confidence intervals. This was confirmed by all p values are greater than the significance level of 0.05. Hence, there is no serial correlation in the residuals of the model.

Breusch-Godfrey Serial Correlation LM Test

H_0 : No serial correlation exists in residuals

H_1 : There exists serial correlation in residuals

Table 25 - Breusch-Godfrey Serial Correlation LM Test for model 3.2

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.110073	Prob. F(2,17)	0.8964
Obs*R-squared	0.065147	Prob. Chi-Square(2)	0.9680

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 06/12/14 Time: 16:05
Sample: 1993 2013
Included observations: 21
Presample missing value lagged residuals set to zero.

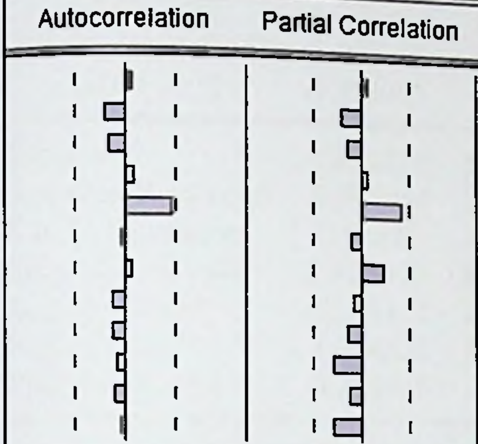
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-2)	0.000956	0.002952	0.323686	0.7501
GDP(-3)	-0.001101	0.003419	-0.321946	0.7514
RESID(-1)	0.014643	0.284464	0.051476	0.9595
RESID(-2)	0.183232	0.395700	0.463059	0.6492

R-squared	0.003102	Mean dependent var	-84.83256
Adjusted R-squared	-0.172821	S.D. dependent var	877.7720
S.E. of regression	950.5995	Akaike info criterion	16.72171
Sum squared resid	15361870	Schwarz criterion	16.92066
Log likelihood	-171.5779	Hannan-Quinn criter.	16.76488
Durbin-Watson stat	1.765551		

Since at 5% significance level, the p-value of the Breusch-Godfrey Serial Correlation LM Test: statistic (0.8964) is greater than 0.05 we do not reject the null hypothesis. Therefore, there is no serial correlation among residuals.

Correlogram Squared Residuals

Date: 06/12/14 Time: 15:57
Sample: 1993 2013
Included observations: 21



	AC	PAC	Q-Stat	Prob
1	0.057	0.057	0.0780	0.780
2	-0.174	-0.177	0.8440	0.656
3	-0.140	-0.122	1.3690	0.713
4	0.066	0.052	1.4928	0.828
5	0.391	0.359	6.1022	0.296
6	-0.041	-0.085	6.1566	0.406
7	0.045	0.205	6.2277	0.513
8	-0.098	-0.072	6.5878	0.582
9	-0.103	-0.132	7.0119	0.636
10	-0.072	-0.250	7.2399	0.703
11	-0.083	-0.105	7.5706	0.751
12	-0.036	-0.256	7.6398	0.813

Figure 11 - Correlogram Squared Residuals for model 3.2

As per the correlogram of squad residuals, no spike could be observed lay beyond the confidence intervals. This was confirmed by the all the p values are greater than the significance level of 0.05. Hence, there is no squared serial correlation in the residuals of the model.

White's Heteroskedasticity

H_0 : No Heteroskedasticity exists in residuals

H_1 : There exists Heteroskedasticity in residuals

Table 26 - White's Heteroskedasticity test for model 3.2

Heteroskedasticity Test: White

F-statistic	1.704572	Prob. F(3,17)	0.2039
Obs*R-squared	4.856172	Prob. Chi-Square(3)	0.1826
Scaled explained SS	5.426489	Prob. Chi-Square(3)	0.1431

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 06/12/14 Time: 15:59

Sample: 1993 2013
Included observations: 21

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	453473.9	317528.1	1.428138	0.1714
GDP(-2)^2	-1.37E-05	1.34E-05	-1.025139	0.3197
GDP(-2)*GDP(-3)	3.23E-05	3.10E-05	1.043662	0.3113
GDP(-3)^2	-1.89E-05	1.79E-05	-1.058576	0.3046

R-squared	0.231246	Mean dependent var	740990.6
Adjusted R-squared	0.095584	S.D. dependent var	1254586.
S.E. of regression	1193121.	Akaike info criterion	30.99169
Sum squared resid	2.42E+13	Schwarz criterion	31.19064
Log likelihood	-321.4127	Hannan-Quinn criter.	31.03487
F-statistic	1.704572	Durbin-Watson stat	2.202519
Prob(F-statistic)	0.203866		

Since at 5% significance level, the p-value of the White's Heteroskedasticity Test (0.2039) is greater than 0.05 we do not reject the null hypothesis. Hence, there is no squared serial correlation in the residuals of the model.

Normality Test (Jarque-Bera Test)

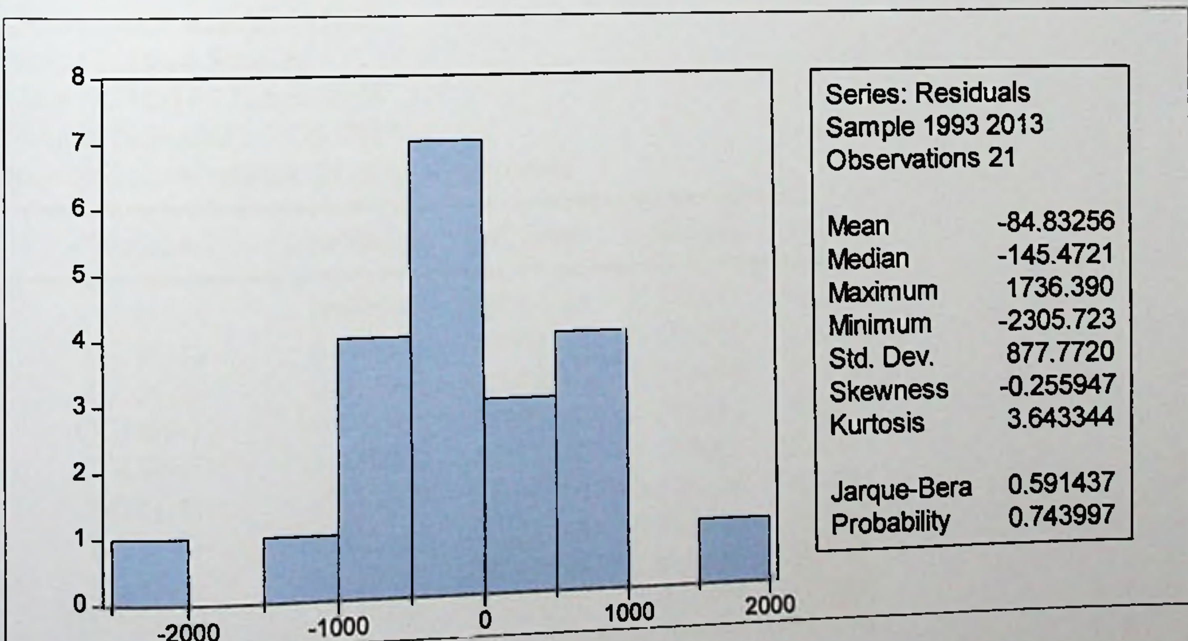


Figure 12 - Jarque-Bera test for model 3.2

H_0 : Residuals are normal

H_1 : Residuals are not normal

Since at 5% significance level, the p-value of the Jarque-Bera Test (0.591437) is greater than 0.05 we do not reject the null hypothesis. Therefore, residuals are normal.

4.8.4 Model 4

In model 4, it was noted that the CGFCF has the following relationship.

$$
\begin{aligned}
CGFCF = {} & 3.16378\,\mathrm{GDP}(-1) - 3.75181\,\mathrm{GDP}(-2) - 2.85530\,\mathrm{CGDP}(-1) \\
& - 3.49654\,\mathrm{CGDP}(-3) + 2.22413\,\mathrm{BOT}(-1) - 2.70272\,\mathrm{BOT}(-2) \\
& + 2.62000\,\mathrm{BOT}(-3) + 4.63084\,\mathrm{CGFCF}(-1)
\end{aligned}
$$

Since at 5% significance level, the value of the test statistics are greater than 0.05 we do not reject the null hypothesis.

Model 4.1 -

Based on the output, of VAR model 4, CGFCF was regressed with GDP(-1), GDP(-2), CGDP(-1), CGDP(-3), BOT(-1), BOT(-2), BOT(-3) and CGFCF(-1).

Table 27 - Least Squares estimate for Model 4 (1st Iteration)

Dependent Variable: CGFCF
Method: Least Squares
Date: 06/12/14 Time: 16:48
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	50538.63	40264.34	1.255171	0.2333
GDP(-1)	0.045844	0.100733	0.455100	0.6572
GDP(-2)	0.033913	0.140642	0.241130	0.8135
CGDP(-1)	-0.841458	0.480564	-1.750981	0.1054
CGDP(-3)	-1.045863	0.882093	-1.185661	0.2587
BOT(-1)	12.38537	13.99309	0.885106	0.3935
BOT(-2)	-0.563484	12.81848	-0.043959	0.9657
BOT(-3)	55.19842	19.37538	2.848895	0.0147
CGFCF(-1)	1.740107	0.355327	4.897199	0.0004

R-squared	0.998794	Mean dependent var	453323.3
Adjusted R-squared	0.997990	S.D. dependent var	475068.8
S.E. of regression	21300.36	Akaike info criterion	23.06836
Sum squared resid	5.44E+09	Schwarz criterion	23.51602
Log likelihood	-233.2178	Hannan-Quinn criter.	23.16551
F-statistic	1242.095	Durbin-Watson stat	2.123327

Prob(F-statistic)	0.000000

Only BOT(-3) and CGFCF(-1) was significant among the considered variables.

Model 4.2 –

Based on the output, of model 4.1 CGFCF was regressed again with BOT(-3) and CGFCF(-1).

Table 28 - Least Squares estimate for Model 4.1 (2nd Iteration)

Dependent Variable: CGFCF
Method: Least Squares
Date: 06/12/14 Time: 16:49
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BOT(-3)	13.42734	8.118632	1.653892	0.1146
CGFCF(-1)	1.252350	0.037088	33.76698	0.0000

R-squared	0.995774	Mean dependent var	453323.3
Adjusted R-squared	0.995551	S.D. dependent var	475068.8
S.E. of regression	31686.54	Akaike info criterion	23.65556
Sum squared resid	1.91E+10	Schwarz criterion	23.75504
Log likelihood	-246.3834	Hannan-Quinn criter.	23.67715
Durbin-Watson stat	2.330218		

Only CGFCF(-1) was significant out of the considered variables.

Model 4.3 –

Based on the output, of 4.2, CGFCF was regressed again with CGFCF(-1).

Table 29 - Least Squares estimate for Model 4.2 (3rd Iteration)

Dependent Variable: CGFCF
Method: Least Squares
Date: 06/12/14 Time: 16:50
Sample (adjusted): 1991 2013
Included observations: 23 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CGFCF(-1)	1.194746	0.012682	94.20515	0.0000

R-squared	0.995469	Mean dependent var	417654.9

Adjusted R-squared	0.995469	S.D. dependent var	468124.8
S.E. of regression	31509.73	Akaike info criterion	23.59649
Sum squared resid	2.18E+10	Schwarz criterion	23.64585
Log likelihood	-270.3596	Hannan-Quinn criter.	23.60890
Durbin-Watson stat	2.814910		

This results also pretty much similar to the results which were received in the 1st model. That means Construction Gross Fixed Capital Formation (CGFCF) depends only on the previous year CGFCF value. This concluded that current CGFCF depend only on the previous year CGFCF and does not have a relationship with any other national economic parameters.

4.8.5 Model 5

In model 5, it was noted that the ACINDEX has the following relationship.

$$ACINDEX = 2.58861\,\text{GDP}(-1) - 4.16299\,\text{GDP}(-2) + 4.37848\,\text{GDP}(-3) + 3.07882\,\text{CGDP}(-1) - 3.23658\,\text{CGDP}(-3) - 3.18353\,\text{BOT}(-2) + 2.61845\,\text{CGFCF}(-1) + \text{C}$$

Since at 5% significance level, the value of the test statistics are greater than 0.05 we do not reject the null hypothesis.

Model 5.1 -

Based on the output, of VAR model 5, ACINDEX was regressed with GDP(-1), GDP(-2), GDP(-3), CGDP(-1), CGDP(-3), BOT(-2) and CGFCF(-1).

Table 30 - Least Squares estimate for Model 5 (1st Iteration)

Dependent Variable: ACINDEX
Method: Least Squares
Date: 06/12/14 Time: 16:51
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	66.05422	9.189162	7.188275	0.0000
GDP(-1)	0.000275	3.71E-05	7.396763	0.0000
GDP(-2)	-0.000176	6.59E-05	-2.664242	0.0195
GDP(-3)	0.000203	4.92E-05	4.117436	0.0012
CGDP(-1)	-0.001251	0.000252	-4.968231	0.0003
CGDP(-3)	-0.002752	0.000339	-8.110277	0.0000
BOT(-2)	-0.025065	0.007836	-3.198533	0.0070
CGFCF(-1)	0.000193	9.81E-05	1.971038	0.0704

R-squared	0.998097	Mean dependent var	291.6857
Adjusted R-squared	0.997073	S.D. dependent var	152.4960
S.E. of regression	8.250676	Akaike info criterion	7.340799
Sum squared resid	884.9575	Schwarz criterion	7.738712
Log likelihood	-69.07839	Hannan-Quinn criter.	7.427156
F-statistic	974.1878	Durbin-Watson stat	2.058199
Prob(F-statistic)	0.000000		

Out of the regression the lagged variables of GDP(-1), GDP(-2), GDP(-3), CGDP(-1), CGDP(-3), and BOT(-2) were significant.

Model 5.2 –

Based on the output, of model 5.1, ACINDEX was regressed with GDP(-1), GDP(-2), CGDP(-1), CGDP(-3) and BOT(-2).

Table 31 - Least Squares estimate for Model 5.1 (2nd Iteration)

Dependent Variable: ACINDEX
Method: Least Squares
Date: 06/12/14 Time: 16:52
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	60.17156	9.544545	6.304288	0.0000
GDP(-1)	0.000288	4.01E-05	7.199364	0.0000
GDP(-2)	-0.000178	7.24E-05	-2.464380	0.0273
GDP(-3)	0.000183	5.29E-05	3.453221	0.0039
CGDP(-1)	-0.001059	0.000255	-4.152937	0.0010
CGDP(-3)	-0.002327	0.000288	-8.079840	0.0000
BOT(-2)	-0.023864	0.008580	-2.781380	0.0147

R-squared	0.997529	Mean dependent var	291.6857
Adjusted R-squared	0.996470	S.D. dependent var	152.4960
S.E. of regression	9.060996	Akaike info criterion	7.507037
Sum squared resid	1149.423	Schwarz criterion	7.855211
Log likelihood	-71.82389	Hannan-Quinn criter.	7.582599
F-statistic	941.8227	Durbin-Watson stat	1.687742
Prob(F-statistic)	0.000000		

All the variables were significant in the regression.

Therefore the model was reconstructed as below.

$$ACINDEX = 60.17156 + 0.000288\ \text{GDP}(-1) - 0.000178\ \text{GDP}(-2) + 0.000183\ \text{GDP}(-3) - 0.001059\ \text{CGDP}(-1) - 0.002327\ \text{CGDP}(-3) - 0.023864\ \text{BOT}(-2)$$

Testing of Stationarity of the model residuals with Augmented Dickey-Fuller test

H_0 : Residuals are non-stationary (There is a unit root)

H_1 : Residuals are stationary (There is no unit root)

Table 32 - Augmented Dickey-Fuller test for model 5.2

Null Hypothesis: RESS has a unit root
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.983851	0.0004
Test critical values:	1% level	-2.685718	
	5% level	-1.959071	
	10% level	-1.607456	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESS)
Method: Least Squares
Date: 06/12/14 Time: 16:54
Sample (adjusted): 1994 2013
Included observations: 20 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESS(-1)	-0.882031	0.221402	-3.983851	0.0008

R-squared	0.452910	Mean dependent var	-0.628209
Adjusted R-squared	0.452910	S.D. dependent var	10.08396
S.E. of regression	7.458653	Akaike info criterion	6.905333
Sum squared resid	1056.999	Schwarz criterion	6.955120
Log likelihood	-68.05333	Hannan-Quinn criter.	6.915052
Durbin-Watson stat	2.058722		

P value < 0.05 we reject H_0

Since at 5% significance level, the p-value of the Augmented Dickey-Fuller test statistic (0.0004) is less than 0.05 we reject the null hypothesis. Therefore the residuals are stationary.

Serial Correlation – Correlogram of Residuals (Q statistics)

Date: 06/12/14 Time: 16:52
Sample: 1993 2013
Included observations: 21

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.116	0.116	0.3277	0.567
		2	0.022	0.009	0.3400	0.844
		3	-0.008	-0.012	0.3418	0.952
		4	-0.283	-0.285	2.6175	0.624
		5	-0.039	0.029	2.6623	0.752
		6	-0.034	-0.025	2.6986	0.846
		7	0.064	0.081	2.8379	0.900
		8	-0.009	-0.117	2.8407	0.944
		9	-0.285	-0.308	6.1038	0.729
		10	-0.105	-0.074	6.5852	0.764
		11	-0.215	-0.178	8.8252	0.638
		12	-0.098	-0.098	9.3369	0.674

Figure 13 - Correlogram of Residuals for model 5.2

H_0 : No serial correlation exists in residuals

H_1 : There exists serial correlation in residuals

As per the correlogram no spike could be observed lay beyond the confidence intervals. This was confirmed by the all the p values are greater than the significance level of 0.05. Hence, there is no serial correlation in the residuals of the model.

Breusch-Godfrey Serial Correlation LM Test

H_0 : No serial correlation exists in residuals

H_1 : There exists serial correlation in residuals

Table 33 - Breusch-Godfrey Serial Correlation LM Test for model 5.2

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.301211	Prob. F(2,12)	0.74[illegible]
Obs*R-squared	1.003845	Prob. Chi-Square(2)	0.6054

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 06/12/14 Time: 16:53

Sample: 1993 2013
Included observations: 21
Presample missing value lagged residuals set to zero.

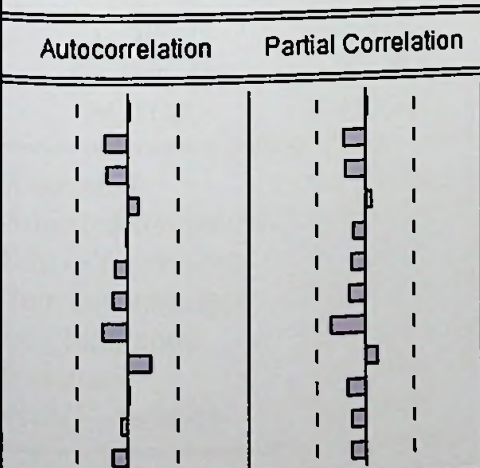
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.141107	10.06374	-0.014021	0.9890
GDP(-1)	-3.18E-05	5.99E-05	-0.531136	0.6050
GDP(-2)	4.21E-05	9.91E-05	0.424461	0.6787
GDP(-3)	6.02E-06	6.54E-05	0.092083	0.9282
CGDP(-1)	6.47E-05	0.000283	0.228398	0.8232
CGDP(-3)	-0.000230	0.000456	-0.504876	0.6228
BOT(-2)	0.001660	0.009399	0.176573	0.8628
RESID(-1)	0.419591	0.550101	0.762753	0.4603
RESID(-2)	-0.048538	0.540794	-0.089753	0.9300

R-squared	0.047802	Mean dependent var	1.44E-13
Adjusted R-squared	-0.586996	S.D. dependent var	7.580973
S.E. of regression	9.550211	Akaike info criterion	7.648531
Sum squared resid	1094.478	Schwarz criterion	8.096183
Log likelihood	-71.30957	Hannan-Quinn criter.	7.745683
F-statistic	0.075303	Durbin-Watson stat	2.067602
Prob(F-statistic)	0.999458		

Since at 5% significance level, the p-value of the Breusch-Godfrey Serial Correlation LM Test: statistic (0.7454) is greater than 0.05 we do not reject the null hypothesis. Therefore, there is no serial correlation among residuals.

Correlogram Squared Residuals

Date: 06/12/14 Time: 16:56
Sample: 1993 2013
Included observations: 21



	AC	PAC	Q-Stat	Prob
1	0.024	0.024	0.0141	0.905
2	-0.200	-0.201	1.0326	0.597
3	-0.180	-0.177	1.9017	0.593
4	0.091	0.059	2.1377	0.710
5	-0.022	-0.100	2.1524	0.828
6	-0.103	-0.115	2.4971	0.869
7	-0.136	-0.145	3.1371	0.872
8	-0.206	-0.314	4.7177	0.787
9	0.201	0.114	6.3418	0.705
10	0.017	-0.164	6.3547	0.785
11	-0.054	-0.126	6.4935	0.838
12	-0.120	-0.131	7.2685	0.839

Figure 14 - Correlogram Squared Residuals for model 5.2

As per the correlogram of squared residuals, no spike could be observed lay beyond the confidence intervals. This was confirmed by the all the p values are greater than the significance level of 0.05. Hence, there is no correlation among squared residuals of the model.

White's Heteroskedasticity

H_0 : No Heteroskedasticity exists in residuals

H_1 : There exists Heteroskedasticity in residuals

Table 34 - White's Heteroskedasticity test for model 5.2

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.097443	Prob. F(6,14)	0.4109
Obs*R-squared	6.717518	Prob. Chi-Square(6)	0.3478
Scaled explained SS	3.254095	Prob. Chi-Square(6)	0.7763

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 06/12/14 Time: 16:58
Sample: 1993 2013
Included observations: 21

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.104587	85.97946	0.059370	0.9535
GDP(-1)	0.000646	0.000361	1.790631	0.0950
GDP(-2)	-0.000678	0.000652	-1.038910	0.3165
GDP(-3)	-2.08E-05	0.000476	-0.043554	0.9659
CGDP(-1)	-0.001908	0.002296	-0.831054	0.4199
CGDP(-3)	0.001183	0.002595	0.455999	0.6554
BOT(-2)	-0.053505	0.077291	-0.692259	0.5001

R-squared	0.319882	Mean dependent var	54.73444
Adjusted R-squared	0.028403	S.D. dependent var	82.80799
S.E. of regression	81.62354	Akaike info criterion	11.90331
Sum squared resid	93273.62	Schwarz criterion	12.25149
Log likelihood	-117.9848	Hannan-Quinn criter.	11.97888
F-statistic	1.097443	Durbin-Watson stat	2.659743
Prob(F-statistic)	0.410888		

Since at 5% significance level, the p-value of the White's Heteroskedasticity Test (0.4109) is greater than 0.05 we do not reject the null hypothesis. Hence, there is no correlation among squared residuals of the model.

Normality Test (Jarque-Bera Test)

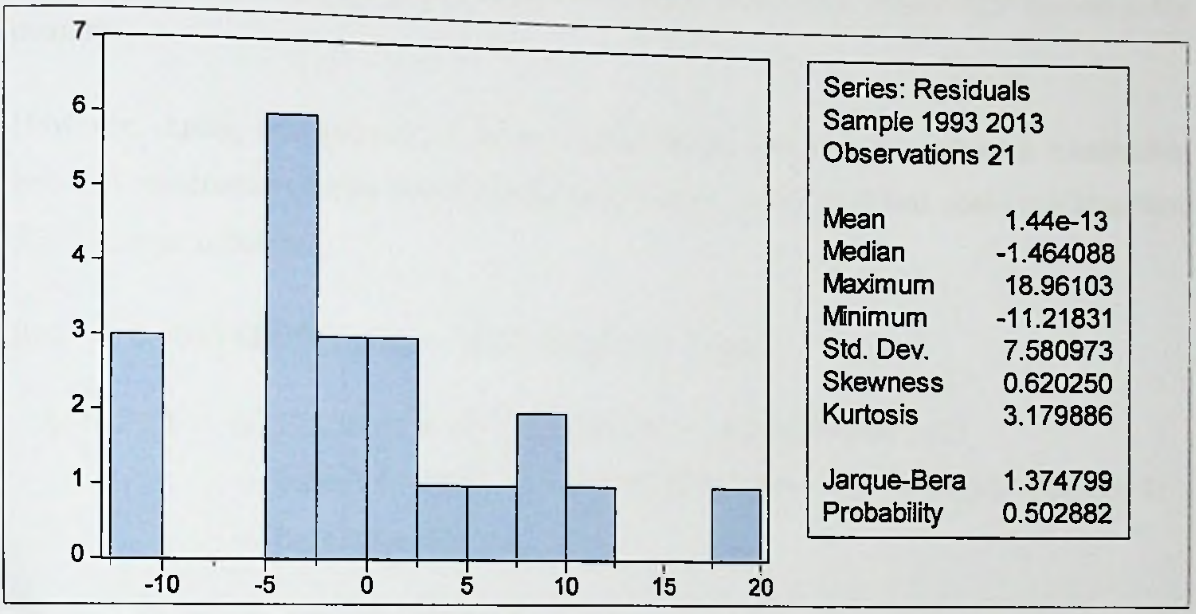


Figure 15 - Jarque-Bera test for model 5.2

Since at 5% significance level, the p-value of the Jarque-Bera Test (0.502882) is greater than 0.05 we do not reject the null hypothesis. Therefore, residuals are normal.

Chapter 5 - Conclusion

In general terms, the construction sector plays vital role in Sri Lankan economy and the entire industry sector has contributed positively towards the GDP growth year-on-year. Also it was noted the construction sector GDP growth was always higher than overall GDP growth in the country.

However, during our exercise to derive mathematical approach to express a relationship between construction sector output and national economic fiscals, It was noted two long term relationships as below.

$BOT = 0.005543\ GDP(-2) - 0.008140\ GDP(-3)$ and;

$$ACINDEX = 60.17156 + 0.000288\ GDP(-1) - 0.000178\ GDP(-2) + 0.000183\ GDP(-3) - 0.001059\ CGDP(-1) - 0.002327\ CGDP(-3) - 0.023864\ BOT(-2)$$

Therefore, it could be concluded that Balance of Trade (BOT) has a relationship between previous year Gross Domestic Products (GDP) and a year before. In another words last two year GDP figures have influenced this year BOT figures.

Further, it explains that all construction cost index (ACINDEX) has an impact from last three year GDP figures plus CGDP figures of last year and two years before plus BOT figures of two years before.

Therefore it is evident that an existence of a strong relationship between construction activity and economic growth in Sri Lanka. Further, this conclusion is par with the decision statements provided by the previous researchers through their studies.

5.1 Recommendation and further studies

In this study it was determined that there exists a long term relationship between BOT and ACINDEX using a VAR model for annual data since 1990 to 2013. Therefore it is recommended to use the fitted model in determining relationships among those variables.

However, no relationships were identified GDP, CGDP and for CGFCF using the methodology followed in this study. Therefore it is recommended to follow another methodology to determine such relationships between the said variables.

References

- Al-Omari, J. A. (1992) *Critique of aspects of development theory using construction industry in a capital-surplus developing economy as an exemplar*, PhD thesis, University of Reading.
- Ball, M. (1988) *Rebuilding construction: economic change and the British construction industry*. London :Routledge.
- Banwell, H. (1964) *The Placing and Management of Contracts for Building and Civil Engineering work*, A report of the Committee under the chairmanship of Sir Harold Banwell, HMSO, London
- Bent E. Sorensen (2005) *ECONOMICS 7395 Spring 2005* March 1 2005.
- Bon, R. 1992. *The future of international construction: Secular patterns of growth and decline.*Habitat International16 (3): 119–128.
- Bowley M. (1966) *The British Building Industry*, Cambridge University Press: London.
- Dlamini, S. (2011).*Relationship of construction sector to economic growth.*School of Construction Management and Engineering, University of Reading, UK.
- Drewer, S (1997) Construction and development: Further reflections on the work of Duccio Turin. *Proceedings of the First International Conference on Construction Industry Development*, Singapore 9-11 December.
- Edmonds, G. A. & Miles, D.W.J. (1984). Foundations for Change: *Aspect of the construction industry in developing countries*. ITG publications, UK.
- Edmonds, G. A., (1979) *The construction industry in developing countries*, International Labour Review, 118, 355-369
- Emmerson, Sir Harold (1962). *Survey of Problems Before the Construction Industries*, A report prepared for the Ministry of Works. HMSO, London.
- Fox, P.W. (1989) *A Study of the Hong Kong Construction Industry Using a Systems Approach*, Unpublished MSc Thesis, University of Salford.
- Great Britain, EDC for Building (1967). *Action on the Banwell Report, A report by a working party of the Economic Development Committee for Building*, NEDO, HMSO: London.
- Hassan, S.A. (2002). *Construction Industry. (Pakistan)*Published by Economic Review 2002.
- Higgin G. and Jessop N. K. (1963 and 1965) *Communications in the Building Industry*. London. Tavistock Publications.

- Hillebrandt P.M. and Meikle, J.L. (1985) *Resource planning for construction.*
- Hillebrandt P.M., (1974) *Economic Theory and The Construction Industry*, MacMillan Publishers Ltd.: London.
- Hillebrandt P.M., (1984), *Analysis of the British construction industry*, MacMillan Publishers Ltd.: London.
- Hillebrandt, P.M. (1985) *Economic Theory and The Construction Industry*, 2nd Edn. Macmillan, London.
- Jin, W., X. Lu, and Y. He. 2003. *A regression model of the growth path of construction industry.* Chinese Civil Engineering Journal36 (3): 105–109.
- Kim, K.H. (2004). *Housing and the Korean Economy,* Journal of Housing Economics, 13, 321-41.
- Miles, D. & Neale R.H., (1991) *Building for Tomorrow: International Experience in Construction Industry Development*, Geneva: International Labour Office.
- Napier, G. (1970) *A Systems Approach to the Swedish Building Industry*, Stockholm:National Swedish Institute for Building Research, Document No. D9:1970
- Ofori G. (1980) "*The Construction Industries of Developing Countries: the Applicability of Existing Theories and Strategies for their Improvement and Lessons for the Future - the Case of Ghana*", Ph.D. Thesis University College, London.
- Ofori, G. (1990). *The Construction Industry: Aspects of its Economics and Management.* Singapore: Singapore University Press.
- Ofori, G. (1993) *Research on construction industry development at the crossroads. Construction Management & Economics*, 11, 175-185.

  Ofori, G. (1994) *Practice of construction industry development at the crossroads.* Habitat International 18, 2, 41-56.
- Phillips Report (1950)*Report of a Working Party to the Minister of Works*, HMSO: London.
- Simon (1944) *The placing and management of building contracts: Report of the Central Council for Works and Buildings*, (Chairman: Lord Simon) HMSO: London.
- Strassmann P.W., (1970) *The Construction Sector In Economic Development.* Scottish Journal of Political Economy, Volume 17, Issue 3, pages 391–409, November 1970
- Tan, W. (2002). *Construction and economic development in selected LDCs: past, present and future.* Construction Management & Economics, 20, 593-632.
- Tassios, S. (1992) "*Structure & function of the construction industry with emphasis on developing countries,*" Distr. limited. Paper ID/WG.528/1. 8 September 1992.

Preparedfor meeting of UNIDO and UNCHS (Habitat), First Consultation on the Construction industry, Tunis, Tunisia, 3-7 May 1993.

- ThanujaRamachandra, James OlabodeBamideleRotimi and RaufdeenRameezdeen (2013): *Direction of the Causal Relationship between Construction and the National Economy of Sri Lanka.* Journal of Construction in Developing Countries, 18(2), 49–63, 2013
- ThanujaRamachandra, RaufdeenRameezdeen (2006). *Study of the relationship between construction sector and the Sri Lankan economy.*Built-Environment-Sri Lanka - Vol. 06, Issue 02: 2006
- The Tavistock Institute of Human Relations (1966) *Interdependence and Uncertainty: a Study of the Building Industry*, London: Tavistock Publications Ltd. [see Crichton, C.]
- Turin, D.A. (1969) Construction Industry, based on the *Proceedings of the International Symposium on Indusm'al Development* held in Athens in Nov-Dec 1967, New York, Monograph no. 2.
- Wang, K. and Zhou, Y. (2000).*Overbuilding: A Game-theoretic Approach.* Real Estate Economics, 28, 493-522.
- Wells, J. (1985). *The Role of Construction in Economic Growth and Development,* Habitat international, *9*(1), 55-70.
- Wells, J. (1986). *The Construction Industry in Developing Countries: Alternative Strategies for Development,*Croom Helm Ltd, London.
- Wood (1975) *The Public Client and the Construction Industries* (Chairman: Sir Kenneth Wood), Great Britain, EDCs for Building and Civil Engineering, London: NEDO, HMSO.
- World Bank, *The Construction Industry: Issues and Strategies in Developing Countries,* International Bank for Reconstruction and Development, The World Bank, Washington DC, 1984.

Appendix

Period	GDP (Current) (Rs. Mn)	CGDP (Current) (Rs. Mn)	BOT (Rs. Mn)	CGFCF (Rs. Mn)	ACINDEX
1990	321784	21541	-702.50	35239	100.00
1991	372345	24535	-997.10	38270	110.40
1992	425283	28485	-1044.60	48005	118.63
1993	499565	32615	-1147.60	59223	127.43
1994	579084	38323	-1558.70	69297	137.58
1995	667772	44455	-1504.50	78385	147.08
1996	768128	48234	-1343.70	85977	153.45
1997	890272	56434	-1224.80	99389	159.18
1998	1017986	69301	-1091.70	116357	165.93
1999	1105963	75538	-1369.20	127569	167.75
2000	1257636	82684	-1797.50	140784	175.50
2001	1407398	95057	-1157.50	161851	196.23
2002	1581885	100404	-1406.60	179463	208.60
2003	1822468	110111	-1538.60	197074	220.58
2004	2090841	127692	-2242.60	263096	245.15
2005	2452782	167999	-2516.50	329611	290.63
2006	2938680	216833	-3370.30	419662	343.60
2007	3578688	264104	-3656.50	537633	387.63
2008	4410682	327138	-5980.60	705374	444.78
2009	4835293	366248	-3122.10	802445	456.25
2010	5604104	423414	-4825.10	996190	465.93
2011	6543313	511220	-9710.00	1118634	490.90
2012	7578554	712272	-9416.70	1400370	550.85
2013	8673870	894683	-7607.70	1631404	590.43