

THE IMPACT OF HEALTH ON ECONOMIC GROWTH: THE
CASE OF TONGA FROM 1970-2011

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*This thesis is dedicated to Melenaite Laukau,
Sela Theodora Hadassah and my late father
Tevita Kavapalu.*

Abstract

The vast impact of globalization has resulted in more liberalization, economic integration, and increasing international trade among countries. These changes are leading to higher economic growth and consequent impacts on the health conditions of the country. Health can be regarded as an addition to economic growth models. There has been a widespread development in the health economics discipline. However, the research on the impact of health on economic growth has been concentrated mostly in developed and developing economies, but there has been marked neglect of small open economies. This study aims to focus on the Island Kingdom of Tonga – a small open economy and a country that falls within the upper middle income category (World Bank, 2012). The study seeks to verify empirically the impact of health on the economic performance of the country. The analysis is based on time series data, the econometric techniques of single, autoregressive distributed lag model (*ARDL*) and the multiple equations framework, vector error correction method (*VECM*).

The study found that there have been substantial impacts of health indicators (life expectancy, infant mortality and fertility rate) on the Tongan economy. A positive effect in terms of life expectancy on economic growth led to an improvement of economic activity through additional years of longevity of the working age population. The dynamic, innovative technique also indicated a uni-directional causality between economic growth and life expectancy variable. The long run causality however, runs mainly from life expectancy to economic growth rather than in the opposite direction. A negative impact was found in the second health indicator (infant mortality) with uni-directional causality running from higher economic growth that may reduce the infant mortality rate. Finally, the fertility rate found a negative impact on economic growth in the long run with no Granger causality among the variables.

Amongst those frameworks, the *ARDL* and *VECM* suggest that in such a small developing country the quantitative impacts are also a novel and important approach in Tonga and may result in a significant impact on the economy for the next decade. The policy implication is that maintaining good health through higher life expectancy is associated with a positive impact on economic growth and this can also channel to other innovations, technological contributions to the country at large.

Acknowledgement

It is my great pleasure and honor to acknowledge the financial assistance, academic support and moral encouragement offered during the production of this dissertation by many individuals, organizations in New Zealand and abroad. I would like to express my sincere gratitude to the New Zealand Development Scholarship for providing financial support to complete this higher level of education. Realizing that words are not enough to express my feeling, but the efforts have made this study feasible during this hard time.

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Last but not least, I would like to express my gratitude to everyone who are impossible to acknowledge by name, but I would ask those whose names do not appear on this page to accept my sincere thanks for whatever role they played, which make the completion of this study. Let me carry the flag of victory, but by the GRACE OF GOD I AM WHAT I AM.

'Ofa moe Hufaki

SDRK

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CHAPTER ONE

OVERVIEW OF THE STUDY

Improving the health and longevity of the poor is an end in itself, a fundamental goal of economic development. But it is also a *means* to achieving the other development goals relating to poverty reduction. The linkages of health to poverty reduction and to long-term economic growth are powerful, much stronger than is generally understood. The burden of disease in some low income regions, especially sub-Saharan Africa, stands as a stark barrier to economic growth and therefore must be addressed frontally and centrally in any comprehensive development strategy. (WHO's Commission on Macroeconomics and Health, 2001)

1.1 Introduction

The economic prosperity of a country can also be considered a health-related issue of nations. Health is a crucial determinant of growth and therefore is related to economics and sound social development. Illness brings suffering and healthier lives are likely to be longer and more fulfilling. These facts alone provide a rationale for development work that improves peoples' health and brings broader benefits to enhance economic growth and social development. Human capital is a key component pillar of economic growth and indispensable for productive populations and the economy as a whole. The Second Millennium Development Goal and Tonga Strategic Development Framework 2011-2014 clearly mentioned the importance of health and education as crucial factors to promote economic prosperity of the country. The examples of such goals are as follows: (a) improved health of the people by promoting healthy lifestyle choice with particular focus on addressing non-communicable diseases, and providing quality, effective and sustainable health services; (b) sound education standards by emphasizing quality universal basic education (Ministry of Finance and National Planning [MFNP], 2010& 2011). International organizations have an interest in this area because they have found there is a robust relationship under these two components. World Health Organization (WHO), the United Nation Development Program (UNDP) and World Bank are strongly supporting these initiatives through various channels to combat and mitigate these economic and social challenges in order to achieve sustainable economic growth (WHO, Joint, & Consultation, FAO Expert, 2003; WHO Regional Office for the Western Pacific, 2006).

There are many health indicators used by researchers of the subject to account for the long run relationship between health and economic growth. Further, they also used a number of proxies to investigate empirically the connection among the parameters. The examples of such proxies are as follows: the life expectancy, mortality rate, fertility rate, health expenditure, health expenditure as a share of gross domestic product, number of hospital beds per 10000, number of physicians per 10000, the average height of adult men, cognitive functioning, the adult survival rate for men, age of menarche (onset of menstruation) for women. After considering all the various health indicator proxies, this research use life expectancy as the principle basis of the study. Additionally, the study also considers the infant mortality rate and fertility rate to establish whether they have a significant impact on economic growth.

This thesis also explores the relationship between health and economic growth for Tonga over a forty years' time span (1970- 2011) and examines whether there is any correlation empirically of the data or not. The study also aims implicitly and explicitly to handle some challenges in dealing with the subject. The study poses some major issues of concern to deal with in this study: What is economic growth? What is meant by economic development? What is the theory behind economic growth? What is meant by good health? How is health spending financed? What is the role of government in relation to health issues? What is the social impact of diseases on the population and economic growth? What is the implication of health indicators of economic growth. Hence, this thesis will examine these subjects which have gained attention of many health economics researchers and details further in the next following chapter what this study means for the literature.

1.2 Motivation of the study

The interest on the subject matter has built up after undertaking the Health Economics course and Time Series, Panel Data Analysis Courses at the University of Canterbury. The motivation grew up during a discussion with Dr Kuntal Das, Lecturer at Economics and Finance Department, University of Canterbury in the past two years about the general research ideas. Further, interest arose started when it was found lately there are few researchers in this field, especially in small Pacific Island Countries (PICs) who specialized in this area. Some important issues are necessary in the context of the PICs region's health context: Population is exponentially growing

relative to the size of land (resources), health related issues are more challenging because of the poor data management in health sectors and this results in problems faced by various international organizations or donors who bring assistance for Health Ministries. This case is applicable in Tonga, there is no unified single database for the Ministry of Health (Personal communication. Na'ati. E. May, 2013).

Although there are many researchers contributing to the subject from developed countries, in developing PICs there is limited research done on the health - growth relationship. Furthermore, there are large health databases available for OECD and developed countries but unfortunately - the case of the PICs is very different. This study will be enabled by collecting relevant health related datasets such as life expectancy, infant mortality rate, education and fertility rate in Tonga for more than forty years and shed light on the impact of health on economic growth. Not only this, does this research provides an empirical account on the implication of health on economic activities, but it also considers the effect of education on growth. It is important to nourish well our stock of working age population with good health and it is important to equip the population with universal quality education.

1.3 Aims and the objectives of the study

This study has two main objectives: first, to establish an econometric framework that characterizes the long run and short run relationship among the variables and second, to provide some in-depth insight on the implications of the theoretical underpinnings on the current study and development.

The specific objectives of the study are:

- To study the trends and pattern of health status and economic growth within the duration of the study.
- To identify the dominant factors influencing health and economic growth
- To assess the overall impact of health status on economic productivity and vice versa
- To recommend some health policy frameworks based on the findings

1.4 Importance of the study

The study has important contributions to the current literature in exploring how intense the implication of health related issues to the economic growth of Tonga. The title of the thesis, which empowered by the interest of the researcher in examining the current health situations are in somewhat statistically correlated with Tonga's economic performances. The author has sought to identify the crucial implications and how it affects economic growth both in the short and long term. There are relevant studies on this issue, but studies in the context of Tonga are quite rare. The significance of the inquiry is connected and related to a number of factors and this was based on the author's experience/motivation and statistical information provided by most prominent international organizations: World Health Organization (WHO), International Monetary Fund (IMF) and World Bank. Local sources are also paramount in this context, such as Tongan Ministry of Health various Annual Reports and health related discussion series. The primary obligation of the researcher in this stance to operationalize in what ways/ how health variable(s) explain their implication for the country's economic activities. Qualitative analysis on the impact of health related issues is indispensable in this context, such as Kupu and Wikinson (1999); Foliaki, Hausia, Koloto and Veikune (2013); Colagiuri, Colagiuri, Na'ati, Muimuiheata, Hussain and Palu (2002). Moreover, Kupu and Wilkinson (1999) also focus on diabetic foot infection, specifically on lower limb amputation from 1992- 1996. The analysis found that the management of the complication is an enormous challenge for the PICs. Similarly, a recent survey by Foliaki et al (2013) was based on the whole group of Tonga (Niuas, Vava'u, Ha'apai, 'Eua and Tongatapu) to assess how vulnerable the population of Tonga for Diabetes in the era of rapid economic development. The qualitative analysis also reveals there are more likely for the population of Tongatapu to have diabetes than the rest of the other islands. The reason behind those studies reflected there is a crucial linkage between economic growth, development and health status of the country.

Some sources such as respective government ministry annual reports have examined the current status of Tonga economic activities, but not empirically identify the economic relationship of health and economic growth. This thesis aims to revisit those challenges and highlight their current situation.

As such, the major significance of this thesis rest in the deep understanding and perception of the researcher based on the country health indicators such as the total fertility rate, infant mortality rate, life expectancy and the like (MOH, 2008, 2009, 2010). This has enabled the author to take an in-depth examination whether there is any statistical relationship between health and economic activities. It is of great significance that this study will be able to merge previous studies and the results of this finding and convey the findings first-hand to the respective government ministry as well as provide the government with positive policy recommendations for further action. It is envisaged that the outcomes of this thesis have the capacity to make a coherent impact on the current policy framework in the quest for improving the status of current economic activity via health related issues with the aim of improving socio-economic development in the Kingdom of Tonga.

The thesis is significant in two main ways. First, it reveals the long run and short run determinant of different health components associated with the economy. Second, it helps policy makers understand and undertake various policy exercises and it also contributes to further studies related to this area of research focus in Tonga.

1.5 Limitations of the Study

Within the Ministry of Health (MOH,) which this study utilizes for most of the time for data collection there are some technical challenges confronted in terms of data management of information dissemination. Some relevant and specific parameters that were expected to be included in the study were not available. This was due to lack of human resources in terms of data analysis personnel, low standard of data compilation and, poor data collection systems. There is no single built- in database for the MOH for data entry. Therefore, a single respective department has collected their own statistical information (Naati. E¹. and Puloka, S². personal communication May 19 , 2013) These challenges were previously witnessed by Kupu (1999) and Finau (1983). In addition, the insufficient data availability of health makes it more difficult in studying how health indicators explain the movement in current economics performances. However, these are

¹ Senior Dietitian at Tonga Ministry of Health.

² Senior Health Administrator at Tonga Ministry of Health

the areas that require further investigation in order to highlight their role in the context of economic growth. Similarly, the human resources development in Tonga and the need to investigate the relationship between high literacy level (skilled workforce) and health are also a significant area and they are seen necessary worthy of further investigation in connection with the economic growth / development. Another the limitation of the study relates to the difficulty of how much it is possible to generalize the results to other small Pacific Island Countries and elsewhere in our region. Finally, the limitation is recognized, but the intention of the thesis is to focus on the primary barriers noted above.

1.6 Outline of the thesis

The overall intention of the study is to investigate the impact of health on economic growth in the context of a small open developed country by focussing on Tonga. The foremost issue is identified from the statement: to investigate the impact of health on economic growth and other macroeconomic variables, and to identify the co-movement of the proposed variables in a small developed country. On the basis of these issues, therefore, the thesis is presented in six chapters. After this preamble, Chapter Two reviews the socio-political and health related background in the Kingdom of Tonga. Chapter Three provides the methodological procedure used to answer the problem statement by incorporating the interrelationship among the proposed variables. It focusses on the dynamic relationship between the proposed variables and the time series properties of the data before the models are specified. Chapter Four deals with the issues of health and the-ory of economic growth and development in the Pacific specifically in the field of Health Economics.

Chapter Five is designed to demonstrate the empirical results that have been estimated with the multivariate methodology developed in Chapter Four. This multivariate framework highlights the interrelation among variables and furnishes additional insights on the role of health in a small open economy like Tonga. Based on the empirical evidence, the final chapter concludes with final recommendations for future proposals.

CHAPTER TWO

Health in the Kingdom of Tonga

“Healthy citizens are the greatest asset any country can have.”
(Winston Churchill)

2.1 Introduction

The direction that Churchill suggests above follows in this chapter specifically on health as an essential fuel of economic development. Without good health, all things work in a mess, utterly disordered fashion with inefficiency and thereby leads to poor economic development. Health is connected in a systematic fashion with other socio-economic factors such as better education, higher nutrition, more research and development, advanced formal. For that reason, the linkage amongst better health and other social economic axioms are strong and this is held true in the case of Tonga.

This chapter is divided into nine sections. The first section covers the background of Tonga ranging from geography to the political transition background in order to set a clear context about the related issues associated with the health situation in the Kingdom. This naturally leads to economic growth and development, health in the country, health expenditure, health spending allocated to non-communicable diseases, issues related to Tonga Ministry of Health (MOH), health system and facilities at MOH, global trends in health issues and conclusion in the last section.

2.2 The Kingdom of Tonga – Background

2.2.1 Geography

The Island Kingdom of Tonga is located in the midst of the central South Pacific. It lies between 15° and 23° 30' south of the equator and 173° and 177° west of the Greenwich. Tonga is about 1,700 kilometers northeast of New Zealand and about 700 kilometers southeast of the Republic

of Fiji (see Figure 2.1).

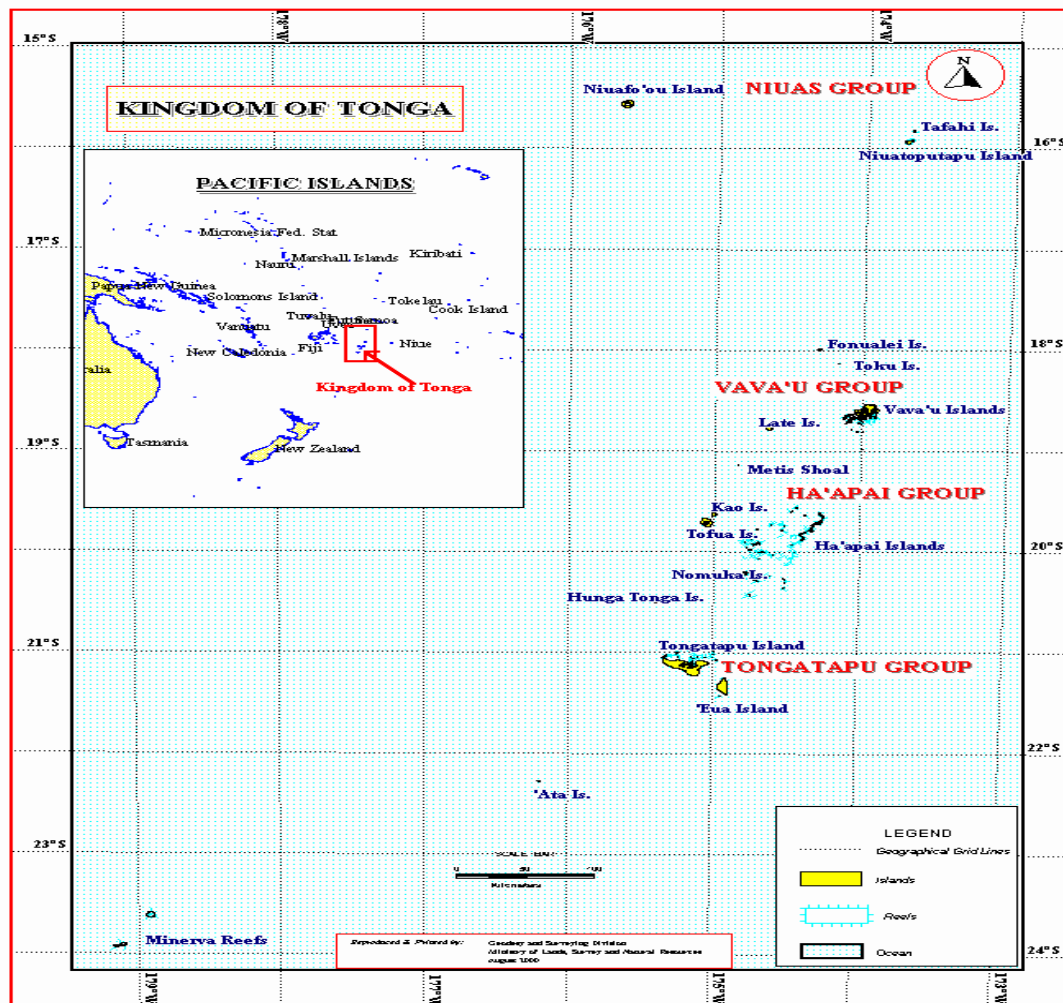


Figure 2.1: Location map of the Kingdom of Tonga

Source: Geodesy & Surveying Section [Ministry of Lands, Survey & Natural Resources], TONGA

The whole group of Tonga is comprised of 172 scattered islands, of which some parts are coral and some are volcanic in origin. Amongst the 172 islands, only 36 are inhabited. These islands are scattered over a sea area of 720,000 square kilometers and this is a major challenge of health

service delivery in the country (Crocombe and USP, 2001 & Foliaki, 2007).

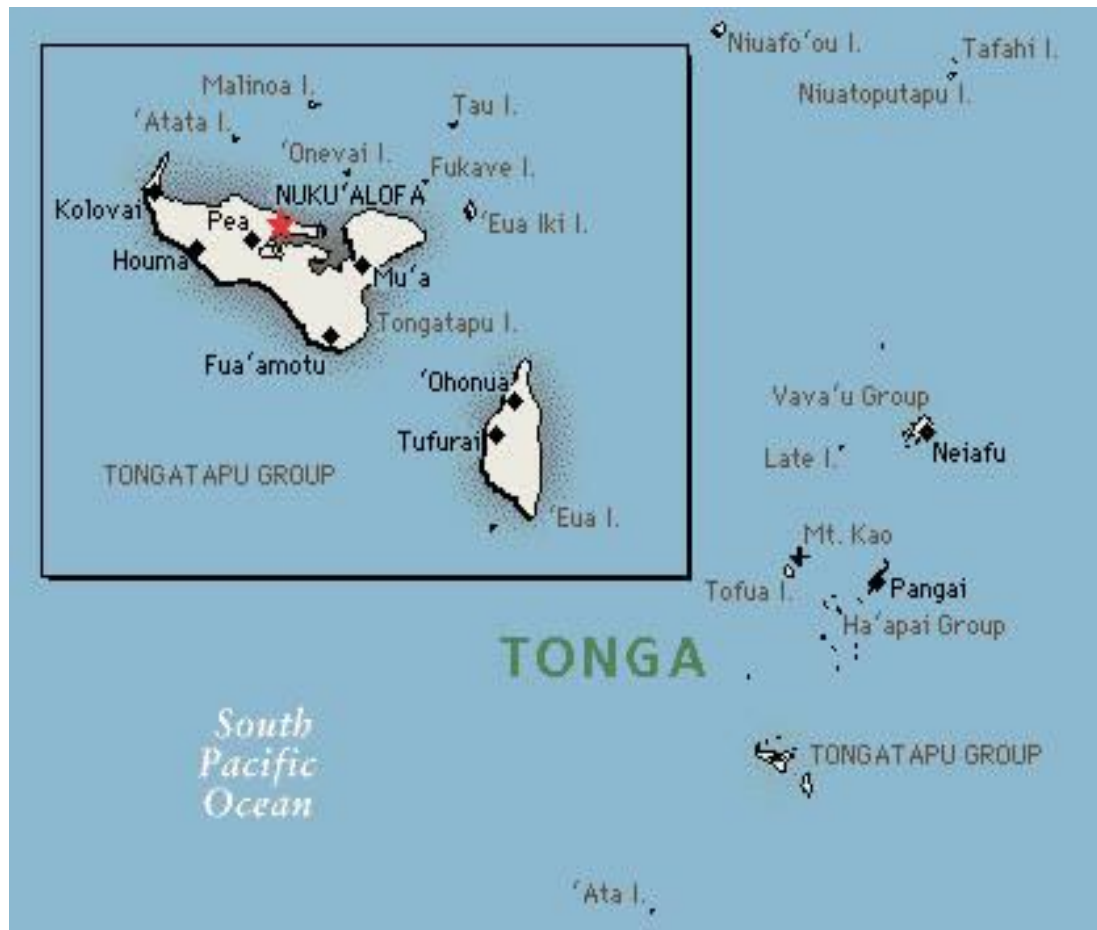


Figure 2.2: Map of Tonga

Source of data: Ministry of Lands, Survey & Natural Resources. (2000).

The geographical location of Tonga has an economic and social impact on its neighboring countries in terms of immigration, trade and other socioeconomic development. Tongatapu is the mainland in which the capital of Nuku'alofa is located, the center of most government administrations, non-government organizations and services infrastructure (see Figure 2.2). It is the most important, commercial, transport and social hub of the Kingdom and thus, all significant government buildings and office headquarters are located at Nuku'alofa³.

³ The Government of Tonga is the major provider of health services in the country through a network of 4 hospitals, 14 health centres and 34 registered health clinics, the main hospital located close to Nuku'alofa and various clinics (MOH, 2008).

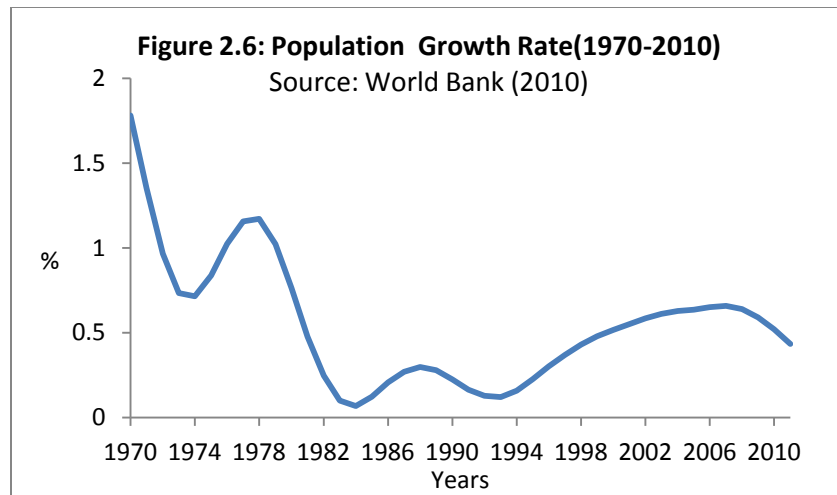
2.2.2 Demographic Status

The population distribution as indicated in the preliminary result of the 2011 Census reveals that close to three quarters (72.9%) of the total enumerated population of 103,036 resides in the mainland of Tongatapu, about 14.4 per cent in Vava'u, Ha'apai (6.4%), 'Eua (4.8%) and the two remotest islands of Niuafu'ou and Niuatoputapu (1.2%) (TDoS, 2012). Tongatapu has consistently experienced positive population growth over the last three decades of intercensus periods 1986/96, 1996/2006 and 2006/11 compared to other islands. This indicates that searching for a better life via rural-urban migration remains important in Tonga diasporas because of the infrastructural, socioeconomic and health services disparities. The annual growth rate of the population in 1986/1996 was 0.3 percent compared to a small increment of 0.4 per cent in 1996/2006. This slow pace has resulted from the rate of emigration between 1986-1987 and diminishing of total fertility rate. (see Figure 2.5).

As discussed by Funaki (1993:126) a significant decline in Tonga's population growth rate is largely explained by the high level of emigration, especially in the working age population in search for employment and economic prosperity. This process is still persisting toward the traditional land of immigrants⁴. Figure 2.6 shows the percentage change in population growth rate between 1970 and 2010. The rate of emigration in those years is very high and truly had socioeconomic implications for the Tongan economy in terms of remittances (Brown, 1995). Connell and Brown (2004) studied the remittances of migrant Tonga and Samoan nurses from Australia and found there is a significant higher proportion of nurse household sent remittances home with a certain agenda⁵. The effect of migration in such a low economic growth country like the case in Tonga lead to higher outward migration and higher remittances and thereby induce better living standard and domestic growth in remittances-receiving economy (Barajas et al., 2009: 9)

⁴ A recent study by Esau (2005) explored three experiences of Tongan immigrants in New Zealand: the migration decision making process, socio-economic changes in the host country, and transnational networks with Tonga. With respect to migration decision, the nuclear family plays an important role as the final decision making unit. Family decision related reasons such as jobs, education were the typical reason of migration to New Zealand. Regarding the socio economic changes, the immigrants income tends to increase as their duration of stay in New Zealand lengthen. Most of the immigrants work at blue collar jobs. Many of the immigrants who were unmarried at time of migration and later married to Tongans. Church also serves a critical support system for the immigrants.

⁵ For example, Valero (2008:21) indicate that health expenditure is a target of remittances.



2.2.3 Health Indicators: Mortality Rate/Life Expectancy and Fertility Rate

Traditionally, infant mortality rates (IMR) are often taken as a reasonable indicator of the standard of living in a country. More specifically, however, it is one of the measures of the overall effectiveness of the health services and other developments in the health sector. Prior to European contact death in a specific age was very common. Based on an investigation by archaeologists, early writings and legends have found that there is a burial place at ‘Atele, about seven kilometers to the east of Nuku’alofa the main capital. The evidence revealed that death was very common under five years of age and about half of the children died before they reached that age, that there was very rarely teenage death and few people reached 40 years of age. The population in that era was estimated to be 30,000 in 1600 with 18,000 in Tongatapu. There were no specific policies to control population in that time (Kupu, 1999 & Finau, 1983). During the Pre-European contact, different civil wars occurred and also there was a recorded virulent epidemic of measles that wiped out nearly 1,000 people, which was about 5% of the total population of Tonga in 1893 (Campbell, 1992; Puloka, 1983 & Green, 1973). Also following the influenza epidemic in 1919 there was a high peak in mortality (Bakker, 1979). As a result, the factors explain why the population had just picked up in the mid twentieth century and witnessed by the population census of 1956. Prior to the census of 1956 there were multi extensive milestone undertaken within the Health Sector. The most notable contributions were made in terms of highly trained, skilled medical practitioners trained in Fiji and the establishment of the Queen Salote School of Nursing in 1953. The results of the new milestones and development for the Health Sector there were declining death rates of 1950s even though there were some annual fluctuations. The general

trend shown was a decline from 10.64 deaths per 1,000 in 1950 to 5.4 in 1959. Periodical epidemics recurred because of the inadequate preventative measures, but overall it shows a general decline in severity (Campbell, 1992).

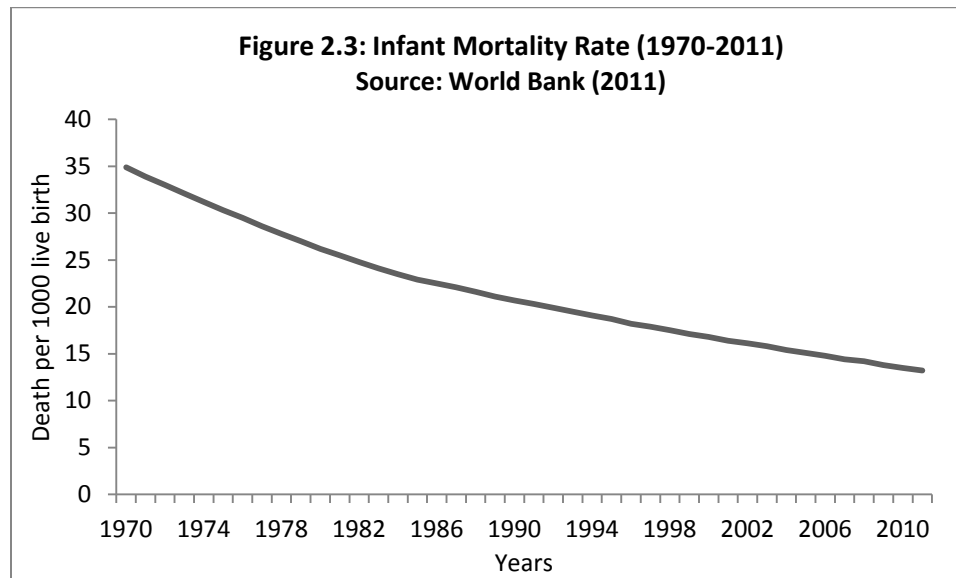


Figure 2.3 illustrates the exponential decline in infant mortality since 1970 and this is attributed to high immunization and vaccination coverage against diseases such as polio in the last three decades, women immunized with tetanus toxoid, the high percentage of pregnant women attending antenatal care and increased percentage of deliveries conducted by trained personnel. More public awareness programs for child care had helped to reduce infant mortality rate (ADB, 2013:31). Figure 2.3 shows the trend in infant mortality rate from 1970- 2010.

Moreover, in comparison to other Pacific Island countries, there are several factors suggested as causes of past mortality decline. These factors include economic development, technological advance in the health sector, social development, especially in education, environmental and nutritional improvements (Taylor, Lewis & Sladden, 1991). The significance of these factors varies in different situations, but they are involved to some extent in health and demographic transition.

According to a recent approach by Taylor et al (2005) from the perspective of the Pacific Island mortality indicates that there is a substantial uncertainty about mortality conditions in the Pacific

Island population⁶. The principal issues with regard to uncertainty around mortality levels include under-enumerated vital registration data; annual stochastic fluctuations in mortality in small populations; errors in the imputation of adult mortality from infant and childhood rates; implausible results from indirect demographic methods; use of possibly inappropriate model life tables to adjust death data or for indirect methods; and inadequately described and implausible projections. They also finally recommend urgent need to improve infrastructure, further training and resources for routine mortality estimation in many PICs in order to better inform and evaluate health and public policy recommendations (Kupu, 1999).

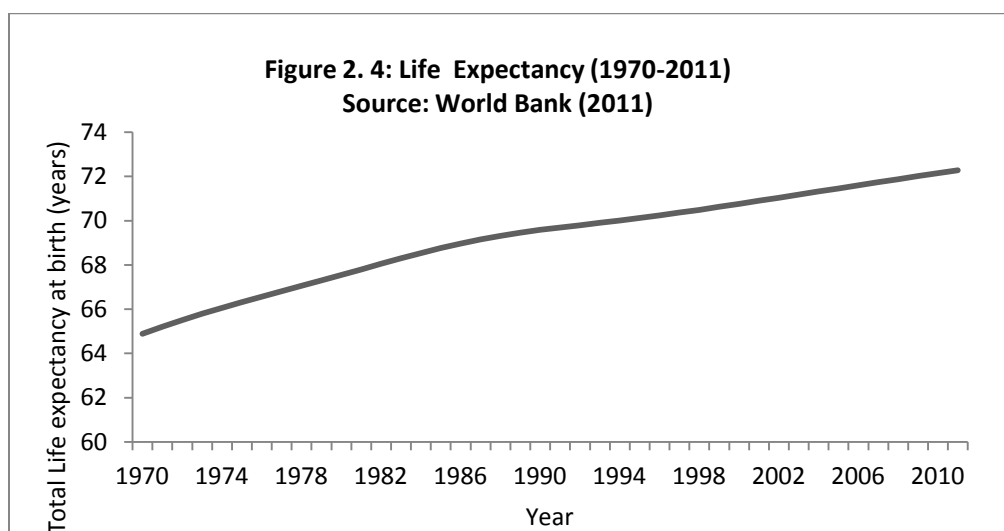
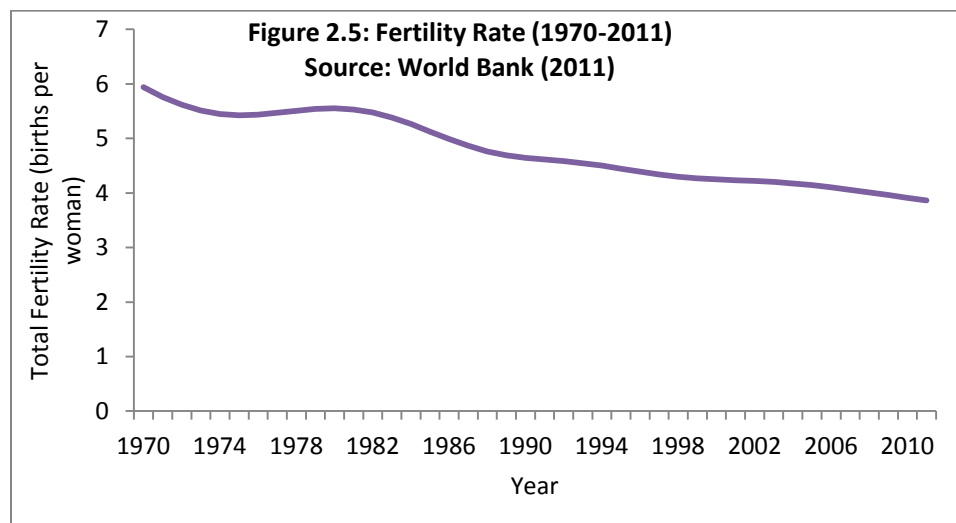


Figure 2.4 shows the aggregate life expectancy from 1970 to 2011. There was a significant improvement in the trend of the life expectancy since 1970. Further improvements in life expectancy are likely to be limited by the increasing prevalence of early onset non-communicable diseases, especially cancer, diabetes, high blood pressure and heart diseases. These conditions are associated with lifestyle risk factors, including the consumption of food that are high in fat, sugar, salt, excessive alcohol consumption and cigarette smoking (UNICEF, 2006; Tutone, V,

⁶ The mortality rate around the Pacific region is not constant. According to United Nations International Children's Fund (UNICEF) statistics in Fiji, the Neonatal Mortality Rate (NMR) accounts for 50% of the under-5 years old deaths (U5MR), and 60% of the Infant Mortality Rate (IMR) of children. Kiribati has corresponding figures on NMR accounting for 41% and 51% of U5MR and IMR respectively. In the Solomon Islands the figures are 42% NMR and 50% of U5MR, and IMR respectively. Vanuatu recorded the figures are 50% of NMR and 57% of U5MR, and IMR respectively. In Tonga's case, according to the 2010 Annual Report of Tonga's Ministry of Health, it provides a Paediatric Service to children from age 0-14, a total of 38,831 or 38% of Tonga's total population of over hundred and three thousands (Matangi Tonga, 2013).

personal communication, April 7, 2013; Fakahau, T, personal communication October 14, 2013).

During the last two decades author had witnessed a remarkable decline in fertility rate (number of births per 1000 women of reproductive age) not only seen in Figure 2.5 but also in the industrialized world. It seems beyond a doubt that the enormous social adjustments of our societies played a major role in this decline, but it cannot be attributed to changing social structures alone (Jensen et al., 2004 & 2002). Joffe (1996) argued that maternal smoking as one of the contributing factors for lower fertility rate. That reason is more likely to occur in our society. Ideally, this condition is related to social behavior and lifestyle risk factors: drugs consumption, smoking habits and unwise alcohol consumption. Further, one of the crucial ideas depicted in Figure 2.5, Taufa (2003) & UNICEF (2006) have argued that emigration has contributed to its reduction, thereby emigration reduces the population of reproductive age in Tonga. On the other hand, parents see children as their main support in old age. The existence of opportunities to emigrate can sustain larger families in the home country. The mentality of Tongans in Tonga even Tongans Overseas⁷ is that having more children increases the likelihood of earning remittances (McMurray, 2003; Fakahau, T, personal communication October 14, 2013; Hoponoa, T. personal communication May 15, 2013).



⁷ The majority of Tongan emigrants are mainly concentrated in three Pacific rim countries known as “traditional land of immigration”: New Zealand, Australia and United States of America (USA); for example see Liava’a (2007).

2.2.4 Political Transition

The transition to form a more democratic system is one of the major influential public interest and important in socio-political discussion since 1980s. The Pro-democracy movement was well supported by members of the public service association in the last decade, demanding a reduction in the substantial authority of the King and the cabinet. This attempt was in a peaceful manner until when the legislative assembly of Tonga was due to adjourn for the year and despite promises of action had done little to advance democracy then arrived to some stage. The government rejected the proposal to increase peoples' representation in the parliament and this led to industrial disputes and riots in 2006. In a chapter of a recent book by Moala (2008) articulates his belief that the riots were a product of how the "Oppressor", failed to sustain a non-violent demonstration and therefore stripped away the people's rights to safe and free expression. Taufe'ulungaki (2007) presented a confidential report from the University of the South Pacific that blamed that both sides (the government and the opposition party: Pro-Democracy Movement and its followers). The Opposition, it was claimed were also guilty of mishandling the democratic demand of the people and further implicated vulnerable population viz youth and deported youth from overseas- which also played a major role in the violence. Later on, the IMF assessed and estimated the impact of this riot financially and stated that the total losses in structures and inventories ranged from 10-25 percent of GDP. This has an adverse impact on the economy, especially in the level of investor confidence and dampening growth (Kumar and Prasad, 2002). Table 2.1 shows the chronology of recent development since 2005.

Table 2.1: Chronology of Recent Developments	
2005 March	Elected MPs enter the cabinet for the first time. Cabinet members had previously been picked by the King.
2005 July-September	Prolonged strike by public sector workers, with violence in the capital. Agreement with unions on a 60, 70 and 80 per cent civil service wage increase.

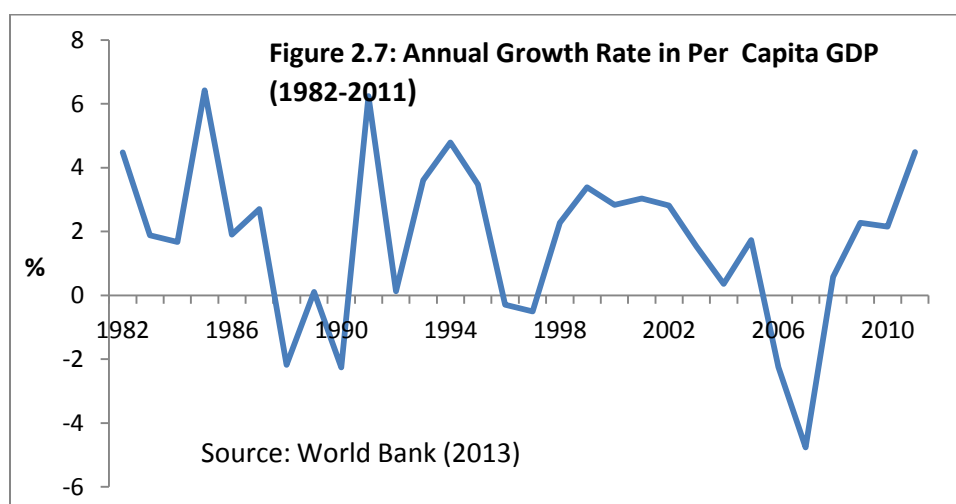
2005 December	World Trade Organization (WTO) agrees to admit Tonga as its 150th member. Negotiations had been ongoing for a decade. Next step: ratification.
2006 March	Fred Sevele becomes PM, the first elected commoner to do so.
2006 June-July	Government's retrenchment program is implemented-about 20 percent of civil servants take a voluntary severance package.
2006 September	King Tupou IV dies, and is succeeded by the Crown Prince.
2006 November	Rioting erupts in the capital Nuku'alofa, in protest at the slow speed of democratic reforms.
2008 August	Coronation of Tupou V
2012 March	King Tupou V died and succeeded by his brother Tupou VI
Source: IMF Country Report, 2007.	

Tonga's government is based on a hereditary constitutional monarchy. The reformed constitution was agreed by the Legislative Assembly in December 2009 and implemented via legislation passed in April 2010. This new constitution considerably abridged the King's authority which was devolved to the Executive (or Cabinet). The Cabinet now answers to the Legislative Assembly. Nevertheless, the King retains the right to veto legislation. Under the new arrangements the Legislative Assembly comprises seventeen people's representatives (PRs), nine noble representatives elected from among the holders of Tonga's thirty three noble titles and up to four other members appointed by the King under the advice of the Prime Minister. The King appoints the Prime Minister on the recommendation of the Legislative Assembly. Tonga's first election under this new regime took place on 25 November 2010 and it was won by Lord Tu'ivakano who was

elected as Prime Minister (Australia, Department of Foreign Affairs and Trade, 2013 & Foliaki, 2007).

2.3 Economic growth and development

Tonga's economy has been prone to various external and internal shocks and is still evident during the last decade. The economic growth was estimated by the Ministry of Finance to have fallen further from a contraction of 0.4 per cent in 2008/09 to a contraction of 1.2 per cent in 2009/10. This is the second consecutive year of negative growth experienced by the economy reflecting the impact of the financial crisis through the fall in remittances from overseas, the decline in tourist receipts, stagnation of exports, the banks' tight lending condition and the impact of Ashika tragedy, the tsunami and tropical cyclone which hit Tonga in September 2009 and February 2010 causing loss of life and severe structural damage. The combination of these developments and the inability of the government to accommodate fiscal stimulus together with the monetary policy easing being muted by tighter credit conditions and the high level of non-performing loans all contributed to suppressing demand and weak economic activity in the Kingdom (NRBT 2011, 'Utoikamanu, 2010). Figure 2.7 shows the Annual growth rate in per capita GDP over twenty years.



Agricultural output continued to remain subdued in 2009/10 as a result of a decline in the export of squash. The adverse impact of climate change such as drought and cyclone Rene has contributed to the decline of primary production in 2009/10. The export of other marine products has

undergone a similar downward trend, this reflected high fuel costs, high operating costs, depletion of fish stocks and thus fishermen turning their focus to harvesting sea cucumber. The entrance of sea cucumber into the export market has had a significant impact on the development of the export sector, however there are serious threats regarding future development and sustainability of this marine product in this industry.

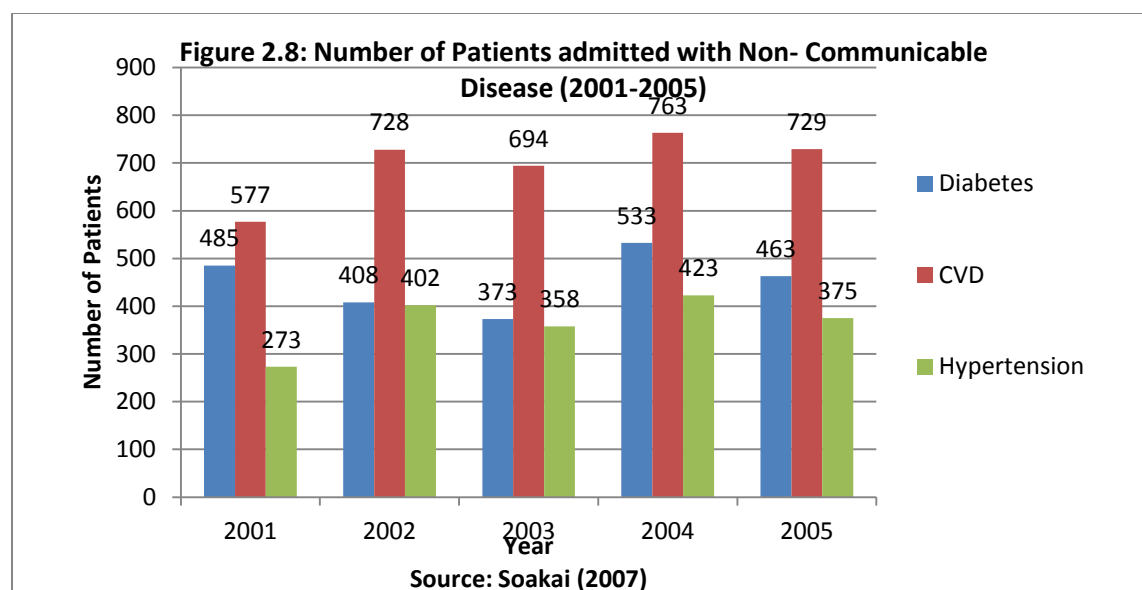
The reconstruction of Nuku'alofa was mostly funded by the China EXIM Bank loan (USD 63 million) and has been completed since the domestic political disturbance in 2006. The completion of this construction has included the Taumoepeau Building, Otto Sanft Building, Narrottam, Lalita Store, Royco and the St George Palace. However, the construction of residential private dwellings at Niuatoputapu was affected by the tsunami and had slowed down due to the fall in remittances and bank tightening lending conditions but to date has been completed. (National Reserve Bank of Tonga [NRBT], 2011; International Monetary Fund [IMF], 2012 and 2009).

The export to GDP ratio is quite negligible it is less than five per cent and mainly destined to neighbouring countries of New Zealand and Australia. The impact through trade is very small in magnitude. Tourism is the second largest source of foreign exchange and stood at a range of eight percent to ten percent of GDP. The remittances emerged as the main source of income for households in Tonga which also dropped by 9 percentage points of GDP (from 2007/08) to 21 percent of GDP (2008/09). The remittances from Australia increased by 50 per cent as a result of the Pilot Scheme for Seasonal Workers (PSWPS) with Australia that was launched in 2008. While remittances from New Zealand declined by 30 percent and the United States declined by 25 percent in 2008. Albeit currency fluctuation impacted the remitting countries, mainly New Zealand, Australia and the United States (IMF, 2010:6 & IMF, 2009:13)

2.4 Health in Tonga

The United Nation Development Program (UNDP) Human Development Index (HDI) Report ranks Tonga in the medium human development category. The HDI in 1990 was 0.649 and in 2000 stood at 0.681. Tonga is, however, ranked 95th in 2012 HDI Report with a higher index value of 0.710 compared to neighbouring countries of Samoa (0.702) and Fiji (0.702) (UNDP, 2012).

Momentous changes in Tongan society have occurred not only in politics, but in various dimensions, including health, social behavior and lifestyle since the post-European contact. Early Tongan society, people used to support their families from local subsistence food, relied on local materials, fresh and nutritious. Today's generation mostly depends on cheaper but less nutritious imported products from overseas. The rural- urban migration figures are rebounding up driven by the ideology of searching for socioeconomic opportunities such as education and better health care services. As noted by the Government of Tonga Budget statement 2012/2013 the loss of skilled personnel, especially in the health and education sectors to international migration is affecting the provision of services across the country at large (Ministry of Finance and National Planning [MFNP], 2012). The rural-to- urban migration has put more pressure on urban infrastructure and related social stresses associated with alcohol consumption. This could have a vast impact on lifestyle during the last two decades and it is evident from the high prevalence of Non Communicable Disease (NCD) such as obesity, diabetes, high blood pressure, cardiovascular diseases (CVD) and the like. Foliaki (2007) in a special report for WHO found that NCDs such as diabetes, cancer and respiratory illnesses are already the leading causes of mortality and morbidity⁸ in Tonga. Figure 2.8 illustrates the increasing number of people admitted to hospital from CVD, diabetes and hypertension.



⁸ Mental illness is another significant causes of morbidity but its actual incidence is unknown (ADB, 2013:32).

Pursuing social development to achieve a better standard of living inevitably impacts in modern Tongan society by scarcity in day-to-day resources and thus migration to a setting with more infrastructures. This is quite common in other Pacific Island Countries, however it is evident that Samoa and Tonga have been the largest recipients of remittances in Pacific region accounting for about 25% of their GDP in 2007 (Jayaraman et al., 2009:618). As mentioned previously Tongatapu is seen as the center of all government administration offices, various government ministries and NGOs is there. The trend of migration based on data collected by the Statistic Department (Tonga Census 2011) explicitly noted that the annual growth rate for Tongatapu from 1986-1996 was 0.5 per cent, 1996-2006 (0.7 per cent) and 2006-2011 (0.8 per cent). This compares to a negative annual growth rate for Vava'u (0.7 per cent), Ha'apai (2.6 per cent), 'Eua (0.8 per cent) and the Niuas (5.2 per cent) in the 2006-2011 Population Census. Rapid urbanization has seen as significantly correlated with health problems such as high NCD, poor sanitation and diet. Other adverse impacts of urbanization are the loss of traditional food as well as congestion and pollution. All these have detrimental impacts have consequences on the health status of the people involved.

The life expectancy for females was estimated to be in the vicinity of 65.4 to 69.0 years and 60.4 to 64.2 years for males in 1996 and this is far lower compared to previous estimates for Tonga by MOH⁹ (2010: 11). The low level of life expectancy compares to a high level of premature adult mortality rate and low infant mortality rate indicating that growing levels of NCDs are having a robust impact on the health status of Tonga (see Hufanga, Carter, Rao, Lopez, Taylor, 2012). The mortality data collected from the Medical Ward in Vaiola Hospital show that 63% of all deaths were due to NCDs. These deaths were premature as well as largely avoidable. The socio-economic implication of this issue stretched further and already compromised the budget of the Ministry of Health as well as incurring substantial costs to society and also to individuals. Preventative program has been weak and therefore there is an urgent need reconsider preventative strategies rather than rely heavily on the curative methodological approach.

⁹ Recently in 2010, a new finding from a research conducted by the Ministry and the University of Queensland, Australia suggest that the life expectancy is even lower by at least three years for both males (65 years) and females (69 years) (see MOH, 2010, pg.10 - 12).

Cardiovascular diseases (CVD) are the leading cause of mortality in Tonga since it has been notified during the last two decades and this commonly happens in most Pacific Island Countries¹⁰. The Ministry of Health is conducting thorough, ongoing disease prevention and control measures to combat this epidemic. Foliaki (2007) noted that the vast majority of deaths attributed to CVD was mainly due to cardiac arrest/infarct with a smaller number coded as “ ischaemic heart disease”, “cardiovascular disease” and heart failure. The majority of death cases is from 65 years old plus. To date, there are increasing new cases of mortality attributed to CVD among the younger age group between 35 to 55 years old and some are as young as 24 years old.

The prevalence of type 2 diabetes or noninsulin dependent diabetes mellitus (NIDDM or type 2 diabetes) is particularly a serious critical issue for Tonga especially for youth. On May 2013 the University of the South Pacific Tonga Campus launched a qualitative analysis on diabetes. The result found that outer islands such as Niuafu’ou had the lowest percentage (23%) of young people living with family members diagnosed with diabetes. This compares with the mainland of Tongatapu with 87 per cent (Koloto, Veikune, Hausia and Foliaki, 2013). The result from the Tonga Steps Survey 2004 indicates that the prevalence of diabetes is still growing. The worrying feature of the trend is seen that the prevalence of diabetes in the younger age group (under 20) years old which approached 5% in 2004 (Foliaki, 2007).

2.5 Health Expenditure in Tonga

Expenditure on health of a country is definitely significant for the livelihood of taxpayers. However, minority groups could be accused of striving to distribute wealth according to what is best for themselves and completely ignoring what is necessary for the whole country’s population. This is what was experienced in Fiji during the second - coup that the military government of that time allocated more of its budget to support military and defence services rather than upgrading health and education sectors (Nisha, 2006; Narayan and Singh, 2007). In the Budget Statement 2012/2013 it was noted that close to TOP \$28 million was allocated to MOH compared to TOP \$27 million in the previous financial year. The largest proportion of the ministry

¹⁰ In terms of non-communicable diseases, cardiovascular disease is the leading cause of mortality in several countries with Nauru recording the highest incidence followed by Tuvalu, Marshall Islands and Fiji. People in several countries are in the pre-hypertension category with a high risk of developing hypertension. Several countries have serious obesity problems and in the Cook Islands, Micronesia, Nauru, Niue, Palau, Samoa and Tonga; more than 60% of population is obese, and in all countries females are more obese than males (Gani, 2009).

expenditure is directed toward curative which include dental and nursing care, leadership, policy advice and program administration, however only a small portion of preventative care as illustrated in Table 2.2

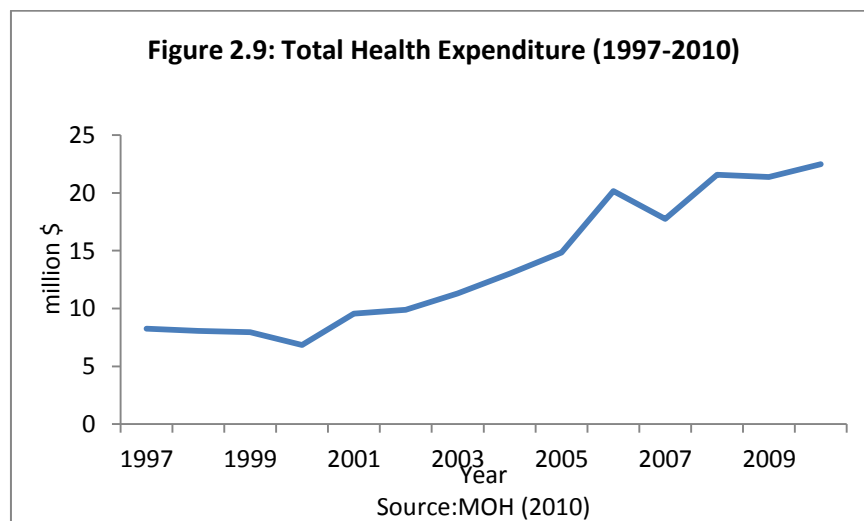
Table 2.2: USES OF MOH FUNDS	2005/2006	Percent
MOH Inpatients Curative	\$5,087,373	29.1
Overseas Treatment	\$875,285	5.0
MOH General outpatient	\$839,314	4.8
Ancillary Services to Health Care	\$778,525	4.5
Pharmaceuticals	\$1,822,943	10.4
Government Administration	\$2,855,282	16.3
MOH Preventative and Public Health	\$1,208,396	6.9
MOH Health Related Functions	\$3,999,250	22.9
TOTAL	\$17,466,368	100

The MOH had financed locally its expenditure from taxation collected by government and some proportions sourced from NGOs¹¹. In 2005/06 this amounted to TOP \$11.1 million donated from the development partners such as donors. The funds from AusAID, NZAid and Japanese International Cooperation Agency (JICA) to support various health programmes and activities have played a significant role in the health sector throughout the country. Additionally, external sources of donors who have provided financial assistance for the ministry such as the World Bank has contributed 55% of the total donor funding for redevelopment and refurbishment of the new Vaiola Hospital. The WHO is a regular source of funding for the MOH since 1970's and it comes direct or indirect to the main system. Various donors targeted certain objectives in the health care system according to their interests. Half of the donor's financial assistances are invested in capital formation of health care providers and approximately two million was invested in training as well as research and development in the ministry (MOH, 2008, and MFNP, 2012). This substantial contribution reflects the inability of the Government of Tonga to support a significant health capital cost out of its limited resources. It has been noted that during the last decade, health expenditure was dramatically increased and largely due to a huge spending on curative and nursing care services (see Figure 2.9 and Table 2.3).

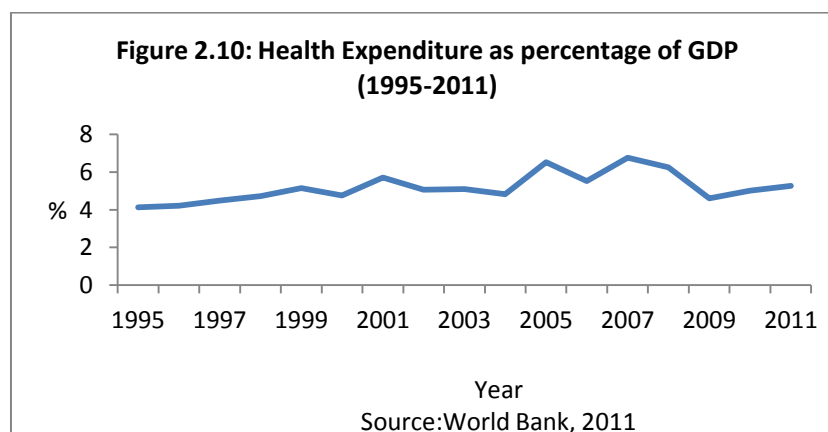
¹¹ The NGOs funds are vastly distributed according to their preference and expectation. The largest shares of funds were spending on maternal and child health, prevention of NCD, education and training of health care personnel. This include Tonga Family Health Association, St Mary Catholic Clinic, Aloua Ma'a Tonga, Vaiola Hospital Board of Visitor, Tonga Red Cross, Salvation Army of Tonga, Tonga Community Development Trust, Tonga National Youth Club, Dr Supileo Foliaki Foundation, Free Church of Tonga, 'Ofa Tui 'Amanaki Centre, Rotary Club, Seventh Day Adventist Church and the Free Wesleyan Church of Tonga (MOH, 2008).

Table 2.3: Recurrent Health Expenditure, by sub-sector, 2006/07-2009/10 (Sources: Ahio et al 2010)

TOP \$m	2004/05	2007/08	2008/09	2009/10
Curative, Dental & Nursing Care	8.6	12.3	13.7	12.0
Preventative Care	1.1	1.1	1.6	1.6
Other Planning & Leadership	3.8	5.8	5.5	5.4
Recurrent Total Health Spending	13.5	19.2	20.9	19.0



It can be seen from Figure 2.10 that the political turmoil on 16th November 2006 had an adverse impacts on the expenditure incurred towards health whereby marked deterioration in health expenditure between 2008 and 2009 followed by an expeditious recovery in 2011. The socio-political restlessness did not affect much the health expenditure in absolute terms, but it can be seen that it continues to rebound back.



The bulk of the expenditure in the late 2007 was due to sharply increased salary cost for civil servants. Consequently, the medical staffing cost leapt by over TOP \$3 million in one year from TOP \$ 7.5 million in 2004/05 to TOP \$10.7 million in 2005/06, taking the salary share from 56% to over 60% of the recurrent health budget. (Ahio, Foliaki and Lavemaau, 2010).

Table 2.4 shows the detailed breakdown of inter- island spending by the district. As seen that Vaiola Hospital in the mainland of Tongatapu accounted for 88 per cent of total national health spending followed by Vava'u (5%), Haapai (3%), 'Eua (2%) and the Niuas (1%) from the outer islands. The specialist medical staff and high tech medical equipments are only available at Vaiola Hospital apart from independent medical team visitors from overseas. Consequently, patients from outer islands requiring acute treatments are generally referred to the main hospital at Tongatapu for the reason of cost effectiveness of delivering secondary health care across the remotest islands. This explains the fact that health expenditure per head in Tongatapu is more than two folds at TOP\$245 per capita compared to other islands.

Table 2.4: Health Expenditure per capita by Island Group 2008/2009				
Island Group	Population	Expenditure	Per Capita Expenditure	% of Population
Tongatapu	75158	18408206	245 ¹²	73
Vava'u	14936	1159393	78	14
Ha'apai	6650	667806	100	6
'Eua	5011	449941	90	5
Niuas	1281	215326	168	1
Total	103036	20900972	203	100
Source: MoH, 2008; TDoS, 2012				

The health spending per capita in the outer island were TOP\$78 for Vava'u, TOP\$100 for Ha'apai, TOP\$90 for 'Eua and TOP\$168 for the Niuas. Overall, the per head expenditure for outer islands is equivalent to one third of the total per capita spending in Tongatapu. Health spending in Vava'u and Ha'apai were only 5 and 3 percent of total health spending respectively. However, 14 percent of the population lives in Vava'u, 6 per cent of the population lives in Ha'apai and one percent in the Niuas. The island of 'Eua could be sufficiently close to Tongatapu and possibly access to secondary health care services from the Vaiola Hospital. This signifies that per capita health expenditure disparities in Tonga have been reflected the difficulty in

¹² This amount expressed in Tongan Pa'anga.

health delivery, especially for remotest islands and thereby led to a significant and sluggish economic growth and development for Tonga.

By looking from the other side of the spectrum of Pacific Island countries, Fiji's health expenditure as a percentage of GDP nested in the same ranges (3% - 5%) as that of Vanuatu, Papua New Guinea and Palau. However, Tonga, Samoa and Solomon Island health's expenditure spending stood in the vicinity of 6% - 8% of GDP, while Tuvalu and Kiribati spending averages more than 9% on health in 2011. (see Table 2.5). For selected Pacific Island countries health spending was taken from the World Bank under the World Development Indicator Database. Again, this shows that Tonga's health expenditure is below the 10 % level and above the 5 % level share of GDP. Historically, health spending in Tonga has been around 3% to 4%, except for a slight rise in 2005/2006 and largely due to 60%, 70% and 80% higher salaries implemented in that year (Ahio et al., 2010).

Table 2.5: Total Health Expenditure as % of GDP 2011 for PICs

3%-5%	6%-8%	Over 9%
Fiji Vanuatu Papua New Guinea Palau	Tonga Samoa Solomon Island	Tuvalu Kiribati New Zealand Marshal Island' Federal States of Micro- nesia Australia
Source: World Bank, 2011		

2.6 Health Expenditure on NCD

NCDs in the Western Pacific region has accelerated in the last two decades ago and Tonga is one of the Pacific Island country with a high prevalence of NCDs. According to the National Health Account (NHA) suggest that Tongan health expenditure for NCD was estimated at TOP \$5 million with an average of 16 percent of total health spending (1% of GDP in 2005/2006) (MOH, 2008). This is higher in comparison to other neighbouring island countries. The international comparison of health outcomes relative to per head spending suggests that the NCD spending in

Tonga is quite low. The per capita spending on NCD was TOP \$51 a year in 2006. The large proportion of spending in the Table 2.6 is on the Pharmaceutical expenditure by 47 percent, then government hospital (17 percent) and overseas treatment (11 per cent). Approximately 90 percent of NCD spending is allocated for curative care services. Almost 22 per cent of the MOH budget on NCD is mainly curative in comparison devoting 0.2 per cent for preventative care services. This pattern of spending replicates the fact that Tonga depends its development partners for the provision of NCD preventative care services. Consequently, government budget priorities based on the previous evidence that NCDs preventative care services are truly a significant public issue (MOH, 2008 and Ahio et al., 2010).

Table 2.6: NCDs Expenditure for 2005/2006			
NCD Services	TOP \$	%	Per capita (TOP \$)
Government Hospital	921600	17.5	8.9
Private Physician	272222	5.2	2.6
Community Centre	30142	0.6	0.3
Diagnostic Laboratories	412207	7.8	4.0
Pharmaceutical Provider	2524819	47.8	24.5
Prevention of NCD	527633	10	5.1
Overseas Treatments	588795	11.2	5.7
Total	5277418	100	51.2
Sources: MOH, 2008 & TDoS, 2011			

2.7 Tonga Ministry of Health

The Vaiola Hospital was first commissioned on the 4th of June 1971 with total cost over a million Pa'anga in that time. As part of the new milestone for the government and the people of Tonga was the new era in development in health care services through the completion of the new Vaiola Hospital amounted close to TOP 70 million in 2010. The final phase of the hospital funded by the government of Japan was commissioned in May 2012 which will permit major progress in health delivery services. Other health centers have been established and funded by the Chinese government for the towns of Vaini and Mu'a. The health centers at Nukunuku, Kolonga and Houma were refurbished with funds from the AusAID. There is also a newly developed non communicable disease clinic build in Niu'eiki Hospital, Eua, under the financial assistance from

the Japanese government (JICA) (MFNP, 2012 and Ministry of Information and Communication [MIC], 2010).

The MOH is responsible for the delivery of preventative and curative health services in the Kingdom. In doing so, the Ministry's core business involves the following (i) provision of health services within the Kingdom, (ii) provision of policy advice to the Minister of Health, (iii) negotiating, management and monitoring of funds allocated by government and donor agencies, (iv) administration of health legislation, (v) collection, management and dissemination of health information.

According to MOH Corporate Plan 2008- 2012 there are six Strategic Key Result Areas (KRA) and goals. This KRA was formulated during a consultation process from the period 2008/2009-2011/2012. The six KRAs are listed below:

1. Build capability and effectiveness in preventive health services to fight the NCD epidemic and communicable diseases.

Objective

To fight the NCD epidemic and communicable diseases using effective preventative health measures, being a good role models and develop public participation and commitment.

2. Improve the efficiency and effectiveness of curative health service delivery.

Objective

To deliver the range and quality services to meet the basic health requirements.

3. Provision of services in the Outer Island Districts & Community Health Centers.

Objective

To provide appropriate services to all the Outer Island Districts and community health centers through effective resourcing. Specialized services will be provided through regular programmed visits.

4. Build staff commitment and development.

Objective

To build staff commitment and development by demonstrating to staff that they are valued.

5. Improve customer services.

Objective

To deliver services in a professional and friendly manner.

6. Continue to improve the Ministry Infrastructure and ICT.

Objective

To improve the standard of existing facilities and ICT, and construct new facilities and introduce new ICT were needed.

The implementation of the above plan has been assigned to relevant key MOH personnel, incorporating the strategies in the annual management plan through the effective allocation of resources and the collaboration with the relevant partners and stakeholders. The Divisional Heads and Managers are in charge of the outer island district and are responsible for ensuring the successful implementation of the plan identified. Each of the major activities in the plan carried out by the MOH is estimated in terms of cost incurred and these are presented as the budget estimates.

2.8 Health Systems and Facilities

May 2012 saw the official opening of the newly refurbished Vaiola Hospital as part of the million Pa'anga final redevelopment phase financed from the government of Japan aid programmes which upgrades the infrastructural status of the hospital to meet with the international standards. The refurbishment was started since 2004 with three major phases. The first two phases of this project included the new Psychiatric Ward, Obstetric Ward and officially opened in 2007. The third phase included the new children's ward (Pediatrics) and the new wing for the medical ward. The last phase includes the main building which accommodates the out patients departments, accidents and emergency wards, special clinics, pharmacy, dental services, hospital administration, mortuary, multipurpose hall, building for the Queen Salote Nursing School and a public car park. The first phase of the redevelopment programmes cost USD \$10 million (equivalent to TOP \$20

million), where as part of the second phase redevelopment project grant aid from the World Bank cost USD \$10 million (TOP \$20 million) to build the new Surgical and Obstetric Ward, Sewage Treatment Plants and Medical Wards. The Australian government is financially responsible for the master plan for the conceptual design of the refurbishment. The final phase of the project was funded by the Japanese government at TOP \$40 million. During the refurbishment and upgrading of the Vaiola hospital is approximately close to \$66 million Pa'anga of related expenditures (MIC, 2012 & Tongan News, 2012). This explains how difficult it was for the government of Tonga to responsibly finance all these redevelopment projects from their limited budgets over half a decade ago.

The current facilities within the country generally have a low to health personnel ratio. There are four major hospitals in the Kingdom (Tongatapu, Vava'u, Ha'apai and 'Eua) of which there are seven health centers in Tongatapu, three in Vava'u, two in 'Eua and two for Niuas. Among those four districts, there are 19 Medical Centers Health (MCH) Clinic in Tongatapu, five in Vava'u, five in Haapai, three for 'Eua and two for Niuas. As noted in Table 2.7 given the distribution of the population among different islands, the number of person per facility is higher in Tongatapu and lower in the least populated remotest Island (Niuas). This fact reveals that more people are in the queues to use the outpatient facilities in Tongatapu compared to least populated district. The absence of hospitals in Niuas means that the access to health facilities is very limited and that is one of the major challenges for the delivery of health care services among the Kingdom.

Table 2.7: Government Health Facilities by Island Group 2010						
	Total	Tongatapu	Vava'u	Ha'apai	'Eua	Niuas
No of Govt Health Facilities¹³	52	27	9	8	4	4
Population	103036	75158	14936	6650	5011	1281
Capita per Facility	1981	2784	1660	831	1253	320
Source: MOH, 2010 , TDoS, 2012						

In terms of health professional personnel in various provinces, the ratio of per capita to medical staff personnel is very high in Vava'u accounted for one medical officer per 14936 people similar to Ha'apai and Eua. For Niuas which has the least population there are two different medical officers in these two islands. The lowest ratio is for Tongatapu which spells out the majority of

¹³ Health Facilities includes hospital, health centres and Maternal Child health clinic.

Table 2.8: Government Health Personnel by Island Group 2010					
Province	No Medical Staff¹⁴	No Staff Nurse¹⁵	No Dental Staff¹⁶	Population	Person per Medical Staff
Tongatapu	63	349	34	75158	1193
Vava'u	1	27	1	14936	14936
Ha'apai	1	17	2	6650	6650
Eua	1	11	1	5011	5011
Niuas	2	2	1	1281	640
Total	67	406	39	10306	1537
Source: MOH, 2010, TDoS, 2012					

medical officer works at Vaiola Hospital at Tongatapu. The case of Niuas reflects the least populated remotest islands and could easily be handled by the medical officer and nurse there. The lack of acute treatment for specific patients reflects the limited resources available in those two islands (see Table 2.8). In Table 2.9 gives a brief overview of the number of bed facility and total patients during 2006.

Table 2.9: Beds, Occupancy rate and total patients, by Island Group, 2006				
Island Division & Hospitals	No of Beds	% of total beds	Occupancy rate	Total Patients days
Tongatapu (Vaiola)	199	71%	58%	42,268
Vava'u (Ngu)	43	15%	33%	5,205
Ha'apai (Niu'ui)	22	8%	25%	1,978
'Eua (Niu'eiki)	17	6%	19%	1,178
Total	281	100%	49%	10,380
Source: 'Ahio et al 2010.				

A major issue of concern the health care delivery in the Kingdom is the outflow of the highly qualified professionals from the PICs and this has been identified as a significant element that has hampered the sustainability of socioeconomic development of MOH. More recent studies by

¹⁴ Medical Staff includes Medical Officer, Health Officer

¹⁵ Nurse staff includes staff, student nurse, staff nurse diplomat.

Fisi'iahi (2001) regarding the “brain drain” suggested that this is merely due to a number of reasons. In the context of Tonga and the most obvious reason is the good employment package offering by the receiving countries. Kerse & Ron (2002); Fisi'iahi (2001) found this is what has happened in Tonga. Most professionals such as medical officers, registered nurses, accountants and lawyers have salaries nowhere near comparable to those in developed countries. In Tonga, the starting salary rate for medical doctors were the TOP \$12,000 (NZD\$8, 976.00 per year) this is far below on the annual salary of junior general practitioner (GP) doctor here in New Zealand¹⁷ (Fisi'iahi, 2006). This is causing a major threat for various government ministries, especially the Ministry of Education, Women Affairs & Culture (MEWAC) and MOH¹⁸. Not to mention those highly qualified personnel who work permanently in regional, international organization in neighbouring countries such as Fiji, Papua New Guinea, New Zealand and Australia. The statistics may appear very negligible for most developing countries with populations of millions however, for more than 100,000 populations in the context of Tonga it is a significant loss in terms of skilled labour (MLCI, 2005).

A recent report from WHO (2004) states that a survey undertaken in the 1995 revealed that 14 doctors had been lost to the MOH in the previous 10 year period. At least eight of the others moved overseas, five doctors were working in Australia, three in New Zealand, two in Fiji, one in Samoa and two were unemployed in the United States of America. As mentioned previously the main reasons as to why the medical officers attrition rate is so high in Tonga. In the context for medical officers in the Kingdom, according to WHO (2004) this is merely due to a multitude of reasons such as salary levels, family reason, such as the interest of the spouse and other extended families were highly influential. Fisi'iahi (2001) also noted that the salary of medical doctors compares to others, such as accountants and is similar even though the duration of training for medical doctors are longer therefore it is totally unfair to start at the same rate. The likelihood of the medical personnel to emigrate overseas is generally high in this context¹⁹. Table 2.10 shows the overview of the health workforce for selected three years.

¹⁷ Junior General Practitioner range from NZD \$60,000- NZD \$70,000 for Auckland areas and for South Island part time GP is NZD\$50-70 per hour (New Zealand Doctor, 2010).

¹⁸ In a recent headline appeared on the New Zealand Kaniva Pacific were told that MOH could not afford to pay the overtime especially the employee at the lab, transport operator, dispensary and at the dental department. This is one of the contributing factor as to why most of local doctors (physician) migrate to nearby country because of the uncertainty of overtime pay (New Zealand Kaniva Pacific, 2013). Similarly, study by Bhatt et al., (1976) found that physician are migrating because they found it later that service condition for Doctors in India not very lucrative.

¹⁹ In a recent article from the New Zealand Kaniva Pacific posted with the title: “Vaiola Hospital staff unpaid overtime work uncertain” The complain

Table 2.10: Public Health workforce in Tonga			
Category	2008	2009	2010
Medical Staff	81	78	67
Dental Staff	35	35	39
Nursing Staff	346	355	406
Technical Staff	110	129	125
Source: MOH, 2010			

2.9 Global trends in health Issues

Today's world is highly mobile, interconnected and interdependent world provides a myriad of opportunities for developed countries to export a multitude of and variety of commodities to less developed countries with the support of various legal trade agreements to accommodate free trade of goods and services. Interestingly, the less developed countries gain access via binding to various international trade agreements with the high expectation to gain advantages through international trade. Recently, Samoa and Vanuatu both ratified their accession package in 2012 as new member of WTO while Tonga did so in 2007. In essence, government does not take serious consideration the global health impact of these decisions (Puloka, S. W, personal communication, May 23, 2013). The obvious and the most clearly logic of this accession is for the economic benefit of the country. According to Legge, Gleeson, Snowden and Thow (2013), trade agreements hold a significant benefit such as increasing export to foreign markets, attracting foreign investment and even accelerating the standard of living. On the other hand, the introduction of trade agreements has impacted on the prevalence of NCDs in the small Pacific Island Countries. The economic theory suggests that trade liberalization encourages socioeconomic development, but in the very extreme case they do not realize how the flood of cheap import puts relates to enhancing export led-growth. For instance, in the context of Tonga it is often realised in everyday families consume the cheapest food owing to budget limitations. Therefore, people at lower income quartile consume as much as possible from the cheapest and unhealthy imported product such as sugary soft drink, sweets and fatty meat. At this juncture, there is a robust connection between trade liberalization and the increasing number of NCDs and thereby leads to severe impact on life expectancy, mortality and fertility rate of the people. Recently, the government has imposed new duties on unhealthy product such as tobacco product. Along with that major adjustment of higher excise duty, the Ministry of Revenue declared a significant change for carbonated drink, lard and dripping which took effect on August 2013. The MOH also clarified that

the imposition of this new duties are as part of their commitment to combat NCDs by increasing the import rates on unhealthy product while reducing the rates on healthy food (Matangi Tonga, 2013).

It is projected that the annual number of deaths due to cardiovascular disease (CVD) would increase from 17 million in 2008 to 25 million in 2030, with annual cancer deaths increasing from 7.6 million to 13 million. Consequently, the total number of annual NCDs deaths is projected to reach 55 million by 2030 whereas annual infectious disease death was projected to decline in the next 20 years. The premature death rates from NCDs are a major consideration in determining their impact. The probability of dying from NCDs between the ages 30 and 70 are extremely high in African countries, Eastern Europe and parts of Asia. Table 2.11 presents life expectancy at birth by region and income (WHO, 2012 & Legge et al., 2013).

Table 2.11: Life expectancy at birth (years) in region, low and high income.						
	Both Sexes		Male		Female	
WHO region	1990	2011	1990	2011	1990	2011
African Region	50	56	48	55	51	58
Region of the Americas	71	76	68	73	75	79
South East Asia Region	59	67	58	65	60	69
European Region	72	76	68	72	76	79
Eastern Mediterranean Region	61	68	59	67	63	70
Western Pacific Region	70	76	68	74	73	78
Low Income	52	60	51	59	54	61
Lower middle income	59	66	58	64	61	68
High income	76	80	72	78	79	83
Global	64	70	62	68	67	72
Source: WHO, 2013						

The life expectancy and infant mortality for PICs are presented in Table 2.11. The life expectancy at birth for both sexes show considerably increasing for selected Pacific Islands Countries. The increasing life expectancy for PICs amounted on average to four to five years over the decade. This significant trend characterizes so many improvements in health delivery in the Pacific region.²⁰ The estimates of mortality presented here have been derived from death registration data collected by WHO statistics 2013. Monitoring the level of infant mortality rates around the regions shows the significant decline in 2000 and 2011 compared to 1990s. This explains the in-

²⁰ Life expectancy at birth continues to increase remarkably in Asia and Pacific countries reflecting a reduction in mortality rates at all ages. The gains in longevity can be attributed to numbers of factors: rising living standard and better nutrition, water and sanitation. Improved life styles, increased education and greater access to quality health services also a crucial role in PICs (OECD, 2013).

frastructural development and high technology facilities within the health sector (ADB, 2013:31). (see Table 2.12).

Table 2.12: Life Expectancy and Infant mortality rate for PICs					
Countries	Life expectancy at birth (years)		Infant mortality rate (1 per 1000 live births)		
	1990	2011	1990	2000	2011
Fiji	66	70	25	19	14
Kiribati	64	67	64	50	38
Papua New Guinea	56	63	64	54	45
Samoa	66	73	25	19	16
Solomon Islands	62	70	34	25	18
Tonga	68	72	21	17	13
Vanuatu	66	72	31	20	11
Source: WHO, 2013					

2.10 Conclusion

This chapter illustrates a significant insight of what is available in terms of infrastructural resources to human resources and its linkage on how to improve the health of its people. Tonga MOH seen during the last two to three decades marked a magnificent improvement of its services. Not to re-iterate of such development/improvements on lower IMR (see Figure 2.3) and high life expectancy (see Figure 2.4). In general speaking Tonga health sectors are doing well as witnessing from their current health situation. MOH stands as the primary body whose responsibility in providing curative and preventive care services, albeit there are some private complementary health clinics have performed the identical services but in a limited scope.

NCDs appear as an epidemic that engulf rapidly the age population and require an urgent effort in collaboration with various government ministries (Ministry of Education and Training, Ministry of Youth and Sport) and other external moderators (WHO, ADB and UNDP) on how to prevent and set-on-shore policies to support the “prevention better than cure policy”. The NCDs epidemic is developing gradually with time and its implication is so virulent thus, there require a collective effort to combat and mitigate the cost not in Tonga but in the Pacific region.

In the next chapter, we will observe how the two distinct perceptions of health and economic growth in methodological procedure are related, how they interact with the other exogenous parameters during the period of study.

CHAPTER THREE

METHODOLOGICAL FRAMEWORK

3.1 Introduction

In applied work, researchers encounter problems in selecting which methodological procedure is appropriate to estimate long and the short run relationship among the variables²¹. In contrast, there exists a methodological debate among the scholars on the relative merit of a particular statistical technique in order to generate more convincing and robust results. In recent methodological argument, it appears that it is hard to deduce a definite conclusion because such empirical verifications are often favored a particular system approach than another approach. Therefore, from that point of view, I shall employ multivariate cointegration framework instead of using a single equation estimation technique. It may be said that a preference for a specific paradigm is presumably influenced by the preference for policy implications (Rao, 2007). Though, there are some researchers who have also preferred such techniques that are easy to implement and user friendly²². However, Rao (2007) also suggested that economic theories should be evaluated on their theoretical and empirical merits, but not on the basis of their policy implications.

Rao (2007) and Smith (2000) summarize the three usefulness stages of research programmes. The classification of these programmes has focused on three categorical facts: purpose or objective, the summary and interpretation of facts. Along these three categories, there are empirical tools to analyze and forecast the outcomes from the observed fact. The objective and interpretability stages are left to the researcher according to his or her preferred economic theories. Thus, the evaluation of the relative pros and cons of such particular technique, it is necessary to characterize how important a particular technique for summarizing the observed facts. It is often found in some stages that there are some conflict in results, but these may differ in their precision and perhaps only marginally. If that happens then we shall invoke Granger (1997) who had observed a computationally simple technique to an acceptable degree of precision will be widely used.

²¹ Kennedy (2003) suggested that good estimator be one that generates a set of estimates of the parameters that makes residuals small.

²² It remains a fact that in good practice with a good results depend as much on the input of sound and imaginative economic theory as on the application of correct statistical methods (Kennedy, 2003)

The development and application of time series technique have become very popular recently in research instead of using the classical estimation of ordinary least squares (OLS). It is said that the use of an estimation technique without acknowledging the integrated properties of variables is not very common in practice especially in the time series approach. For example, in the case of *VECM* it is compulsory to verify the order of integration and unit root test prior the estimation of long and the short run relationship among the variables²³. By proceeding without checking the order of integration may result in spurious regression problems; see Engle and Granger (1987).

The purpose of this chapter is to characterize the time series methods used in this study. It starts with a unit root test that is employed to examine the integrated properties of the variables that is the conventional test of Augmented Dickey Fuller, (1979) (ADF) test. In order to proceed further by estimating the cointegrating vector and using the Johansen maximum likelihood (JML) and Pesaran et al (2001) autoregressive distributed lag model (ARDL) approach for cointegration to assess the dynamic interaction between economic growth and health variables.

This chapter is organized as follows: The methodology section present unit root test using the Augmented Dickey Fuller Test, Cointegration with the Johansen Maximum Likelihood Technique on section 3.2.1 to 3.2.3. Section 3.2.4 gives the estimation procedure such as univariate modelling. The *VECM* approach and Granger Causality framework on section 3.2.5, then the data, sources and construction and final conclusion in the last section.

3.2 Methodology

3.2.1 Unit Root Test

The formulation of the data sets for further statistically examinations are also important to check the stationary properties of all series prior the cointegration and causality tests. Hence the cointegration analysis to be valid required further investigation as to whether the order of integration of the variables of interest is similar. First, the stationary properties validated prior conducting the cointegration tests.

The classical estimation methods are based on the assumption that the mean and variances of the series are constant (Engle, Ng, & Rothschild, 1990 and Engle, 1982). However the application of

²³ Obayelu and Salau (2010) noted that is a prerequisite for *VECM* estimation about the determination of the characteristics of the time series variables in the model as to whether they stationary or non stationary. Thus *VECM* restricted the long run behaviour of the endogenous variables to converge to their cointegrating relationship while allowing for short run adjustment dynamics.

the unit root tests has shown that the means and variances of many macroeconomic variables are non-constant and therefore the usual assumptions are not satisfied (Rao, 2007). Hendry and Juselius (2000) suggested that variables exhibiting a shift in its mean are a non stationary process as is a variable with a heteroscedastic variances over time. Time series variables that also follow a random walk process are often called “non stationary” over a period of time. It will become stationary if converted by using the first difference d times. It is also noticed some relationship exists between the Durbin Watson (DW) statistic and non-stationary; see Rao (2007). Phillips (1986) suggested that when a regression is running between the unit root variables, the DW statistics converges to zero²⁴. Once the variable is stationary, then referred to an integrated of order d or $I(d)$. The usual Augmented Dickey Fuller (ADF) unit root tests (Dickey and Fuller, 1979, 1981) tests are performed. The variables: economic growth, capital, labour, life expectancy, infant mortality, fertility rate, education, age dependency ratio and trade openness are generally non-stationary. To minimize this drawback the ADF test can control for higher order serial correlation when higher order lags are used as follows:

$$\Delta X_t = \alpha_0 + \alpha_1 X_{t-1} + \alpha_2 t + \sum_{i=2}^p b_i \Delta X_{t-i+1} + u_t \quad (3.1)$$

where p is the number of lagged changes in X_t it is essential to assume that error term u_t is serially uncorrelated. That is a necessary condition for the test to be validated that is not dealt with the original DF test (Brooks, 2002). The optimal lag order can be determined by using number of model selections: the Schwarz Information Criterion (SIC), Akaike Information Criterion (AIC) or Hannan Quinn Criterion (HQ). Thus the lag length automatic selection criterion used in this investigation relied on Schwarz Information Criterion. At this end the null against the alternative hypothesis: $H_A = \alpha_1 < 0$ the null hypothesis of the unit root is not accepted if there observed t -statistics is sufficiently negative compared to MacKinon (1996) lower tail critical value at the accepted level of significance. The equation (3.1) can also be examined whether the variables can be characterized as $I(1)$ process with the inclusion of intercept and time trend. Similarly, two other tests can be conducted: the equation (3.2) which also allows the series to be

²⁴ If there is no serial correlation, the DW will be around 2. The DW statistic will fall below 2 if there is a positive serial correlation (in the worst case scenario, it will be near zero) (Tripathy, 2011)

characterized as $I(1)$ process with an intercept or test with the series to be $I(1)$ process to the exclusion of intercept and time trend (3.3).

$$\Delta X_t = \alpha_0 + \alpha_1 X_{t-1} + \sum_{i=2}^p b_i \Delta X_{t-i+1} + u_t \quad (3.2)$$

$$\Delta X_t = \alpha_1 X_{t-1} + \sum_{i=2}^p b_i \Delta X_{t-i+1} + u_t \quad (3.3)$$

Hence, the three cases, the null hypothesis tested are H_0 : the series has a unit root against the H_A : the series is stationary. The important characteristic of the ADF test over the DF test in general is that it is asymptotically valid even in the presence of a moving average component if sufficient lagged difference terms are included in the test specification (Said and Dickey, 1984). Similarly, Kumar (2011) noted that the ADF approach test takes care of the higher order correlation by adding lagged difference term of the dependent variable to the right hand side of the regression.

3.2.2 Co-integration

In time series economic data analysis is often found as non-stationary variables. The use of ordinary least squares (OLS) relies on the stochastic process being stationary. When the stochastic process is non-stationary, then the use of OLS can produce invalid estimates (Song and Wong, 2003 and Smeral and Song, 2013). This may find the \bar{R}^2 is much higher than the DW , t -ratio is also too high and leads to over rejection of the null hypothesis in the slope coefficient estimates and finally yields a result with no economic meaning at all. Granger and Newbold (1974) coined such estimates a “spurious regression”. To overcome such shortcoming requires the specified equation to transform into valid regression by taking the first difference of the variables. This method solves only the statistical problems but not the theoretical economic interpretability of the specification. By doing so, taking the first difference might lose significant information in the long run, but in this investigation deals with the growth rate of variables.

The spurious relationship among variables may not cease and also advised to check the existence of the long run relationship between the time series. It is also assumed that economic data have a

long run relationship or variables are moving together over time, even though they follow their own individual trend but will not drift too far from each other. They are moving together into some point (Hossain, 2012). Thus co-integration is feasible when two or more variables are integrated of the same order and both are moving together in the long run.

3.2.3 Co-integration Test: The Johansen Maximum Likelihood Technique

Johansen (1988, 1991) and Johansen & Juselius (1990) proposed a maximum likelihood technique to determine the existence of cointegrating vectors in the system. This approach is a variant of the *VAR* methodology and usually known in literature as Johansen Maximum Likelihood or *VECM*. In the *VAR* model, all the variables are identified and estimated on the basis of the theoretical economic theory. Prior to when *VECM* technique is applied, pretesting of series for unit root is necessary. The basic *VAR* model as follows:

$$\Delta X_t = \phi + \sum_{i=1}^h \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \mu_t \quad (3.4)$$

where X at period t is non-stationary in level form and the vector of $I(1)$ variables and ϕ is a constant. Let start with the vector autoregressive model of equation (3.4). Johansen and Juselius (1990:169) formulated the objective as the hypothesis of cointegration as the hypothesis of reduced rank of the long run impact matrix $\Pi = \psi\lambda'$, where ψ and λ are the cointegrating vectors and weights respectively. The main crux of Johansen and Juselius (1990) work is to examine whether the coefficient of the matrix Π cothe long run relationshipout long run relationship among the variables in the system equation. On the other hand, to examine whether the current information contains in the long run relationship are moving together to equilibrium (Hossain, 2012).

Prior to the application of the cointegration framework, it is necessary to test the order of the *VAR*. In essence, it is important theoretically to determine the lag length of the *VAR* model. By doing so, the Akaike Information Criterion (AIC) and Schwarz Bayesian Crterion (SBC) are also a significant statistical criterion for model selection of the optimal lag (Mohammadi et al., 2008; Ali et al., 2008; Bragoudakis, 2005 & Lima and Panb, 2003). The test for the presence of the cointegrating vector(s) is examined with the procedure that assumes there is no deterministic

trend in the data or allows for linear deterministic trend in the data or allow for quadratic deterministic trend. For this purpose, Eviews version 8 provides five options to attempt i.e. assume no deterministic trend with no intercept or trend, no deterministic trend with intercept, allow for linear deterministic trend with intercept, allow for linear deterministic trend with intercept and trend, allow for quadratic deterministic trend with intercept and trend in the cointegrating vector. The selection of intercept²⁵ and linear trend is crucial in cointegration test. Kumar (2011) attempt all options while using Microfit version 5²⁶ in the analysis of Demand for Money for OECD countries, then choose the ones which yields the meaningful estimates. If the underlying variables are moving together, this does not imply that trend should be used in the cointegration analysis (Pesaran and Pesaran 1997). If the series is highly trended with time, then choose the option three: allow for linear deterministic trend in the data with, intercept (no trend) in the cointegrating vector (Ishaq, M, personal communication, September 2, 2013 & Hossain, 2012).

To determine the number of cointegrating vectors in the system equation initially started with $r = 0$ to $r = k - 1$ unless we fail to reject the null of no cointegration equation. The test for cointegration also performed through trace and maximum eigenvalue tests. The trace statistics null hypothesis of “ r ” cointegrating relation against the alternative of “ k ” cointegrating relationship is computed as:

$$TraceTest = -T \sum_{i=r+1}^k \ln(1 - \lambda_i) \quad (3.5)$$

where T is the sample size and $\hat{\lambda}_{r+1}, \hat{\lambda}_k$ are the $k - r$ smallest squared canonical correlation. The critical value may be used to determine whether the hypothesis that there are at most r cointegration vector is rejected or not (MacKinnon, Haug and Michelis, 1999). The inclusion of linear trend may affect the critical value if it's included. The other restricted maximum likelihood test ratio is referred to as the maximum eigenvalue test is computed as:

$$Maximum \ Eigenvalue \ Test = T \sum_{i=1}^r \ln([1 - \hat{\lambda}_i^*] / [1 - \hat{\lambda}_i]) \quad (3.6)$$

²⁵ For nonlinear cases in which the intercept term is omitted; it can no longer have the same meaning, however and could possibly lie outside the interval (Kennedy, 2003).

²⁶ Microfit version 5 software provides similar five options: no intercepts or trends, restricted intercepts no trends, unrestricted intercepts no trends, unrestricted intercepts restricted trends, and unrestricted intercepts and unrestricted trends (Pesaran and Pesaran, 2009).

where $\hat{\lambda}_1^*$, $\hat{\lambda}_r$ are the 'r' largest squared canonical correlation. The null of no cointegration is rejected when computed both trace and eigenvalue test statistics are greater than the corresponding critical values 5% or 10% levels. The alternative hypothesis of one or more cointegrating vectors are not rejected if the computed trace and eigenvalue statistics are less than the critical values.

3.2.4 Estimation Procedure: Univariate Modelling

The main focus of this study is to explore the implication of health indicators on economic growth and their causality during the period of study by employing the annual time series data for the period of 1970 to 2011. Hence, to address the aforementioned problems I would use the *ARDL* method developed by Pesaran and Shin (1995) & Pesaran, Shin and Smith (2001) to characterize the impact of health indicators on economic growth. The study proposes to utilize the cointegration framework which has obtained much attention since Granger formally introduced in 1981. A simple framework of the *ARDL* technique using a model with two variables and a maximum of two lags is explained in Appendix A. This technique has its own merits: first, there is no formal test for cointegration (Ghosh, 2009). Second, when compared to General to Specific methodology (GETS) and Engle and Granger (EG) two step procedure, *ARDL* minimizes the endogeneity problems and all the variables are assumed to be endogenous²⁷ (Pesaran and Shin, 1999). Third, the short and long run variables are estimated simultaneously, which also removes the problems associated with omitted variable and autocorrelation (Pesaran and Shin, 1999). Fourth, the *ARDL* procedure does not require a general perception of the order of integration of variables which are of significance in the EG and Fully Modified OLS (Narayan, 2004; Pesaran and Pesaran, 1997). Finally, *ARDL* also has the information about the structural break in time series data (Wahid and Shahbaz, 2009). All these techniques require that the variables have the same order of integration. Pesaran and Pesaran (1997) point out that the residual based cointegration tests are inefficient and can lead to misleading result, especially when there are more than two *I*(1) variables under consideration. Hence, to overcome this problem, Pesaran et al. (1996, 2001) proposed the *ARDL* framework that does not require the classification of the variables in *I*(0) or *I*(1). Pesaran and Shin (1999) argued that the *ARDL* technique can be reliably used in

²⁷ Note that GETS with instrumental variables method is also adequate in solving the problem of endogeneity.

small samples to estimate and test hypothesis on the long run coefficient in the both cases where the underlying regressors are $I(0)$ or $I(1)$.

The *ARDL* procedure consists of two stages. The first stage shows the presence of the long run relationship between variables of concern is examined by computing the F -statistics to test the significance of the lagged levels of variables of the series in the error correction form of the underlying *ARDL* model (Karfakis and Phipps, 2001). The test statistic is a joint test of the null hypothesis that the coefficients C_0 and C_1 in equation (3.6a) equal zero, that is testing whether the lagged level of variables X and Z are jointly insignificant against the alternative hypothesis that $C_1 = C_0 = 0$. The rejection of the null hypothesis implies the existence of the long run relationship among the variables. The error correction version of the *ARDL* (p, q) in the variables X_t and Z_t is given by:

$$\Delta X_t = \alpha + \sum_{i=1}^p D_i \Delta X_{t-i} + \sum_{j=1}^q E_j \Delta Z_{t-j} + C_0 X_{t-1} + C_1 Z_{t-1} + \varepsilon_t \quad (3.6a)$$

Similarly,

$$\begin{aligned} \Delta \ln Y_t = & \alpha_0 + \sum_{i=1}^p \beta_i \Delta \ln Y_{t-i} + \sum_{i=1}^p \varphi_i \Delta \ln K_{t-i} + \sum_{i=1}^p \gamma_i \Delta \ln L_{t-i} + \sum_{i=1}^p \theta_i \Delta \ln H_{t-i} \\ & + \delta_1 \ln Y_{t-1} + \delta_2 \ln K_{t-1} + \delta_3 \ln L_{t-1} + \delta_4 \ln H_{t-1} + \varepsilon_t \end{aligned} \quad (3.6b)$$

where $H = LE, IMR$ or FR . The computed F -statistic under the null hypothesis of (3.6a) is $H_0 : C_1 = C_0 = 0$ and null hypothesis of (3.6b) $H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$ have a non-standard asymptotic distribution regardless of the integration of the series. Pesaran et al., (2001) provide the tabulated appropriate critical value which consists of sets, one assuming all regressors are purely $I(1)$, and the other assuming they are all purely $I(0)$ ²⁸. These bands cover all possible combinations of variables, including fractionally integrated ones into $I(1)$ and $I(0)$. The null hypothesis postulating there is no long run relationship would be rejected (not rejected), if the computed F -statistic were higher (lower) than the upper (lower) band of the bound of the critical value. If the calculated F -statistic falls outside this band, a conclusive decision can be made without any knowledge of whether the underlying variables are $I(1)$ or $I(0)$. On the other hand, if the F -

²⁸ See Pesaran, Shin and Smith, (2001 ,pp. 300-301) for more details.

statistic falls within the band, information on the integration is necessary before making a decision regarding the long run relationship.

In the second stage, if the variables in each equation are found to be cointegrated, the dynamic structure of the equation can be estimated using the *ARDL* framework²⁹. The dynamic structure of the *ARDL* (p, q) model takes the following form:

$$X_t = \alpha + \sum_{i=1}^p D_i X_{t-i} + \sum_{j=1}^q E_j Z_{t-j} + \varepsilon_t \quad (3.6b)$$

where X_t is an endogenous variable, α is an intercept, Z_t is a vector of explanatory variables, p and q are respectively the lag lengths of the X_t and Z_t , and ε_t is the random error term. Finally the goodness of fit criteria and properties of the models is given in the diagnostic tests. They consist of the Durbin Watson (DW) test for autocorrelation of the residual, autoregressive conditional heteroscedasticity (*ARCH*) and the Breusch Godfrey *LM* test for serial correlation on the residual.

3.2.5 VECM and Granger Causality

As discussed in previous sections that numbers of the cointegrating vector can be fully identified via using trace and eigenvalue test statistics. The cointegration between dependent and exogenous explanatory variable now exist as presented in Chapter 6. Then it can be noticed that there is at least a single aspect of causality (Granger 1969). The Causality refers to the ability of one variable to predict the other. In Granger (1969) causality test for two variables x_t and y_t involve in the following specification of *VAR* model to be estimated:

$$y_t = c_1 + \sum_{i=1}^n \delta_i x_{t-i} + \sum_{j=1}^n \alpha_j y_{t-j} + e_{1t} \quad (3.7)$$

²⁹ The order of the lag in the *ARDL* frameworks are selected using the four choices criterion. They are Theil (1971) R- Bar Squared criterion proposed by Pesaran and Smith (1994); the Akaike Information Criterion (AIC) proposed by Akaike (1973); the Schwarz Bayesian Criterion (SBC) proposed by Schwarz (1978); and the Hannan- Quinn Criterion (HQC) proposed by Hannan and Quinn (1979). Refer to Pesaran and Pesaran (1997) for the properties of the last three criteria.

$$x_t = c_2 + \sum_{i=1}^n \phi_i x_{t-i} + \sum_{j=1}^n \varphi_j y_{t-j} + e_{2t} \quad (3.8)$$

As also assume that e_{yt} and e_{xt} are uncorrelated white noise error terms. Hence, the series x_t does not Granger cause y_t , if $\delta_1 = \delta_2 = \dots = \delta_i = 0$ while the latter hypothesis is tested using the F - test.

If there is no cointegration between variables of interest than the standard causality test of Granger (1969) can be applied. However, if the cointegration exist, then the causality can be examined by using the vector error correction mechanism (VECM) as formulated below:

$$\Delta y_t = \sigma_0 + \sum_{i=1}^n \sigma_{1i} \Delta y_{t-i} + \sum_{i=1}^n \sigma_{2i} \Delta x_{t-i} + \sum_{i=1}^n \sigma_3 \Delta ECT_{t-n} + \varepsilon_t \quad (3.9)$$

The short term dynamics of the VECM in equation (3.9) can be tested using the Wald test ($\chi^2 test$) with the hypothesis that the set of parameters is simultaneously equal to zero. If the test fails to reject the null hypothesis this suggest that removing the variables from the model will not substantially harm the fit of the model itself. The long term causality is tested by examining whether the error correction term coefficient σ_3 in the model is statistically different from zero. This confirms that the respective EC term is significant with expected negative sign in their own equation. In essence, this test is vital to explore the endogeneity problems in the system (Kumar, 2011).

3.2.6 Data: Sources and Construction

This paper covers 41 annual observations which were started from 1970-2011 to account on the impact of health indicators for the country economic activity. The data were extracted from the various sources, including the data for GDP was sourced from National Account Main Aggregates Database of the United Nations Statistics Division. All monetary variables have been converted to constant 2005 prices in US dollar.

The data for labour stock was proxies by using working age population (between 15 years of and 65 years old) and were acquired from the World Bank under the World Development Indica-

tor web site. The definition of labour force is succinct and is clearly that people at the age between 15 to 65 are either employed or unemployed. The human capital variable in this paper is considered to be equivalent to average years of secondary schooling. The average year of attainment was employed to account on the impact of educational level of human capital on Tonga's economic growth and the productivity growth. This data were obtained from Barro and Lee Educational Attainment Dataset.

The construction of capital stock variable was using Perpetual Inventory Method (PIM). The data for investment was proxied using gross fixed capital formation (GFCF). The GFCF was formerly known as gross fixed investment which include land improvements (fences, ditches, drains and so on); plants, machinery and equipment purchases; the construction of roads, schools, offices, hospitals, private residential dwellings and commercial and industrial building. The variable construction is conducted to generate stock of capital. A standard PIM was employed as given below:

$$K_t = K_{t-1} + I_t - \delta K_{t-1},$$

where K_{t-1} is the stock of capital at period $t-1$, I_t is the gross fixed capital formation at period t , and δ is the depreciation rate. The capital stock series are estimated with the assumption that the depreciation rate is 4 per cent and the initial capital stock is 1.24 times the level of GDP; see Rao, Singh, Sharma and Lata (2007).

The infant mortality rate, life expectancy, fertility rate, age dependency ratio and trade openness were taken from World Bank (World Development Indicator) database. Infant mortality rate as formally defined by the WHO as the number of infants dying before reaching one year of age, per 1,000 live births in a given year. There are different types of mortality, however, this paper opt to focus on the infant mortality³⁰. The life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. The variable fertility rate represents the number of children which would be born to a woman if she were to live to the end of her child bearing years and bear chil-

³⁰ IMR has been criticised as a measure of population health because it is narrowly based and likely to focus the attention of health policy on a small portion of the population and exclude the majority. Reidpath and Allotey (2003) suggested the comprehensive measure such as disability adjusted life expectancy (DALE) have come into favour as feasible alternatives. This is more comprehensive measure of population's health. However this is complex for small poor resources country like Tonga but DALE is a better measure of population health than IMR.

dren in accordance with current age specific fertility rates. The age dependency ratios formally define by the WDI as the ratio of dependent- people younger than fifteen or older than sixty four- to the working age population. Data are shown as the proportion of dependents per 100 working age population. The explanatory variable trade openness is the summation of export and import as a share of gross domestic product.

3.3 Conclusion

The main focus of this chapter has been to articulate ways of exploring the interrelationship between health and economic growth, to be more precise, the relationship between life expectancy, infant mortality, fertility rate and economic growth and the causal direction during a specific period of the study. Recent contributions on Econometrics show that most macroeconomic series is non-stationary. One solution to overcome this anomaly is to employ a cointegration analysis. The econometric approach of cointegration has obtained much attention in academic literature since the concept was articulated formally by Granger (1981). Thus, in this study investigates the co-movements of the variables simultaneously by employing a time series approach.

In time series modelling as an alternative to single and simultaneous equation modelling, *VAR* model has now become an integral part of Econometrics. This concept arose as a result of the inherent problems associated with the model specification, and this approach allows data to speak for themselves rather than the researcher specifying the dynamic structure of the model (Gujarati, 1995). This study considers the *VECM*, a variant of the *VAR* framework to test research problem highlighted in Chapter One.

The major advantage of *VAR* is its simplicity in specification and estimation. Moreover, it is useful in analyzing all the variables symmetrically. In spite of the *VAR* framework's simplicity, it does have some limitations such as the choice of lag length, the difficulty of ensuring stationarity of all the parameters employed. The proposed estimation procedure, *ARDL*, is applied to investigate the hypothesis set out in Chapter One. The variables were selected depending on data availability and models' appropriateness of the economic setting of Tonga. The related secondary data for various data construction were collected from various sources. The outcomes of these models are discussed in the next chapter.

CHAPTER FOUR

HEALTH AND ECONOMIC GROWTH

4.1 Introduction

Researchers of the subject implicitly examine the significant impact of economic growth as well as the health of the economy at large. Individual researchers such as Wang (2011), Mayer (2001), French (2012) and Morand (2005) among others, have conducted intensive research into the significant relationship between economic growth and health. International organizations and foreign donors have also shown increasing interest in the subject, especially in developing countries and OECD countries. These organizations include the World Health Organization (WHO), World Bank, Asian Development Bank (ADB) and the United Nation Development Program (UNDP) have worked collaboratively with Pacific Island Countries (PICs). Their interest is restricted to the main channels that connect health to economic productivity, from good health to gain better education, from good health to sustainable growth and high living standards. These areas in the current literature are so important for small PICs.

In a similar vein, the Government of Tonga Strategic Plan Development Eight 2006/07-2008/09 and 2011- 2014 have also emphasized the importance of health status and better living standards. The Plan states that this also emphasize the importance of healthy households nexus to the socio-economic development and economic growth³¹ (MOF, 2011). The Tongan government is committed to support the private sector through healthy households because they argued there is a strong impact of health on economic growth.

This chapter builds on from the previous chapters and provides a brief overview of economic growth and some related theories. It then focuses on the relationship between health and economic growth and integrates the role of human capital in economic growth by reviewing the health- growth literature. By doing so, this chapter also reviews how the responsiveness of

³¹ The Tonga Strategic Development Framework (TSDF) 2011-2014 stated succinctly the outcomes objectives related to the nexus between private sectors and economic growth: The dynamic public and private sector partnership as the engine of growth, by promoting better collaboration between government and business, appropriate incentives and streamlining of rule and regulation. (see more of the Objectives and Vision stated in this TSDF 2011-14, MOF (2011))

prominent researcher in the analysis of health and economic growth. The causal relationship between health expenditure, various health indicators and GDP is also reviewed before concluding the chapter.

4.2 Overview of economic growth/development

Economic growth has multi-dimensional implications on the economy per se. It enhances living standards, generates more employment and helps to improve infrastructural development in health sectors, specifically and leads to improvement in the quality of life of people. These long theoretical assumptions have been empirically established as the nexus between health inputs (e.g., health expenditure) and Quality Adjusted Life Year; see Singer et al., (1995 & 1998) and Nixon and Ulmann (2006). In simple language, economic growth is the process of increasing the productive capacity of the economy as a result either increasing national income or total accumulation of output over a period of time.

4.3 Theories of Economic Growth

Economic growth began in ancient time about 3000 BC, where humans living in the Nile Valley and at the mouth of the Euphrates and Tigris Rivers had made many technological innovations that brought tremendous impacts in living conditions. History also suggests that it was a war that drove the inhabitants of this region to invest more in technology (Sabillon, 2008). The historical and archaeological evidence shows that from about 3000 BC to 1000 BC, the Middle East had much higher levels of manufacturing and the fastest rate of economic development in that time³². The long schedule of history and the development of the theoretical concept of economic growth has popularized in the work of Adam Smith, Thomas Malthus and David Ricardo. However, Adam Smith had introduced that production can be expressed as a function of capital, labour and natural resources (or land). Later, researchers on economic growth have experienced a boom, beginning with the work of Romer (1986). The new endogenous growth theories have focussed on productivity advance that drive the technological progress and the importance of boosting human capital in the form of education; see Barro (1996). An area that has lacked atten-

³² 2 Ibid., p. 75, 110. *The Cambridge Economic History of Europe* Vol. II, p. 21, 28.

tion in the sphere of growth theory was the dual interaction between health and economic growth. The notion of capital in the neoclassical model can be usefully broadened from physical goods to include human capital in the form of education, formal training, research and development, work experience and health.

The extension of the neoclassical Solow (1986) model to include human capital as an additional factor input in the original production function; see Mankiew et al., (1992). However, in their extended neoclassical model explained about eighty percent variation in the growth rate in their cross country sample. In regard to Schumpeterian approach, growth is characterized by the initial endowment of human capital, which impacts a country's capability to innovate and to catch up on the technology of the industrialized countries (see Nelson and Phelps, 1966; Benhabib and Spiegel, 1994; Howitt, 2005).

The empirical research on human capital has inevitably been focussed on education for a very long time (for example, Psacharopoulos & Schultz, (1984); Barro, (2000); Bloom, Canning & Sevilla, (2004); Nelson, & Phelps, (1966); Lau et al., (1993)). Some researches carried out on the relationship between health and economic growth found a significant positive relationship between health and economic development. The model that incorporates human capital specifically health was found to be a crucial variable for capital in Akram et al., (2008); Bloom et al., (2004); Weil (2007); Arora (2001); Malik (2006); Sachs (1997); Bloom et al., (2001); Barro (1996) and Barro & Lee (1994). Other related approaches were found in Bloom et al., (2004) who have investigated also the effect of human capital on economic growth. Recently, the endogenous causality between health indicators and economic growth has been one of the focal point of interest for many researchers in the health economics discipline (such as Devlin and Hansen, 2001; Balaji, 2012). Most of the approaches are used to investigate the relationship between health and economic growth have employed panel data analysis rather than a time series framework.

Different approaches to economic growth result in different answers to the question of how health conditions affect a country's economic performance over a period of time. Howitt (2005) provides a simple version of the Shumpeterian growth theory and raise six different channels

through which population health impinges on long run economic performance. He suggests the following six aspects³³:

1. productive efficiency - healthier workers are more productive since they tend to have more strength, attentiveness and stamina;
2. life expectancy – if there is an increase in life expectancy this would be reduced the skills-adjusted death rate and hence raise the total productive worker then it has a positive impact on the aggregate output level of the country;
3. learning capacity – individuals are well nourished, vigorous and alert will gain more from a given amount of education than children who are malnourished;
4. creativity – individuals who are in good health have more likely to be more efficient in producing new ideas on research and development and work effectively;
5. coping skills – good health generally enable people cope better and resilience faster in stress situation and adapt to the disruptive and stressful impacts of technological change; and
6. inequality – an improvements in health may lead to a reduction in inequality and this lead to equal economic advantages via the increase in education received by people who get equal opportunities for education.

4.4 Sources and measurement of economic growth

There are many factors that contributed to the economic growth of a country. In general, if economic growth takes place, a country must either be able to acquire sufficient endowments or discover a more efficient channel by using the existing resources to avoid waste and unsustainable utilization of resources. The crucial ingredients of sustainable economic growth are increases in the supply of labour stock, improvements in physical and human capital stock and increases in productivity brought by technological progress. Changes in supply factors are the largest impacts on economic growth.

Classical economists of the time such as Adam Smith (1776), David Ricardo (1817), Thomas Malthus (1798) and much later Frank Ramsey (1928), Allyn Young (1928), Frank Knight (1944) and Joseph Schumpeter (1934) have provided basic ingredients that appear in modern theories of

³³ See Howitt (2005:14) have thoroughly articulated in more details of these channels.

economic growth. These ideas included the basic approaches of competitive behaviour and equilibrium dynamic, the role of diminishing returns and its relation to the accumulation of physical and human capital, the interplay between per capita income and the growth rate of population, the impacts of technological progress in the forms of increased division and specialisation of labour and discoveries of new goods, discoveries of novel production method and the role of monopoly power plays as a crucial incentives for technological improvements (*see* Barro and Sala-i-Martin, 2004)

Following from the above mentioned concepts, it can be noted that human capital is an integral element of economic growth. The investment in human resources has taken a center stage in the study of developing countries; *see* Strauss and Thomas, (1998). They further noted that since investment such as schooling or a formal education/research and development is a form of human capital, one might expect it to be also related to labour market access which eventually leads to economic success. Furthermore, the connection between health as a source of human capital and economic development have not received much critical attention in the literature; although in the past two decades, there have been a considerable improvements in the way that researchers have been trying to shed light on the complex interrelationship between health and other indicators (e.g., health expenditure, nutrition, economic development).

4.5 Nexus between health, health expenditure and economic growth

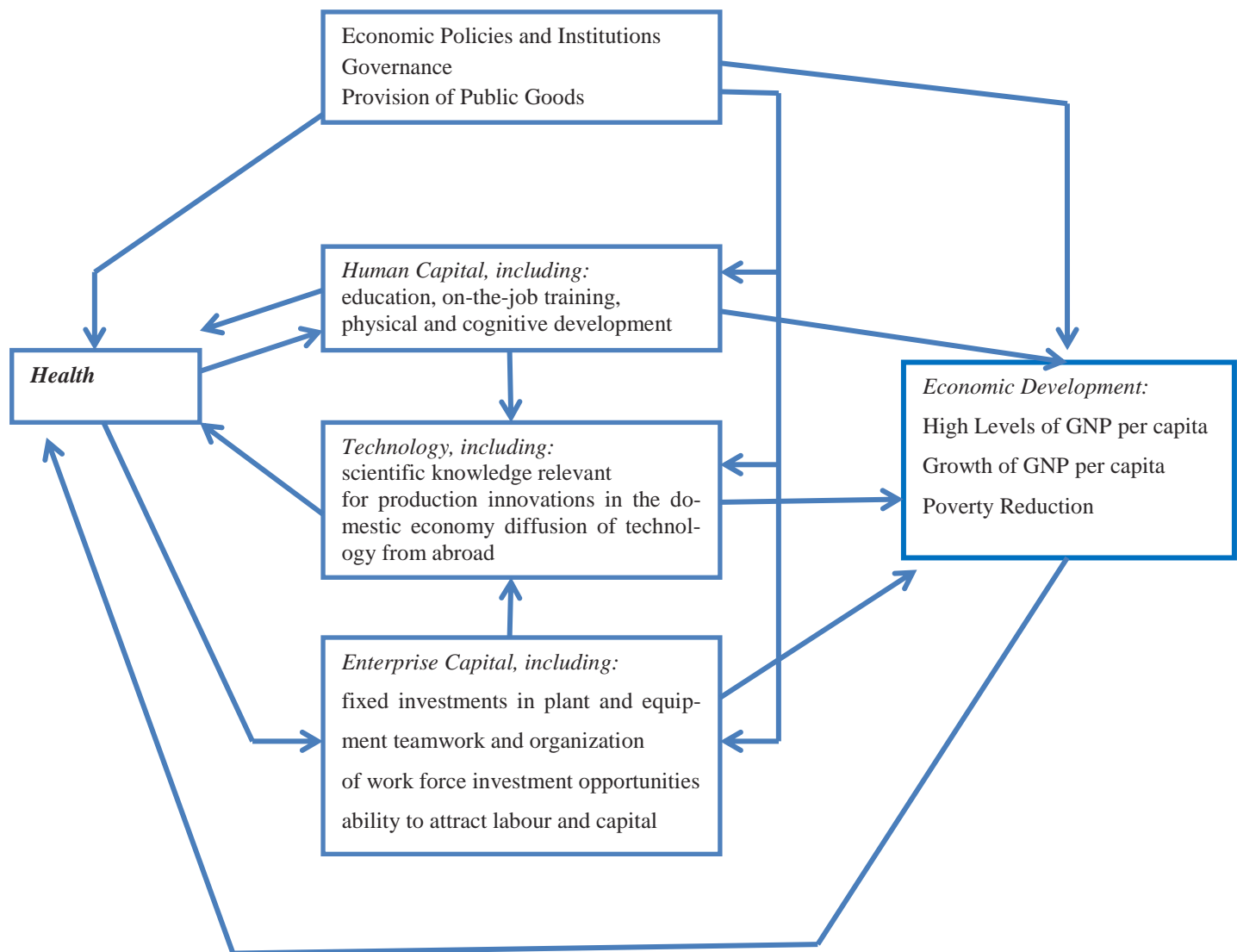
There has been a substantial literature investigating the causal effect of health and GDP, whereby the health variable has been measured using different indicators according to its environment and nature of economic status settings³⁴. For example, in Akram et al., (2008); Malik, (2006); Pritchett and Summers, (1996) have used infant mortality as their health indicator to account for its effect on economic growth. Some researchers used total fertility rate as their health indicator (e.g., Tallin, 2006; Bhargava et al., 2001). The life expectancy seem as the popular indicator of health often employed in time series approaches and also the panel data approaches to measure its impact on GDP. This includes the following: Akram et al., (2008); Bloom et al., (2004); Weil, (2007); Arora, (2001); Malik, (2006); Sach, (1997); Bloom et al., (2001); Barro, (1996); Caselli,

³⁴ Data unavailability for health is one of the crucial impediments that confronted with health economics researchers especially for less developing countries.

Esquivel and Leford (1996). Health expenditure and health expenditure as a share of GDP indicator are quite popular in the work of Mehrara and Musai,(2011); Wang, (2011); Narayan et al., (2010); Beraldo et al., (2009); Lago-Penas et al., (2013); Gerdtham et al., (1992); Amiri and Ventelou, (2012). However, the using of probability of survival by age and gender as another approach to measure how health affect GDP (e.g., Mayer 2001) . Moreover, Gerdtham et al., (1989), Li and Huang (2009) employed a novel approach in literature of health economics by using micro data as the number of hospital beds per 10,000 person and number of physicians per 10,000 person as their reasonable proxy for health.

A report from WHO (2001) illustrates the status of health among the many contributors to enhancing economic development. It also argues that economic output is a function of policies and institutions (e.g., economic policies, good governance and supply of public goods) on one hand, and factor inputs (e.g., human capital, technology and enterprise capital) on the other hand. Good policies and institutions are a critical ingredient in which they help to determine both economic performances for any given level of capital and technology accumulation. The implication of health has its own economic effects on human capital and on enterprise capital. Health per se, is affected by the prevailing policies and institutions (e.g., since education promotes health). The multi sectorial relationship is illustrated in Figure 4.1. The contribution of health is not limited to only the health sector alone. One of the most powerful contributors to reduce child mortality, for example, is the literacy of mothers which is the bi-product of the education system and mothers or parents. Safer water and better sanitation reduce the incidence of diarrhea and other disease and are also viewed as a critical input into poverty eradication and long term economic development (World Bank 1999, Smith, 1999; Asafu-Adjaye, 2004).

Figure 4.1 Health as an input into economic development



Source: Report of the commission on macroeconomics and health (December, 2001:26)

4.6 Health and Economic Growth

A body of literature relating health and economic growth has emerged slowly since the early part of the last century. Although, different approaches have also identified several channels through which health affects the level of economic performance of a country. The recent work of Akram,

Padda and Khan (2008) also used the age dependency, health expenditure, life expectancy and mortality rate as a primary measure of health that impact on economic productivity for Pakistan. In their findings, they explicitly noted that all health variables have a significant role in determining the long run implication on economic growth. However, the error correction model reveals that health variables do not have a significant impact on economic growth even though that relationship occurs only on long run phenomena. Malik (2006) focussed on the analysis of health indicators on life expectancy, mortality rate and fertility rate by using a five year dataset of India from 1975-80, 1985-90 and 1997-03. Additionally, he also looks at the impact of HIV/AIDS incidence of economic growth by using growth rates as a proxy for economic growth. The study found that HIV/AIDS was not a factor influencing income, but other diseases could provide a better explanation as to why growth rates change over time. Bhargava, Jamison, Lau and Murray (2001) investigates the impact of adult survival rates (ASR) on GDP growth rates at 5 year interval for 92 countries. The result shows that ASR is a significant predictor and positively correlated with economic growth. Other variables included in the studies are trade openness and the ratio of investment to GDP. The result shows that openness of the economy was positively associated with the growth rates as well as the investment/GDP ratio. Similarly, Currais and Rivera (1998) identified the role of health status on productivity. In the study, they explore the existence of the reverse causation suggested by a previous study. Currais *et al.*, (1998) employ the Hausman Test and various sets of instrumental variables were used as exogenous determinant of health expenditure. The result shows that health affects income growth both positively and significantly. Nevertheless, the possible presence of endogeneity could have biased the results observed.

Numerous studies have been conducted on the relationship between economic growth and health, however the findings are controversial. Based on a study implemented in some Asian countries having 24 years of continuous annual data, Djafar and Husaini (2011) found the results which show that Asian countries are proportionally distributed into four major cycles: virtuous, vicious, health lopsided and economic growth lopsided cycle. Lower middle income countries have the most dynamic cycle since they are distributed into all four cycles, while the other countries are only distributed into two cycles. Djafar *et al.*, (2011) also tested the causation between economic growth and health. The finding shows that the causality between economic growth and health is more likely to occur only in the long run rather than in the short run. Moreover, the causality be-

tween economic growth and health vary across countries. Hence, Djafar *et al.*, (2011) tends to conclude that Asian countries should concentrate in the long run causality running from economic growth to health rather than vice versa. Preston (1975) shows a direct relationship between a country's GDP and the life expectancy of its population. The study shows that infant mortality, life expectancy and general health improve as per capita income rises specifically among nations with the lowest per capita income. The result shows that the income elasticity of child mortality rates has been estimated within the vicinity of -0.2 and -0.4 indicating that 10% increase in per capita income is associated with a 2% to 4% fall in child mortality (*see* Pritchett and Summers, 1996). Similar results emerged in the Commission on Macroeconomics and Health (CMH, 2001) indicates that a 1% increase in per capita income in developing countries may result in as many as 33,000 fewer childhood deaths each year. Sorlie, Backlund and Keller (1995) suggests that people with higher income and better overall social economic conditions have on average better health outcomes than do less affluent individuals. Sorlie *et al.*, (1995) found that men in the United States with family incomes in the top 5% of the income distribution have a life expectancy that are 25% longer than do those in the bottom 5%. Chang, Cosby and Mirvis (2008) describe the nexus of how health may also lead to wealth. The study shows that illness and death is the common causes of increasing poverty in the world and the economic consequences of illnesses are among the leading causes of personal debt in the United States. Improved health that prolongs working years also promotes income growth by extending the duration of economic productivity. Better health is associated with better quality of life and may boost economic value of raising economic productivity.

More recently, Majdi (2012) has implemented a study on how health care cost affects GDP per capita for 15 countries of the north and south banks of the Mediterranean during the period of 1990-2008. The result shows that health care costs are positively correlated with economic growth. The estimation gives a modulus of elasticity of the growth on GDP with regard to health care cost of 0.86 in the countries of the Northern Bank Mediterranean and 1.2 in the countries of the South Bank Mediterranean. Majdi (2012) also includes other variables, similar to previous studies such as Preston (1975) and Malik (2006) that are basically focused on life expectancy, mortality rate and the implication of human capital (education) on economic growth. The result also indicates that none of the explanatory variables are negatively correlated with the per capita GDP. An increase in the life expectancy of 10% generates a rise of economic growth by 18.9%.

Similarly, an increased rate of schooling by 10% is associated with a rise in the growth of the GDP per capita of about 7.7%. Bloomington, Canning and Sevilla (2001) formulate the effect of health on economic growth by using microeconomic data from 1960 to 1990. The model in this study employs the production function as adopted in the Solow model with output expressed as a function of total factor productivity, capital stock and human capital. Bloomington *et al.*, (2001) adds new variables in explaining human capital that correspond to work experience plus health; whereas life expectancy is used as a proxy for health. This study has found consistent with the microeconomic evidence that health has positive and statistically significant effects on economic growth. It also suggests that a one year improvement in a population life expectancy contributes to an increase by 4% in output. This is a significant large effect indicating that increasing expenditure on improving health might be justified clearly on the ground of its impact on labour productivity.

The conceptualization of the impact of health on income and vice versa is still debatable in most academic journals. Mayer (2001) reveals robust evidence that there exists a long term conditional Granger causality from health to income in modern economic development. The findings show that health improvements in the 50-70 years age group can contribute importantly to income growth. This means that healthier grandparents may also contribute to strengthening the economy of younger families, reducing the burden on young adults. The result relates to the probability of survival by age and gender group and indicates that contribution of health to economic performances are considerable and should be taken into account by policy makers.

Following the same variables employed in earlier studies (*for example*, Preston, 1975; Malik, 2006; Bhargava *et al.*, 2001), Weil (2007) adds foreign variables to the literature on economic growth by using the average height of adult men and age of menarche as a reasonable indicator of health status. The basic idea of using these new variables is that menarche serves as a good indicator of malnutrition for infant age groups and childhood. As the country grows wealthier, girls reach menarche earlier. The result shows health has played a slightly larger critical role, such as minimizing demand for health care services and fosters role involvement when young stayed healthy. Thus, the conclusion is that health is an important determinant of income variation in cross country regression.

4.7 Role of human capital and economic growth

Human capital (educational attainments or health indicators) of the labour force affect the aggregate output. Mankiw, Romer and Weil (1992) have modelled technological progress or growth total factor productivity as a function of the level of education. Ideally, an educated labour force is more likely for inventing, creating, implementing and adopting new technology thereby generating growth. This role of human capital may be as an engine for attracting other factor such as physical capital, which also contribute to per capita income growth. Lucas (1988) also suggested that physical capital fails to flow to poor countries because of their relatively poor endowment of complementary human capital.

Researchers of the subject have identified several channels through which health affects the level of output in a country. One channel is that healthier people are better workers. They spend more time and work harder in the work force and think clearly. Beyond this indirect channel of health, the improvements in health raise the incentive to acquire schooling since the investment in schooling can be amortized over longer working life. Healthier individuals also have less absenteeism and thereby higher cognitive function and hence receive a better education for a given level of schooling. The reduction in the rate of mortality may also lead people to save for retirement, thus raising the level of investment and physical capital per worker (Weil, 2007).

Undoubtedly, the significance of health in the growth process has gained a tremendous attention in the literature. The importance of human capital as a productive element in the production process in terms of education is noted by Lucas (1988). Grossman (1972) noted also that good health contributes to better economic performances of the workers and thereby increase the labour productivity growth. In addition, health is a pure complement to growth; better health and economic growth shall be a two sides of the same coin.

The labour share in the national income is about two-thirds in most countries. Labour thus contributes the most significant ingredient of the factors of production. The changes in its productivity can significantly affect aggregate income. Therefore, the productivity of labour is a function of two types: the skills of workers, which derive from their innate physical and mental capabilities, education through training and other investment in their human capital; and the efficiency of labour organization and management. As such, improvements in health can also affect labour

productivity through both these two channels (Jack, 1999:41). Li and Huang (2009) investigate the impact of health investment on economic growth by using two proxies to characterize health: one is the number of hospital beds per 10,000 person; another one is the number of doctors per 10,000 people (which they assert is absolutely adequate to measure the impact of health on the economic growth of China³⁵). The results show a positive impact on health and education on economic growth as well.

The quality and quantity of human capital, which also act as a fulcrum in the production process of any economy. The better the health of its population, the more likely a country is to enhance its economic performance. The lowest mortality rate indicates a greater contribution for labour force participation rate, and greater contribution toward economic activities. In addition, a reduction in morbidity rate decreases the absenteeism of workers and thereby increases productivity leading to an improvement in economic growth.

An economy with high economic activity also generates more jobs and usually per capita income increases. This increases the ability of the consumers to spend on a better and adequate health care services and furthermore, health status improves. With the highest per capita income persons are more likely to meet their nutritional needs and thereby decrease health related problems. Pritchett and Summer (1996) confirm that increases in a country's income will tend to raise health status. A similar approach finds that wealthier is indeed healthier, but how much healthier depends on how the increase in wealth is distributed; see Biggs et al., (2010). It is also true that higher per capita income countries is associated with increasing tax revenue for the government. Therefore, this has an impact on government revenue in the form of government budget allocated for respective government ministries such as health and educational sectors³⁶.

It also argued that health, economic growth and social development are highly correlated to one another. Healthier population contributes positively to economic and social development while economic development tends to improve standard of living. Nevertheless, it is assumed that the greater health expenditure spend on health of its citizens the higher the social and economic improvement and prosperity of its country. In some studies they have explored there is a robust

³⁵ A panel dataset of 28 provinces in China with time span from 1978 to 2005 to study the relationship between human capital and economic growth in China.

³⁶ For example the total budget estimates 2013-2014 for Tonga Ministry of Health (MOH) is TOP 30 million, TOP 41 million for Ministry of Education & Training (MOET) this compare to 2012-2013 budgets estimates for MOH was TOP27million, TOP46 million for MOET; see MOF (2012& 2013)

connection between income inequality and the residential concentration of poverty and affluence society. Residential segregation diminishes the opportunity for social cohesion. This phenomena is ideally obvious in the experience of the researcher in small Island countries such as Fiji and Tonga (Kawachi and Kennedy, 1997).

Recently, New Zealand Ministry of Foreign Affairs and Trade (MFAT, 2010) identifies other connections between health and economic development:

1. improved learning – improved nutrition and reduce disease, specifically on early childhood may lead to improved cognitive development and children will gain more school with less days absent due to ill health;
2. health and investment – employers tend to invest when the workforce is healthier or better educated;
3. increased availability of land for productive use – eliminating particular illnesses may allow cultivation or other use to be made of previously unused land; and
4. reduced treatment burden – initiatives that prevent certain illness or provide for their early stage treatment can reduce and avoid the major downstream cost associated with illness and subsequent complication.

As previously mentioned, improved health outcomes, reduces the depreciation rate of human capital, which also makes investment in education more attractive and thus economic development (Mayer, 2001; Asafu-Adjaye, 2004: 204)

4.8 Causal relationship between health expenditure and economic growth

Public health spending has become a crucial spending in any government budget allocation, particularly in less developing countries because of the health related issues discussed in the previous section. In practical perspective, this is due to the fact that higher significant portion of

health costs is associated with curative instead of preventative services³⁷. This view is consistent with Zon and Muysken (2001) and largely due to the ageing of the population.

Recent statistics from WHO (2013) indicated that the aggregate health expenditure as a share of GDP shown a general tendency to rise in the Western Pacific Region³⁸ compared to other regions. This brought attention of many researchers in analyzing the causal relationship between health expenditures (or other health indicators) and economic growth and this has been a critical subject of extensive literatures in health economics. The reviewed literature on the subject mostly investigated the causal relationship between health expenditure and GDP in developed countries whereby a strong positive correlation exists between them in most cases (e.g., Erdil and Yetkiner, 2009; Devlin and Hensen, 2001). Nevertheless, there has hardly been any research done in developing countries using these two variables. Possibly this reason is due to the lack of data availability as a result of poor data management in small island countries³⁹.

Recent work by French (2012) found that better health improves income more generally while income in turn also affects health. Theoretical perception of the subject of the relationship between health expenditure (or health indicators) and economic growth (GDP) indicates there must be a bidirectional relationship. Erdil and Yetkiner (2009) investigates the Granger causality relationship between real per capita GDP and real per capita health care expenditure using a large macro panel data analysis. The findings verify that the dominant type of Granger causality is bidirectional. The analysis show there exists one way causality generally running from income to health in low and middle income countries whereas the reverse holds for high income countries. Following the previous work by Grossman (1972) and Van Zon and Muysken (2001) health expenditure can be examined as a form of investment in human capital. Hence, human capital has been regarded as an engine of growth (see Lucas 1988; Edil and Yetkiner 2009). Consequently, an increase in health expenditures were ultimately lead to an increase in economic growth. Similarly, higher health care spending enables higher labour supply and productivity, which results

³⁷ Curative Care: outpatient consultation and emergency services, conduct hypertension and diabetic clinic once a month, postnatal care and dental care; Preventative care services: delivery of health education services, home visits, immunization programs for schools, village inspection, retail and food stores inspection and engage villages and youth committee's in health related activities (MOH, 2003)

³⁸ Total expenditure on health as a percent of GDP for Western Pacific regions were raising to 6.4 per cent in 2010 compare to 5.9 per cent in 2000 (see WHO, 2013:140).

³⁹ According to Soakai (2006: 104) this shown in the situation of Fiji and Samoa with health information systems, and recognize that decisions that are made on poor information give poor results. So we want to ensure that we have an information base that is reliable, accurate and also timely.

in higher income. Therefore, theoretically, the causal relationship between health care spending and GDP could be either or both directions.

It is commonly believed that economic growth enables people to live better, longer lives and enjoy good health. First, economic growth implies rising per capita income and part of this increased income is translated into the consumption of higher quantity/quality of nutritious food, better medical services and the like. As a result, health- as measured by life expectancy, improves with an increase in income (Fogel, 1997)

An example of an empirical test has been carried out by Devlin and Hensen (2001). They tested the Granger causality between health expenditure and GDP by using annual OECD data from 1960-1987 and concluded that there would be Bi directional Granger causality between health expenditure and economic growth (GDP). Similarly, Erdil and Yetkiner (2009) applied the Granger causality framework to nineteen low- income, twenty two lower middle- income, ten upper- middle income and twenty four high income countries from the period 1990-2000. They have concluded there is one way causality, the pattern of causality is different in lower income countries and middle income countries as compared to high income countries. One way causality generally runs from GDP lower income countries and middle income countries, whereas the reverse holds for high income country.

Dreger and Reimers (2005) explore the link between health expenditure and GDP for a sample of 21 OECD countries using the recently developed panel cointegration technique. In contrast to previous studies, the analysis considers the fact that health care spending is not only determined by income. However, there are some additional driving forces in the medical progress which is proxied by various variables such as life expectancy, infant mortality to examine its causal impact on economic productivity. Similar studies found in Hansen and King (1996) conducted a country by country unit root test prior to the cointegration tests and indicated that panel data estimates of the GDP and the health spending relationship may be spurious. Blomqvist and Carter (1997) later conclude that there is a significant cointegration among health spending and GDP. Murphy and Okunade (2000) model the total aggregate health care spending by using 1960-1996 for United State data and conclude the existence of the stable, long run relationship between aggregate health care spending and GDP, population age distribution, managed care enrollment, the number of practicing physicians and government deficits. Roberts (2000) found no conclusive

evidence to support the presence of a cointegration relationship between health care spending and GDP. MacDonald and Hopkins (2002) account of the unit root properties of health care spending and GDP for OECD members. The evidence establishes that when the data are considered as a panel there exist a strong evidence of unit root for both GDP and health care spending data.

4.9 Causal relationship between life expectancy and economic growth

A large amount of literature now exists on the cross national correlation between income and population health through life expectancy, unfortunately they find it very difficult to be certain about the robustness of their estimates in the reported studies. Barbones (2008) and Wilkinson (1994), suggested that the change in inequality is significantly related to a change in life expectancy and infant mortality, also suggesting a causal relationship. However, these correlations are not robust with respect to sample or control. It can be concluded that there is a strong, consistent, statistically significant correlation between income inequality and population health, but though there are some evidences that this relationship is causal. The relative stability of income inequality over time in most countries makes causality difficult to test. In support of the above mentioned arguments Acemoglu and Johnson, (2006) findings were consistent with the fact that a large part of the variation in life expectancy during the sample period is exogenous, driven by the epidemiological transition, so the upward bias in the estimates resulting from reverse causality and common shocks to income per capita and health. Webber (2002) also argued that life expectancy can be influenced by various factors other than health care, such as religious objections to blood transfusions; the limited access to medical care of females in some Muslim countries; economic factors such as purchasing power; and geographical considerations including natural geological and meteorological disasters. This is because these variables measure the symptom and not the underlying cause factor and thereby it is difficult to assess any causal relationship among the variables. Contrary, Dowrick, Dunlop and Quiggin (1998) indicate there is no reason to expect a causal relationship between life expectancy and output per se. Any relationship must arise from increased consumption of specific goods and services.

4.10 Causal relationship between fertility rate and economic growth

The relationship between population health and economic growth has been subject to debate for hundreds of years⁴⁰. The most influential school of thought is the so-called “Malthusian school” that asserts that given limited resources, population growth may hamper economic growth. Alternatively, another school called the “Neo Boserupian” school of thought is more optimistic (Boserup, 1981). It argues that population may have a scale effect that is beneficial to economic growth. Economic growth can also affect fertility because with more income, parental human capital spurs and hence raises the return on investment in human capital of children relative to investment in the number of children. Also, Galor and Weil (1996) show that with growth, the real wage of women rises, which leads to lower fertility. Similarly, a high fertility rate among poor households is also likely to generate and reduce investments in education per child - this phenomena is known as “quality-quantity trade-off”. A high fertility environment can also entail especially the large human capital cost for women. When women have higher fertility rates, therefore parents may opt to invest less education for their children and therefore in the long run would contribute less return to economic growth of the country (Sachs and Malaney 2002). Yamata (1984) also believe that the decline in infant mortality that is merely due to an increase in per capita income triggers a subsequent decline in fertility rate. This dynamic relationship among fertility rate and infant mortality rate lies in the heart of the so called “demographic transition”. Ahituv (2001) argues that families with low levels of human capital choose to have more children; also income per head in developed countries grows faster than in developing countries. Finally, his study found that for the estimates of the interplay between fertility and output obtained the regressions are biased downward.

⁴⁰ The debate started after Malthus published his famous book *An Essay on the Principle of Population* in 1798.

4.11 Conclusion

The main purpose of this chapter was to review and identify related health issues that are linked to health and economic growth. Researchers have opted various methodologies, health indicators from different time period, depending on the availability of the data set. The importance of adopting the most appropriate research method was based on reviewing the literature that revealed the vital connection include the issues of related diseases such as NCDs (Communicable Diseases) that are also a major contributing factor that impacted the health status of any country. At this juncture, this would be affected the socio-economic development in Tonga as well as in the PIC health status.

In so doing, a review of related issues in literature was also conducted to identify types of health indicators and methodologies are previously used by researchers in health economic development areas especially in the nearby region. It was revealed that most of the notable research in health and economic growth issues largely specialize in panel data analysis and mostly in the industrialized countries and employed different forms of quantitative approach for their research purposes. There are few studies have focussed on a time series approach. On balance, however the adoption of both approaches is also leaving it for the preferences of the researchers and the availability of the data.

Despite the related measures used by previous researchers, there is a related indicator of health which are always found their positive contribution to economic growth that is health expenditure. Thus, the health expenditure data that I have collected from the Vaiola Hospital was missing more than ten years. In that stance, I also ignore this variable while looking for consistent and continuous data set as employed in this analysis.

Health can impact productivity and economic growth in multi dimensions. It is more common that a healthy labour force may be more productive because workers would have more physical and mental capabilities and be absent from work less often. Healthier workers normally have longer life expectancy than unhealthy ones and may consequently induce to invest more on education, hence, may receive greater returns to economic growth.

The conceptual models based on this framework have been structured to investigate various hypotheses that have been set out in Chapter One. Since the analysis involves time series data and it

is important to employ the appropriate estimation framework to overcome the problems of spurious regression. The proposed estimation procedure, *ARDL* and *VECM* are applied to investigate the hypotheses set in this chapter. Time series data covering the period 1970-2011 are used. The variables are selected depending on the data available and the model appropriateness to Tonga economic setting. The outcomes of these models are discussed in Chapter Five.

CHAPTER FIVE

RESULTS: THE IMPACT OF HEALTH ON ECONOMIC GROWTH

5.1 Introduction

The econometric models developed in chapter four considered the hypothesis set out in chapter one. This chapter presents the main result, statistical properties and interpretation of those estimated models. The general theoretical models have been subjected to more specific modelling and were employed to measure the implication of health on economic growth in the Kingdom of Tonga.

As the time series dataset have been employed in this empirical work, it is imperative at first hand to test the stationary property of each variable. Engle and Granger (1987) suggested that if time series are non- stationary, then the conventional hypothesis testing is likely to be not only inconsistent, but also the assumption of the usual asymptotic econometric properties unsatisfied and standard statistical tests will be invalid. Literature of the subject suggested a positive approach on how to deal with non- stationary series data in a sense to avoid spurious and nonsense results in the regression (Gujarati, 2005). Thus the models are estimated using the autoregressive distributed lag (*ARDL*) framework. This approach has several crucial properties such as a derivable long run solution and economically interpretable error correction representation of the specification at the level and the first differences of the variables. The Eviews version 8 computer software has been employed for empirical investigation.

The structure of this chapter is designed as follows: Section 5.2 presents the results from ADF Unit root test follow by the cointegration result test in Section 5.3. The estimation and validation of the econometric models obtained from *ARDL and VECM* framework and the empirical result from the macroeconomic health variable interactive influence on GDP are presented. Section 5.5 considers the direction of causality between health indicators and economic growth with the final remark in the last section.

5.2 Unit Root Test Results

The first task of this analysis is to justify each of the variables, whether it contains unit root in level or not and to re-check the property of stationarity of interest variables. By doing so, it is necessary to identify whether there is a long run relationship amongst the parameters. Hence, knowing the order is so important for optimal inference (Phillips and Perron, 1988). The unit root test results are presented in Table 5.1 based on the Augmented Dickey Fuller (ADF) test. There are some other unit root tests also available in Eviews version 8: Phillips Perron (1988), Kwiatkowski-Phillips- Schmidt-Shin (1992), Elliott- Rothenberg-Stock (1996), Point Optimal and Ng- Perron (1995) unit root test. Nevertheless, to conserve space the focus was on the ADF unit root test. The ADF unit root test also indicates that the null hypothesis – the variables in their levels contains unit root with, intercept but no trend - the null can be accepted. The other option of choosing intercept with linear trends also accepted the null at 5% level. However, proceeding further by transforming the variables into the first difference, the test statistics rejected the null hypothesis for all variables with, intercept but no trend, no further unit root tests are per-

Table 5.1: Unit Root Test

Variables	Test Statistics [p-value]		Variables	Test Statistics [p-value]	
	With inter- cepts but no trend	With inter- cept and trend		With intercepts but no trend	With in- tercept and trend
LY	-1.499[0.523]	-1.843[0.664]	Δ LY	-3.285[0.022]	-3.413[0.063]
LK	-1.275[0.631]	-1.916[0.627]	Δ LK	-3.827[0.005]	-3.868[0.022]
LL	1.294[0.998]	-3.527[0.052]	Δ LL	-7.519[0.000]	-1.716[0.724]
LLE	-0.092[0.942]	-5.825[0.000]	Δ LLE	-2.187[0.214]	-0.282[0.988]
Openness	-2.258[0.190]	-4.042[0.015]	Δ Openness	-7.959[0.000]	-7.854[0.000]
AGEDEP	0.870[0.993]	-7.439[0.000]	Δ Agedep	-4.908[0.000]	-1.499[0.811]
EDU	-2.012[0.280]	-0.129[0.992]	Δ EDU	-5.187[0.000]	-5.574[0.000]
LFR	-0.399[0.899]	-2.150[0.502]	Δ LFR	-2.601[0.101]	-3.533[0.051]
LIMR	-0.510[0.878]	-2.660[0.257]	Δ LIMR	-1.394[0.574]	-1.059[0.922]
5% critical value	-2.9369	-3.5266	5% critical value	-2.9369	-3.5266

Notes: Variables are expressed in log form and Δ indicates the first difference of the variable. Unit root test regressions were run with constant and trend and intercepts with no trend. Legend: LY = Log (GDP); LK = Log (Capital stock); LL = Log (labour); LLE= Log (Life Expectancy); Openness =Openness to trade; EDUSEC= Average year of secondary schooling; AGEDEP= Age dependency ratio.

formed. Therefore, the result shown in Table 5.1 is consistent with the null hypothesis that the variables are integrated of order one $I(1)$. The next step, is to proceed by invoking the Johansen-Juselius co-integration technique to determine the existence of the long run relationship among the proposed variables.

5.3 Cointegration Test Results

As statistically confirmed in the previous section that variables of interest have contained unit root in level and stationary in their first difference. It is important, of course, to determine the lag length of the VAR prior apply the Johansen multivariate cointegration technique. By dealing with this procedure there are two issues that should be considered in this discussion. One is that when keeping adding more lags, this may consequently induce superfluous lags in addition to the correct one and this may result in insignificant and inefficient estimates. Nonetheless, missing the correct lags may result under fitting of the model which is too short and lead to serially correlated errors (*see*, Canova, 1995; Humboldt & Yang, 1998; Liew, 2004). To overcome this problem, several manipulations of the VAR selection of lag length have been estimated. There is no such rule indicated in recent literature as to how many lags should be considered if datasets are collected annually, quarterly or in monthly basis. A pragmatic approach in deciding the optimal lag length is to initially start with the lowest lag and then increase systematically by keeping track of the estimated coefficient and stop adjusting the lag if there is no significant improvement on the estimates (Kumar, 2011). The optimum lag lengths of the vector autoregressive were started with the 3rd order model. A constant term was included in all regression tests. A dummy variable was included that characterizes the socio-political instability of the civil servants, industrial dispute in 2005 lead on to a riot in 2006. The value one was generated on those two years and zero otherwise. Surprisingly, when the dummy variable was tested in ordinary least squares, it does not have any statistically significant impact at a conventional level therefore this was dropped from the specification model. The inclusion of the instability dummy variable is expected to have a significant negative coefficient because riots and political upheaval is likely to escalate further government expenditure for reconstruction of the main capital of Nuku'alofa, borrowing from other international organizations (such as ADB, the World Bank and Chinese soft loan) and other related social-economic cost that may consequently contributed to sluggish growth (IMF 2012).

It should be characterized that employing the Johansen methodology is sensitive to the selection of lag length. Using the linear lag selection procedure based on classical criteria such as the

Table 5.2 Tests for the Order of VAR					
Order	Selection	3	2	1	0
Equation	Criteria				
Equation (5.6a)	AIC	-40.356*	-36.150	-31.306	-16.694
	FPE	3.89e-23*	2.43e-21	2.99e-19	5.57e-13
	SIC	-38.138*	-34.614	-30.453	-16.694
Equation (5.7a)	AIC	-29.897*	-28.879	-26.715	-11.852
	FPE	1.35e-18*	3.49e-18	2.95e-17	8.37e-11
	SIC	-27.679*	-27.343	-25.862	-11.682
Equation (5.8a)	AIC	-34.054*	-29.968	-25.455	-12.856
	FPE	2.12e-20*	1.17e-18	1.04e-16	3.07e-11
	SIC	-31.836*	-28.432	-24.602	-12.686
Notes: Lag length is based on the Akaike Information Criterion, Final Prediction Error and Schwartz Bayesian Criterion. The * indicates lag order selected by the criterion.					

Akaike Information Criterion (AIC), the Final Predictor Error (FPE), Schwartz Bayesian Criteria (SBC) and Hannan-Quinn Information Criterion (HQ) is an adequate measure of model determination. A recent finding by Liew (2004) shows that AIC and FPE are much more superior than SBC under the study in the case of less than sixty observations⁴¹. By doing so, it can minimize the chance of under estimation while improves the chance of recovering the true lag length. In the light of Liew (2004) the AIC, FPE tests had been carried out for various lags structure between one and three lags then the appropriate lag model is selected. In contrast, Judge *et al.*,

⁴¹ Hatemi (2003) argued that Schwarz (1978) Bayesian information criterion and the Hannan and Quinn (1979) information criterion perform better than the other depending on the properties of the true VAR model.

(1988) and Cheung & Lai (1993) suggested that AIC and SIC can be useful for selecting the right lag order for Johansen's tests⁴². The results are reported in Table 5.2. In most cases the application of AIC, SBC and FPE criterion mostly preferred the higher lag length for each equation. The Johansen-Juselius (1990) multivariate cointegration technique was then ap-

Table 5.3 Johansen-Juselius Test for Multiple Cointegration: Equation (5.6a)									
Result of λ_{trace} Test					Result of λ_{max} Test				
H ₀	H _A	Eigenvalue	Trace Statistics	Critical Value (5%)	H ₀	H _A	Eigenvalue	Max-Eigen Statistics	Critical Value (5%)
r = 0*	r > 0	0.8542	132.87	47.856	r = 0*	r > 0	0.8542	73.180	27.584
r ≤ 1*	r > 1	0.6194	59.690	29.797	r ≤ 1*	r > 1	0.6194	36.708	21.131
r ≤ 2*	r > 2	0.4353	22.981	15.494	r ≤ 2*	r > 2	0.4353	21.718	14.264
r ≤ 3	r > 3	0.0326	1.2632	3.8414	r ≤ 3	R > 3	0.0326	1.2632	3.8414
Trace test indicates 3 cointegrating equations at 5% level. The * denotes a rejection of the null hypothesis at the 5 % level									

plied to detect the number of cointegrating vectors (CVs), r, which bind the variables together. This method is convincing because it provides a general framework for determining and examining the cointegrating relationship in the context of the *VECM* framework. Hence, by treating all variables as endogenous, this procedure would circumvent the arbitrary selection of the dependent variable in the cointegrating equations. The results of cointegrating equations (CVs) are reported in Table 5.3 to 5.5. Each equation reported in Table 5.3 to 5.5 has tested the impact of health variables (LE, IMR and FR) on economic growth. Table 5.3 to 5.5 present maximum eigenvalue, the trace statistics at 5% critical value. These tests are performed using the unrestricted intercept (with no trend) in cointegrating equation and in each *VAR* model. This also allows for linear, deterministic trend in the data. Both maximum eigenvalue statistics and the trace test (λ_{trace}) statistics suggest the presence of CVs which can be selected for each equation in the model.

⁴² It is widely believed that strongly consistent lag order selection criteria such as the Schwarz Information Criterion (SIC) and Hannan-Quinn Criterion (HQC) are better suited for the analysis of finite lag order VAR models than the less parsimonious Akaike Information Criterion (AIC). In contrast, for infinite order auto regression, the AIC is regarded as more appropriate (Kilian, 2001).

Table 5.4 Johansen-Juselius Test for Multiple Cointegration: Equation (5.7a)									
Result of λ_{trace} Test					Result of λ_{max} Test				
H ₀	H _A	Eigenvalue	Trace Statistics	Critical Value (5%)	H ₀	H _A	Eigenvalue	Max-Eigen Statistics	Critical Value (5%)
$r = 0^*$	$r > 0$	0.7025	82.283	47.856	$r = 0^*$	$r > 0$	0.7025	46.078	27.584
$r \leq 1^*$	$r > 1$	0.4181	36.204	29.797	$r \leq 1^*$	$r > 2$	0.4181	20.580	21.131
$r \leq 2^*$	$r > 2$	0.3339	15.623	15.494	$r \leq 2^*$	$r > 3$	0.3339	15.442	14.264
$r \leq 3$	$r > 3$	0.0047	0.1811	3.8414	$r \leq 3$	$r > 4$	0.0047	0.1811	3.8414
Trace test indicates 3 cointegrating equations at 5% level. The * denotes a rejection of the null hypothesis at the 5 % level									

Table 5.5 Johansen- Juselius Test for Multiple Cointegration: Equation (5.8a)									
Result of λ_{trace} Test					Result of λ_{max} Test				
H ₀	H _A	Eigenvalue	Trace Statistics	Critical Value (5%)	H ₀	H _A	Eigenvalue	Max-Eigen Statistics	Critical Value (5%)
$r = 0^*$	$r > 0$	0.7972	98.324	47.856	$r = 0^*$	$r > 0$	0.7972	60.638	27.584
$r \leq 1^*$	$r > 1$	0.5243	37.686	29.797	$r \leq 1^*$	$r > 1$	0.5243	28.237	21.131
$r \leq 2$	$r > 2$	0.2158	9.4487	15.494	$r \leq 2$	$r > 2$	0.2158	9.2414	14.264
$r \leq 3$	$r > 3$	0.0054	0.2072	3.8414	$r \leq 3$	$r > 3$	0.0054	0.2072	3.8414
Trace test indicates 2 cointegrating equations at 5% level. The * denotes a rejection of the null hypothesis at the 5 % level									

Again Table 5.3 to Table 5.5 suggest that maximum eigenvalue and trace statistics reject the null hypothesis when $r = 0$ in each equation. Table 5.3 for example, that the hypothesis $r = 0$ is rejected as the computed value of the test statistics (132.87) is greater than the critical value

(47.856). Also signifies that the null hypothesis for $r = 1$ and $r = 2$ are also rejected. Furthermore, the next step also identified that the null hypothesis at most three cointegrating vectors ($r = 3$) also accept the null hypothesis at the 5 % level of significance. Hence, there is adequate information to ascertain that there are three cointegrating vectors. Based on the results, it could be advanced evidence that there are three common factors is driving the entire system equations.

In a similar fashion, the null hypothesis that there is at least one cointegrating vector among variables is accepted for each model. In each models the equation, both the maximum eigenvalue and trace statistics consider a similar number of CVs.

The result reported in Table 5.3 indicates that trace statistics (λ_{trace}) and maximum eigenvalue test (λ_{max}) have three cointegrating vectors. This also implies the existence of multiple long run relationship and the emerging issue of identification of the structural relationship among variables is important. At this junction, one requires to invoke further clarification from economic theory to characterize the feasible cointegrating relationship of interested variables.

In the present study in terms of the growth model reported in Table 5.3 to Table 5.5 the possible relationship that can be expected among cointegrating vectors are analyzed. Moreover, a single equation was employed in order to give signals of the CVs among the growth model. Based on these results this study presumes that CVs captures the long run proportionality between economic growth, labour stock, capital stock, health variables (such as life expectancy, infant mortality and fertility rate). The result shown in Tables 6.2 to 6.4 often suggest that theoretical variables should not diverge from one another. The economic growth, regression relationship with health is just one example.

Now we have statistically established there is a cointegrating relationship among variables as indicated on the results shown in Table 5.3 – Table 5.5, the next step in the model generating procedure requires the construction of the multivariate *VECM* for each *VAR* model generated. By following the general *VECM* equation for each growth model presented in Table 5.3 – Table 5.5 this is corresponding to the error correction model or error correction term (ECT) which is the lagged residual of the cointegrating vector. It measures the deviation of the series from the long run equilibrium relationship.

5.4 The ARDL Results

The results from *ARDL* approach is presented in this section. The dependent variables in the specification are economic growth, which are also regressed on capital stock, labour stock, life expectancy infant mortality, fertility rate, education, age dependency ratio and trade openness. However, most of the variables are also converted into logarithmic form; the coefficients indicate the elasticity of the dependent variable in response to a one percent change in economic growth. As statistically confirmed in the previous section (see Table 5.1) that all variables contain unit root and stationary in their first difference by using the ADF test. The *ARDL* approach does not require pre-testing variables to be done; therefore unit root test could help decide as to whether the *ARDL* model should be used or not.

The next step basically focussed on equation (3.6b) is estimated to examine how to attain the long run relationship among the variables. Since the observation is annual data and one lag is chosen as the maximum lag length in the *ARDL* and estimated for the period 1970-2011. The SIC is used for this purpose to select the order of the lags. The critical value is also reported in Table 5.6 – Table 5.8 based on Pesaran, Shin and Smith (2001) critical value. For practical reasons unrestricted intercept with no trend is chosen and in the second round the unrestricted intercept and unrestricted trend are chosen. The computed *F*- statistics with unrestricted intercept with no trend of equation (5.6a) in Table 5.6 (*F*- statistics = 7.814192) is a bit higher than the upper bound critical value at 5% level of significance (4.35). Similarly the 10% level of significance (5.61) is also lower than the *F*- statistics using the unrestricted intercept with no trend. Moreover, the calculated *F*- statistics (*F*- statistics = 7.576992) is higher than the upper bound critical value both at 5% and 10% level of significance using the unrestricted intercept and unrestricted trend. These results signify that the null hypothesis of no cointegration cannot be accepted at 5% and 10% level and hence, there is a cointegration relationship between explanatory variables and economic growth.

Overall the calculated *F*-statistics from equation (5.6a) – (5.8e) in Table 5.6 to Table 5.8 exceed the upper bound of the critical value of *F*-statistic and therefore the conclusive decision has been accomplished that all variables from equations (5.6a) to (5.8e) are cointegrated. Hence, the *ARDL* procedure can be applied to estimate the equations without the knowledge of whether the underlying variables employed in the models are $I(0)$ or $I(1)$.

Table 5.6: Equations (Life Expectancy)	Unrestricted intercept and no trend ⁴³ (Critical Value of <i>F</i> -Statistics)	Unrestricted intercept and unrestricted trend (Critical Value of <i>F</i> -Statistics)	Significance level
(5.6a) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln LE_t + \varepsilon_t$	4.29-5.61	5.17-6.36	10%
<i>F</i> -Statistics	7.814192	7.576992	
(5.6b) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln LE_t + \alpha_4 EDU_t + \varepsilon_t$	3.74-5.06	4.40-5.72	10%
<i>F</i> -Statistics	6.914478	6.942388	
(5.6c) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln LE_t + \alpha_4 AGEDEP_t + \varepsilon_t$	2.86-4.01	4.40-5.72	5% and 10%
<i>F</i> -Statistics	5.015099	6.914478	
(5.6d) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln LE_t + \alpha_4 OPEN_t + \varepsilon_t$	3.74-5.06	4.40-5.72	10%
<i>F</i> -Statistics	6.184334	6.032581	
(5.6e) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln LE_t + \alpha_4 EDU_t + \alpha_5 AGEDEP_t + \alpha_6 OPEN_t + \varepsilon_t$	2.12-3.23	2.87-4.00	1% and 5%
<i>F</i> -Statistics	3.252091	4.864205	
Legend: Y = gross domestic product; K = capital stock; L = labour; LE = life expectancy; IMR = infant mortality; FR = fertility rate; EDU = secondary education; AGEDEP = age dependency ratio; OPEN = trade openness			

⁴³ See Pesaran, Shin and Smith, 2001

Table 5.7: Equations(Infant Mortality Rate)	Unrestricted intercept and no trend (Critical Value of <i>F</i> - Statistics)	Unrestricted intercept and unrestricted trend (Critical Value of <i>F</i> - Statistics)	Significance level
(5.7a) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln IMR_t + \varepsilon_t$	4.29-5.61	5.17-6.36	10%
<i>F</i> -Statistics	7.658350	7.978871	
(5.7b) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln IMR_t$ $\alpha_4 EDU_t + \varepsilon_t$	3.74-5.06	4.40-5.72	10%
<i>F</i> -Statistics	6.255990	6.336558	
(5.7c) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln IMR_t$ $\alpha_4 AGEDEP_t + \varepsilon_t$	2.86-4.01	3.47-4.57	5%
<i>F</i> -Statistics	4.577425	5.328113	
(5.7d) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln IMR_t$ $\alpha_4 OPEN_t + \varepsilon_t$	3.74-5.06	4.40-5.72	10%
<i>F</i> -Statistics	5.842471	6.288691	
(5.7e) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln IMR_t$ $+ \alpha_4 EDU_t + \alpha_5 AGEDEP_t + \alpha_6 OPEN_t + \varepsilon_t$	2.12-3.23	2.87-4.00	1% and 5%
<i>F</i> -Statistics	3.095214	4.105719	
Legend: Y = gross domestic product; K = capital stock; L = labour; LE = life expectancy; IMR = infant mortality; FR = fertility rate; EDU = secondary education; AGEDEP = age dependency ratio; OPEN = trade openness			

Table 5.8: Equations(Fertility Rate)	Unrestricted intercept and no trend (Critical Value of <i>F</i> - Statistics)	Unrestricted intercept and unrestricted trend (Critical Value of <i>F</i> - Statistics)	Significance level
(5.8a) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln FR_t + \varepsilon_t$	4.29-5.61	5.17-6.36	10%
<i>F</i> -Statistics	5.157580	6.234228	
(5.8b) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln FR_t + \alpha_4 EDU_t + \varepsilon_t$	3.74-5.06	4.40-5.72	5%
<i>F</i> -Statistics	4.487602	5.474045	
(5.8c) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln FR_t + \alpha_4 AGEDEP_t + \varepsilon_t$	2.86-4.01	3.47-4.57	1% and 10%
<i>F</i> -Statistics	3.453771	7.098072	
(5.8d) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln FR_t + \alpha_4 OPEN_t + \varepsilon_t$	3.74-5.06	4.40-5.72	5%
<i>F</i> -Statistics	4.943540	5.036586	
(5.8e) $\ln Y = \alpha_0 + \alpha_1 \ln K_t + \alpha_2 \ln L_t + \alpha_3 \ln FR_t + \alpha_4 EDU_t + \alpha_5 AGEDEP_t + \alpha_6 OPEN_t + \varepsilon_t$	2.12-3.23	2.87-4.00	1% and 5%
<i>F</i> -Statistics	3.381167	4.721340	
Legend: Y = gross domestic product; K = capital stock; L = labour; LE = life expectancy; IMR = infant mortality; FR = fertility rate; EDU = secondary education; AGEDEP = age dependency ratio; OPEN = trade openness			

5.4.1 Empirical Results: Life Expectancy – Growth Model

Table 5.9 provides the established long-run relationship between the variables employed in the model and shows the evidence as a prerequisite for the second stage of the analysis. The fundamental specification was based on the traditional simple growth model⁴⁴: Income or GDP as a function of labour and capital. This analysis also extended the growth model by including one health variable which is the life expectancy. Equation (6.6a.1) incorporates with traditional variables of the growth model with the health variable (life expectancy) to examine whether the magnitude of life expectancy has differing impact on growth.

Equation (5.6a) has been estimated on the basis of the theoretical argument advanced previously. The results of this growth model in terms of the direct and indirect impact of factor inputs are reported as equation (6.6a.1) in Table 5.9 with usual diagnostic statistics. The equation has relatively good exogenous power in terms of adjusted R^2 , the F -statistics are significant at one per cent level. The Durbin Watson (DW) test statistics indicates no positive or negative autocorrelation, which implies that the equations are methodologically unbiased. As presented by the estimated value of adjusted R^2 , the estimated growth equation (5.6a) explains 68 percent of the variation of Tonga's economic growth. In essence, all the variables are having the expected sign (in equation 6.6a.1) and also statistically significant at the one percent level. One variable was plugged-in to the initial growth model, but it yields insignificant impact on economic growth. This also tested the impact of education on economic growth (equation 6.6b.2), the age dependency ratio (equation 6.6c.3), trade openness (equation 6.6d.4), and the final specification by adding together all controlled variables in one equation to observe the indirect and direct implication on economic growth. This counter intuitive result could be due to the simultaneous inclusion of education, age dependency ratio, trade openness. Hence, in an attempt to improve the result, the variables with statistically insignificant t-ratios have been dropped one at a time. Finally, the result became statistically significant and well accepted as the appropriate growth model.

The equation (5.6a) has been re-estimated by controlling for education (EDU in equation 6.6b.2), age dependency ratio ($AGEDEP$ in equation 6.6c.3), trade openness ($OPEN$ in equation 6.6d.4) and put together all exogenous variables in the last equation 6.6e.5. Therefore, all of the esti-

⁴⁴ Author refers to empirical model is based on aggregate production function that expresses a country's output as a function of capital stock, labour and human (health) capital.

mated results in single equations have significantly contributed to economic growth and attained the expected sign as previously assumed except capital stock ($\ln K$) was insignificant. All estimated equations are reported in Table 5.9. Equation (6.6e.5) of Table 5.9 for example, also indicates a relatively good fit to the data and the model diagnostic statistics indicates no concern. The estimated value of adjusted R^2 explains 77 percent of the variation of economic growth. Note that the coefficients of life expectancy ($\ln LE$) in equation (6.6a.1 - 6.6e.5) in all specifications of Table 5.9 retained the expected sign and is statistically significant in the long run demonstrating their impact on growth.

The variable life expectancy also impact on growth is a primary focus of this chapter. The estimated slope coefficient suggested that a one percent increase in life expectancy is associated with an increase of 4 per cent on economic growth a year. The life expectancy estimates in all equations are also similar within the vicinity of 3 - 4 % a year. This indicates that life expectancy ($\ln LE$) in Tonga plays a positive role in enhancing economic growth development. The result, therefore, rejects the null hypothesis that life expectancy has no impact on economic growth. Thus, the magnitude of the impact of life expectancy is quite significant compared to other explanatory variables, the labour stocked and capital stock.

The growth equation has incorporated education as it is traditionally assumed that human capital is important for the development and growth of a country (equation 6.6b.2). The new growth theory presumes that an increased level of human capital contributes positively to growth. Thus the results support that human capital contributed positively to growth in Tonga, and its effect is paramount for its economic development.

The age dependency ratio (AGEDP) coefficient is negative and statistically significant at the ten per cent level of significance in the long run and short run. The long run relationship reflects that one per cent increase in age dependency ratio leads to reduce 0.15 percent in economic growth.

The inclusion of trade openness simultaneously with life expectancy established a significant impact on the growth model. The slope coefficient of trade openness (OPEN) is negative and also significant at 10 per cent level of significance, meaning that in the long run a one per cent increase in trade openness is associated with a fall by 0.1 per cent on economic growth. In es-

sence, the coefficient is strictly negative because trade is negative every year. On the other hand, exports are always less than imports per annum and may consequently induce a trade deficit. In such a small open economy like Tonga trade is also a key component for growth and they are relatively dependent entirely on imported products rather than focussing on the “export led growth” principle as usually adopted in small developing countries.

A notable feature of the final estimated equation of the growth model is that the inclusion of all variables together with the traditional variables (equation 6.6e.5) still retains the expected sign and significance level except that the capital stock ($\ln K$) is insignificant. This counter intuitive result could be merely due to the simultaneous inclusion of age dependency ratio, trade openness and education variable. In an attempt to improve the significance of the result, variables with statistically insignificant t ratios have been plugged-in one by one and therefore revert back to single equation estimations (equation 6.6a.1 – 6.6d.4)

The coefficient of $ECT_{(-1)}$ referred to as speed of adjustment, measures a short run deviation of economic growth from the long run equilibrium level. In equations (6.6a.1 – 6.6d.4) of Table 5.9 all speed of adjustment coefficient estimates is attained the expected sign and are significant at one to ten per cent level of significance. In equation (6.6d.4) the estimated final equation, the speed of adjustment coefficient is -0.51, reflecting a moderate convergence in the long run. It also indicates that economic growth in the short run declines by 0.51 per cent in response to a one per cent positive deviation from the long run equilibrium level. The coefficient of $ECT_{(-1)}$ is significant and also implies that all explanatory variables are jointly exerting a short run impact on economic growth.

The empirical result shows that life expectancy, trade openness, age dependency ratio, education and stock of labour have a significant effect on growth rather than capital stock and consistently contribute to economic growth in the long run. In essence, the results also indicate that labour stock is more potent than life expectancy, age dependency ratio and education in driving Tonga’s growth process. In terms of the magnitudes of the coefficient, the trade openness has the least size coefficient and this implies the fact that a collective effort is required to improve trade balance and boost economic performance for the country.

In such a small open developing island country like Tonga trade openness is the main determinant of the growth process and it has a vital impact on life expectancy also. This study has been further extended to account for the effect of infant mortality rate of economic growth with other controlled variables: age dependency ratio, education and trade openness. The outcome of this investigation shall be reported and discussed in the next subsection.

Table 5.9 Life Expectancy-Growth Models
<p>Equation (6.6a.1) Long Run Coefficients:</p> $\ln Y = -26.6 + 0.59 \ln K + 0.80 \ln L + 4.08 \ln LE$ <p style="text-align: center;">(-4.92)*** (2.02)*** (3.39)*** (3.57)***</p> <p>$\bar{R}^2 = 0.68$, $SER = 0.24$, $DW = 2.05$, $LM \chi^2(1) = 0.11$, $ARCH \chi^2 = 0.08$</p> <p>Short – Run Coefficient:</p> $\Delta \ln Y_t = 0.016 + 1.003 \Delta \ln Y_{t-1} - 0.51 \Delta \ln K_{t-1} + 0.52 \Delta \ln L_{t-1}$ <p style="text-align: center;">(0.982) (3.09)*** (-1.63) (0.388)</p> $-0.54 \Delta \ln LE_{t-1} - 0.551 ECT_{t-1}$ <p style="text-align: center;">(0.076) (-1.754)*</p> <p>$\bar{R}^2 = 0.41$, $F - stat = 4.78$, $DW = 1.96$</p>
<p>Equation (6.6b.2) Long Run Coefficients:</p> $\ln Y = -22.6 - 0.07 \ln K + 1.16 \ln L + 5.02 \ln LE + 0.07 EDU$ <p style="text-align: center;">(-3.72)*** (-0.27) (3.86)*** (3.52)*** (2.18)**</p> <p>$\bar{R}^2 = 0.61$, $SER = 0.027$, $DW = 1.68$, $LM \chi^2(1) = 6.33$, $ARCH \chi^2 = 0.031$</p> <p>Short – Run Coefficient:</p> $\Delta \ln Y_t = 0.011 + 1.00 \Delta \ln Y_{t-1} - 0.49 \Delta \ln K_{t-1} + 0.52 \Delta \ln L_{t-1}$ <p style="text-align: center;">(0.71) (3.03)*** (-1.57) (0.38)</p>

$$+0.90\Delta \ln LE_{t-1} - 0.01\Delta EDU_{t-1} - 0.55ECT_{t-1}$$

(0.12) (-0.56) (-1.70)*

$$\bar{R}^2 = 0.41, F-stat = 3.85, DW = 1.95$$

Equation (6.6c.3) Long Run Coefficients:

$$\ln Y = 107.0 + 0.63 \ln K - 30.6 \ln L + 5.12 \ln LE - 0.15 AGEDEP$$

(1.41) (2.06)** (-1.72)* (3.38)*** (-1.74)*

$$\bar{R}^2 = 0.71, SER = 0.02, DW = 2.10, LM \chi^2(1) = 0.35, ARCH \chi^2 = 0.0003$$

Short – Run Coefficient:

$$\Delta \ln Y_t = 0.001 + 0.92 \Delta \ln Y_{t-1} - 0.61 \Delta \ln K_{t-1} + 5.11 \Delta \ln L_{t-1}$$

(0.11) (2.91)*** (-2.22)** (2.02)*

$$+7.4 \Delta \ln LE_{t-1} + 0.02 \Delta AGEDEP_{t-1} - 0.92 ECT_{t-1}$$

(0.98) (1.76)* (-2.96)***

$$\bar{R}^2 = 0.58, F-stat = 7.63, DW = 2.00$$

Equation (6.6d.4) Long Run Coefficients:

$$\ln Y = -26.1 + 0.82 \ln K + 1.69 \ln L + 2.31 \ln LE - 0.001 OPEN$$

(-4.57)*** (2.55)** (2.67)** (1.49)** (-1.79)*

$$\bar{R}^2 = 0.74, SER = 0.024, DW = 1.96, LM \chi^2(1) = 0.007, ARCH \chi^2 = 0.219$$

Short – Run Coefficient:

$$\Delta \ln Y_t = 0.01 + 0.86 \Delta \ln Y_{t-1} - 0.42 \Delta \ln K_{t-1} + 0.37 \Delta \ln L_{t-1}$$

(0.64) (2.54)*** (1.29) (0.28)

$$+1.89 \Delta \ln LE_{t-1} - 0.0005 \Delta OPEN_{t-1} - 0.62 ECT_{t-1}$$

(0.26)	(-1.11)	(-1.98)*		
$\bar{R}^2 = 0.44$, $F - stat = 4.47$, $DW = 1.93$				
Equation (6.6e.5)Long Run Coefficients:				
$\ln Y = -81.9 + 0.18 \ln K + 13.4 \ln L + 5.4 \ln LE + 0.06 EDU$				
(-2.47)**	(0.62)	(2.60)***	(1.98)*	(1.78)*
$+0.06 AGEDEP - 0.0015 OPEN$				
(1.96)*	(-2.04)**			
$\bar{R}^2 = 0.77$, $SER = 0.025$, $DW = 1.87$, $LM \chi^2(1) = 5.10E - 05$, $ARCH \chi^2 = 0.51$				
Short – Run Coefficient:				
$\Delta \ln Y_t = 0.02 + 0.25 \Delta \ln Y_{t-1} - 0.16 \Delta \ln K_{t-5} - 2.6 \Delta \ln L_{t-1}$				
(-0.01)	(2.62)***	(-1.96)*	(1.91)*	
$-0.89 \Delta \ln LE_{t-3} + 0.25 \Delta EDU_{t-5} - 0.03 \Delta AGEDEP_{t-4} - 0.0001 \Delta OPEN_{t-1} - 0.51 ECT_{t-1}$				
(-0.88)	(2.03)**	(-2.49)***	(-0.26)	
(-1.83)***	$\bar{R}^2 = 0.61$, $F - stat = 5.35$, $DW = 2.16$			

Note: ***, ** and * are significance at 1,5 and 10 percent levels respectively. T-ratios are given in the parenthesis. The R^2 coefficient of determination, adjusted for degree of freedom; F= F-statistic; SER= standard error of the estimates; LM= Lagrange multiplier test for serial correlation;ARCH= Engle’s Autoregressive Conditional Hetroscedasticity test;DW=Durbin Watson statistic measures the serial correlation in the residuals.

5.4.2 The Infant Mortality Rate – Growth Model

This section is based on the equation (5.7a) and examining the assumption that whether the infant mortality rate ($\ln IMR$) has impacted gross domestic product, this includes capital stock, labour stock, education, age dependency ratio and trade openness, which are paramount to evaluate its impact on economy productivity performances. The model is focussed on Infant Mortality

Rate in which as the second appropriate proxy of health was employed. Moreover, it also investigates whether the $(\ln IMR)$ has a different impact on the growth model and other then controlled for the other the traditional modelable in traditional model of economic growth.

Table 5.10 shows several interesting results regarding the impact of infant mortality rate of economic growth. The initial estimate equation shown in (6.7a.1) reveals the goodness of fit which is estimated by adjusted. It also implies that exogenous variables explain about 68 per cent of the variation in the dependent variable. The DW statistic is greater than two, there is evidence of no positive and negative serial correlation. The F -statistic is statistically significant at one per cent level and confirms the hypothesis that the proposed variables in the equation (6.7a.1) jointly contributed to the growth model during the period 1970-2011. The Breusch-Godfrey LM test ($LM \chi^2$) statistic for serial correlation with the null hypothesis of the test is that there is no serial correlation in the residual. The reported $LM \chi^2(1) = 0.45$ indicating lower statistics corresponding to higher p -values and consequently accept the null hypothesis that residuals are serially uncorrelated. In addition, the test whether there exists any evidence of strong autoregressive conditional heteroscedasticity (ARCH) in the residual was reported. It was confirmed a strong evidence that the statistics ($ARCH \chi^2 = 0.003$) shows the absence of ARCH in the residual.

The estimated equation (6.7b.2), shows a higher adjusted R^2 value. The standard error is quite negligible, the F -statistics are significant at one per cent level of significance. It can be analyzed that considering the t -ratios for a single variable is quite high which also signifies lower probability values associating with the rejection of the null hypothesis that infant mortality rate has significant negative effects on economic growth. The explanatory variable capital stock and labour have their expected sign and are significant at the one percent level of significance. The inclusion of human capital (EDU) does not have any intense impact on the model albeit the sign is correct. Overall, the results also find that variables employed are likely to have a more convincing impact on economic growth.

The result shown in equation (6.7c.3) shows the importance of age dependency ratio together with the exogenous variables and the impact of infant mortality rate. Note that the age dependency ratio is negatively correlated with economic growth and insignificant. Similarly, the stock of labour is not significant at the conventional level of significance. This counter intuitive idea

results from putting simultaneously all variables with the traditional variable of growth model. Ideally, the focus of this study is on the implications of health measures on economic productivity. Furthermore, the results also show there exist a sluggish movement in the slope coefficient of infant mortality ($\ln IMR$) and reduced by 0.1 per cent. Thus, this evidence shows there is a complementary relationship prevailing between infant mortality rate ($\ln IMR$) and GDP.

Having established the relationship between infant mortality rate ($\ln IMR$) and age dependency ratio with economic growth, attention is directed to combine the impact of trade openness with an infant mortality rate into growth. In simple OLS procedure of the effect of trade openness, education on infant mortality rate ($\ln IMR$) reveals that education has a strong negative correlation with infant mortality rates, infant mortality rate while trade openness has positive sign and highly significant at the one percent level of significance, meaning that both education and trade openness have a convincing result. However, the combination taken in the equation (6.7d.4) yields that trade openness obtains the expected sign, but not significant at the conventional level of significance. The coefficient of infant mortality rate ($\ln IMR$) still kept its significance level. It also argues that the implication of infant mortality ($\ln IMR$) in the long run is attained even though the number of explanatory variables is changing. It can be seen from the diagnostic statistics associated with equation (5.7d) given as (6.7d.4) in Table 5.10 that there is no evidence of serial correlation or heteroscedasticity in the residual. The *DW* test statistics appear that there is no positive and negative autocorrelation identified. Overall, it signifies that the model is methodologically unbiased.

The results are reported in Table 5.10 for equation (6.7d.4) and indicate that the elasticity of infant mortality rate is negative and significant at the five percent level. The equation shows that one per cent increase on infant mortality rate would induce a 0.22 percent decrease in economic growth. Although the short run elasticity of infant mortality remains negative, the magnitude has gone up from 0.22 to 1.9 from long- run to short – run. The coefficient infant mortality in the short run is insignificant, meaning that ($\ln LIMR$) does not have any significant impact to economic growth.

The results of the final equation of the infant mortality model with the age dependency ratio, trade openness are reported as equation (6.7e.4) in Table 5.10. The coefficient of $ECT_{(-1)}$ has the expected sign and is statistically significant at one per cent level. The high absolute value of $ECT_{(-1)}$ also indicates that the speed of adjustment to the long run equilibrium is much faster when it deviates from the short run. Ideally, this result indicates that capital stock, labour stock, infant mortality rate, age dependency ratio, trade openness and education are potent driving forces in determining the economic growth structure of the economy. Nevertheless, the DUM0506 shows a negative sign, but insignificant impact on economic growth, therefore it has been dropped from the final estimation. Finally, the result demonstrates that infant mortality has a negative and significant impact on growth model. The other control variables find no significant contribution to our model in the long run. In the case of short run it is suggested that labour stocked and age dependency ratio has a strong effect on the economic performance of the country.

Table 5.10 Infant Mortality Rate-Growth Models

Equation (6.7a.1) Long Run Coefficients:

$$\ln Y = -10.8 + 0.65 \ln K + 1.12 \ln L - 0.28 \ln LIMR$$

$$(-2.88)^{***} \quad (2.57)^{***} \quad (4.62)^{***} \quad (-3.84)^{***}$$

$$\bar{R}^2 = 0.68, \quad SER = 0.02, \quad DW = 2.12, \quad LM \chi^2(1) = 0.45, \quad ARCH \chi^2 = 0.003$$

Short – Run Coefficient:

$$\Delta \ln Y_t = 0.014 + 0.96 \Delta \ln Y_{t-1} - 0.36 \Delta \ln Y_{t-6} - 0.67 \Delta \ln K_{t-1}$$

$$(0.37) \quad (2.62)^{***} \quad (-2.38)^{**} \quad (1.91)^*$$

$$-0.17 \Delta \ln K_{t-2} + 2.4 \Delta \ln L_{t-6} - 0.75 \Delta \ln LIMR_{t-2} - 0.62 ECT_{t-1}$$

$$(-1.08) \quad (-1.65) \quad (-0.46) \quad (-1.86)^*$$

$$\bar{R}^2 = 0.53, \quad F - stat = 4.49, \quad DW = 1.95$$

Equation (6.7b.2) Long Run Coefficients:

$$\ln Y = -12.4 + 0.76 \ln K + 1.13 \ln L - 0.28 \ln LIMR + 0.013 EDU$$

$$(-3.07)^{***} \quad (2.79)^{***} \quad (4.61)^{***} \quad (-3.81)^{***} \quad (0.68)$$

$$\bar{R}^2 = 0.69, \quad SER = 0.024, \quad DW = 2.21, \quad LM \chi^2(1) = 0.88, \quad ARCH \chi^2 = 0.09$$

Short – Run Coefficient:

$$\Delta \ln Y_t = -0.007 + 0.76 \Delta \ln Y_{t-1} - 0.52 \Delta \ln K_{t-1} - 7.63 \Delta \ln L_{t-1}$$

$$(-0.22) \quad (2.46)^{***} \quad (-1.68)^* \quad (-2.62)^{***}$$

$$+8.53 \Delta \ln L_{t-2} - 1.18 \Delta LIMR_{t-1} - 0.01 \Delta EDU_{t-1} - 0.51 ECT_{t-1}$$

$$(2.94)^{***} \quad (-0.71) \quad (-0.35) \quad (-1.72)^*$$

$$\bar{R}^2 = 0.53, \quad F - stat = 5.13, \quad DW = 1.91$$

Equation (6.7c.3) Long Run Coefficients:

$$\ln Y = 40.9 + 0.79 \ln K - 11.1 \ln L - 0.25 \ln LIMR - 0.06 AGEDEP$$

(0.77) (2.83)*** (-0.90) (-3.22)*** (-0.97)

$$\bar{R}^2 = 0.70, SER = 0.024, DW = 2.20, LM \chi^2(1) = 1.08, ARCH \chi^2 = 0.06$$

Short – Run Coefficient:

$$\Delta \ln Y_t = -0.015 + 0.96 \Delta \ln Y_{t-1} - 0.65 \Delta \ln K_{t-1} + 5.06 \Delta \ln L_{t-1}$$

(-0.48) (3.32)*** (-2.25)** (2.06)**

$$-1.49 \Delta LIMR_{t-1} + 0.02 \Delta AGEDEP_{t-1} - 0.75 ECT_{t-1}$$

(-1.03) (1.94)* (-2.44)***

$$\bar{R}^2 = 0.54, F-stat = 6.65, DW = 2.01$$

Equation (6.7d.4) Long Run Coefficients:

$$\ln Y = -12.8 + 0.77 \ln K + 1.14 \ln L - 0.22 \ln LIMR - 0.0004 OPEN$$

(-3.00)*** (2.76)*** (4.49)*** (-2.43)** (-0.74)

$$\bar{R}^2 = 0.70, SER = 0.024, DW = 2.10, LM \chi^2(1) = 0.35, ARCH \chi^2 = 0.17$$

Short – Run Coefficient:

$$\Delta \ln Y_t = -0.02 - 0.37 \Delta \ln Y_{t-4} + 0.29 \Delta \ln K_{t-4} - 7.9 \Delta \ln L_{t-2}$$

(-0.71) (-1.22) (1.11) (-2.80)***

$$+9.9 \Delta \ln L_{t-3} - 1.9 \Delta LIMR_{t-3} - 0.0005 \Delta OPEN_{t-1} - 0.44 ECT_{t-1}$$

(3.46)*** (-1.27) (-1.11) (-1.73)*

$$\bar{R}^2 = 0.44, F-stat = 4.34, DW = 1.89$$

Equation (6.7e.5) Long Run Coefficients:

$$\ln Y = 45.7 + 0.93 \ln K - 12.7 \ln L - 0.23 \ln LIMR - 0.009 EDU$$

(0.33) (2.96)*** (-0.40) (-2.17)** (-0.19)

$$-0.06 AGEDEP - 0.00013 OPEN$$

(-0.43) (-0.17)

$$\bar{R}^2 = 0.72, SER = 0.025, DW = 2.22, LM \chi^2(1) = 1.20, ARCH \chi^2 = 0.21$$

Short – Run Coefficient:

$$\Delta \ln Y_t = -0.007 + 0.88 \Delta \ln Y_{t-1} - 0.60 \Delta \ln K_{t-1} + 4.84 \Delta \ln L_{t-1}$$

(-0.22) (2.94)*** (-1.96)* (1.98)*

$$-1.19 \Delta LIMR_{t-1} - 0.02 \Delta EDU_{t-1} + 0.02 \Delta AGEDEP_{t-1}$$

(-0.76) (-0.73) (1.77)*

$$-0.0004 \Delta OPEN_{t-1} - 0.94 ECT_{t-1}$$

(-1.05) (-2.75)***

$$\bar{R}^2 = 0.47, F-stat = 5.41, DW = 2.05$$

Note: ***,** and * are significance at 1,5 and 10 per cent levels respectively. T-ratios are given in the parenthesis. The R^2 coefficient of determination, adjusted for degree of freedom; F= F-statistic; SER= standard error of the estimates; LM= Lagrange multiplier test for serial correlation; ARCH= Engle's Autoregressive Conditional Heteroscedasticity test; DW=Durbin Watson statistic measures the serial correlation in the residuals.

5.4.3 Fertility Rate – Growth Model

A number of specifications have been analyzed to examine the effect of fertility rate ($\ln FR$) and other explanatory variables on economic growth. The basic model as specified in equation (5.8a) examines the effect of fertility rate (as proxy for health) on economic growth together with traditional variables in growth model, trade openness, education and age dependency ratio. The estimated coefficients are presented in Table 5.11. The initial equation (6.8a.1) reports the elasticity coefficient of economic growth in response to one per cent change in the exogenous explanatory variables. The impact of fertility rate ($\ln FR$) during the period of study was negative and statistically significant. A one percent increase in fertility rate would decrease by 0.33 per cent in economic growth, indicating that it has a policy implication on the economic performance of the country. The capital stock has a significant and positive impact on economic growth. The labour stock also has a positive and significant impact on our growth model.

The estimated equation (6.8b.2) represented the inclusion of education and fertility rate together with capital stock labour variables. The result of this estimation reported in Table 5.11 indicates a relatively good fit to the data and the model diagnostic indicates no serious econometric problems. The coefficient of capital stock is positive and significant at one percent significance level. That the stock of labour variable is, however, positive and significant at one per cent level of significance, whereas the estimated coefficient of fertility rate is negative and statistically significant at the five per cent level. Besides the negative impact of fertility rate, the impact of education is not positive and yet is insignificant in the long run. In the short run the education variable does not have any positive impact, but obviously insignificant. Therefore, it confirms there is no theoretical implication of time lag between changes in economic growth, changes in fertility rate and education. The age dependency ratio, fertility rate, capital stock and labour affect economic growth only in two lags. The estimated equation is reported in Table 5.11 as (6.8c.3). The diagnostic tests of the specification indicate there are no econometric pathologies such as serial correlation, heteroscedasticity of the residual. The adjusted R^2 for this equation is reasonable in explaining the variables that affect the economic growth function during the period of study.

While both fertility rate and age dependency ratio have a negative impact on economic growth in the long run estimators, the age dependency ratio is insignificant both in short and long-run estimate regression. The estimated coefficient of fertility rate suggests that a one percent increase is associated with a decrease in economic growth of almost 0.73 percent. A notable result in terms of this regression is that when age dependency ratios are entered into the specification, the size of the capital stock and labour coefficient changed both in the long run and short run. The capital stock had changed from positive to negative impact while the significance levels are still attained at conventional levels. The labour had changed from a negative sign in the long run to the expected sign in short-run but still insignificant. In such a small country like Tonga when the stock of labour and capital enter the equation they are the most crucial determinant of growth rather than an age dependency ratio and fertility rate.

Furthermore, the final equation of the fertility rate model has been incorporated to include capital stock, labour, education, trade openness, age dependency ratio and the fertility rate are reported in equation (6.8e.5). The capital stock and fertility rate have the correct sign and statistically significant at one and five per cent level of significance. This suggests that both capital and fertility rate have a strong impact on the productivity of the country. The coefficient of labour, education, age dependency ratio and trade openness have the correct sign except education variables, but not significant at any conventional significance level. The short run specification indicates a good relative fit and the significance of the error correction term of the equation (6.8e.5) is quite reasonable and as the theory presumes the $ECT_{(-1)}$ is negative and statistically significant, suggesting a deviation from the long run economic productivity growth during this period. The magnitude of the deviation is corrected by 103 per cent in the next year.

In total, the results indicate that the level of fertility rate has a strong impact on economic performance in such a small open economy like Tonga albeit the insignificance of labour stock, education, age dependency and trade openness variable at the aggregate level. However, the significant part of this framework is that none of the variables diverge from the long run equilibrium position.

Table 5.11 Fertility Rate-Growth Models

Equation (6.8a.1) Long Run Coefficients:

$$\ln Y = -15.8 + 0.93 \ln K + 1.18 \ln L - 0.33 \ln LFR$$

$$(-3.80)^{***} \quad (3.28)^{***} \quad (3.05)^{**} \quad (-1.88)^{*}$$

$$\bar{R}^2 = 0.64, SER = 0.025, DW = 2.19, LM \chi^2(1) = 0.92, ARCH \chi^2 = 0.80$$

Short – Run Coefficient:

$$\Delta \ln Y_t = 0.03 + 1.05 \Delta \ln Y_{t-1} - 0.60 \Delta \ln K_{t-1} - 0.43 \Delta \ln L_{t-1}$$

$$(2.81)^{***} \quad (3.47)^{***} \quad (-2.02)^{**} \quad (-0.39)$$

$$+1.05 \Delta LFR_{t-1} - 0.67 ECT_{t-1}$$

$$(1.87)^{*} \quad (-2.19)^{**}$$

$$\bar{R}^2 = 0.47, F-stat = 6.17, DW = 2.04$$

Equation (6.8b.2) Long Run Coefficients:

$$\ln Y = -17.3 + 1.02 \ln K + 1.32 \ln L - 0.42 \ln LFR - 0.008 EDU$$

$$(-3.94)^{***} \quad (3.48)^{***} \quad (2.98)^{***} \quad (-2.11)^{**} \quad (-0.26)$$

$$\bar{R}^2 = 0.66, SER = 0.025, DW = 2.90, LM \chi^2(1) = 1.71, ARCH \chi^2 = 0.07$$

Short – Run Coefficient:

$$\Delta \ln Y_t = 0.03 + 1.04 \Delta \ln Y_{t-1} - 0.59 \Delta \ln K_{t-1} - 0.35 \Delta \ln L_{t-1}$$

$$(2.79)^{***} \quad (3.39)^{***} \quad (-1.96)^{**} \quad (-0.32)$$

$$+1.09\Delta LFR_{t-1} - 0.008\Delta EDU_{t-1} - 0.66ECT_{t-1}$$

(1.90)*

(-0.29)

(-2.12)**

$$\bar{R}^2 = 0.47, F-stat = 4.95, DW = 2.01$$

Equation (6.8c.3) Long Run Coefficients:

$$\ln Y = 169 + 0.62 \ln K - 39.6 \ln L - 0.73 \ln LFR - 0.20 AGEDEP$$

(1.48)

(2.12)**

(-1.53)

(-2.98)***

(-1.55)

$$\bar{R}^2 = 0.74, SER = 0.023, DW = 2.36, LM \chi^2(1) = 3.18, ARCH \chi^2 = 1.02$$

Short – Run Coefficient:

$$\Delta \ln Y_t = 0.02 + 1.10 \Delta \ln Y_{t-1} - 0.71 \Delta \ln K_{t-1} + 2.0 \Delta \ln L_{t-1}$$

(2.31)**

(3.78)***

(-2.52)**

(0.63)

$$+0.85\Delta LFR_{t-2} + 0.006AGEDEP_{t-1} - 0.99ECT_{t-1}$$

(1.47)

(0.41)

(-2.99)***

$$\bar{R}^2 = 0.58, F-stat = 7.59, DW = 2.18$$

Equation (6.8e.5) Long Run Coefficients:

$$\ln Y = 133.5 + 1.22 \ln K - 33.3 \ln L - 0.50 \ln LFR - 0.02 EDU$$

$$(0.80) \quad (3.78)^{***} \quad (-0.87) \quad (-2.05)^{**} \quad (-0.60)$$

$$-0.17 AGEDEP - 0.001 OPEN$$

$$(-0.90) \quad (-1.54)$$

$$\bar{R}^2 = 0.71, SER = 0.025, DW = 2.30, LM \chi^2(1) = 1.91, ARCH \chi^2 = 0.66$$

Short – Run Coefficient:

$$\Delta \ln Y_t = 0.01 + 0.88 \Delta \ln Y_{t-1} - 0.60 \Delta \ln K_{t-1} + 2.86 \Delta \ln L_{t-2}$$

$$(1.66) \quad (2.60)^{***} \quad (-2.05)^{**} \quad (1.54)$$

$$-2.02 \Delta LFR_{t-1} + 2.00 \Delta LFR_{t-2} - 0.03 \Delta EDU_{t-1} + 0.004 \Delta AGEDEP_{t-1}$$

$$(-1.04) \quad (1.10) \quad (-0.86) \quad (0.55)$$

$$-0.0004 \Delta OPEN_{t-1} - 1.03 ECT_{t-1}$$

$$(-1.04) \quad (-2.75)^{***}$$

$$\bar{R}^2 = 0.64, F - stat = 5.74, DW = 2.07$$

Note: ***, ** and * are significance at 1, 5 and 10 per cent levels respectively. T-ratios are given in the parenthesis. The R^2 coefficient of determination, adjusted for degree of freedom; F= F-statistic; SER= standard error of the estimates; LM= Lagrange multiplier test for serial correlation; ARCH= Engle's Autoregressive Conditional Heteroscedasticity test; DW=Durbin Watson statistic measures the serial correlation in the residuals.

5.5 Causality between Health Indicators and Economic Growth

In the previous Section 5.3 we statistically established that the models are cointegrated and well specified. The focus now turns on Granger non causality testing. Since the variables are non-stationary, the causal inference in multivariate approaches is made by estimating the parameters of the specifications reported in Appendix B with the error correction term (ECT). The notion of inclusion of the error correction term in the VAR model allows the estimated model to take into account the long run equilibrium constraints. At the same time it also permits flexibility in the short run dynamics captured by the VAR; see Wilamoski and Tinkler, (1999). Moreover, the use of the cointegration error correction term in the Granger Causality Model is a necessary condition because of the feasibility of the spurious co - movement among the variables. Thus the cointegration analysis chooses to identify conditions under which relationships are not spurious. The usual standard Granger Causality which may not be able to diagnose any causal relationship between the variables of interest with the error correction term, the cointegration ensures that Granger Causality exists at least in one direction. Therefore the Granger Non-Causality will imply the presence of neither short and long run relationship among the variables; see Engle and Granger (1987). At this end, the causality can only be decided through the significance of the lagged error correction term.

The results of Granger Causality tests are reported in Table 5.12. The intention here is primarily focused with the interrelationship between economic growth and life expectancy, infant mortality rate, fertility rate only the results of these relationships are reported. As presented here the results are sensitive to depart from standard assumptions and some diagnostic tests are performed on the residual of each specification. The serial correlation in the residuals, the Jarque and Bera (1980) normality test, which is asymptotically distributed χ^2 , the Engle's autoregressive conditional heteroscedasticity test indicate that all the equations pass the test at 5% and 10% level of significance and the results are reported in Table 5.12. This also implies that there is no significant departure from the standard assumption. The inference of causality has been deduced from the lagged error correction term and is applicable at 5% or 10% level of significance.

Table 5.12: Multivariate Granger Causality Tests Based on <i>VECM</i>				
MODELS	Equation No	Test for Causality of	By	ECT
Life Expectancy Model	(7.1a)	$\Delta \ln Y$	$\Delta \ln LE$	-0.026 (-1.80)*
	(7.1d)	$\Delta \ln LE$	$\Delta \ln Y$	0.0003 (1.27)
Infant Mortality Rate Model	(7.2a)	$\Delta \ln Y$	$\Delta \ln IMR$	0.086 (0.72)
	(7.2d)	$\Delta \ln IMR$	$\Delta \ln Y$	-0.020 (-2.17)**
Fertility Rate Model	(7.3a)	$\Delta \ln Y$	$\Delta \ln FR$	0.076 (0.617)
	(7.3d)	$\Delta \ln FR$	$\Delta \ln Y$	0.0428(1.58)
Notes: ** and * are the significance levels at 5% and 10% respectively. P-values are reported in the parentheses. Legend: $\Delta \ln Y$ = Real Gross Domestic Product; $\Delta \ln LE$ = Life Expectancy; $\Delta \ln IMR$ = Infant Mortality Rate; $\Delta \ln FR$ = Fertility Rate.				

Table 5.13: Diagnostic Tests on Granger Causality				
Equation	Variables	$LM_{\chi^2}(1)$	$ARCH_{\chi^2}(1)$	$JNB_{\chi^2}(1)$
	Life Expectancy-Growth Model			
(7.1a)	$\Delta \ln Y$	0.0014	1.128	0.935
(7.1d)	$\Delta \ln LE$	9.209	0.130	2.122
	Infant Mortality-Growth Model			
(7.2a)	$\Delta \ln Y$	0.0173	1.396	0.205
(7.2d)	$\Delta \ln IMR$	2.821	0.221	0.783
	Fertility Rate-Growth Model			
(7.3a)	$\Delta \ln Y$	0.463	1.702	1.558
(7.3d)	$\Delta \ln FR$	22.46	1.166	1.389
Notes: The test statistics are as follows: LM = Lagrange multiplier test for serial correlation, ARCH = Engle's Autoregressive conditional heteroscedasticity test and JNB =normality of the residuals. Legend: $\Delta \ln Y$ = Real Gross Domestic Product; $\Delta \ln LE$ = Life Expectancy; $\Delta \ln IMR$ = Infant Mortality Rate; $\Delta \ln FR$ = Fertility Rate				

Table 5.12 shows the Granger Causality results by using the *VECM* framework. The result of Life Expectancy-Growth Model (see Appendix B.1 equation 7.1a and 7.1d) indicates unidirectional causality, that is the significance of the ECT term in the economic growth equation (7.1a) but not in the life expectancy equation (7.1d). The equation (7.1a) also shows Granger causality from life expectancy to economic growth but the vice versa is not true. The ECT measures the speed of adjustment to past shocks in the equilibrium and emerges as significant channels of influencing the growth model. This implies that variables in the growth model have a strong tendency to adjust to their past disequilibrium by moving towards the trend value of their counterparts. The null hypothesis that life expectancy does not Granger cause the economic growth is rejected at the 10 % level of significance and shows there is a causal relationship between life expectancy and economic growth.

The hypothesis that infant mortality rate does not “Granger causes” economic growth hypothesis is accepted, but the reverse shows there is a causal relationship between economic growth and infant mortality (based on the equation 7.2a and 7.2d of Table 5.12). The reason why the reverse is true because of the significance of the error correction term at 5% level. The result reported for fertility rate – growth model shows that none of the models have the causal relationship. The lagged ECT term in equation (7.3a) and (7.3d) is both insignificant and this implies that the lack of significance of the error correction term signifies that long run causality from fertility to economic growth and economic growth to fertility does not exist. It also indicates that the relationship between fertility rate (indicator for health) and economic growth are insignificant as reported in Appendix C.3. The short run dynamics of the life expectancy growth model reported in Appendix C.1 of the equation (7.1a) indicates that there exists a unidirectional granger causality running from life expectancy to economic growth however the converse is false. In summary, there is no bidirectional short run granger causality running from infant mortality and fertility rate of economic growth as reported in Appendix C.1 and C.3. The estimated equation (7.1a) indicates that increased additional year in life expectancy leads to increase economic growth. In other words, there exist a feedback between life expectancy and the economic performance of the country. In contrast, the other two health indicators: infant mortality rate and fertility rate do not have a critical impact on this empirical analysis and it is not theoretically plausible for these health indicators to improve economic growth as empirically tested.

5.6 Conclusion

This chapter investigates the impact of health (life expectancy, infant mortality rate, fertility rate), education, trade openness and age dependency ratio in Tonga for the period from 1970 to 2011 in terms of economic growth. The *ARDL* regression analysis has been used to analyze the impact of these macroeconomic variables on the economy. The empirical findings from each estimated final model indicated a relative goodness of fit of the data as measured by adjusted R^2 and F-statistics. The Lagrange multiplier test for heteroscedasticity provides no evidence to suggest a departure from the assumption of homoscedastic disturbance. Likewise the Engle's Autoregressive Conditional Heteroscedasticity test and DW statistic measure the serial correlation in the residual are statistically reliable in most cases.

The empirical analysis supports that there are positive economic contributions from health to growth via interaction with other macroeconomic variables. In more detail the life expectancy variable is statistically significant but also positively related to economic growth. Hence, life expectancy serves an important promoter of economic growth and development. The infant mortality is negatively correlated with the economic growth, unfortunately in some stance that is insignificant. Similarly, the fertility rate is also negatively related to growth and highly significant. This signifies there is a strong impact on the economic productivity of Tonga during the duration of study.

Thus the empirical result provides some significant implications for Tonga economy. The trade liberalization (via trade openness) of the economy was inextricably linked to ongoing globalization and international economic integration. The health of the people is so vulnerable to many factors ranging from short to long term processes. The most robust finding of this analysis is that good health may bring positive growth for the entire economy albeit its improvements are so small.

CHAPTER SIX

CONCLUDING COMMENTS AND RECOMMENDATIONS

6.1 Introduction

Econometric models can be valuable mechanisms for testing alternative economic policies, for making projections about the future movement of the economy as well as making comparative studies that measure the specific impact of health conditions on the whole economy. For instance, the life expectancy growth model developed in Chapter Five has aimed to establish and quantify the likely impacts of changing longevity, mortality and fertility rate on economic performances of the country.

This chapter proposes to synthesize the important outcomes emerging from the entire study discussed in the previous five chapters. The outline of this chapter is as follows: Section 6.2 reviews the major finding of the thesis from earlier chapters. The scope for future research is delineated in the last Section.

6.2 The Major Conclusions of the Research

Chapter One examined the importance of health in the current context of Tonga. The objectives were based on how the patterns of health status affect the economic performance of the Kingdom during the specified duration of the study. It also identifies factors that impact health and GDP; the factors that contribute to ill health and thereby lead to poor economic development. This chapter also emphasizes the importance of health as a key component of high living standards, better education and economic prosperity.

Chapter Two focussed thoroughly on the political, social and overall background on health, economic growth and its impact on Tonga as well as Pacific Island Countries. The literature also explores health indicators that are most employed in past studies to measure health impact on GDP such as life expectancy, infant mortality and fertility rate. The chapter also examined the current position of Tonga according to United Nation Development Program (UNDP) Human Development Index (HDI) Report (UNDP, 2012). The health spending by the Ministry of Health and how it is allocated to the crucial services provided is discussed.

Chapter Three dealt with the relevant econometric model in order to investigate the problems raised. The models and the analytical framework were derived from previous theoretical and empirical analysis on the impact of health on GDP in developing countries. Consequently, this study adopted the cointegration technique of Johansen and Juselius (1990), the ARDL approach and VECM, so that the simultaneity bias inherent in previous literature could overcome. These techniques have formed a useful contribution to the existing literature.

To test the macroeconomic variables, three different models have been used: Life Expectancy Model, Infant Mortality Rate Model and Fertility Rate Model. The implication of life expectancy ($\ln LE$) on GDP ($\ln Y$) (as shown in Table 5.9 equations (5.6a.1) to equation (5.6d.5)). Equation (6.7a.1) to equation (6.7e.5) were formulated to examine the impact of infant mortality rate, education, age dependency ratio and trade openness on GDP. Equation (6.8a.1) to equation (6.8e.5) of Table 5.11 considered the factors that determine the effect of fertility rate of economic growth. Finally, all models also incorporated a dummy variable which examines the impact of the industrial dispute from 2005 to 2006 but unfortunately it does not have any significant contribution in all estimates.

The dynamic models set out in chapter three and four have subsequently been used in the empirical investigation in accordance with the objective and the results were discussed in chapter five:

- The first empirical test found that all variables of interest contain unit root with intercept but no trend. However, proceeding further by transforming the variables into first difference, the test statistics rejected the null hypothesis of non-stationary for all variables with intercept.
- It was empirically confirmed that macroeconomic variables are stationary. This study also found that health indicators, other control variables (e.g., education, trade openness, age dependency ratio, capital, labor) and GDP are cointegrated with the same order. The theoretical assumption holds that all variables are moving together and there is a long run relationship. In general, however, health indicators are likely to have a substantial impact over the economic performance of Tonga either positive or negative.

- Results indicate that life expectancy has a positive impact on economic growth in the long run of all cases and is statistically significant. This relationship confirms the complementarity between private human capital investment and economic growth (see Table 5.9)
- The impact of other control variables in the life expectancy growth model yields a significant effect on economic growth. The variable education has a positive contribution to economic growth and is also significant (equation 6.6b.2 in Table 5.9). Similarly, the age dependency ratio reduces the economic performance of the country during the duration of study (see equation 6.6c.3 in Table 5.9).
- The estimates from the infant mortality, growth model (Table 5.10) suggest that infant mortality has a negative impact on economic growth. This has reflected the obligation of the government in terms of budget allocation to reconsider and prioritize the services provided by each respective portfolio according to whether they attain the minimum standard requirements to combat the level of infant mortality nationally.
- All estimates of infant mortality, growth models in Table 5.10 ascertain there is no doubt that there exists a negative impact of infant mortality on economic growth and is highly significant at the five per cent level. The other control variables yield an insignificant contribution for the overall estimates. Figure 6.1 provides a significant connection of mortality to economic growth.
- The results found in the fertility rate growth model signify the negative impact of fertility rate of economic growth. Ideally, in such a small island country like Tonga, very low GDP per head⁴⁵ compared to GDP per head in well developed countries⁴⁶ its government could withstand financial hardship to cope with population growth and counter the urbanization process⁴⁷. Tonga is not financially prepared to withstand the cost of increasing simultaneously the growth rate of population and an increase of productivity. The marginal impact of the age dependency ratio, education and trade openness does not replicate much significance on the overall growth model of Table 5.11. It shows in equations

⁴⁵ GDP per capita for 2012 is US\$4,494 (World Bank, 2013)

⁴⁶ For example, GDP per capita for the year 2012 in United States is USD49,965; United Kingdom (USD38514); New Zealand (USD37749) (World Bank, 2013)

⁴⁷ Traditionally in Britain the Department of Environment which is responsible for strategic planning on national basis. Central to the process of policy making is the need to monitor housing and population trends. The last thirty years demonstrates very dramatically the impact of the counter urbanisation process such as the amount of land approval on the basis of an anticipated population increase since 1961. In contrast, 850 dwelling units allocated to the immediate and small villages of the district for the period 1983-2001 had been built in the first six years to counter population growth in East Northants (Lewis, Mcdermott, & Sherwood, 1991).

(6.8b.2), (6.8c.3) and (6.8e.5) that the coefficient of education and age dependency ratio are also insignificant. Figure 6.1 illustrates a linkage between fertility rate, child mortality and high dependency ratio of economic growth. The evidence presented here illustrates that health is also linked to economic development. The top half of Figure 6.1 shows the age-structural effects of demographic transition as seen by a change in the dependency ratio. High level of fertility and child mortality which may result of child illness along with a reduction in labor force brought on by mortality and early retirement can consequently induce high dependency ratio that ultimately reduces income. In the other hand, a reversal of these effects can reduce the dependency ratio, which increases the per capita income. Moreover, the childhood health can also affect adult health (Fogel, 2005). The lower half of Figure 6.1 illustrates the implication of illness and malnutrition operating via other factors such as reduced investment in human and physical capital in reducing labour productivity. Overall, reduced labor productivity has a direct impact on reducing income per capita. Thus, economic conditions influence health as well.

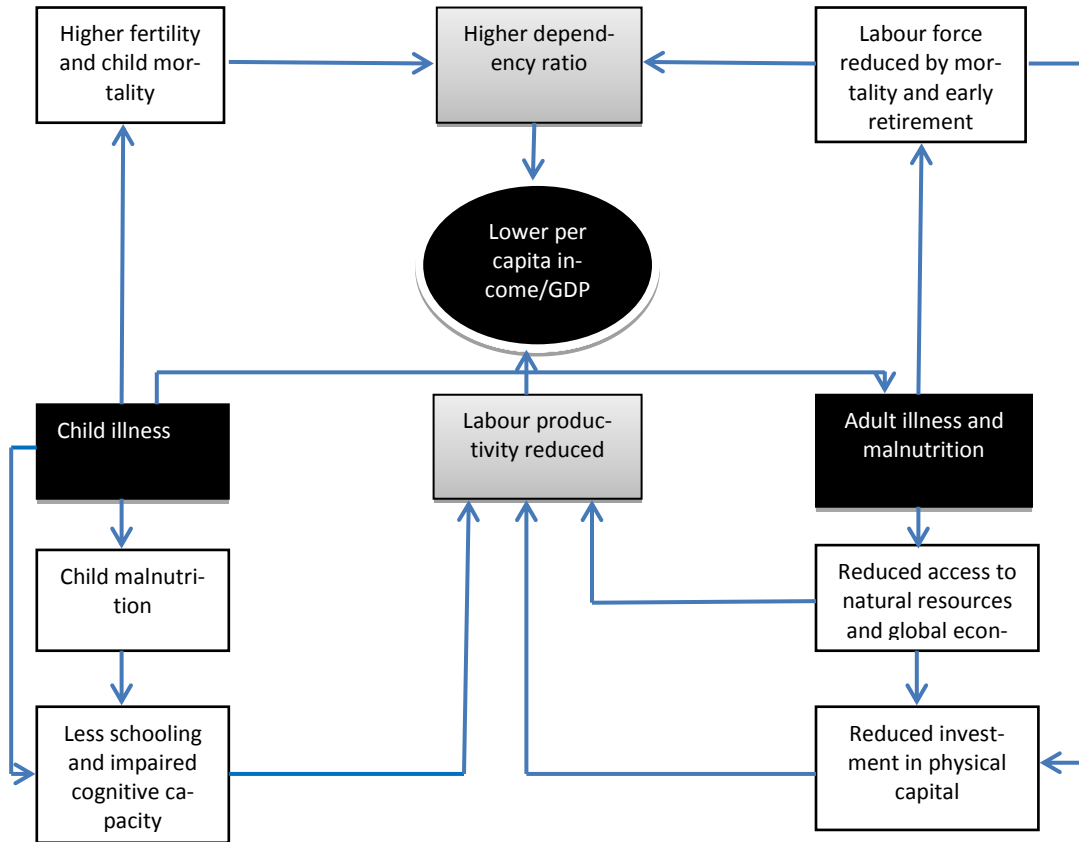
The methodological framework is extended to consider the co-movement among the variables. Therefore the cointegrated vectors and error correction model was employed to examine thoroughly the interrelationship between each of the variables. Without any assumption assigned to health indicators, trade openness, age dependency ratio, education and economic growth as the dependent variable in their correlations were taken and vector error correction approach was applied to each model: Life Expectancy Model (Section 5.4.1), Infant Mortality Rate Model (Section 5.4.2) and Fertility Rate Model (Section 5.4.3).

- The overall econometric evidence suggested that the variables included in the models have a cointegrating relationship. The coefficient of $ECT_{(-1)}$ referred to as speed of adjustment, which measures the short run deviation of economic growth from the long run equilibrium level. For example, in equation (6.6a.1) to equation (6.6d.5) of Table 5.9, equation (6.7a.1) to equation (6.7e.5) of Table 5.10 and equation (6.8a.1) to equation (6.8e.5) of Table 5.11 that all speed of adjustment coefficient estimates is attained the expected sign and significance at one per cent level, also signify that all

explanatory variables are jointly exerting a short run impact on economic growth. Therefore, *VECM* models suggest that the health indicators (life expectancy, infant mortality rate and fertility rate) play a significant role in impacting on economic growth.

- A uni-directional causality has also found in the relationship between life expectancy and economic growth, thus providing further support for the claim that life expectancy and economic growth are complementary. The innovative technique of life expectancy *VECM* model point to the fact that while there is a uni-directional relationship between life expectancy and economic growth, the latter is highly sensitive to the former. The implication is that increases in additional years of longevity would mean that it would be more likely for skilled labor to spend more time in the labor force. The result supports the claim that life expectancy is complementary to economic growth in small developed countries like Tonga. Similarly, there is a uni-directional causality between economic growth and the infant mortality rate. The hypothesis is that infant mortality does not “Granger causes” economic growth, then the null hypothesis is accepted, however the reverse is true, meaning that better economic growth is causing low infant mortality (equation 7.2a and 7.2d). The fertility rate growth model shows there is no Granger causality between fertility rates and GDP.

Figure 6.1: Health nexus to GDP



Source: Adapted from Prah et al (2001)

6.3 Limitations of the Study

Within the Ministry of Health (MOH,) which this study utilizes for most of the time for data collection there are some technical challenges confronted in terms of data management of information dissemination. Some relevant and specific parameters that were expected to be included in the study were not available. This was due to lack of human resources in terms of data analysis personnel, low standard of data compilation and, poor data collection systems. There is no single built- in database for the MOH for data entry. Therefore, a single respective department has collected their own statistical information (Naati. E⁴⁸. and Puloka, S⁴⁹. personal communication May 19 , 2013) These challenges were previously witnessed by Kupu (1999) and Finau (1983). In addition, the insufficient data availability of health makes it more difficult in studying how

⁴⁸ Senior Dietitian at Tonga Ministry of Health.

⁴⁹ Senior Health Administrator at Tonga Ministry of Health

health indicators explain the movement in current economics performances. However, these are the areas that require further investigation in order to highlight their role in the context of economic growth. Similarly, the human resources development in Tonga and the need to investigate the relationship between high literacy level (skilled workforce) and health are also a significant area and they are seen necessary worthy of further investigation in connection with the economic growth / development. Another the limitation of the study relates to the difficulty of how much it is possible to generalize the results to other small Pacific Island Countries and elsewhere in our region. Finally, the limitation is recognized, but the intention of the thesis is to focus on the primary barriers noted above.

6.4 Scope for further research

There is an immense work to be done based on the current research which can be modified and analyzed in various dimensions. There is no doubt a lot of room for improvement which can be administered with richer datasets and presumably, more time. A very interesting area to look at empirically could be to investigate the determinants of health expenditure in the Kingdom of Tonga and to what extent it has a strong impact on the health of the people. In addition, another area of interest for further study is to look at the impact of non- communicable diseases such as diabetes, high blood pressure, cardiovascular disease and heart diseases on worker morbidity in Tonga and in other Pacific Island Countries. This would be an interesting impact on the level of productivity at large⁵⁰. Yet, another line of research should be taken into consideration is the impact of traditional culture, custom and traditional values in health⁵¹ and also on economic growth. Ideally, there exists a strong impact of culture and traditional values on health and also on economic growth as well (Tutone. V. Personal communication, April 12, 2013; Pulu. M, personal communication, September 26, 2013). Similar views put forward by Evans et al (2002) also advise Tonga national policy makers to be aware of the health impact of “commodities of doubtful benefit” and of the role of trade in health of the population.

⁵⁰ The rapidly growing of NCDs is connected to the increasing rates of overweight and obesity, minimal physical activity, smoking. Economic development, improved access to processed imported food and the adoption of western dishes with high fat and sugar content have had an adverse impact on people's health (Legge et al., 2013)

⁵¹The high incidence of obesity reflects both cultural tastes and inadequate public understanding of health risk associated with poor diet and limited physical activities (ADB,2013:33)

The presence of the data would benefit the Tongan MOH not only in the case of Tonga but it would be applicable for other PICs. The government would be better to forecast in their next five or ten year plan on how to withstand financial challenges within the midst of economic hardship allowing financial priority to be given combating certain NCDs. The Tongan MOH could also benefit from this analysis through better policy advice, in conjunction with better and more precise data. They are more likely to obtain a reliable forecast on how to mitigate certain NCDs within the bounds of budget constraint. The next section will focus on the difficulties confronted mostly in the production of this thesis.

6.5 Difficulties Encountered

Limitations of the data were the main impediments confronted with the researcher. For example, data for the following variables were not available such as: hospital beds (1,000 people), human resources (for example, the number of physicians, number nurses and midwives, the number of dentists); wages paid for human resources, aggregate expenditure allocated for preventative and curative care, data on expenditure for noncommunicable diseases.

Data in Tonga during the period 1976- 1997 was found to be difficult to obtain or classified and is therefore not available⁵². This data is significant for *ex-post* and *ex-ante* forecasts as well it has crucial implications for the subject of this research. The researcher was forced to attempt to gather this data from different sources. The unavailability or the limitation of the availability of such important data puts serious restriction on the level of disaggregation of the model and perhaps caused important variables to be ignored. Thus, the application of the current framework presented is only a beginning and there will always be a room for further improvement as more statistical data become available. For instance, expenditure on human resources, related expenditure on NCDs and expenditure on communicable diseases from 1970 to the most recent time. This study is significant in explaining the impact of health on economic growth in Tonga as well as indicating a framework for the study of this issue in other PICs.

⁵²The researcher tried different modes such e- mail and on- site visit to MOH to get data for non communicable diseases and related health data, unfortunately they said they will send it back later. To date, I have not received a response since my last contact. Most of the MOH annual reports especially from 1970-1980 are missing and thereby added to the possibility of data unavailability.

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Appendix A

Simple Framework of ARDL Model

A simple description of the ARDL estimation technique using a model with two variables and a maximum of two lags are explained below:

Suppose the long run relationship is given in the form below:

$$y_t^* = \alpha + \beta x_t \quad (1)$$

And the associated error correction model can be written as follows:

$$\Delta y_t = \phi \Delta y_{t-1} + \rho \Delta x_t - \lambda (y_{t-1} - \alpha - \beta x_{t-1}) + \varepsilon_t \quad (2)$$

Equation (2) can be written in the level form as:

$$y_t = (1 + \phi - \lambda) y_{t-1} - \phi y_{t-2} + \rho x_t - (\rho - \phi \beta x_{t-1}) + \lambda \alpha + \varepsilon_t \quad (3)$$

Or

$$y_t = a_1 y_{t-1} + a_2 y_{t-2} + b_0 x_t + b_1 x_{t-1} + c + \varepsilon_t \quad (4)$$

Where

$$a_1 = 1 + \phi - \lambda,$$

$$a_2 = -\phi$$

$$b_0 = \rho$$

$$b_1 = \lambda \beta - \rho$$

$$c = \lambda \alpha$$

Equation (4) can be estimated using OLS and the coefficients of the long and short run relationship can be obtained in the following manner.

In the long run

$$\hat{\beta} = \frac{\hat{b}_0 + \hat{b}_1}{1 - \hat{a}_1 - \hat{a}_2} \quad \text{and} \quad \hat{\alpha} = \frac{\hat{c}}{1 - \hat{a}_1 - \hat{a}_2}$$

Where $\hat{a}_1 - \hat{a}_2$, \hat{b}_0 and \hat{b}_1 are OLS estimates of $a_1 - a_2$, b_0 and b_1

The short run relationship (in EC form) can be shown as follows:

$\hat{\lambda} = 1 - \hat{a}_1 - \hat{a}_2$ and $\hat{\rho}$ and $\hat{\phi}$ are given by $-\hat{a}_2$ and \hat{b}_0 respectively.

APPENDIX B

VECTOR ERROR CORRECTION MODELS

B.1: Life Expectancy

$$\begin{aligned}\Delta \ln Y_t &= \alpha_{11} + \sum_{i=1}^{p-1} \alpha_{12} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \alpha_{13} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \alpha_{14} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \alpha_{15} \Delta \ln LE_{t-s} \\ &+ \sum_{i=1}^{p-1} \alpha_{16} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \alpha_{17} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \alpha_{18} \Delta EDU_{t-s} + ECT_{1,t-1} + \varepsilon_{1t}\end{aligned}\tag{7.1a}$$

$$\begin{aligned}\Delta \ln K_t &= \alpha_{21} + \sum_{i=1}^{p-1} \alpha_{22} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \alpha_{23} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \alpha_{24} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \alpha_{25} \Delta \ln LE_{t-s} \\ &+ \sum_{i=1}^{p-1} \alpha_{26} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \alpha_{27} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \alpha_{28} \Delta EDU_{t-s} + ECT_{2,t-1} + \varepsilon_{2t}\end{aligned}\tag{7.1b}$$

$$\begin{aligned}\Delta \ln L_t &= \alpha_{31} + \sum_{i=1}^{p-1} \alpha_{32} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \alpha_{33} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \alpha_{34} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \alpha_{35} \Delta \ln LE_{t-s} \\ &+ \sum_{i=1}^{p-1} \alpha_{36} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \alpha_{37} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \alpha_{38} \Delta EDU_{t-s} + ECT_{3,t-1} + \varepsilon_{3t}\end{aligned}\tag{7.1c}$$

$$\begin{aligned}\Delta \ln LE_t &= \alpha_{41} + \sum_{i=1}^{p-1} \alpha_{42} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \alpha_{43} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \alpha_{44} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \alpha_{45} \Delta \ln LE_{t-s} \\ &+ \sum_{i=1}^{p-1} \alpha_{46} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \alpha_{47} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \alpha_{48} \Delta EDU_{t-s} + ECT_{4,t-1} + \varepsilon_{4t}\end{aligned}\tag{7.1d}$$

$$\begin{aligned}\Delta AGEDEP_t &= \alpha_{51} + \sum_{i=1}^{p-1} \alpha_{52} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \alpha_{53} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \alpha_{54} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \alpha_{55} \Delta \ln LE_{t-s} \\ &+ \sum_{i=1}^{p-1} \alpha_{56} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \alpha_{57} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \alpha_{58} \Delta EDU_{t-s} + ECT_{5,t-1} + \varepsilon_{5t}\end{aligned}\tag{7.1e}$$

$$\begin{aligned}\Delta OPEN_t &= \alpha_{61} + \sum_{i=1}^{p-1} \alpha_{62} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \alpha_{63} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \alpha_{64} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \alpha_{65} \Delta \ln LE_{t-s} \\ &+ \sum_{i=1}^{p-1} \alpha_{66} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \alpha_{67} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \alpha_{68} \Delta EDU_{t-s} + ECT_{6,t-1} + \varepsilon_{6t}\end{aligned}\quad (7.1f)$$

$$\begin{aligned}\Delta EDU_t &= \alpha_{71} + \sum_{i=1}^{p-1} \alpha_{72} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \alpha_{73} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \alpha_{74} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \alpha_{75} \Delta \ln LE_{t-s} \\ &+ \sum_{i=1}^{p-1} \alpha_{76} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \alpha_{77} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \alpha_{78} \Delta EDU_{t-s} + ECT_{7,t-1} + \varepsilon_{7t}\end{aligned}\quad (7.1g)$$

B.2: Infant Mortality Rate

$$\begin{aligned}\Delta \ln Y_t &= \delta_{11} + \sum_{i=1}^{p-1} \delta_{12} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \delta_{13} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \delta_{14} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \delta_{15} \Delta \ln IMR_{t-s} \\ &+ \sum_{i=1}^{p-1} \delta_{16} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \delta_{17} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \delta_{18} \Delta EDU_{t-s} + ECT_{1,t-1} + \mu_{1t}\end{aligned}\quad (7.2a)$$

$$\begin{aligned}\Delta \ln K_t &= \delta_{21} + \sum_{i=1}^{p-1} \delta_{22} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \delta_{23} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \delta_{24} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \delta_{25} \Delta \ln IMR_{t-s} \\ &+ \sum_{i=1}^{p-1} \delta_{26} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \delta_{27} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \delta_{28} \Delta EDU_{t-s} + ECT_{2,t-1} + \mu_{2t}\end{aligned}\quad (7.2b)$$

$$\begin{aligned}\Delta \ln L_t &= \delta_{31} + \sum_{i=1}^{p-1} \delta_{32} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \delta_{33} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \delta_{34} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \delta_{35} \Delta \ln IMR_{t-s} \\ &+ \sum_{i=1}^{p-1} \delta_{36} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \delta_{37} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \delta_{38} \Delta EDU_{t-s} + ECT_{3,t-1} + \mu_{3t}\end{aligned}\quad (7.2c)$$

$$\begin{aligned}\Delta \ln IMR_t &= \delta_{41} + \sum_{i=1}^{p-1} \delta_{42} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \delta_{43} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \delta_{44} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \delta_{45} \Delta \ln IMR_{t-s} \\ &+ \sum_{i=1}^{p-1} \delta_{46} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \delta_{47} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \delta_{48} \Delta EDU_{t-s} + ECT_{4,t-1} + \mu_{4t}\end{aligned}\quad (7.2d)$$

$$\begin{aligned}
\Delta AGEDEP_t &= \delta_{51} + \sum_{i=1}^{p-1} \delta_{52} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \delta_{53} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \delta_{54} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \delta_{55} \Delta \ln IMR_{t-s} \\
&+ \sum_{i=1}^{p-1} \delta_{56} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \delta_{57} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \delta_{58} \Delta EDU_{t-s} + ECT_{5,t-1} + \mu_{5t}
\end{aligned} \tag{7.2e}$$

$$\begin{aligned}
\Delta OPEN_t &= \delta_{61} + \sum_{i=1}^{p-1} \delta_{62} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \delta_{63} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \delta_{64} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \delta_{65} \Delta \ln IMR_{t-s} \\
&+ \sum_{i=1}^{p-1} \delta_{66} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \delta_{67} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \delta_{68} \Delta EDU_{t-s} + ECT_{6,t-1} + \mu_{6t}
\end{aligned} \tag{7.2f}$$

$$\begin{aligned}
\Delta EDU_t &= \delta_{71} + \sum_{i=1}^{p-1} \delta_{72} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \delta_{73} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \delta_{74} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \delta_{75} \Delta \ln IMR_{t-s} \\
&+ \sum_{i=1}^{p-1} \delta_{76} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \delta_{77} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \delta_{78} \Delta EDU_{t-s} + ECT_{7,t-1} + \mu_{7t}
\end{aligned} \tag{7.2g}$$

B.3: Fertility Rate

$$\begin{aligned}
\Delta \ln Y_t &= \sigma_{11} + \sum_{i=1}^{p-1} \sigma_{12} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \sigma_{13} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \sigma_{14} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \sigma_{15} \Delta \ln FR_{t-s} \\
&+ \sum_{i=1}^{p-1} \sigma_{16} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \sigma_{17} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \sigma_{18} \Delta EDU_{t-s} + ECT_{1,t-1} + \tau_{1t}
\end{aligned} \tag{7.3a}$$

$$\begin{aligned}
\Delta \ln K_t &= \sigma_{21} + \sum_{i=1}^{p-1} \sigma_{22} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \sigma_{23} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \sigma_{24} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \sigma_{25} \Delta \ln FR_{t-s} \\
&+ \sum_{i=1}^{p-1} \sigma_{26} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \sigma_{27} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \sigma_{28} \Delta EDU_{t-s} + ECT_{2,t-1} + \tau_{2t}
\end{aligned} \tag{7.3b}$$

$$\begin{aligned}
\Delta \ln L_t &= \sigma_{31} + \sum_{i=1}^{p-1} \sigma_{32} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \sigma_{33} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \sigma_{34} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \sigma_{35} \Delta \ln FR_{t-s} \\
&+ \sum_{i=1}^{p-1} \sigma_{36} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \sigma_{37} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \sigma_{38} \Delta EDU_{t-s} + ECT_{3,t-1} + \tau_{3t}
\end{aligned} \tag{7.3c}$$

$$\begin{aligned}
\Delta \ln FR_t &= \sigma_{41} + \sum_{i=1}^{p-1} \sigma_{42} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \sigma_{43} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \sigma_{44} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \sigma_{45} \Delta \ln FR_{t-s} \\
&+ \sum_{i=1}^{p-1} \sigma_{46} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \sigma_{47} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \sigma_{48} \Delta EDU_{t-s} + ECT_{4,t-1} + \tau_{4t}
\end{aligned} \tag{7.3d}$$

$$\begin{aligned}
\Delta AGEDEP_t &= \sigma_{51} + \sum_{i=1}^{p-1} \sigma_{52} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \sigma_{53} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \sigma_{54} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \sigma_{55} \Delta \ln FR_{t-s} \\
&+ \sum_{i=1}^{p-1} \sigma_{56} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \sigma_{57} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \sigma_{58} \Delta EDU_{t-s} + ECT_{5,t-1} + \tau_{5t}
\end{aligned} \tag{7.3e}$$

$$\begin{aligned}
\Delta OPEN_t &= \sigma_{61} + \sum_{i=1}^{p-1} \sigma_{62} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \sigma_{63} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \sigma_{64} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \sigma_{65} \Delta \ln FR_{t-s} \\
&+ \sum_{i=1}^{p-1} \sigma_{66} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \sigma_{67} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \sigma_{68} \Delta EDU_{t-s} + ECT_{6,t-1} + \tau_{6t}
\end{aligned} \tag{7.3f}$$

$$\begin{aligned}
\Delta EDU_t &= \sigma_{71} + \sum_{i=1}^{p-1} \sigma_{72} \Delta \ln Y_{t-s} + \sum_{i=1}^{p-1} \sigma_{73} \Delta \ln K_{t-s} + \sum_{i=1}^{p-1} \sigma_{74} \Delta \ln L_{t-s} + \sum_{i=1}^{p-1} \sigma_{75} \Delta \ln FR_{t-s} \\
&+ \sum_{i=1}^{p-1} \sigma_{76} \Delta AGEDEP_{t-s} + \sum_{i=1}^{p-1} \sigma_{77} \Delta OPEN_{t-s} + \sum_{i=1}^{p-1} \sigma_{78} \Delta EDU_{t-s} + ECT_{7,t-1} + \tau_{7t}
\end{aligned} \tag{7.3g}$$

Appendix C

Dep Variable	Appendix C.1: Granger Causality of Life Expectancy - Growth Model							
	Short- Run Lagged Differences (F-test)							Lagged ECT
	$\Delta \ln Y$	$\Delta \ln K$	$\Delta \ln L$	$\Delta \ln LE$	$\Delta AGEDEP$	$\Delta OPEN$	ΔEDU	ECT
(7.1a) $\Delta \ln Y$		0.994	0.048	5.126***	0.013	1.572	0.058	-0.026 (-1.80)*
(7.1b) $\Delta \ln K$	1.813		0.718	4.354**	0.784	1.279	2.093	-0.042 (-2.6)***
(7.1c) $\Delta \ln L$	0.893	0.504		1.450	1623.0***	0.360	36.22***	0.0003 (5.33)
(7.1d) $\Delta \ln LE$	2.126	0.642	0.746		0.071	1.886	0.0313	0.0003 (1.27)
(7.1e) $\Delta AGEDEP$	0.213	1.489	311.6***	1.247		2.054	1.791	0.290 (46.83)
(7.1f) $\Delta OPEN$	0.137	0.064	0.665	0.229	0.665		0.761	-9.22 (-1.59)
(7.1g) ΔEDU	0.301	1.480	1.079	2.097	1.655	0.083		0.083 (0.950)
Notes: *, **, and *** denote statistical significance at the 1 per cent, 5 percent and 10 per cent levels, respectively. The t-statistics are shown in parenthesis and square brackets.								

Dep Variable	Appendix C.2: Granger Causality of Infant Mortality Rate- Growth Model							
	Short- Run Lagged Differences(F-test)							Lagged ECT
	$\Delta \ln Y$	$\Delta \ln K$	$\Delta \ln L$	$\Delta \ln IMR$	$\Delta AGEDEP$	$\Delta OPEN$	ΔEDU	ECT
(7.2a) $\Delta \ln Y$		0.491	0.514	0.444	0.332	0.768	0.228	0.086 (0.72)
(7.2b) $\Delta \ln K$	0.545		0.641	0.301	0.304	0.588	0.685	0.156 (1.11)
(7.2c) $\Delta \ln L$	0.2005	2.826		2.039	166.06***	0.915	11.843***	-0.0018 (7.99)***
(7.2d) $\Delta \ln IMR$	0.283	0.681	1.612		0.595	0.578	4.327**	-0.02 (-2.17)**
(7.2e) $\Delta AGEDEP$	0.0090	1.061	397.6	1.729		0.715	8.661***	-1.4 (64.3)***
(7.2f) $\Delta OPEN$	0.0185	0.1915	0.379	0.214	0.397		0.245	30.07 (0.54)
(7.2g) ΔEDU	0.135	0.049	0.676	0.911	1.270	0.133		0.325 (0.429)
Notes: *, **, and *** denote statistical significance at the 1 per cent, 5 percent and 10 per cent levels, respectively. The t-statistics are shown in parenthesis and square brackets.								

Dep Variable	Appendix C.3: Granger Causality of Fertility Rate- Growth Model							
	Short- Run Lagged Differences (F- test)							Lagged ECT
	$\Delta \ln Y$	$\Delta \ln K$	$\Delta \ln L$	$\Delta \ln FR$	$\Delta AGEDEP$	$\Delta OPEN$	ΔEDU	ECT
(7.3a) $\Delta \ln Y$		0.0868	0.3073	1.765	0.415	1.051	0.0072	0.076 (0.617)
(7.3b) $\Delta \ln K$	0.665		0.027	3.274*	0.932	0.907	1.313	0.120 (0.837)
(7.3c) $\Delta \ln L$	0.612	1.542		1.524	966.8***	0.511	14.558***	-0.002 (-7.5)***
(7.3d) $\Delta \ln FR$	0.242	0.124	3.533**		2.296	1.768	2.023	0.0428 (1.58)
(7.3e) $\Delta AGEDEP$	0.922	2.556	288.16***	3.188*		2.296	6.165***	-1.80 (55.0)***
(7.3f) $\Delta OPEN$	0.069	0.130	1.104	0.630	1.172		0.428	20.07 (0.35)
(7.3g) ΔEDU	0.831	1.945	0.846	1.379	1.484	0.0318		0.673 (0.891)
Notes: *, **, and *** denote statistical significance at the 1 per cent, 5 percent and 10 per cent levels, respectively. The t-statistics are shown in parenthesis and square brackets.								