Chapter 1

Introduction

Historically, agriculture and the rural sector have been a major source of output and employment in developing countries. However, over the past three decades the share of agriculture in world gross domestic product (GDP) has been steadily declining in favour of manufacturing and the services sectors. This is demonstrated by the increasing migration of labour to the urban sector and the decreasing contribution of agriculture to total employment. However, the decline in agriculture's contribution to GDP has been much faster than its decline as a provider of employment (Rao, Coelli, & Alauddin, 2004).

As stated by Ali (1989), existing literature on the role of agriculture in economic development may be said to have two aims: to provide a broad historical perspective and to try to draw lessons from the experiences of the developed countries in their early stages of economic development with the intention of applying these lessons to the present day developing countries. For many of the developed countries in Europe, and in Japan and also the USA, a dynamic agriculture accompanied and in some instances, directed the process of industrialisation and growth. This pattern was repeated for many recently industrialised countries.

In the discussion of the role of agriculture in economic development, a leading question is how agriculture contributes to economic growth, and especially to pro-poor growth. It is a theme which has been much debated and even a synopsis would take volumes. Witt (1965) explains the changing view of the role of the agriculture sector in economic development. During the 1950s, most development economists were dubious about the role of agriculture. They argued that industrialisation was the dynamic element of the development process, supporting this view with the presumed generalisation that there is surplus labour in the agricultural sector where their marginal product is practically zero. Hence, labour is potentially available for the industrial sector and more of the labour force in agriculture could be removed without a loss in farm production. Political leaders held complementary views. Steel mills were symbols of power. Development was synonymous with industrialisation. Agriculture was equated with poverty, and industry with wealth despite the examples of Canada and New Zealand.

Agriculture was correlated with colonialism and with a dependent status in world economic events. There is evidence of more concern with food supplies in recent years. A few economists have been arguing for a priority in food production. They give a higher priority to agriculture than previously. A third view is that agriculture is an intimately interrelated sector in the development process. It has a role to play, but so do other sectors. A "balance" of effort is needed, whatever that may be.

A number of authors have dealt with agriculture's contributions to development. The Kuznets and Johnston-Mellor analyses are most familiar (Johnston & Mellor, 1961; Kuznets, 1961). Johnston and Mellor (1961) concentrate on the cross-sectoral transactions, including products, factors, and money. They list five categories of contributions: farm products for domestic consumption, the export of farm products and consequent earnings of foreign exchange, the transfer of manpower to the non-agricultural sector, the flow of money into capital formation, and the increased rural cash income as a market for industrial products. Kuznets (1961) points to three rather than five contributions and considers them more in relation to economic development in general than to other sectors. He lists them as product, market and factor contributions.

The product contribution of agriculture comes first from a rise in farm production in and of itself. The gross national product (GNP) is larger because the agricultural sector has added a larger volume of farm products (Kuznets, 1961). Johnston and Mellor (1961) also have product contributions to meet the expanding demand for farm products, and to fill some part of export demand. The market contribution, as described by Kuznets (1961), concentrates on the opportunity which a margin over family consumption provides for domestic trade, international trade and division of labour. Agriculture buys both production and consumption goods by selling some of its product, thus making it possible for other sectors to emerge and grow. As this occurs there are substantial changes in the economic structure. The changing structure in agricultural marketing is another example of this emergence and growth of other sectors. Three of Johnston and Mellor's five contributions can be included here. The movement of farm products to the domestic market, to the foreign market, and the flow of industrial goods to agriculture, all are part of Kuznets' market contribution. The factor contribution is the third of Kuznets' categories. He explains, “Thus if agriculture itself grows, it makes a product contribution; if it trades with others, it renders a market contribution; if it

transfers resources to other sectors, these resources being productive factors, it makes a factor contribution" (Kuznets, 1961, p. 69). The resources being transferred may be the compulsory transfer of capital, the loan of capital funds, or transfer of labour. Thus, in reality, Kuznets has identified three subsets of factor contributions, while Johnston and Mellor have made this area two sets of their total of five. They are the transfer of manpower and capital formation.

Application of the lessons learnt from the historical perspectives to the present–day developing countries is difficult. Policies that worked for one country may not be a solution for another as no two economies can be identical. For example, Myint (1975) expressed his view of conceptual difficulties of economic policies designed to increase agricultural sectors capacity to contribute to economic development.

1.1 Background

The agriculture sector plays an integral part in the Sri Lankan economy. Sri Lanka's agricultural sector is dualistic in nature, comprising of an export-oriented plantation sector and a less developed food crop production sector. The former produces tea, rubber and coconut on large to medium estates, and the latter accounts for paddy, subsidiary food crops, fruits, vegetables and livestock, predominantly on small-holdings. Throughout the 1990s, plantation crops remained the most important foreign exchange earner in terms of local value addition and the largest single employer in the country. At the same time, the non-plantation agriculture sector has remained an important source of rural income and employment (Herath, 2007). In 2008, this sector contributed 12 per cent to the GDP (Central Bank of Sri Lanka [CBSL], 2008a). The agriculture sector's contribution is significant in terms of employment. According to the labour force survey report of 2008, the agriculture sector absorbs over one third of the country's labour force.

At the time of independence in 1948, the Sri Lankan economy was largely agricultural. Nearly 50 per cent of national output was from agriculture. Even this figure did not sufficiently reflect the significance of agriculture in the economy due to two main reasons. First, a substantial proportion of the contribution of manufacturing was from processing of plantation crops. Second, a significant share of the contribution of services too came from services related to transport, insurance and banking of plantation crops. This predominance in agriculture

continued for about the next three decades. With the structural transformation occurring in the economy, agriculture currently contributes only around 12 per cent to the GDP. The economy has become more diversified with services and manufacturing sectors contributing significantly (Sanderatne, 2011). In 2010, the manufacturing sector contributed 29 per cent to the GDP, while the services sector contributed 59 per cent (CBSL, 2010a).

Although its relative position in the economy has been declining with the growth of other sectors, which reflects the normal pattern of structural change during economic development, the agriculture sector continues to play a vital role in the Sri Lankan economy in terms of the country's economic growth and poverty reduction. Nearly 80 per cent of the population resides in rural areas, the majority of whom still depend directly or indirectly on agriculture for their livelihoods (Herath, 2007). Agricultural exports accounted for 24 per cent of total exports in 2011, contributing nearly 12 per cent of the growth of export earnings in that year. Minor agricultural products, which generated US dollars 235 million in 2011, are increasingly becoming an important source of export earnings for the country. Furthermore, 11 per cent of industrial exports are also based on agricultural outputs (CBSL, 2011a). These statistics emphasise the strategic importance of the agricultural sector and highlight its influence on national income, employment and foreign trade in the Sri Lankan economy.

The average growth rate of the sector has been very low (less than 2.5 per cent) over the last several years despite continuous assistance provided by the government. Agricultural productivity also remains low, raising concerns that comprehensive development is needed in the sector to enhance growth prospects of the overall economy (Institute of Policy Studies [IPS], 2002). Had the agriculture sector performed better, export earnings would have been higher, import needs less and inflationary pressures could have been more restricted through reduced food prices (Sanderatne, 2011, p. 128). Even though its relative position in the economy has been declining with the growth of other sectors, agriculture continues to play a vital role in the Sri Lankan economy.

1.2 Research problem

As noted above, the agriculture sector holds an important role in the Sri Lankan economy and it is evident in terms of its notable contribution to GDP, contribution to export earnings and to employment generation. As a result, the important role played by the agricultural sector in the Sri Lankan economy is recognised by policy makers expecting it to play a leading role in enhancing economic growth since independence. Important roles have been assigned to the sector, which have been based around objectives such as achieving food security, self-sufficiency in food production, livelihood improvement, improving the productivity of the sector, expanding agricultural export earnings, improving employment opportunities, and development in the rural income focusing on poverty alleviation. Development in agriculture has been considered by the successive governments as a path to poverty alleviation.

Unfortunately, public policy towards agriculture has not been consistent in Sri Lanka. According to Bandara and Jayasuriya (2009), government administrations have experimented with a wide variety of policy regimes since independence. They have switched from open- free market policies (up to 1959) to import substituting industrialisation (ISI) policies (1960-1977) and export-oriented liberalisation policies (after 1977). To promote its objectives in the agriculture sector, successive governments have adopted a wide range of policies. The governments' conflicting aims of having low food prices for consumers and high producer prices have led to gross policy inconsistencies and ad-hoc policy changes. Since the late 1970s, the agriculture sector has been subjected to a mixture of policy reforms to increase exports, improve productivity, diversify and commercialise production, liberalise trade, improve access of the poor to productive assets and support services, and to foster private sector participation (Asian Development Bank [ADB], 2007). The affirmed aim of these policy planners is to increase output in agriculture and thereby contribute to increased GNP and to raising the real incomes of the poor. Furthermore, improving productivity of the sector and transforming traditional agriculture into high value agriculture has been given high priority in recent policy frameworks.

The most recent policy framework envisaged that the agriculture sector would grow at a faster rate of 4-5 per cent with a higher contribution from the non-plantation sector (Ministry of Finance and Planning, 2006). Within the liberal economic environment, current agriculture

policy is directed towards improving productivity of both plantation and non-plantation sectors making them more competitive and creating exportable surpluses or import substitution to strengthen the balance of payment situation of the country, while increasing the income levels of the people who engage in such cultivation.

Therefore, it could be said that government has continued to, and is planning to, direct resources in an attempt to develop the agriculture sector giving priority to agricultural development. However, when it comes to results after implementation of such policies, they are not always as expected. Agricultural growth rates have been poor in comparison to expectations. Hence, each of the policies initiates intense discussions both within the country and between government agencies and foreign donors, making them significant subject areas of study. Therefore, there is a need for a theoretical and empirical analysis of results of such policies. Hence, an attempt is made in this study to investigate economy-wide impacts of possible alternative policy scenarios for the agriculture sector.

1.3 Research methodology

To examine the economic impact of policies in agricultural or non-agricultural sectors, it is essential to adopt an appropriate methodology. This often requires a baseline scenario against which the policy experiment can be evaluated. Construction of a model of the particular sector of interest is one way of forming a counterfactual which can be used to evaluate the outcomes of a policy change in the light of the model's structure and assumptions. Since the main interest of this study is to see how domestic sectoral policies affect the overall economy, there is a need to have an analytical framework of the overall economy's structure that allows evaluation of the effects of a wide variety of policies on economic variables. It would be difficult to do such analysis in a partial setting as partial equilibrium models focus on detailed modelling of a particular sector and consider the impact of policy on other sectors small enough to be ignored in practice.

Several studies have been conducted in Sri Lanka in order to examine the impacts of different agricultural policy scenarios on selected individual crop sectors. These fragmented research studies do not shed enough light on the economy-wide impacts of existing agricultural policies, and there is no established analytical framework to evaluate the impacts of future

policies. There are several methodologies available in order to capture the interactions among sectors in an economy. As summarised by Ali (1989), methodologies used to capture the interactions among sectors can be classed under input-output analysis, mathematical programming models, computable general equilibrium (CGE) models and multimarket analysis. The methodology considered most appropriate for the questions addressed in this thesis is multi-sectoral models known as CGE models. In this study we mainly concentrate on the agricultural sector and develop an agriculture-focused CGE model so that impacts on the sector, economy-wide impacts, regional impacts and impacts on households can be examined.

1.4 Objectives of the research

The main objective of this study is to evaluate economy-wide impacts of agricultural policies in Sri Lanka. Specifically, the study aims to look at the effects of different policies in the agriculture sector including examining the impacts of an increase in productivity of primary inputs, expanding land area under cultivation and agricultural trade liberalisation on macro variables, industry level, regional level and household consumption. It is appropriate to implement a general equilibrium model as these policies have economy-wide impacts. Hence, the specific objectives of the study are:

1. To develop an economic model for the Sri Lankan economy focusing on the highly disaggregated agriculture sector that can be used to analyse agricultural sector policies.
2. To identify the linkages between the macro economy, sectoral outputs and household income and consumption in Sri Lanka.
3. To analyse the impact of different agricultural policies on the macro economy, sectoral level, regional level and welfare of households in Sri Lanka.
4. To make policy recommendations to strengthen the agriculture sector and its contribution to the overall economy.

1.5 Organisation of the study

To achieve the objectives specified above, the thesis is organised under seven chapters as follows. The next chapter, Chapter 2, starts out with a brief description of the Sri Lankan economy giving emphasis to the agriculture sector. It will expand the discussion on the agriculture sector in Sri Lanka incorporating key characteristics of the sector. Furthermore, different regions in Sri Lanka will be described in order to get insight into the research.

Chapter 3 is dedicated to carrying out a comprehensive literature review in order to shed light on the research. Evaluation of the outcomes of previous research is imperative to make a new contribution to the existing literature. Chapter 4 presents the methodology for the research. This chapter will review the theoretical structure pertinent to constructing a multi-sectoral CGE model for Sri Lanka. Chapter 5 describes the process of developing the data base for the model. In order to develop the data base, a published input-output (I-O) table for the country will be modified using several other data sources.

Policy simulations will be conducted and the results of identified policy simulations on the Sri Lankan economy will be presented in Chapter 6. Ultimately, in Chapter 7, conclusions and policy recommendations will be presented that will help the policy makers in Sri Lanka to develop the agriculture sector for the benefit of the country.

Chapter 2

An Overview of the Sri Lankan Economy

Historically, Sri Lanka was considered predominantly an agricultural economy. Over the past decades, agriculture's contribution to the Sri Lankan economy has been steadily declining with the increased contribution from the manufacturing and services sectors. However, the agriculture sector is still recognised as a key contributing sector to the economy due to its links with other sectors in the economy. The objective of this chapter is to provide a review of the Sri Lankan economy focusing on its structure and development, its agriculture, and agricultural policies in order to set the context for modelling the impacts of domestic agricultural policies on the macro economy, domestic industries, households and regions.

This chapter is organised as follows. Section 2.1 outlines the socio-economic profile of the country. It describes the country's position among various socio-economic indicators. Section 2.2 describes the historical background of its economic growth and structural features. It explores the development process since independence and the changes in the economic structure. Section 2.3 uncovers the characteristics of the Sri Lankan agricultural sector, while Section 2.4 covers the evolution of agricultural policies and development strategies in the agricultural sector, exploring the nature and impact of government policies on the sector. Section 2.5 describes the regions of Sri Lanka and evaluates the extent of regional disparities. Section 2.6 provides a summary of the chapter.

2.1 Socio-economic background of the economy

Sri Lanka is an island, situated at the southern extremity of the Indian subcontinent, historically renowned as "the pearl of the Indian Ocean". While its present official name is the Democratic Socialist Republic of Sri Lanka, it was known by a variety of names in ancient times. Ancient Greek geographers called it "Taprobane" and Arabs referred to it as "Serendib". The Portuguese named it "Ceilão" when they arrived in 1505, which was translated into English as "Ceylon" when they ruled the country (Rajasingham, 2001). The inhabitants of the country referred to it as "Sri Lanka" or "Sinhale". The country encompasses

a total land area of 65,610 sq. km, which has an astonishingly varied and wide array of eco-systems. Sri Lanka's recorded history reaches back at least 2500 years.

A topographic map of the island suggests the shape of a hat. It has mountainous terrain with an average elevation of 3700 feet (1128 m) in the central part. This is surrounded by an upland area ranging between 1000 to 3000 feet (305 to 914 m) above mean sea level. The rest of the country consists of a coastal plain, broad in the north and narrowing in the east, west and the south. More than three-quarters of the land area is arable and the climate is suitable for most tropical crops (Ponnambalam, 1981). The rain-shadow effect caused by the central mountains has given rise to two pronounced zones, the Wet Zone and the Dry Zone. The Wet Zone has an annual rainfall of 2500-5000 mm, and rises to 2500 m above mean sea level. The Dry Zone is spread over much of the lowland plains. Despite a rainfall of 1250 mm-1900 mm per annum, this region has a long drought period of about 5 months. A narrow Intermediate Zone with a mean annual rainfall between 1900 and 2500 mm lies between the Wet and Dry Zones, and there are two extra dry coastal strips with prolonged drought periods in the north-west and south-east coastal regions forming the Arid Zone with a mean annual rainfall of less than 1250 mm (Peiris, G., 1977). The central hills are the source of major river systems which provide irrigation water for downstream crop production. At the time of independence from British colonial rule in 1948, the Sri Lankan economy was dominated by export-oriented, commercial plantation crops and paddy farming for domestic consumption.

According to the most recent population counts, Sri Lanka has a population of more than 20 million, with a very high population density of 333 persons per sq. km (CBSL, 2011a). The annual rate of population growth was around 2.5 per cent in 1948 (Ponnambalam, 1981). It has declined and has become more or less stable around 1 per cent during recent years (Table 2.1). The population consists of several ethnic and religious groups. Around 75 per cent of the population are Sinhalese. Other ethnic groups are made up of Sri Lankan Tamils (approximately 11 per cent), Indian Tamils (about 4 per cent), Sri Lankan Moors (around 9 per cent) and others (Malays and Burghers of Portuguese and Dutch descent) (DCS, 2012b). It is a multi-religious population comprising Buddhists, Hindus, Christians and Islamists. Most of Sri Lanka's Sinhalese are Buddhists, most of its Tamils are Hindus, and most of its Moors follow Islam. Christians, particularly Roman Catholics, are also an important religious minority.

Table 2.1: Key socioeconomic indicators

Socioeconomic indicators	
Land area	62,705 sq.km.
Midyear population (2011)	20.8 Mn
Population density (2011)	333 persons per sq.km.
Population growth rate (2011)	1 per cent
Crude birth rate (2010)	17.6 per 1000
Crude death rate (2010)	6.2 per 1000
Infant mortality rate (2007)	8.5 per 1000 live births
Dependency ratio (2010)	48.4 per cent
Expectation of life at birth (2007)	
Male	70.3 years
Female	77.9 years
Literacy rate (2010)	91.9 per cent
Gini coefficient of household income (2009/2010)	0.49
Population below US$ 1 a day (1990-2005)	5.6 per cent
Population below US$ 2 a day (1990-2005)	41.6 per cent
Poverty head count index (HCI) (2009/2010)	8.9
Prosperity index (2007)	52.7
Human development index (HDI) (2011)	0.69 (rank:97)
Sectoral distribution of population (2001)	
Urban	22 per cent
Rural	72 per cent
Estate	6 per cent
Sectoral distribution of employment (2009)	
Urban	32.6 per cent
Rural	25.1 per cent
Estate	42.3 per cent
Labour force participation rate (2011)	48.2 per cent
Unemployment rate (2011)	4.2 per cent

Source: CBSL, Annual reports (various issues)

The distribution of the population is very uneven. The vast majority of the people live in the rural areas including estates. According to the census of population and housing 1981, 22 per cent of the total population reside in urban areas, 72 per cent reside in rural areas and only 6 per cent reside in the estate sector (CBSL, 2008b). However, this situation is constantly changing with an increasing component of the population moving to and around urban areas (IPS, 2004).

Development operations in Sri Lanka have taken place in a challenging environment, marked by a civil conflict with changing intensity in the northern and eastern parts of the country for nearly three decades (ADB, 2007). The conflict between the Sri Lankan government and the Liberation Tigers of Tamil Eelam (LTTE) was one of the longest-running civil conflicts in Asia. The structure and dynamics of the conflict revolves around ethnic issues and a demand for a separate state based on ethnicity. There are various interpretations to the history and causes of the conflict, which broke out in 1983.

Three decades of war distorted Sri Lanka's economy, hindered development and reduced the country's potential growth. The economic costs of the conflict have been severe: (i) a decline in economic growth by 2−3 per cent annually, (ii) 40 per cent less per capita income than that could have been achieved if not for the conflict and (iii) foregone foreign investment. The Institute of Policy Studies (IPS) in Sri Lanka estimates the total cost of the conflict at 170% of the GDP in 1984−1996 (Arunatilake, Jayasuriya, & Kelegama, 2000, 2001). The conflict has contributed to fiscal deficits (typically about ten per cent of GDP), which raised the public debt to more than 100 per cent of GDP in the early 2000s. Although the public debt has declined, it remained high at 93 per cent of GDP in 2006. Budgeted defence spending rose slightly from 2.5 per cent of GDP in 2006 to 2.7 per cent of the projected GDP for 2007 (ADB, 2007). The end of the conflict in 2009 has provided an enormous opportunity to revive economic growth.

Sri Lanka has performed well across a wide range of human development indicators since the early years of independence. The country is usually cited as an example of a developing country which has offered the people a high standard of social welfare (Sahn, 1987). Sri Lanka is a middle-level achiever in relation to the HDI, ranking 102nd among 179 countries in 2007 (Table 2.1). It was one of the first developing countries to invest in human resources and to

promote gender equality. Sri Lanka is primarily on track to achieve most of the Millennium Development Goals (MDG) including primary school enrolment, gender parity in primary and secondary school enrolment and provision of reproductive health services. Life expectancy at birth among men and women, for example, has averaged 70 and 77 years, respectively, which is higher than the average among middle-income countries. The literacy rate is over 90 per cent (Table 2.1). The country's high achievement in human development is evident when the HDI is compared with its member countries in the South Asian region. According to United Nations Development Programme (UNDP) (2007), Sri Lanka recorded the highest HDI among the SAARC (South Asian Association for Regional Cooperation) countries in 2005 (Table 2.2).

Table 2.2: Sri Lanka among other SAARC countries in 2005 and 2007 in terms of HDI

	2005		2007	
Country	HDI	World Rank	HDI	World Rank
Sri Lanka	0.743	99	0.759	102
India	0.619	128	0.612	134
Pakistan	0.551	136	0.572	142
Bangladesh	0.547	140	0.543	146
Nepal	0.534	142	0.553	144
Bhutan	0.579	133	0.619	132
Maldives	0.741	100	0.771	95

Source: CBSL (2010b); UNDP (2007, 2009)

2.1.1 Sectoral performances: agriculture, manufacturing and services

In colonial Sri Lanka, agriculture was the predominant sector of the economy in terms of value adding and employment generation. At the time of independence from British colonial power in 1948, Sri Lanka inherited a dualistic agricultural economy which is in existence even today. This consists of an export-oriented plantation agricultural sector and a domestic non-plantation agricultural sector. The plantation agricultural sector is concerned with the production of tea, rubber and coconut. Non-plantation agriculture is dominated by rice and includes other cereals, spices, vegetables, sugar, meat and dairy products (Gunawardana & Somaratne, 2000). At the time of independence, the share of the agricultural sector in GDP was about 46 per cent,

while the share of the services sector was about 42 per cent. The share of the industrial sector was relatively small and was around 11 per cent (Table 2.3).

In the 1950s, plantation crops not only contributed a large share of agricultural output, but also contributed to manufacturing output with processing of tea, rubber and coconut. The processing of these tree crops accounted for over 60 per cent of manufacturing output. Other factory industry was negligible. Furthermore, most of the services were ancillary to and supportive of the plantation crops (Sanderatne, 2005). The major structural change in the Sri Lankan economy in recent decades has been the reduction in the share of agriculture and expansion of the share of the manufacturing sector. Until 1960, there was no significant change in the sectoral composition of GDP. Agriculture remained as the major contributor to GDP (Liyanage, 2000). Two significant changes in the sectoral composition of the economy have occurred since the 1960s. Firstly, as Table 2.3 shows, the contribution of agriculture to GDP declined from 46.6 per cent in 1950-54 to 17.2 in 1998 and to 12.1 in 2005. Secondly, the economy has become more service oriented.

The decline in the relative importance of agriculture reflects the normal pattern of structural change during economic development as well as the impact of specific policy interventions. The contribution of the services sector increased its share from 42.3 per cent in 1950-54 up to around 60 per cent in 2008 (Table 2.3). The share of the industrial sector, which was steady at around 10 per cent up to about the mid-1950s, expanded quickly after that time exceeding 20 per cent by the late 1980s. This was mostly due to rapid growth in the manufacturing sector, the share of which increased from 5 per cent in 1960-64 to 13 per cent in 1984-89. During the 1960s and until the mid-1970s, the sector expanded in response to the momentum generated by import restrictions and public sector investment. By the end of 2008, the share of industry neared 30 per cent of GDP. Since the late 1970s, the most dynamic sector within manufacturing has been the garment industry, which has also emerged as a major earner of foreign exchange. The share of the services sector increased steadily until the mid-1970s and then expanded very rapidly following the 1977 policy reforms.

The provincial contribution to GDP has not been uniform. Western Province where the majority of the development work is carried out, contributes nearly half of the GDP, while the rest of the provinces contribute the other half. Central, Southern and North Western Provinces

contribute around 10 per cent each, while the contribution from each of the other provinces is around 5-6 per cent (Figure 2.1).

Table 2.3: Sectoral composition of GDP, 1950-2008[1]

Sector	1950-54	1960-64	1970-77	1984-89	1998	2005	2008
Agriculture, forestry, fishing and hunting	**46.6**	**46.1**	**36.8**	**27.2**	**17.2**	**12.5**	**12.1**
-Plantation	29.8	26.7	17	8.7	5.3	3.1	2.8
-Domestic agriculture	14.1	8.3	17.5	14.9	5.2	8.8	8.7
Industry	**11.2**	**10.3**	**16.5**	**21.4**	**26.9**	**28.4**	**28.4**
-Manufacturing (excluding export processing)	5	5.6	9.1	12.9	17.2	17.4	16.9
-Construction	4.2	2.4	4.9	7.3	6.7	6.2	6.5
Services	**42.3**	**43.6**	**46.7**	**51.4**	**54.8**	**59.4**	**59.5**

Source: Athukorala and Jayasuriya (1994); Department of Census and Statistics [DCS] (2002c); and CBSL (2008a)

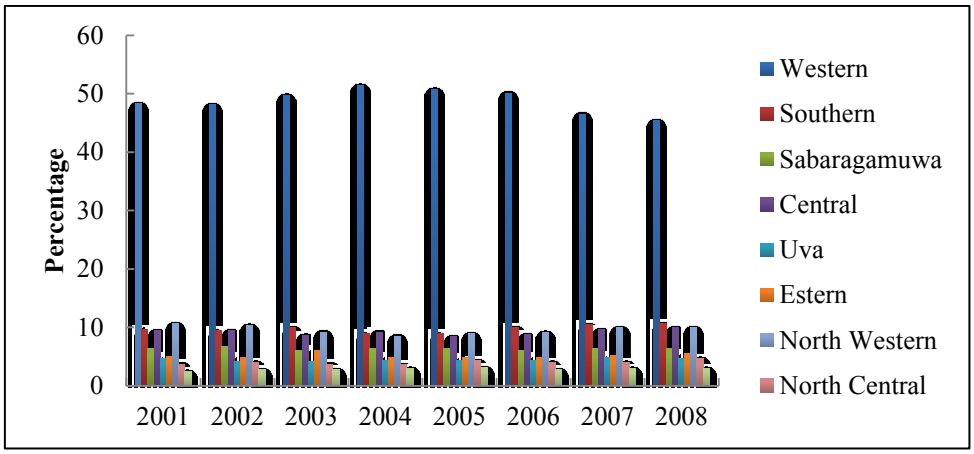

Figure 2.1: Provincial contribution to the GDP

Source: CBSL (2009)

[1]Note: Estimates for 1950 to 1970 are at 1959 factor cost, estimates for 1971-83 are 1970 factor cost, estimates for 1984-89 and are at 1982 factor cost

Estimates for 1998 are at (1998) constant prices

Estimates for 2005 and 2008 are at 2002 constant prices

2.1.2 Employment structure and unemployment

According the CBSL (2009), the total labour force in Sri Lanka surpasses 7 million. The sectoral distribution of employment does not reflect changes in sectoral composition of GDP. Even in 1986/1987, nearly half the number of employed people were engaged in agriculture and other primary sector activities producing less than a quarter of the total national product. The manufacturing sector employed only 12.5 per cent of the total number of employed people in the same year (Liyanage, 2000). While the share of agriculture is only about a fifth of GDP in 2005, its contribution to employment is much larger, accounting for about 31 per cent in 2005. Employment in the manufacturing sector increased from 12 per cent in 1953 to 24 per cent in 2004, while that of the services sector increased from 35 per cent to 45 per cent in the above years. (Table 2.4)

Table 2.4: Trends in employment structure in selected years

Sector	1953	1963	1971	1981	1991	2001	2009
Agriculture	53	53	50	45	42	33	33
Manufacturing	12	12	12	15	20	22	25
Services	35	35	38	40	38	45	42

Source: Bandara and Jayasuriya (2009); CBSL, Economic and Social Statistics (various issues)

Unemployment has been a serious and persistent problem over the last few decades. Unemployment rates, which fluctuated in the range of 11-12 per cent in the 1950-1960 period, accelerated thereafter. Central bank surveys estimated unemployment at 24 per cent in 1973, 15 per cent in 1978/1979, 12 per cent in 1981/82 and 15.5 per cent in 1986/87. However, recent surveys by the Department of Census and Statistics (DCS) record it at 7.6 per cent and 6 per cent in 2000 and 2006, respectively. A major proportion of unemployment is accounted for by women. Female employment also expanded rapidly during the last few decades, but has not kept pace with the large additions to the labour force.

Out migration of labour has been an important factor in the Sri Lankan labour market. In the early 70s, it took the form of a brain drain of professionals to developed countries, but in the 80s and 90s it provided an important option for semi-skilled female workers, mainly to Middle Eastern countries like Saudi Arabia, Kuwait and United Arab Emirates (U.A.E). The

remittances made by these migrant workers have become a major source of foreign exchange earnings for the country (Alailima, 2000).

2.1.3 External linkages in the Sri Lankan economy

The structural changes in the economy are reflected in the country's trade pattern. The modern Sri Lankan economy has been heavily trade dependent, exporting plantation crops and importing rice, wheat flour, and sugar, as well as manufactured consumer goods. At the time of independence, the Trade Dependency Ratio (TDR), that is the sum of imports and exports of goods and services as a share of GDP, was 70 per cent and remained almost unchanged throughout the 1950s. From then, up to 1977, it declined due to the combined impact of sluggish export performance and rigorous import controls. Following trade liberalisation in 1977, TDR started increasing dramatically, attaining 83 per cent in 1980, and then declining to about 65 per cent on average during the 1980s (Athukorala & Jayasuriya, 1994). TDR increased up to 77 per cent in 2000 and declined to about 63 per cent in 2007 (Table 2.5). The trade dependence is mainly industrial. Manufactured goods dominate exports, while capital goods and raw materials for industries dominate imports.

At the time of independence, Sri Lanka was predominantly an agricultural economy with plantation exports acting as the main engine of growth. Plantation exports generated nearly 90 per cent of the export earnings and accounted for about 30 per cent of the GDP. The manufacturing sector accounted for less than 0.5 per cent of the total export earnings (Karunaratne, 2000). Even in 1977, agricultural exports contributed to 80 per cent of total exports, while the industrial sector contributed only 17 per cent. By 1989, the combined share of the "traditional triple", that is tea, rubber and coconut in merchandise exports had declined to 40 per cent, while manufactured exports accounted for 46 per cent, with garments alone accounting for 30 per cent (Table 2.6). A significant diversification of exports occurred in the 1980s. In recent years, the contribution of industrial exports reached 76 per cent of total exports. Forty-three per cent of this consists of textile and garments. Agricultural exports were led by the tea sector accounting for about 23 per cent of total exports in 2008.

Table 2.5: Trade dependence of the economy

Year	Imports to GDP	Exports to GDP	Imports and exports to GDP
1950	31.8	38.3	70.1
1960	31.5	28.2	59.7
1965	25.6	25.5	51.1
1970	17.6	15.3	32.9
1975	20.7	15.2	35.9
1977	18.1	19.1	37.2
1985	24.1	37.4	61.5
1997	38.9	30.8	69.7
2000	44	33.4	77.4
2005	41.3	32.3	73.6
2008	38.5	24.8	63.3

Source: Athukorala and Jayasuriya (1994); CBSL (2009)

Composition of imports, too, has changed dramatically over the last few decades. Dominance of consumption goods in the total imports in earlier years has changed to dominance of intermediate and investment goods in recent decades (Table 2.7). This is due in part to the intense dependence on imported raw materials by the domestic industrial sector. About 60 per cent of the total real output by the domestic industry is directly related to the use of imported inputs (Cuthbertson & Athukorala, 1991).The largest contribution to imports expenditure of the country is intermediate goods, which record 60 per cent of total import expenditure. Out of that, 15 per cent is accounted for by petroleum imports, 12 per cent by textile imports and four per cent by fertiliser imports. Expenditure on imports of consumer goods accounted for only 18 per cent of total import expenditure. When the structure of imports in 1977 is considered, 45 per cent of the expenditure was on intermediate goods imports, while 42 per cent was on consumer goods imports (CBSL, 2008a). The decline in the share of food imports reflects the expansion of import substitution production, both in manufacturing and domestic (food-production) agriculture.

Table 2.6: Export structure, selected years (1974-2008)

Sector	Percentage share of total exports						
	1974	1977	1980	1989	1995	2005	2008
Agricultural products	**80.1**	**80.5**	**61.6**	**43.7**	**21.8**	**18.2**	**22.8**
Major agricultural products (Tea, rubber and coconut)	71.6	72.8	54.4	39.4	18.3	15.3	19.2
Minor agricultural products	8.5	7.7	7.2	4.3	3.5	2.9	3.6
Industrial exports	**14.5**	**16.9**	**32.6**	**58.1**	**75.4**	**78**	**75.7**
Manufactured products	3.6	5.6	14.4	22.7	24.5	30.3	30
Textile and garments	0.8	2.2	10.4	31.4	48.7	45.6	42.6
Petroleum products	10.1	9.1	7.8	4	2.2	2.1	3.1
Mineral exports	3.9	5	4.6	5.6	2.3	2.3	1.5

Source: Athukorala and Jayasuriya (1994); CBSL (1995, 2005a, 2008a)

Table 2.7: Import structure, selected years (1950-2008)

Category	Percentage share (as a percentage of total imports)							
	1950	1960	1970	1980	1989	1995	2005	2008
Consumer goods	72.2	61	56	29.9	24.5	18.9	18.5	18.2
- Food and beverages	45	38.3	46.3	18.9	14.5	10	8.5	10.7
Intermediate goods	15.2	20.1	20	47.7	56.4	55.8	60	59.5
Investment goods	12.6	18.1	23.6	24	17.6	22.9	21.1	21.3

Source: Cuthbertson and Athukorala (1991); Athukorala and Jayasuriya (1994); CBSL (1995, 2005a, 2008a)

The Western countries continued to be the main destination for Sri Lankan exports in 2008, while the Asian countries dominated Sri Lanka's imports. While the USA and UK remained the largest export destination countries, India, Singapore, Iran and China are the foremost import originating countries. Among the key export destinations, the USA is the most important market for Sri Lanka, accounting for 23 per cent of total exports. However, in terms of imports, India continued to be the largest source of imports, accounting for nearly 25 per cent of Sri Lanka's imports in 2008. This highlights the unique position India holds as the major trading partner country (CBSL, 2008a).

When the composition of foreign exchange receipts is considered, commodity exports accounted for more than 90 per cent in the 1950s and 1960s. Earnings from tourism and

remittances by migrant workers then began to make a significant contribution. From 1966 onwards tourism became one of the fastest growing sectors of the economy until the ethnic conflict in 1983 slowed down its growth. As the tourist industry lost its momentum, remittances from migrant workers became a major source of foreign exchange receipts. The share of these remittances in total current account receipts increased from two per cent in 1980 to 13 per cent in 1989. By mid-1985, "exported workers" had become the single most important source of foreign exchange exceeding earnings from tea exports. The majority of the labour force employed overseas is employed in the Middle Eastern region, European countries and Asian countries (Athukorala & Jayasuriya, 1994).

2.1.4 Investment and savings

The level of investment in the economy was around 26 per cent of the GDP and the savings ratio has been around 23 per cent of the GDP in recent few years (Table 2.8). The investment level shows a drop in recent years as a result of the global economic down turn, volatility in international trade, intensification of the civil conflict and several other reasons (CBSL, 2009).

Table 2.8: Investment and savings ratios

Year	Investment as a share of GDP	Savings as a share of GDP
2003	22	21.5
2004	25.3	22
2005	26.8	23.8
2006	28	22.3
2007	28	23.3
2008	27.6	17.8
2009	24.5	23.9

Source: CBSL (2009)

2.1.5 Land and resources

Sri Lanka's major natural resources are land and water. Around 96 per cent of the total area of the country is land and the rest is inland waters. Out of the total land mass of the island, only

50 per cent is arable due to unsuitable terrain, inland water bodies and forest conservation. According to available data, around 80 per cent of the land is controlled by the state with the balance held privately. Expanding population has exerted much pressure on the land limiting its per capita availability to 0.29ha (IPS, 2004; Samaratunga & Marawila, 2006). Nearly one-third of the land area is used for agricultural purposes and another one-third is used for forestry and wild life conservation. The balance is used for other purposes including human settlement, urban development and infrastructure (Table 2.9).

Table 2.9: Land use of different sectors in Sri Lanka for year 2000

Land use category	Land area (ha)	As a percentage
Built-up lands	30,370	0.65
Non-agricultural lands	21,470	0.46
Homesteads	786,743	16.7
Tea	199,622	4.24
Rubber	199,661	4.24
Coconut	301,701	6.41
Mixed and other perennial crops	43,265	0.92
Paddy	530,536	11.28
Sparsely used cropland	812,656	17.27
Other cropland	51,529	1.09
Dense forest	689,662	14.66
Open forest	198,738	4.22
Forest plantation	73,447	1.56
Scrub-land	363,592	7.73
Grass-land	65,550	1.39
Mangroves	3,532	0.08
Marsh	14,013	0.29
Water	161,330	3.43
Barren land	34,650	0.74
Archaeological reservation	1,560	0.03
Wildlife reservation	94,510	2.01
Forest reservation	26,678	0.57
Total	4,704,810*	100

Source: Samaratunga and Marawila (2006)
(*Land use in the 7 provinces excluding North and Eastern Provinces)

Agricultural land comprises land under paddy, permanent crops and other temporary crops. The area under agricultural use has increased slightly over the years, but 44 per cent of the potential agricultural land, that is nearly 20 per cent of the total land area, is sparsely used. Paddy accounts for 27 per cent and plantation crops (tea, rubber and coconut) occupy 40 per cent of the agricultural land. Land under agricultural use, particularly paddy lands in the Wet Zone and marginal tea, rubber and coconut lands, have been steadily converted to non-agricultural purposes over the recent past (Samaratunga and Marawila, 2006).

This could be attributed to increased demand for land by both local and foreign investors, low productivity of privately owned small agricultural holdings and the high replanting cost of plantations (Samaratunga & Marawila, 2006). From the total cropping area, 16 per cent is under permanent crops (CBSL, 2008b). The most recent census in Sri Lanka for agriculture was conducted in 2002, which shows 14 per cent of the total land is arable land, 11 per cent is under plantation and permanent crops, and 27 per cent is under forest.

2.1.6 Poverty and income distribution

The national poverty HCI for Sri Lanka shows a steady decline since 1995/96 (Table 2.10). The HCI reported in 2006/2007 is nearly 50 per cent of the HCI reported in 1990/91, indicating a halving of the incidence of poverty during the period of 1990 to 2015 in accordance with MDG declared in 2000 by the United Nations. As shown in the Table 2.10, the main drop in national poverty is in the rural sector, which consists of about 80 per cent of the Sri Lankan population. It has dropped from 24.7 per cent in 2002 to 15.7 per cent in 2006/07, which is a reduction of about 36 per cent of the poverty incidence (DCS, 2008c).

In terms of income distribution as explained by the Gini coefficient, Sri Lanka experienced a relatively unequal trend in income from 1953 to 2003/04 (Table 2.11). This trend shows two distinct parts. According to the Table 2.11, the trend depicts relatively equitable income distribution until the early years of the 1970s. This was attributed to the emphasis of government policy on equity (Karunatilake, 1971). However, the Gini coefficient has increased over the past three decades, as in other South Asian countries, from 0.35 (in 1973) to 0.46 (in 2003/2004) indicating a rise in inequality. This was due to the implementation of decentralisation and adaptation of open economic policies in order to shift from a closed and

controlled economy to an outward-looking economy with a market orientation (Balisacan & Ducanes, 2006, p. 13).

Table 2.10: Poverty Head Count Index (Sri Lankan population below poverty line)[2]

Sector	HCI (percentage by survey period)			
	1990/91	1995/96	2002	2006/07
Sri Lanka	**26.1**	**28.8**	**22.7**	**15.2**
Sector				
Urban	16.3	14.0	7.9	6.7
Rural	29.5	30.9	24.7	15.7
Estate	20.5	38.4	30.0	32.0

Source: DCS (2008c)

Table 2.11: Income inequality by Gini coefficient

Year	Gini Coefficient	
	Household income	Income receivers
1953	0.46	0.5
1963	0.45	0.49
1973	0.35	0.41
1978/79	0.43	0.5
1981/82	0.45	0.52
1986/87	0.46	0.52
1996/1997(a)	0.43	0.48
2003/2004(b)	0.46	0.50

Source: CBSL (2008b)

Note: [a] Excluding Northern and Eastern Provinces,
[b] Excluding Kilinochchi, Mullaitivu and Mannar districts

[2] According to the DCS (2008c), Sri Lanka used several poverty lines made on different surveyed data using diverse approaches until 2004 when the Official Poverty Line (OPL) was established by the DCS based on Household Income and Expenditure Survey (HIES) data from 2002. The year 2002 value of the OPL is Rs. 1,432 real total expenditure per person per month and the value of the OPL for 2006/07 is Rs. 2,233 real total expenditure per person per month.

2.2 Overview of economic growth and structural change in the economy

Sri Lanka was a relatively affluent open agricultural economy in 1948. To many observers this seemed the country with the best prospects for successful development in Asia with high levels of per capita income in Asia at that time (Abeyratne, 2008). It recorded high standards of literacy, health, and life expectancy comparable to those of many industrial countries, in spite of being one of the world's poorest countries in terms of per capita income. In contrast to the violence and turmoil that gripped the Indian subcontinent countries in the immediate post-war years, Sri Lanka was an "oasis of stability, peace and order" (Athukorala & Jayasuriya, 1994; Bandara & Jayasuriya, 2009).

Sri Lanka inherited from the British colonial period, a structure that can be called a “dualistic export economy” with close dependence of national income on foreign trade and a split of the economy into modern and traditional sectors (Snodgrass, 1966). The modern export-oriented plantation sector, including tea, rubber and coconut and their related activities which used extensive land suitable for cultivation was largely based on foreign capital and controlled by foreign entrepreneurs who employed cheap immigrant labour. That sector had very few economic relations with the traditional agricultural sector which revolves around cultivation of paddy. Firm establishment of an export economy was the “strength as well as the weakness of the economy” (Wickremeratne, 1977).

The post-independence development policy in Sri Lanka has been influenced by different economic and political ideologies that changed from time to time with changes on the political front. They have shifted from noninterventionist, open, free market policies (up to 1959) to rigid ISI policies (1960-1977) and export-oriented liberalisation (after 1977). Since 1977, the fundamental direction of policy has not changed, though there have been differences in the degree and scope of liberalisation measures under different administrations (Bandara & Jayasuriya, 2009, p. 409). The changes in the economy due to the changes in the policy regimes have not been limited to the relative contributions and significance of the sectors, but have also led to qualitative changes within them. The character of agriculture, manufacturing and services has changed considerably.

Despite the difference in ideological approaches of the governments that held power after independence, there were several key elements of development policy which were constant during the period 1948-1977. The changes in political power among different groups produced changes in development policies which had important economic and social outcomes, but they were minor variants of the main policy regime and did not make a strategic difference in the basic economic structures. The key elements of the policy regime included the priority given to the development of domestic agriculture for import substitution of rice by expanding and strengthening the domestic agriculture sector, the large scale public investment on social welfare and human capital development, the liberal use of subsidies and administered prices including a highly subsidised ration of rice covering almost the whole population, free distribution of state land to the landless and poor, and mobilisation of resources to maintain high levels of public expenditure (Gunatillake, 2000, p. 133).

At the time Sri Lanka became independent, many of the key determinants of the development policy regime were already built into the system. By 1948, government took the sole responsibility of providing free health care and education to the population as a whole. A subsidised ration, which cost around 15 per cent of government's current expenditure, was provided to all citizens. Most of the post-independence decade turned out to be a time of liberal trade with just a few low taxes on imports and exports. During this time there was a bias towards agriculture, and objectives of self-sufficiency in paddy rice and subsidiary food crops were high on the political agenda. Government administrations during this period viewed agrarian policies as the ultimate solution to the island's social and economic problems (Cuthbertson & Athukorala, 1991). These policies were to involve opening up the Dry Zone, the heartland of the ancient civilisation of Sri Lanka with new settlement schemes. The government continued its heavy commitment to the provision of social welfare services, in particular free health services, free public education and the supply of subsidised food.

Major macroeconomic indicators for Sri Lanka in 1950 showed that the country to be in a strong position. The balance of payments was strong. Trade balance had a substantial export surplus, as did the overall current account. The revenue base of the plantation sector was used as the main source of finance for the expansion of public expenditure (Cuthbertson & Athukorala, 1991). At that time, Sri Lanka showed a great dependence on exports of tea, rubber and coconut. In 1950, these three items accounted for more than 90 per cent of total

exports. World market conditions were favourable for those three crops. These conditions made it easy for the government to continue its subsidies.

There was a sudden drop in the prices of major exports followed by a drop in government revenue and foreign exchange earnings in the 1950s. In 1952, large deficits emerged in the trade and current accounts of the balance of payments (Table 2.12) and in the government's current account (Table 2.13). Therefore, the government had to reduce the food subsidies and other welfare-promoting activities in an attempt to eliminate those deficits. In 1959, balance of payment deficits led the country to impose import controls, which became progressively more stringent in successive years, accompanied by increasing state intervention in the economy. This continued to be the major policy response until 1977. During 1956-1960 the role of the government was more direct as well as more extensive.

The government, during the period of 1956 to 1965, continued its policy response under the framework of socialist policies. Import substitution remained the main focus in development. Public investment programmes continued to favour development of the domestic agriculture sector. Plantation agriculture was taxed more heavily as a source of revenue. Over a long period, there were no new plans to react to the gradual weakening of export prices and the terms of trade. This period witnessed profound changes in the ownership and management of economic enterprises. Several important private enterprises were nationalised, including passenger transport, insurance and banking and large segments of import and wholesale trade enterprises. Nationalisation of foreign-owned plantations became a major policy issue. This process was interrupted by a partial liberalisation period during 1965-1970. Another important policy response was to acquire equity through income transfer and redistribution. The food subsidy was restored to its full level and it accounted for 16 per cent of government current expenditure and nearly two thirds of the entire capital budget at the end of the 1950s. Apart from that, there was emphasis on industrial development and efforts to mobilise foreign assistance for the investment programmes which required capital equipment and technology from abroad.

Beginning in the 1960s, import restrictions were extensive with import duties and exchange controls in response to a balance of payments problem. The industrialisation effort began to be evident in the late 1950s, and after 1960, it became an important part of development strategy.

Table 2.12: Balance of payments, 1950-2009 (US $ million)

Year	Exports	Imports	Trade balance	Current account balance	Capital & financial account balance	Overall balance
1950	296.5	246.3	50.2	28.8	-4.6	35
1952	309.3	352	-42.7	-93.6	5.3	-79.3
1955	397.5	310.4	87.1	67.8	-10.3	58.5
1960	377.2	421.3	-44.1	-46.2	0.4	-40.3
1965	400.9	403.6	-2.7	12.2	8.8	19.7
1970	338.7	391.8	-53.1	-58.8	56.6	-7
1973	366.4	412.9	-46.5	-25.1	67.3	45.9
1974	511.2	701.1	-189.9	-136.4	83.6	-57
1975	563.4	767.3	-203.9	-111.4	58.2	10.4
1977	767.1	726.2	40.9	144.1	36.7	360.9
1980	1064.7	2051.2	-986.5	-660	398.3	-191.9
1985	1315.3	2044.3	-729	-419.5	333	-49.3
1990	1983.9	2686.4	-702.5	-377	514.1	118.7
1995	3806.6	5311.1	-1504.5	-786.5	698.6	51.5
1996	4095.1	5438.8	-1343.7	-676.9	459	-67.8
1997	4639	5863.8	-1224.8	-392.9	602.2	162.9
1998	4797.8	5889.5	-1091.7	-225.9	413.4	36.8
1999	4610.1	5979.3	-1369.2	-563	372.9	-263.2
2000	5522.3	7319.8	-1797.5	-1066	443	-521.9
2001	4816.9	5974.4	-1157.5	-215.1	562	219.8
2002	4699	6105.6	-1406.6	-236.5	444	338
2004	5757.2	7999.8	-2242.6	-648	631	-205
2005	6346.7	8863.2	-2516.5	-650.2	1224	501.4
2007	7640	11296.5	-3656.5	-1401.5	2096.7	530.5
2008	8110.6	14091.2	-5980.6	-3885.7	1773.2	-1384.8
2009	7084.5	10206.6	-3122.1	-214.4	2594.1	2725.3

Source: CBSL (2010a)

Table 2.13: Government fiscal operations

Year	Percentage of GDP		
	Revenue and grants	Expenditure	Overall surplus (+)/deficit (-)
1950	16.1	20.3	-4.1
1952	21.3	27.1	-5.8
1955	22.6	20.4	2.2
1959	21	27.2	-6.2
1960	21.1	27.1	-6.1
1965	22.8	27.8	-5
1970	20.5	26.9	-6.4
1971	20.5	27.8	-7.3
1972	22	28.3	-6.3
1973	22.2	27.3	-5.1
1974	21.2	24.5	-3.3
1975	20.6	27	-6.4
1977	19.7	24.2	-4.5
1980	23.5	42.7	-19.2
1985	24.4	34	-9.7
1990	23.2	31	-7.8
1995	21.8	30.5	-8.7
1997	19.4	26.4	-7
1998	17.9	26.3	-8.4
1999	18.3	25.2	-6.9
2000	17.2	26.7	-9.5
2001	17	27.5	-10.4
2002	17	25.4	-8.5
2004	15.3	22.8	-7.5
2006	17.3	24.3	-7
2007	16.6	23.5	-6.9
2009	15	24.9	-9.9

Source: CBSL (2010a)

It was seen as the solution for employment and balance of payment problems. Government promoted industrialisation through an import substitution policy. Even with firm import controls and higher export volumes, government had to face large budgetary deficits and balance of payment problems as a result of maintaining consumer subsidies and expansion of capital-intensive industrial activities.

Higher tariff levels and other quantitative import restrictions largely contributed to private sector participation in industrial development. Import restrictions led to reductions in a wide range of imported manufactured goods, and created a potentially profitable market with the virtual elimination of outside competition for local entrepreneurs. As a consequence, the country witnessed the growth of a large number of consumer goods industries, largely based on imported inputs catering to local demand (Balakrishnan, 1977, p. 197).

The government which came to power in 1965 integrated foreign aid and investment into the economy as a means of increasing the rate of investment. It helped to resolve the balance of payment difficulties, to overcome any entrepreneurial shortages and to improve the technical knowledge in the country. The policy orientation during this period was towards promoting exports by inducing industrial exports. There was a 25 per cent devaluation of the rupee relative to the dollar in 1967. It was replaced in 1968 by a new policy of partial devaluation of the Sri Lankan rupee and the creation of a dual exchange system favouring non-traditional exports and important imports. These policy changes did not help to improve the balance of payments as expected because of generally falling export prices and increases in import prices. Therefore, external borrowings had to be made to finance the continuing deficit.

The new government elected to power for the 1970-1977 period continued the programme of foreign aid and maintained the dual exchange rate. During this period, the government had to respond to external shocks, both global and domestic. There were three global shocks in the first few years of the regime. The first was caused by devaluation of the rupee, the second by the steep rise in oil prices and the third by shortages in the world food market coupled with the rise in price of rice and wheat flour. The government also had to deal with another political and social crisis in 1971, the wide-spread youth insurgency. The responses of the government to those crises were to move further in the direction of redistribution and public ownership. It introduced a programme of land reform for acquisition of plantations by the state. Apart from

that, the government introduced other measures to acquire private businesses, which constrained private initiative and enterprise during that period.

Food production slowed down during this period in both paddy and plantation sectors. Growth in the manufacturing sector was also much slower than during the 1965-1970 period. Imports of raw materials for existing industries were severely constrained because of inadequate foreign exchange. New investments were discouraged. Sri Lanka had one of the most inward-looking, protectionist and state-controlled economies by the mid-1970s (Cuthbertson & Athukorala, 1991; Somaratne, 1998). The constraints imposed during this period improved the government budget deficit and balance of payments by the time the new government came to power in 1977. Furthermore, increases in prices in the main export commodities during 1970-1977 created favourable conditions for economic recovery.

Since policy changes in the 1970-1977 period did not cause a significant acceleration of the growth rate of the economy, the new government, in 1977, initiated a series of major policy reforms aimed at liberalising the economy with the objectives of a higher growth rate of GDP and a major expansion of employment opportunities. This change transformed the Sri Lankan economy from an inward-looking, closed economy, which was managed through direct administrative controls, to one that was outward-looking and market oriented. These policies included revising the tariff structure by replacing quantitative restrictions by tariffs, lowering nominal protection given to import substitution industries, introducing flexible exchange rates, encouraging foreign investment, special assistance for exports, privatisation of some government industries and services and reduction of food subsidies (Bruton, Abeysekera, Sanderatne, & Yusof, 1992; Cuthbertson & Athukorala, 1991). The private sector was encouraged to participate in all aspects of the economy. Agricultural pricing policies were changed to create and maintain strong producer incentives to increase output.

These reforms were in sharp contrast to past economic regimes. Foreign assistance was aggressively sought and successfully obtained. Fiscal policies were used to support market orientation and private sector emphasis on economic growth and by creating a climate conducive to private investment and private economic enterprises. The emphasis in government expenditure shifted from consumption, welfare and social development to investment (Sanderatne, 2005). The first few years of this new policy regime helped to achieve

high economic growth after a long period of low growth since independence[3]. However, the expansion of economic activity was uneven and the rural sector was largely excluded from the benefits flowing from many economic activities (Fernando, 2000). By 1985, the economy had undergone significant structural changes, specifically in the export sector. In exports, the share of manufacturing soon overtook that of agriculture.

The economic reforms and enhanced foreign funds led to a high rate of growth till 1983 when ethnic violence resulted in a setback (Figure 2.2). The subsequent period of terrorism diluted business confidence, foreign investment and tourism and displaced agriculture and few industries in the North. The weak performance in the late 1980s led the government to adopt further structural reforms to strengthen budgetary management and to improve the balance of payments, which had weakened considerably. The economy was liberalised further after 1989. The process of privatisation gained momentum by the end of 1993 (Sanderatne, 2005).

From the mid-1980s, policy makers began to be concerned about the persistence of a high degree of poverty and malnutrition despite high rates of economic growth. Even though there were significant changes in the style of management, the main elements of macroeconomic management and development policy were continued without any important change after this time period. During the 1990s, governments renewed structural adjustment programmes while concentrating on poverty alleviation (Gunatillake, 2000).

These reforms included the removal of remaining subsidies, privatisation of public sector enterprises, further liberalisation of the import regime through tariff reforms, more market-oriented management of the exchange rate to maintain and enhance export competitiveness, further relaxation of exchange controls, and improvement of incentives for private sector investment, both domestic and foreign. The poverty alleviation programmes aimed at providing income transfers to the poor to increase current consumption and to cover the nutritional deficit of poor households.

[3] GDP growth rate in 1978 was 8.2 per cent which was the highest recorded growth rate by far since independence. It was equivalent to the GDP growth rate recorded in 1968.

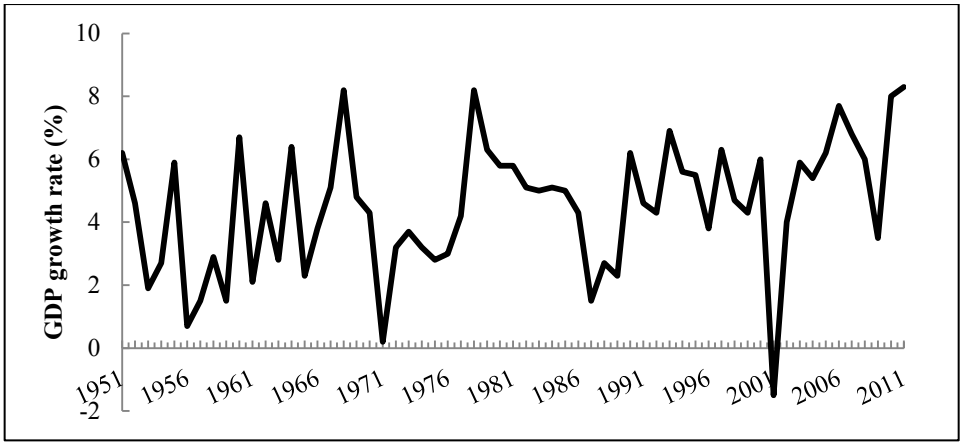

Figure 2.2: GDP growth rate in Sri Lanka (1951-2011)
Source: CBSL (2011a)

Elections in 1994 brought about a change of government. However, despite the change of rule, continuity of economic policy was assured. The new government adhered to open economic policies supposedly 'with a human face'. The private sector was considered as the engine of growth by pursuing market-friendly policies, and government intervention was limited to areas where markets failed. In principle, they served the welfare of the people (IPS, 2008; Sanderatne, 2005). Corporate taxes and tariffs were revised downward and exchange controls were further relaxed, while the rupee was allowed to depreciate to maintain the competitiveness of Sri Lankan exports.

These efforts, aimed at accelerating growth, had to be halted due to resumption of military operations in the North, which resulted in military expenditure rising to unprecedented levels. The sense of insecurity caused by acts of terrorism by the LTTE affected many economic sectors, discouraging new domestic and foreign private investment.

The new government in 2002 offered a strategy for accelerated development called 'Regaining Sri Lanka' (RSL). As the key elements of the programme required Sri Lanka to regain control of the economic situation, the RSL framework identified the acceleration of privatisation of commercial activities, reformation of the legal foundations of the economy and an increase in efficiency as critical. The RSL policy initiative sought to eliminate the rigidities for investment, which had made the country less competitive than other countries in East Asia, by means of deepening economic liberalisation. Accordingly, allowing the private sector to perform a leading role in the economy, and deregulation were measures for putting the country

back on track. Furthermore, the country's Poverty Reduction Strategy Paper (PRSP) was also integrated into the RSL. This highlights the trickling down of economic gains for poverty reduction. However, the strategy did not succeed as expected due to several reasons. One of the main reasons was that the economic gains did not trickle down. The growth was highly centred on the Western Province with only little gains to other areas. With the change of government after the 2004 general election, there was a halt to these reforms. The change of government within two years shows the resilience of the people over the policy package and the peace process of the government (Government of Sri Lanka, 2002; IPS, 2008).

The government which took office in 2004 launched a five-point-nation-building programme called 'Rata Perata' (Country Forward: Creating Our Future Building Our Nation), which included a new economic order, durable peace with dignity, investing in people, clean governance, and ensuring law and order. This regime adopted a different strategy to that of the RSL regime, recognising the importance of social policies for growth and economic stability. It emphasised an equitable distribution of income by providing enhanced relief for the poor and vulnerable, while encouraging more economic activities in the rural areas, through support of small and medium enterprises. Furthermore, the government continued with welfare measures even at a time of high fiscal constraints despite the resistance of the multilateral financial institutions. Some polices such as restoring the fertiliser subsidy, broadening the poverty alleviation programme, and continuation of electricity, transport and petroleum subsidies were carried out to address the issues of poverty and unbalanced growth at the time. The build-up of security expenditure and rising debt services during the past two decades precluded public investment in economic infrastructure, and human resource and skills development, which fell from 14 per cent of GDP in 1985 to about 5 per cent in 2004 (Ministry of Finance and Planning, 2006).

The most recent development plan is named "Mahinda Chinthana: Vision for a New Sri Lanka". It provides a development framework for the country with a ten-year horizon, 2006-2016. Its objective is to raise the GDP growth rate in excess of 8 per cent. Furthermore, it tries to integrate the positive attributes of the market-oriented economic policies, while safeguarding domestic aspirations by providing necessary support to domestic enterprises and encouraging foreign investment. Prevalence of a peaceful domestic environment after the end of the war, and improved investor confidence will be helpful in achieving those targets. The

new plan refers to creating an economy which is largely private sector driven, more dynamic and regionally integrated by emphasising the importance of regional development (Ministry of Finance and Planning, 2006). Sri Lanka's GDP grew by eight per cent in 2010 and 8.3 per cent in 2011 (Figure 2.2). This was the first time that Sri Lanka achieved economic growth of eight per cent or above in two successive years in post-independence history (CBSL, 2011a).

2.3 The agricultural sector in the Sri Lankan economy

As in many other developing countries, the agricultural sector plays a fundamental role in the economy of Sri Lanka in terms of its contribution to the economy and as a key element in development strategy. However, it faces ever increasing challenges related to productivity improvement, efficient resource allocation, enhancing competitiveness and providing adequate livelihoods for producers. The following section attempts to review the unique role of agriculture in the economy and the underlying policies.

Agriculture is the backbone of the rural livelihood and contributed the largest share of total output until recently. Its contribution to the total GDP declined gradually with the expansion of other sectors. As described in previous sections, the agricultural sector still constitutes a fifth of Sri Lanka's GDP and provides employment to about 33 per cent of the labour force (CBSL, 2011a). About 65 per cent of the country's population is largely dependent on agriculture for their livelihood. The agricultural sector in Sri Lanka consists of the export crops sub-sector which is dominated by tea and includes rubber, coconut and other minor export crops such as cinnamon and spices, and the import-competing food crop sub-sector which is dominated by rice and includes a range of subsidiary food crops, livestock and dairy products (Bandara & Jayasuriya, 2009). At independence, the three plantation crops dominated exports, while significant quantities of rice, wheat and other food products were imported.

Within the agricultural sector, the output share of plantation agriculture has declined sharply during last two decades. The relative contribution to GDP by the non-plantation sector is over four times that of plantation agriculture (Athukorala & Kelegama, 1998). The main reason for the decline in output of the plantation sector is the nationalisation of plantation companies and their estates in the early 1970s. Although the country's economic growth performance since

the late 1970s has been satisfactory relative to the performance of many similar developing countries, its agricultural sector performance has been inadequate. The growth of the sector was around 2 per cent per annum during 1996-2005 (Figure 2.3). Agricultural output is significantly determined by the prevailing weather conditions. Failure of monsoon rains, and droughts cause fall in yields in many crops. Therefore, the growth of the agricultural sector is often associated with output instability. Recent developments in the sector have improved the output of most domestic agricultural crops, boosted exports of plantation crops, and improved the growth rate of the sector. However, the export agricultural sector was affected by the global economic downturn (CBSL, 2008a; IPS, 2009).

The declining proportion of agriculture in the GDP and a rising share of industry and services are commonly observed in economic development. The agricultural sector's contribution to GDP gradually declined from about 35 per cent after independence to some 30 per cent in 1970. During the last three decades the share has declined further and it was 12 per cent in 2008. The share of agricultural products in total exports declined from 90 per cent in the early 1970s to 40 per cent in 1987 and to 25 per cent in 2000 (Figure 2.4).

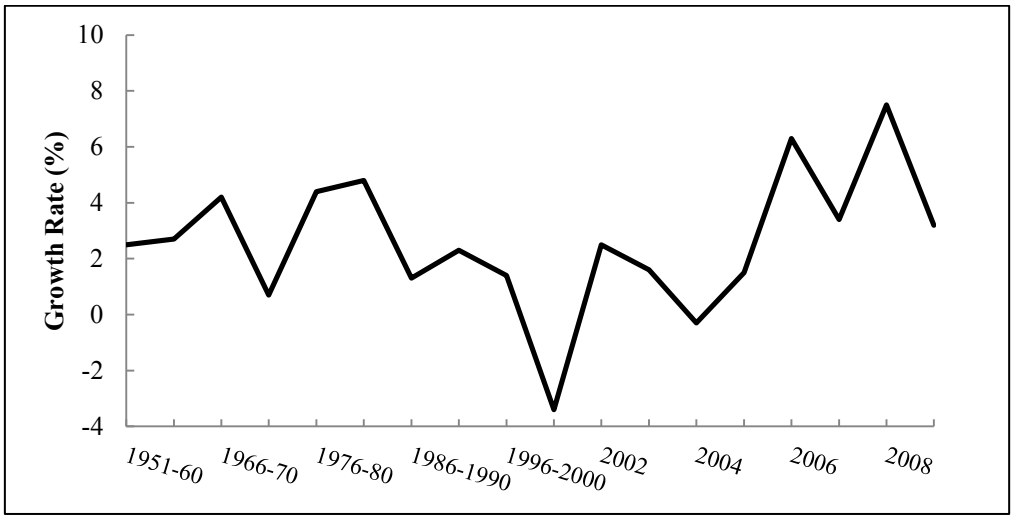

Figure 2.3: Agricultural sector growth rate
Source: Fernando (2000); CBSL (2009)

Expansion of the domestic food crops sector during the 1970s and 1980s is also a contributory factor to the reduction of the share in exports (Wickramasinghe, 2005). This measurement of the decline in terms of gross export earnings undermines the continuous importance of tea and other agricultural products in the balance of payments. Since most of Sri Lanka's

manufacturing exports are based on domestic processing of imported inputs particularly in garments, agriculture is much more important in terms of net foreign earnings than is indicated by gross export earnings (Athukorala & Kelegama, 1998).

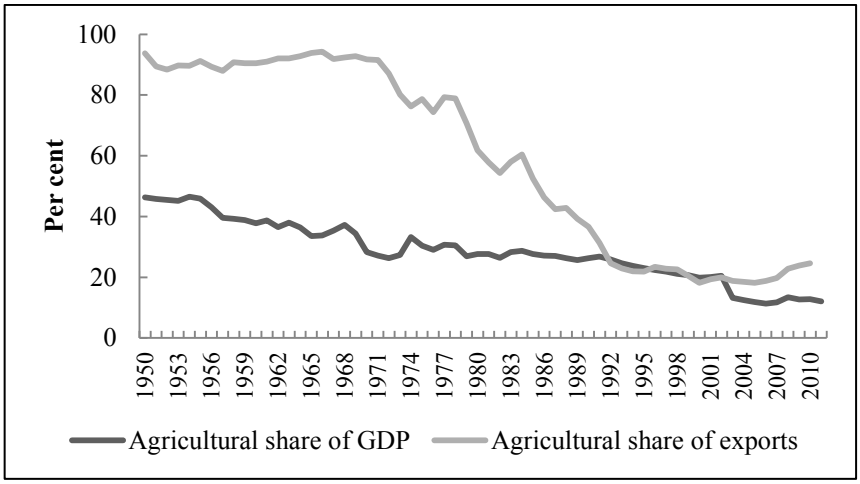

Figure 2.4: Agriculture's share in GDP and exports, Sri Lanka, 1950-2005
Source: CBSL (1998, 2011a)

The employment percentage in the agricultural sector shows a gradual decline over the last three decades while the expansion of the domestic food crop sector was able to absorb some labour at a lower rate. The agricultural sector was able to absorb more than half of the labour force in 1953. In 1990 this declined to 47 per cent and in 2008 it further declined to 33 per cent (Figure 2.5). There is a significant variation of employment distribution in the agricultural sector among districts and provinces (DCS, 2008d).

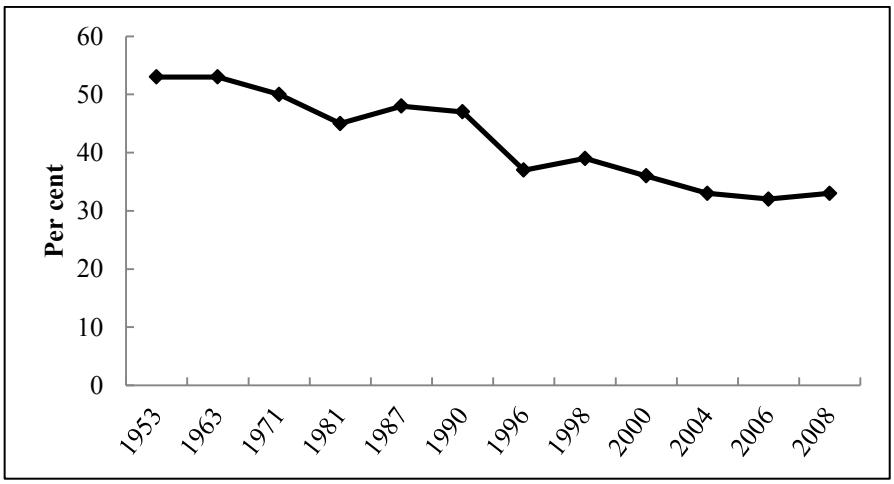

Figure 2.5: Agriculture's share in employment
Source: DCS (2008d); Bandara and Jayasuriya (2009)

The Uva Province recorded the highest percentage of employed population engaged in agriculture, while the Western Province recorded the lowest share (Figure 2.6). Unlike in the service and industry sectors, a higher percentage of self-employed and unpaid family workers were employed in the agricultural sector.

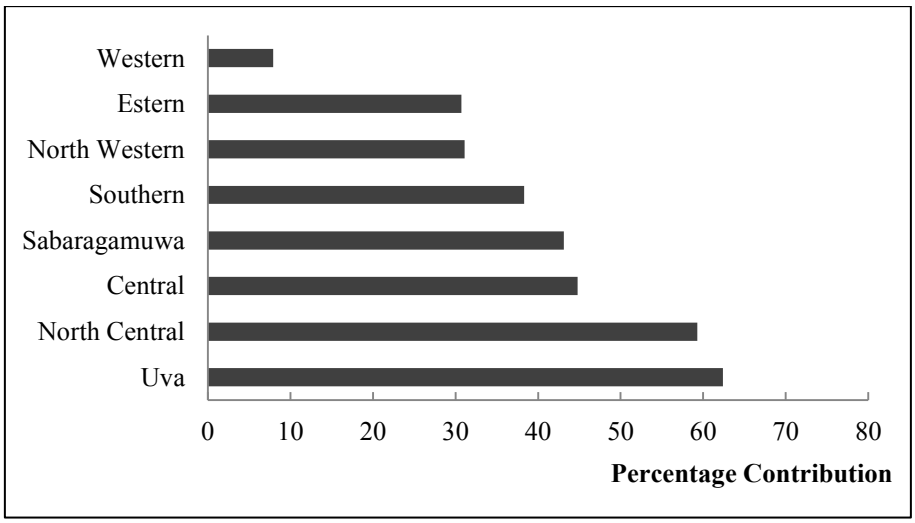

Figure 2.6: Agriculture's share in employment of different provinces
Source: DCS (2008d)

Agricultural labour productivity stagnated in the 1990s and 2000s. In terms of 1996 factor cost prices, agricultural labour productivity in 1995 was Rs. 79,363 and it had slowly increased to Rs. 88,468 in 2006, showing an increase of 11.5 per cent (CBSL, 1995, 2008a). The low productivity of crops is one of the main reasons for low labour productivity. The use of modern technology is not wide-spread in Sri Lanka. As a result, poor improvement in quality and productivity reduces the return on labour. This stagnating labour productivity causes reduction of wage rates in relative terms. A comparison between the increasing trends in the food price index and the agricultural wage index shows that the food price index is growing much faster than the wage index, resulting in a reduction in real wages in the agricultural sector (Herath, 2007).

2.3.1 Extent under agricultural holdings

Out of the total land area devoted to agriculture, only 84 per cent is utilised for crop and livestock production, while the rest of the area is distributed among forest, pasture and meadows. According to the most recent census of agriculture conducted in 2002, around 50

per cent of the total agricultural land area is covered by permanent crops and 27 per cent is covered by paddy cultivation which is the main staple crop (Table 2.14). The land area under tea is 212,000 ha. Over 55 per cent of this land is under state-owned plantations, while the remainder is held by small holders possessing less than 20 ha each. Rubber and coconut are predominantly smallholder crops. More than 85 per cent of Sri Lanka's tea production, 65 per cent of rubber production and 17 per cent of coconut production are exported (Athukorala & Kelegama, 1998).

Table 2.14: Land use pattern within agricultural holdings, 2002

Type	Percentage
Permanent Crops	49
Asweddumised Paddy	27
Temporary Crops	8
Forest Land	7
Land under Roads, Buildings, etc.	4
Land not classified elsewhere	3
Land not suitable for Cultivation	2

Source: DCS (2009b)

Paddy cultivation accounts for about 717,000 ha in Sri Lanka (DCS, 2009b). The majority of farmers in the paddy sector are small-scale producers. The paddy sector employs about half of the total agricultural labour force in Sri Lanka and about 20 per cent of the total labour force. Nearly 95 per cent of the domestic rice requirement is now coming from local production. Other non-plantation crops such as maize, pulses, chili, onion and potatoes, and a range of tree crops, such as cinnamon, cardamom, cloves, pepper and coffee, are based mostly on home garden activities. These non-plantation tree crops are mostly export oriented (Athukorala & Kelegama, 1998). Unfavourable conditions in the Northern and Eastern Provinces as a result of the internal conflict caused a reduction of the extent of lands cultivated under paddy in 2007 by up to 57 per cent and 46 per cent, respectively, compared to cultivated land area in 1982. Compared to total land area cultivated under paddy in Northern and Eastern Provinces in 1982, a reduction of 57 per cent and 46 per cent in these provinces could be observed in 2007 (DCS, 2010a, p. 2).

2.3.2 Performance of subsectors in agriculture

The export-oriented tree crop sector and the domestic food crop sector are the two main agricultural sectors in Sri Lanka. Tea, rubber and coconut are the major commercial crops grown both in plantations and smallholdings primarily for export. This plantation sector has been characterised by its large holdings and labour-oriented management since pre-independent times. These three crops together contributed about 25 per cent of agricultural GDP. Minor export crops comprising mainly of spices contributed around two to four per cent to the agricultural GDP. The domestic food crops sector is associated with cultivation of paddy and other food crops for domestic consumption. The entire food crop sector accounted for more than 60 per cent of the agricultural GDP. The livestock and fisheries sectors contribute around 20 per cent to the agricultural GDP (Table 2.15).

2.3.2.1 Export crop sector

Tea has contributed enormously, as a single commodity, to the country's foreign exchange earnings over a considerable period of time. It contributed 1.2 per cent of overall GDP, 14 per cent for the foreign exchange earnings and 6 per cent of employment in 2002. Sri Lanka mainly produces and exports bulk tea and Sri Lanka's share in the global tea market is around 20 per cent (Weerhewa, 2003). The early practice of tea production has changed, with small-holdings now replacing estate cultivation. Some trends in principal export agricultural crops are shown in Table 2.16.

Table 2.15: Percentage shares of GDP in agriculture sector, selected years

Activity	Percentage share					
	1998	2000	2002	2004	2006	2008
Tea	12.5	12	11.3	11.5	105	9.7
Rubber	2.2	1.7	1.7	2.8	5.5	4.8
Coconut	10.2	8.1	10.9	10.3	9	11.1
Minor export crops	3.5	2.5	3.5	3	3.3	2.5
Paddy	13.5	14.8	13.6	11.8	11.7	16.9
Other food crops	29.9	31.5	30.6	28.2	28.9	25.8
Other agricultural products	10.4	9.8	8.6	10.1	11.6	10.1
Livestock and fisheries	17.7	19.4	18.7	22.3	19.6	19.2

Source: DCS, National accounts (various issues)

Table 2.16: Trends in principal export agricultural crops

Category	Unit	2000	2002	2003	2004	2005	2006	2007	2008
Tea									
Production	kg mn	306.8	310.6	304.8	309.4	317.2	310.8	305.2	318.7
Total extent	ha '000	189	211	211	211	222	222	222	222
Cost of production	Rs/kg	110.6	124.1	135.6	157.3	168.4	188.4	236.5	262.6
Rubber									
Production	kg mn	87.6	90.5	92	94.7	104.4	109.2	117.6	129.2
Total extent	ha '000	157	157	115	115	116	120	120	122
Cost of production	Rs/kg	44.5	54	63.3	73.4	76.12	97.2	112.7	110
Coconut									
Production	nuts mn	3096	2392	2562	2591	2515	2785	2869	2909
Total extent	ha '000	444	395	395	395	395	395	395	363
Cost of production	Rs/nut	3.27	3.85	4.9	7.5	7.5	7	10.25	12.47

Source: CBSL, Annual reports (various issues)

Rubber is the second most important plantation crop and it used to be the country's main foreign exchange earner. This sector showed a setback after the late 1970s as demand for natural rubber started declining due to increasing demand for synthetic rubber. Domestic demand for natural rubber has increased during recent years and at present more than 50 per cent of the domestic production is locally used (Figure 2.7). Coconut is an important commodity both in terms of exports and domestic consumption. Main coconut products produced in the country are desiccated coconut, copra, coconut oil and fresh nuts. Desiccated coconut is made primarily for exports. Copra has a demand both in the export market as well as in the local market for making coconut oil. At present more than 80 per cent of coconut production is consumed domestically.

All export crops other than tea, rubber and coconut are broadly classified as minor export crops. Minor export crops also play an increasingly important role in the Sri Lankan economy in terms of export earnings. These crops mainly consist of spices, such as cinnamon, pepper, cloves, cardamom and nutmeg, and beverages such as coffee and cocoa. Most of the spices are

mainly confined to the small-holding sector of which the contribution is more than 80 per cent of the total extent under each crop (DCS, 2008e). Production figures of minor export agricultural crops are illustrated in Table 2.17. Spices alone contributed 1.5 per cent of total export earnings and 8.27 per cent of total agricultural exports in 2005. Cinnamon is the major export earning item among this group contributing Rs. 8,948 Mn in 2008.

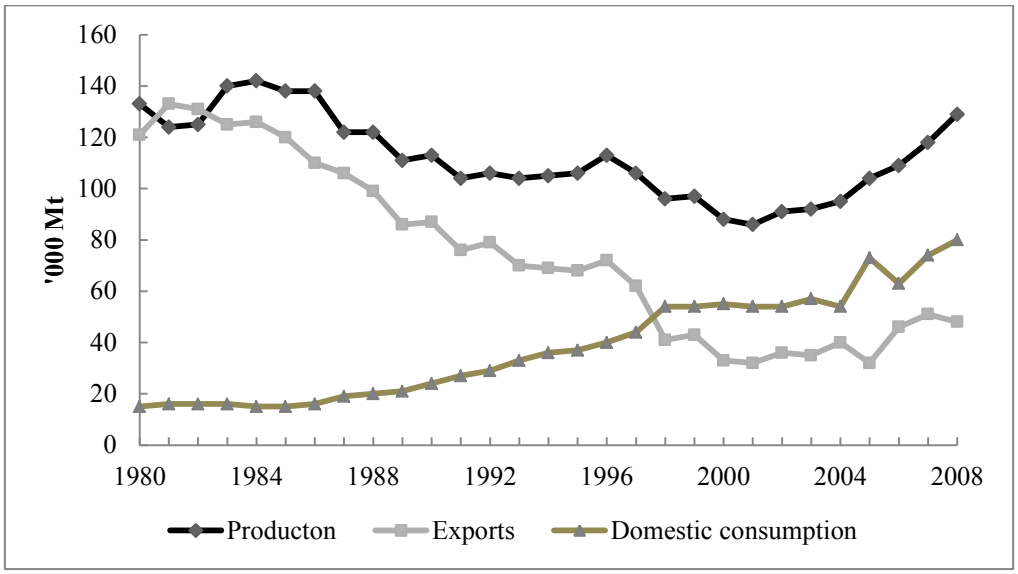

Figure 2.7: Total production, exports and domestic consumption of rubber

Source: Rubber Research Institute of Sri Lanka (2008)

Table 2.17: Production of minor export agricultural crops

	Production (MT)							
Crop	2000	2002	2004	2005	2006	2007	2008	2009
Coffee	2540	2360	3490	3525	3500	2979	3081	2437
Cocoa	1300	1100	600	900	810	393	1695	2453
Cinnamon	13490	13000	14875	14450	15900	16505	14899	15626
Pepper	10676	12600	12020	14270	14440	16597	12897	12306
Clove	1700	4100	3575	6080	3575	2990	8203	3032
Cardamom	62	60	74	80	80	90	71	64
Nutmeg	1100	1600	1515	1860	1925	5553	2174	3092
Cashew Kernels	935	1288	1732	1811	1944	2331	1000	2400

Source: CBSL (2009)

2.3.2.2 The domestic food crop sector

Rice is the staple food crop in the country comprising the biggest share in agricultural GDP. Paddy is the largest single crop and it is cultivated in all provinces. A significant increase in production over the last few decades has brought the country to near self-sufficiency in rice. Owing to the increased cultivated area with new improved high yielding varieties and fertiliser usage, a continuous growth in the paddy sector has been achieved. The growth momentum achieved during the 70s in the paddy sector came to a standstill during the 80s and low growth occurred in the 90s with fluctuations in production (Wickramasinghe, 2005). Paddy production in 1950 was around 649 thousand MT and increased four times to 2,412 thousand MT by the 1990s (Figure 2.8).

Other field crops (OFC) constituted an important component in the Sri Lankan domestic agriculture sector before independence. These crops were mainly cultivated under rain-fed conditions on small-holdings. Since the government focused mainly on achieving self-sufficiency in rice during the 1950 and 1960s, the domestic requirement of the OFCs was fulfilled from imports. This sector started receiving government support from the beginning of the 1970s to promote high-value cash crops. Crops such as chilli, onions and potatoes were given heavy protection from competition with the aim of increasing their production among the other traditional crops such as kurakkan, maize, green-gram and cowpea.

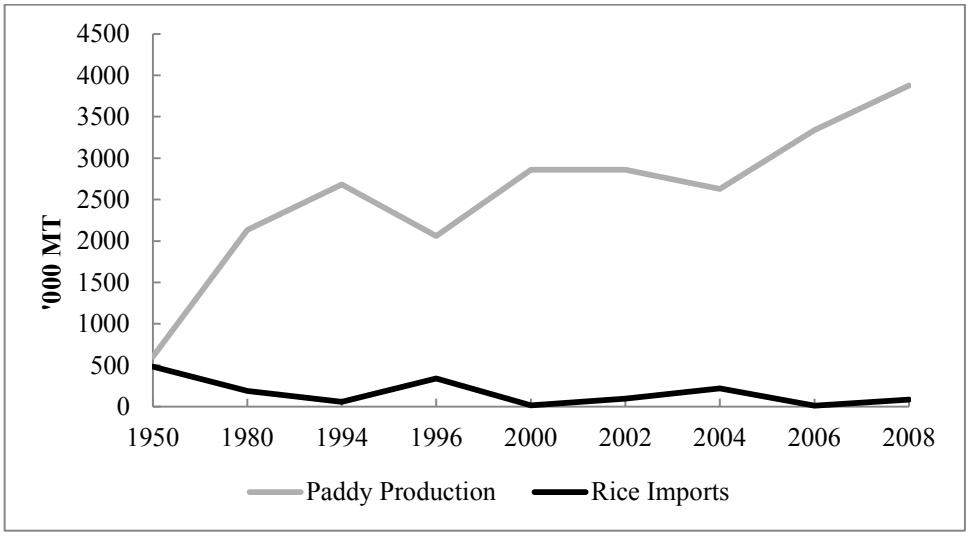

Figure 2.8: Paddy production and rice imports, 1950-2008
Source: CBSL (1998, 2008a)

Before 1977, the domestic food crop sector was heavily protected. With the economic liberalisation after 1977, it started becoming vulnerable to international competition. Its contribution to agricultural GDP has shown a continuous decline during recent years. Production figures of some OFCs are shown in Table 2.18.

Table 2.18: Production of some selected field crops in Sri Lanka

	Production ('000 MT)					
Crop	1992	1995	1998	2002	2005	2008
Red Onions	54	48	38	36	53	49
Potatoes	79	82	26	89	79	75
Chillies	74	65	63	12	13	51
Cowpea	18	16	13	10	11	12
Maize	29	35	34	28	42	112
Kurakkan (finger millet)	5	5	4	4	7	7
Green-gram	23	16	16	10	9	9

Source: DCS, 2000; CBSL (2005a, 2009)

Although the government has tried to increase food production in the country by implementing numerous policies, food products like wheat, rice, sugar, milk and milk products are continually being imported to meet growing domestic demand for food. The value of total food imports has risen rapidly over the years. Agricultural imports in terms of food and beverage accounted for 10 per cent of total imports in 2008 (Table 2.19).

Table 2.19: Share of agricultural imports

Category	Percentage share			
	1976-77	1980-81	1993-94	2007-08
Agricultural imports	**34.2**	**18.9**	**13.2**	**10.1**
- Rice	11.2	2.6	0.7	0.3
- Flour	15.1	5.4	0.2	0.01
- Wheat and mesline	2.8	1.7	2.6	2.4
- Sugar	2.4	6	3.3	1.4
- Milk and milk products	1.7	1.6	2.4	1.9
Other imports	**65.8**	**81.1**	**86.8**	**89.9**

Source: Compiled from data reported in CBSL, Annual reports (various issues)

2.4 Review of agricultural sector policies

This section reviews the policy evolution in the agricultural sector. First it discusses the policies in the pre-liberalisation period, which is from independence in 1948 to 1977. The discussion is then extended to include the policies in the post-liberalisation period, that is, from 1977 when Sri Lanka liberalised its economy to the present.

2.4.1 Policies in the pre-liberalisation period

The policy orientation in Sri Lanka during the first decade following independence in 1948 maintained a commitment to noninterventionist policies which ensured the continuity of the basic structural features of a classical export economy. Policy on export crops consisted of increasing the productivity of land under these crops without increasing the total acreage, whereas domestic agricultural policy consisted mainly of encouraging improvement of production of crops in that sector. Therefore, economic policy was biased towards domestic food production. The objectives of self-sufficiency in rice and subsidiary crops remained high on the political agenda (Athukorala & Jayasuriya, 1994; Richards & Stoutjesdijk, 1970). Export taxes on agricultural crops were initially a major source of government revenue. Levies on exports also financed agricultural research, extension and replanting programmes in plantation crops. On the production side, policy involved major investments in irrigation, fertiliser subsidies and provision of rice and other agricultural research and extension services.

There was also a public distribution system for procurement and marketing of paddy and other commodities aimed at making rice more affordable for consumers. Beginning in the late 1950s, Sri Lanka chose a strategy of "forced" import substitution. Basic fundamentals of this strategy created incentives against plantation agriculture (Athukorala & Kelegama, 1998). Many inputs including fertilisers, seeds and credit were provided, often at a subsidised rate. This bias intensified over the next two decades as import restrictions were tightened in response to growing balance of payment difficulties, and export duties were increased to meet expanding government budgetary requirements. Foreign exchange controls and quantitative restrictions on imports were imposed to achieve food self-sufficiency. There was a significant continuity in the policy commitments to encourage domestic food production.

The rice sub-sector was granted special incentives, and other import-competing agricultural products also gained noteworthy protection through an import substitution strategy. This continued until 1977 and started to change as a result of the policy shift away from import-substitution towards more liberal premarket policies (Athukorala & Kelegama, 1998; Bandara & Jayasuriya, 2009). As a means of encouraging farmers to expand their production, security of tenure was given to tenants by the 1958 Paddy Lands Act. The act was expected to bring relief to a large number of tenant farmers by giving them a permanent and secure right to the land as a means of providing incentives to increase production and to eliminate payments of high rents to landlords. Crop insurance for paddy was introduced in 1958/59 with the aim of increasing paddy production by guaranteeing farmers against losses caused by natural disasters or from adoption of new cultivation practices.

Apart from incentives offered to increase production, effective price incentives were also offered to the domestic food crop sector. Paddy was the first product to be brought under a guaranteed price. The objective of this scheme was to encourage increased production by assuring the producer a guaranteed price, and to ease the flow of peasant food crops to domestic markets by lessening the economic involvement of middlemen. This resulted in government being directly involved in procuring excess supply (Karunatilake, 1971). The guaranteed price acted as a floor support price keeping open market farm prices from falling below a certain level. This was supported by the rice seed improvement programme and a breeding programme using both local and imported varieties producing several varieties of high yielding seed material. The government maintained a price support scheme for other subsidiary crops like red onions, maize, chillies, green-gram and potatoes in addition to paddy.

The frequent use of various inputs was encouraged by a liberal supply of institutional credit under the agricultural credit scheme. Research on subsidiary food crops was concerned mainly with developing new varieties, improved management and fertiliser practices. To promote cultivation of subsidiary food crops, a new credit scheme was introduced to provide short-term credit. Credit limits were determined on a national basis rather than regionally. Therefore, the amount of credit given was insufficient, especially for cultivation in the Dry Zone where labour costs are very high. This caused farmers to depend on other sources such as private traders for credit (Karunatilake, 1971).

Government policy was aimed, not only towards improving the viability of domestic agriculture, but also towards improving plantation industries as Sri Lanka's export crops faced continuous competition from other producers, mostly in the South Asian region. Especially after 1955, the government took steps to enhance the economic position of the plantation industry so that it could face competition. In this connection, rehabilitation of tea and rubber was seen as a priority since the competitive position Sri Lanka maintained weakened as a result of a sharp fall in prices and the negative effects of synthetic releases as substitutes. The tea replanting subsidy scheme was introduced in 1959 to encourage regular and systematic replanting with a high yielding strain of vegetatively propagated tea for large estates. At the same time, a tea rehabilitation scheme was introduced to provide subsidies for improving conditions of tea lands and to adopt soil conservation methods for the smallholders.

In 1962, another scheme was introduced for rubber and tea replanting which involved a subsidy for replanting uneconomic rubber lands with high yielding vegetatively propagated tea varieties. Similarly, replanting subsidies involving high yielding plant material and fertiliser were introduced for the rubber and coconut industries. Cocoa was the only minor export crop able to attract resources under a replanting scheme. Tea, rubber and coconut research institutes were responsible for handling these schemes and providing advice on replanting.

Land reform policy was one of the main agricultural policies and was implemented during the 1970s with benefits to poor and landless farmers (Herath, 2007). Under the land reform laws of 1972 and 1975, private ownership of lands was subjected to a ceiling and lands owned by public companies were acquired by the Land Reform Commission (LRC). By the end of 1976, around 900,000 acres were transferred to the LRC. The estate lands acquired were controlled by two state companies, the People's Estate Development Board and the State Plantations Corporation (Peiris, G. H., 1978).

During this period, the government supplied subsidised inputs such as fertiliser, pesticides, tractors, improved seed and planting material, as well as rural credit to encourage food self-sufficiency. Large amounts of state investment went into irrigation development and land settlement programmes in the Dry Zone. There was a noticeable improvement in research and extension services, crop insurance, and marketing and agrarian service institutions. Direct marketing assistance programmes such as purchasing of paddy by the Paddy Marketing Board

(PMB) and other subsidies such as guaranteed prices for paddy and other crops were also provided during this period (Herath, 2007).

2.4.2 Policies in the post-liberalisation period

After the 1977 policy liberalisation, consumer food subsidies were abruptly reduced and focus on food self-sufficiency was enhanced. The new government emphasised the revitalisation of the plantation sector and self-sufficiency in rice (Figure 2.9). Public investments in major irrigation systems were expanded as a key move towards rice self-sufficiency. These reforms shrunk trade protection in the manufacturing sector. Explicit export taxes on plantation crops were also reduced during the 1980s. Further reforms included the abolition of government involvement in purchasing paddy output and relaxation of restrictions on foreign capital participation in agriculture. Nonetheless, the liberalisation was not uniform. Crops that were extensively cultivated in the North (e.g. red onions, chilies, grapes) were subjected to liberalisation, while protection for other crops such as potatoes was retained or increased.

The strategy for agricultural development included the following major components.

1. A programme of public investment in land and irrigation infrastructure and land settlement.
2. A programme for rehabilitation of the export tree crop sector including development subsidies for replanting and fertiliser.
3. Liberalisation of internal trade of farm products and changes in prices.
4. Implementing new laws for greater administrative control of the peasant sector.
5. Changes in land policy to enable the flow of private capital and enterprise into agriculture and agro-based industries.
6. Involvement of the private sector in the management of land settlement.
7. Special incentives for non-traditional exports and for processing of sugar, milk products, livestock production and fisheries (Herath, 2007).

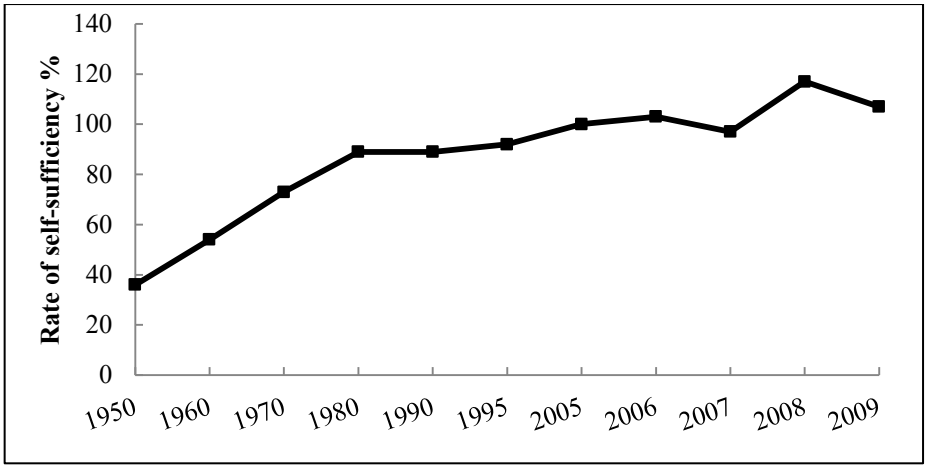

Figure 2.9: Rice self-sufficiency ratio 1950-2009

Source: Kikuchi, Baker, Samad, and Weligamage (2002); DCS (2011d)

Agriculture received a major share of public investment after 1977. Allocations to the agriculture sector amounted to 47 per cent of total budgetary provisions in 1980-1984 (Shanmugaratnam, 1984). The heart of this public investment allocation was the Accelerated Mahaweli Programme. More than 60 per cent of this was planned to be met by foreign assistance. It provided for a resettlement of thousands of poor landless families and the improvement of existing irrigation facilities for huge areas in the Dry Zone. Plans regarding the plantation sector included replanting and factory modernization, and granting of subsidies for replanting and fertiliser for both large estates and small-holders.

Regarding marketing policies, the state assumed the role only of market regulator and price stabiliser. Instead of the Guaranteed Price Scheme (GPS) for paddy, the government offered a floor price as the lower limit and set a ceiling price as the upper limit, allowing market prices to fluctuate between those two limits. The ceiling price was the sale price of rice from government stocks. Apart from that, in 1979, there was a fertiliser subsidy scheme which provided a subsidy of 85 per cent for urea, 55 per cent for sulphate of ammonia and 75 per cent for others.

The policies implemented in this period did not have a logical progression. The focus of policy had changed frequently responding more to political and economic forces than to the needs of sector development. Diversification towards commercial agriculture was the main policy thrust for the agriculture sector during the period 1989-1995. The policy strategies which had a potential impact on agriculture included reduction of rigidities in the tariff system, devaluation

of the currency to promote exports, removal of the fertiliser subsidy from 1990, increasing interest rates for rural credit schemes and promoting crop diversification and export of non-plantation crops (Gunawardana & Somaratne, 2000; Herath, 2007). Export duties on plantation crops were eliminated in 1992, while the high rates of nominal protection for import-competing agriculture were maintained. Governments often used regulatory controls to accomplish protection and price stability. Tariffs on agricultural imports were progressively reduced until 1993.

The major policy focus during 1994-1999 was on the elimination of institutional and policy obstacles in the agriculture sector. There was a mixture of policies in this period. Some supported subsistence agriculture and others continued to foster commercialisation. Some of the important changes after the early 1990s were concerned more with a shift from various forms of non-tariff barriers (NTBs) to tariff-based import restrictions. There was also an important effort towards liberalising import competition in the food industry. Trade policy continued to protect rice and several other import-competing food crops through tariffs and specific duties that fluctuated seasonally. As part of the Uruguay Round Agreement on Agriculture (AoA), the government bound all its tariffs on agricultural goods in 1995. Almost all agriculture tariffs were fixed at a 50 per cent ceiling, which was one of the lowest tariffs in the Asian region (Athukorala & Kelegama, 1998).

Because of low fixed tariffs and low-applied tariffs (within the range of 28 to 35 per cent), production of some domestic food crops showed a gradual reduction which in turn triggered ad-hoc tariff changes to meet producers' demands (Herath, 2007, p. 18). As a result, there were frequent changes in the tariff policy on main food crops to sustain the food security of the country, and to maintain producer and consumer satisfaction following crop failures and excess crop production in some seasons.

In addition, regardless of the shrinking share of agriculture in GDP and suggestions by various studies for the removal of subsidies, agricultural producer subsidies remained as an important component in agricultural policy (Bandara & Jayasuriya, 2009; Herath, 2007). Even though the World Bank (WB) insisted on the fertiliser subsidy being removed, the government decided to reinstate it as a result of strong political and economic pressure (Herath, 2007; World Bank, 1996). Other specific policies that affected the agriculture sector in this period

were: reduction of interest rates for agricultural credit, reduction of turnover tax on agricultural inputs, removal of government intervention in marketing by abolishing the PMB, which involved procuring paddy while reintroducing a minimum purchase price scheme for selected crops, widening the scope of agricultural insurance by establishing an agricultural and agrarian insurance board which permitted private companies to insure crop activities, initiating a fee-based private extension service by the department of agriculture in 1999 and introducing forward contract mechanisms to support rural financing. Registration of title for land was introduced in 1998 for the registration of titles to lands (Herath, 2007).

During 2000-2005 the major emphasis was on the policy for commercialisation and productivity improvement of agriculture in order to shift from low-value to high-value products. The government's strategy was to achieve competitiveness by increasing productivity, lowering production costs and adding value to raw materials by creating a peaceful environment with the help of the ceasefire agreement in 2002 relating to the 19-year-old civil conflict (Government of Sri Lanka, 2002). These policies promoted commercial agriculture in the domestic agricultural sector. They included:

1. Promoting more secure land ownership by providing more poor families with secure title to land and relaxing restrictions on sales, sub-division and mortgage of granted state lands.
2. Maintaining a similar set of tariff and trade policies as in the previous period, but with frequent changes in the tariff rates for different commodities to provide greater certainty to farmers, processors and traders. According to Herath (2007), the applied tariff rate of many food commodities were reduced to 28 per cent in 2002.
3. Initiating private-public partnership in research, extension, processing, value addition and upgrading the agricultural marketing systems including livestock, fisheries and forestry sub sectors.
4. Discouraging acquisition of plantation lands for non-agricultural purposes and replanting of uneconomic tea and rubber plantations with high-yielding clones.
5. Upgrading existing agricultural marketing systems and setting up new systems of modern agricultural wholesale markets in different areas of the country to link a network of competitive private sector-based agricultural retail markets. For example, upgrading and expanding the range of services provided by Dambulla Dedicated Economic Centre (DDEC) established in the Central Province, and establishment of new economic centers

will be established in Embilipitiya, Ampara, Vavuniya, Marassana, Kegalle, Pannegamuwa and Nuwara Eliya.

6. Shifting responsibility for commercial seed production, veterinary services and extension services to the private sector.

The government elected in 2004 proposed another policy regime for the agricultural sector. The vision for this policy statement was to have an agricultural sector contributing to regional equitable economic growth, rural livelihood improvement and food security through efficient production of commodities for consumption, for agro-based industries, and for exporting competitively to the world market while achieving an annual growth rate of 5 per cent during the planning period (Ministry of Finance and Planning, 2006). This policy statement has the following objectives; to increase domestic agricultural sector to ensure food and nutrition security, to promote agricultural productivity and to ensure sustainable growth, to maximise benefits and minimise adverse effects of globalisation on domestic and export agriculture, to enhance incomes and living standards of the farming community, to apply environmentally friendly techniques, and to promote agro-based industries.

Increasing productivity of the export agricultural sector has been identified as an important strategy to strengthen the balance of payments position of the country. In order to enhance the competitiveness of plantation sector products in the international market, research and cost reduction strategies have been emphasised in the policy framework. The policy regime on paddy sector mainly focuses on providing a guaranteed price, fertiliser subsidy and concessional bank credit. Other subsidiary crops are also expected to benefit from irrigation schemes, subsidised inputs and concessionary bank credit.

This policy statement says that the agricultural sector will grow at a rate of more than 5 per cent per annum during the planned period. This will be achieved from a combination of an increase in extent of production and improvement of the productivity of all sub-sectors. Growth rates of the extent and productivity that are required to achieve the overall 5 per cent growth rate by the individual sub-sectors are summarised in Table 2.20.

The major drive of all these strategies has been technological progress. Technological progress can be used to transform the subsistence agriculture to a high productive commercially

oriented one. However, it can be seen that this aspect has been ignored when it comes to allocation of resources in the non-plantation sector. In the proposed investment plan on agriculture, only 1.9 per cent has been allocated for technology research, while 33 per cent has been allocated for fertiliser subsidy (Table 2.21).

Table 2.20: Expected growth rates of extent and productivity

Sub-sector	Rate of increase over the 10 year period	
	Extent (%)	Productivity (%)
Plantation sector		
Tea	0.1	20
Rubber	2	5
Coconut	5	20
Non-plantation sector		
Paddy	0.1	10
Field crops, vegetables, fruits and other	0.8	25
Export agricultural crops	3	30
Livestock	2	5

Source: Ministry of Finance and Planning (2006)

Table 2.21: Proposed investment plan for agriculture 2007-2016

Key activities	Percentage of share (%)
CBO formation and mobilisation	1.7
Rural credit and financing	21.9
Extension and education	3.9
Human resource development	3.2
Food and nutrition security	1.3
Marketing facilitation	15.6
Bio and soil research	12.5
Seed and planting material production	4.1
Assistance on fertiliser	33.4
Technology research	1.9

Source: Ministry of Finance and Planning (2006)

Moreover, in 2007, the government introduced a three-year national policy under the theme "Api Wawamu-Rata Nagamu" (let us grow – let us develop) to promote local agricultural production, to ensure food and nutrition security of the people, and to reduce foreign exchange spent on food imports. Attempts have been made to transfer new technology to farmers with a view to improving agricultural productivity under this campaign (CBSL, 2007).

2.4.3 Subsidy policy

Production subsidies are the most common forms of internal support extended to both the plantation and non-plantation sectors by the government. The main subsidised inputs provided include chemical fertiliser, irrigation water and water management, agricultural extension, and seed quality certification services. Among these policies, fertiliser subsidy policy is debatable as the government continues to provide fertiliser subsidy regardless of the opinions from institutions like the WB and the Asian Development Bank (ADB).

The fertiliser subsidy programme is one of the longest-lasting, most expensive and most politically sensitive policies employed to encourage rice cultivation in Sri Lanka (Weerhewa, Kodithuwakku, & Ariyawardana, 2010). This was initiated in 1962, with the aim of making fertiliser available to farmers at a lower cost to maximise the benefits from high-yielding rice varieties (HYV) introduced during the green revolution. It initially covered only the paddy sector and was extended to cover other crops as well in 1985. It was expected that low fertiliser prices would boost the adoption of HYVs, improve land productivity and decrease the cost of production, resulting in more profitable paddy farming, which in turn would lower the prices of paddy and rice. The subsidy was completely withdrawn in 1989 and reinstated in 1994. The subsidy scheme has been in operation since then with several changes in the rate of subsidy, fixing the fertiliser price, the type of fertiliser that was subsidised, crop sectors that were assisted and the distribution systems (Herath, 2007). It is still available to growers of import-competing crops, particularly small-holders.

Originally, a fixed fertiliser subsidy was introduced for paddy. It applied to different fertiliser types, urea, sulphate of ammonia (nitrogen fertiliser), muriate of potash/MOP (potassium fertiliser) and triple super phosphate/TSP (phosphorus fertiliser). These were subsidised at different rates. However, a revision made in 1997 restricted the subsidy to urea since it is the most widely used fertiliser in Sri Lanka. The method of deciding on the subsidy varied from

time to time. It was either a fixed sum per unit amount of fertiliser or a variable sum to maintain a fixed price in the market. In 2005, the fixed rate of subsidy was Rs. 23,000 per metric ton of urea. It was revised in late 2005, fixing the price at Rs. 350 per 50 kg bag of urea regardless of the world market price (IPS, 2006). Expenditure on fertiliser subsidy is around Rs. 26 billion and it accounts for around 2.24 per cent of the total government expenditure (Table 2.22). The ten-year investment plan of the Government of Sri Lanka (2007-2016) allocated about 30 per cent of its total funding in the agriculture sector to the fertiliser subsidy for the ten-year period (Herath, 2007).

Table 2.22: Expenditure on fertiliser subsidy 1987-2009

Year	Expenditure on fertiliser subsidy (Rs. million)	Expenditure on fertiliser subsidy as a percentage of total government expenditure
1987	600	0.94
1988	347	0.45
1989-1993	-	-
1994	630	0.37
1995	1345	0.66
1996	1500	0.69
1997	1895	0.81
1998	2152	0.80
1999	1390	0.5
2000	1733	0.52
2001	3650	0.94
2002	2448	0.61
2003	2191	0.52
2004	3572	0.75
2005	6846	1.17
2006	11867	1.66
2007	11000	1.31
2008	26450	2.65
2009	26935	2.24

Source: Ekanayake (2006); CBSL, Annual reports (various years)

Paddy production uses the greatest proportion of inorganic fertilisers used in agriculture in Sri Lanka and it also uses the highest proportion of the total subsidy on fertiliser (Figure 2.10). Since 2006, subsidies have been provided for paddy and plantation crops grown by small-holders. State-owned companies import fertiliser for the paddy sector and the distribution of subsidised fertiliser is solely done by the Agrarian Service Centers. There is no contribution by the private sector. Subsidised fertiliser used by the plantation crops is administered by government authorities, namely, the Tea Small Holdings Development Authority (TSHDA), the Rubber Development Board (RDB) and the Coconut Cultivation Board (CCB). Since 2009, farmers have been required to sell 500 kg of paddy per hectare to the government at a guaranteed price.

Studies have shown that the removal of the fertiliser subsidy in 1990 did not cause any drop in fertiliser used by farmers, but farm profits declined (Wickramasinghe, 2005). A study on the impact of the fertiliser subsidy on paddy cultivation in Sri Lanka (Ekanayake, 2006) concluded that demand for fertiliser is a function of paddy prices rather than prices of fertiliser. The study further implied that the subsidy could be withdrawn gradually over time and recommended alternative strategies for targeting the poor to safeguard their income. Although this subsidy does not directly support the productivity improvement, the government of Sri Lanka is willing to continue it to protect poor farmers. According to Herath (2007), this is a political motive as poor farmers are not really protected because there is no targeting mechanism.

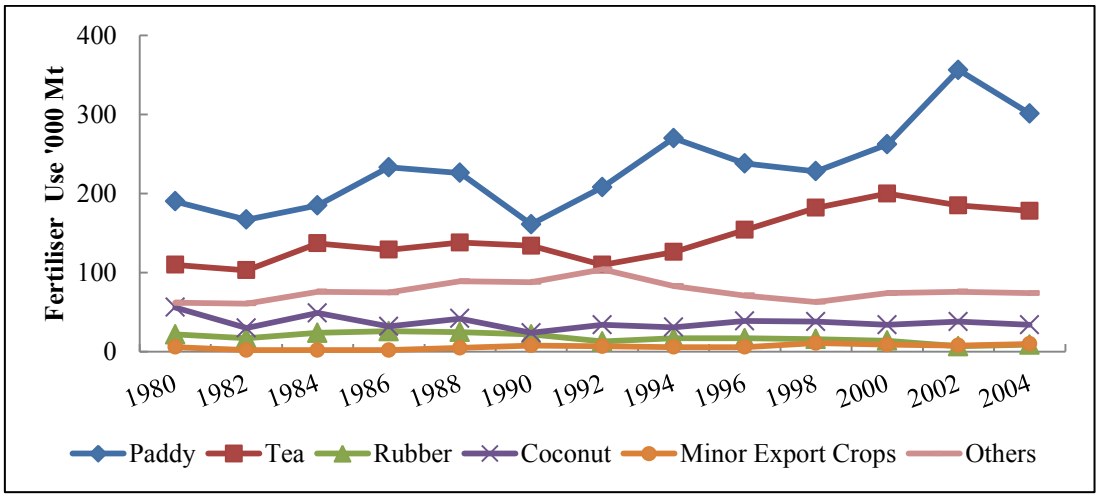

Figure 2.10: Fertiliser usage by crops

Source: Ministry of Plantation Industries (2008)

2.5 Regions of Sri Lanka

This section provides a brief overview of different regions in the country. It then examines the socio-economic disparities among regions.

2.5.1 Brief overview of current regions of Sri Lanka

At present, Sri Lanka is divided into nine administrative "regions" that have been used as units for planning, coordinating and implementing development activities and central government policies at sub-national level. The provinces, namely, Western, Central, Southern, Sabaragamuwa, Uva, North Western, North Central, Northern and Eastern, consider as regions in the regional development planning in Sri Lanka. Provincial councils were established in 1987 as an intermediate layer of government with considerable development powers to decentralise government functions (Uduporuwa, 2007).

Sri Lanka has been experiencing a regionally imbalanced economic growth for the last three decades (Herath, 2010). Disparities in development among regions are clearly distinct (Herath, 2010; UNDP Sri Lanka, 1998). According to Uduporuwa (2007), Sri Lanka is experiencing increasing disparities and widening income inequalities between regions despite several strategies implemented targeting regional development. Economic development and physical and social infrastructure are unevenly spread among regions. All of the regions have very different growth rates, per capita income levels, poverty rates and structure of provincial economies. The most developed core region in the country is situated in the Western Province. The majority of the major economic activities such as industry, trade, commerce and services occur within this region. Furthermore, all major towns in the country are directly connected to Colombo city, which lies in the Western Province, rather than to any other regional centre. As a result, regional disparities are clearly evident in most of the remaining areas in the country. Northern and Eastern Provinces were badly affected by the three decades of civil conflict that ended in 2009, and which hindered development initiatives by the government and the conducting of major economic activities. With the end of that civil conflict, a fast recovery of economic activity is taking place in both the provinces.

2.5.2 Inter-regional disparities

Growing regional inequalities symbolise a persistent development challenge in most countries (Shankar & Shah, 2003; Karunaratne, 2007a; Karunaratne, 2007b). The problem of increasing regional disparity has attracted a growing concern recently in Sri Lanka. Table 2.23 summarises the demographic situation of nine provinces of Sri Lanka. Area wise North Central is the largest province occupying 16 per cent of Sri Lanka's total land area, but inhabits only six per cent of the total population. On the other hand, Western Province is the smallest province containing the largest proportion of the total population of the country. Presently, about 5.8 million out of the 21 million total population, which is nearly 28 per cent of the total population, reside in Western Province. The rest of the population is spread unevenly among the other eight provinces. Although Central, Southern and Sabaragamuwa Provinces are relatively small in terms of land area, these provinces have a significant proportion of the population.

Table 2.23: Population, land area and population density among provinces 2010

Province	Population ('000)	Land area (sq. km.)	Share of population (%)	Share of land area (%)	Population density (Persons per sq.km.)
Western	5,865	3,684	28.4	5.6	1,632
Central	2,689	5,676	13.0	8.7	482
Southern	2,494	5,544	12.1	8.4	463
Sabaragamuwa	1,943	4,968	9.4	7.6	395
North Western	2,342	7,888	11.3	12.0	312
North Central	1,240	10,472	6.0	16.0	127
Uva	1,326	8,500	6.4	13.0	159
Northern	1,193	8,884	5.8	13.5	144
Eastern	1,561	9,996	7.6	15.2	167

Source: CBSL (2010b)

Population concentration into Western, Central, Southern and Sabaragamuwa Provinces has not been a phenomenon in the recent past. Historical evidence suggests that these four provinces accounted for the largest population share even before the European colonial period. Initial stage of public policies after resuming political independence in 1948 devoted to

decrease the population concentration in these regions by introducing resettlement schemes in North Western and North Central Provinces. As a result, population concentration in these four regions decreased from 71 per cent in 1946 to 63 per cent on 2010 (CBSL, 2010; Karunaratne, 2007b).

Socio-economic development of these provinces also varies from province to province as a result of several factors. High concentration of population, industries and employment in the Western Province has become a major cause of spatial imbalance in development. According to Uduporuwa (2007), economic policies after 1978 contributed mainly to popularise development in the Western Province, and this has created a dualistic pattern of economic growth and widened the difference between the Western Province and the other provinces.

A cross-sectional evaluation of all provinces shows that the size of the Western Province's economy is the largest. Western Province contributes nearly 50 per cent of the total GDP in Sri Lanka, while the other provinces collectively contribute the rest of the GDP. Six provinces contributed less than ten per cent to the national economy in 2009 (Table 2.24).

Table 2.24: Contribution to national GDP by province 1999-2010

Region	Year (%)											
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Western	48.7	49.6	48.3	48.1	47.9	51.4	50.8	50.1	46.5	45.4	45.1	45.1
Central	9.2	9.4	9.4	9.5	8.6	9.2	8.5	8.8	9.6	9.8	9.6	10
Southern	9.6	9.4	9.7	9.5	9.9	8.9	8.9	10	10.5	10.5	10.2	10.7
Sabara-gamuwa	6.4	6.7	6.4	6.8	6.4	6.4	6.4	6.1	6.4	6.4	6.3	6.3
Uva	4.1	3.9	4.6	4.2	4.6	4.3	4.5	4.3	4.9	4.5	4.6	4.5
North Western	10.4	10.4	10.7	10.3	10	8.5	8.9	9.1	9.9	9.9	10.3	9.4
North Central	4.1	3.9	3.7	4	4.7	3.6	4.3	4	4	4.7	4.8	4.8
Northern	2.5	2.2	2.4	2.7	2.9	2.9	3	2.8	2.9	3.2	3.3	3.4
Eastern	5	4.5	5	4.9	5.5	4.9	4.7	4.9	5.2	5.6	5.8	5.9

Source: CBSL, Economic and social statistics of Sri Lanka (various issues)

While Western Province was having an average real GDP growth rate of 6.5 per cent 1997-2008, the rest of the country grew by 2.3 per cent. For example, average growth rates in Uva and Sabaragamuwa Provinces were 3.2 and 0.7 per cent, respectively, during the same period (Herath, 2010). According to the CBSL (2011b), all provinces have reported higher growth rates in 2010 in line with improvements in the country's economic environment. Provincial per capita income provides further evidence for disparities among regions (Figure 2.11). In 2009, it was Rs. 430,000 (US$3,314) in the Western Province, which was 1.6 times the national per capita income. All the other provinces recorded almost half of that. Sectoral contribution to GDP of the provinces is shown in Figure 2.12.

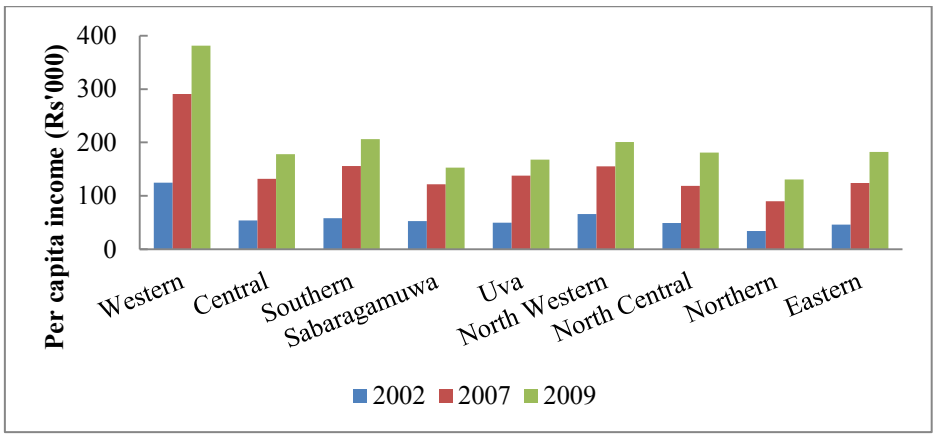

Figure 2.11: Per capita GDP at provincial level (Rs. '000)

Source: CBSL, Economic and social statistics of Sri Lanka (various issues); CBSL (2011b)

Note: 2002 estimates are based on current factor cost prices compiled by the CBSL, and 2007 and 2009 estimates are based on current market prices.

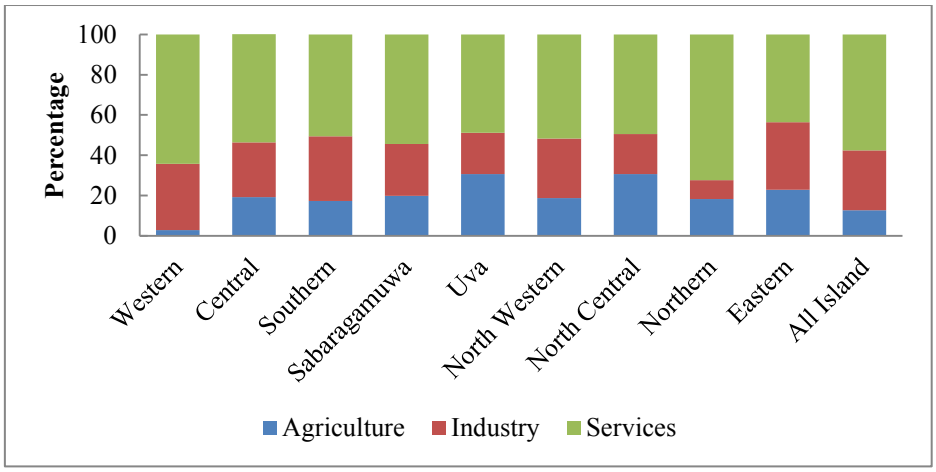

Figure 2.12: GDP composition of the provinces

Source: CBSL (2010b)

There are substantial variations in the structure of GDP across provinces. Agriculture accounted for nearly three per cent of GDP in Western Province, while it accounted for more than 15 per cent in the other provinces. In both Uva and North Central Provinces, agriculture accounted for nearly one third of GDP. The service sector was the most dominant single sector accounting for more than 40 per cent in all provinces.

2.5.3 Comparison of regional socio-economic conditions

Employment structure exhibits a significant variation among provinces. Of the total labour force in the Western Province, only 8.5 per cent are involved in agriculture. In all the other provinces more than one third of the labour force is employed in the agricultural sector. Sixty-nine per cent of the total labour force in Uva Province is engaged in agriculture. On the other hand, more than 60 per cent of Western Province labour force is engaged in service related activities (Table 2.25).

Table 2.25: Distribution of employment by sector and province 2002 (percentages)

Province	Agriculture		Industry		Services	
	2002	2010	2002	2010	2002	2010
All island	**32.7**	**34.5**	**33**	**20.9**	**59.1**	**44.7**
Western	7.9	8.5	17.2	30.6	40.5	60.9
Central	42.3	46.4	25.5	12.4	37.4	41.3
Southern	37.1	39.5	19	21.3	45.7	39.2
North Western	36.9	36.8	25.7	22.7	37.5	40.6
North Central	59.4	57.2	11.9	11	28.6	31.8
Uva	59.3	69.4	11.2	7.9	29.5	22.7
Sabaragamuwa	40.9	40.1	25.4	18	33.7	42.9
Northern[a]	39.1	39.1	9.6	13.5	51.2	47.3
Eastern	38.5	38.5	10.5	15.4	51.1	46.2

Source: DCS (2002a, 2002b, 2010b)

Note: [a] In 2002, only part of the Northern Province was included in the labour force survey. For further details see DCS (2002b)

Considering the spatial pattern of poverty in Sri Lanka, Western Province records the lowest poverty level. Uva Province has recorded the highest drop in poverty and inequality since

2006/07 (Table 2.26). The largest share of the poor population in Sri Lanka in 2006/2007 was reported from Uva Province, while the next highest was reported from Sabaragamuwa Province. Six point five per cent of households in the Western Province considered to be poor despite recording the lowest HCI (8.2 per cent) among all provinces (DCS, 2009a).

Table 2.26: Poverty and inequality by province [a] -2006/07 and 2009/10

Province	HCI		% of poor households		Poverty gap index		Squared poverty gap index	
	2006/07	2009/10	2006/07	2009/10	2006/07	2009/10	2006/07	2009/10
Sri Lanka	**15.2**	**8.9**	**12.6**	**7**	**3.1**	**1.7**	**0.9**	**0.5**
Western	8.2	4.2	6.5	3	1.5	0.8	0.4	0.2
Central	22.3	9.7	18.2	8.2	4.6	1.8	1.4	0.5
Southern	13.8	9.8	11	7.5	2.6	1.8	0.8	0.5
Northern	-	12.8	-	10	-	2.1	-	0.6
Eastern	10.8	14.8	9	12.4	2.1	3.2	0.6	1.1
North Western	14.6	11.3	12.2	8.2	2.9	2.4	0.9	0.8
North Central	14.2	5.7	11.8	4.6	2.8	1	0.8	0.3
Uva	27	13.7	23.8	12	6.2	2.4	2.1	0.7
Sabaragamuwa	24.2	10.6	20.2	8.7	4.9	2.1	1.5	0.7

Source: DCS (2008c, 2011c)

Note: [a] All the poverty indicators were calculated based on Household Income and Expenditure Surveys conducted by the DCS. HIES 2006/07 did not cover the whole Northern Province. HIES 2009/10 covered only Jaffna and Vavuniya districts in the Northern Province and it did not cover Mannar, Kilinochchi and Mullaithivu districts as they were out of reach of the survey due to massive mine clearance and resettling in the aftermath of the rescue operations.

The Prosperity Index of Sri Lanka (SLPI) is developed by the Central Bank of Sri Lanka (CBSL) to measure the level of prosperity achieved by provinces on a comparative basis. This shows that only Western and Central Provinces achieved a level of prosperity above the national average (CBSL, 2008a). The SLPI incorporates 20 variables that represent various facets of the lives of people. The variables are classified into economic, business climate, health, education, wealth and major socio-economic infrastructure related groups and given weights of 20, 10, 20, 20, 5, and 25 per cent, respectively (for more details see CBSL, 2008a, p. 51). Northern and Eastern Provinces recorded the lowest SLPI mainly due to the underperformance shown in the economy and business climate sub-index (Figure 2.13).

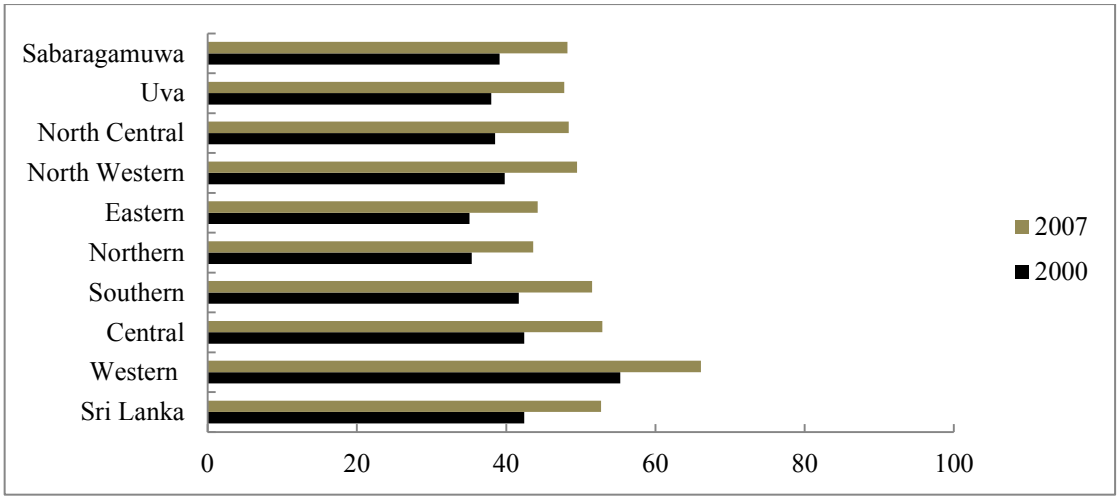

Figure 2.13: Prosperity Index of Sri Lanka by province

Source: CBSL (2008a)

The social indicators show that Western Province recorded the highest literacy rate (96.4 per cent) in 2003/04. This could be attributed to the better educational and employment opportunities that prevail in the province. Southern, North Western and North Central Provinces also had literacy rates above 90 per cent, which was above the national average of 92.5 per cent (Figure 2.14). Figure 2.15 shows the number of schools (government, private and other) in each province as a percentage of the total schools in the country in 2002. Western and Central Provinces recorded the highest number of schools and account for almost one third of all the schools in the country. Northern, Eastern, Uva and North Central Provinces each have less than 10 per cent of all the schools.

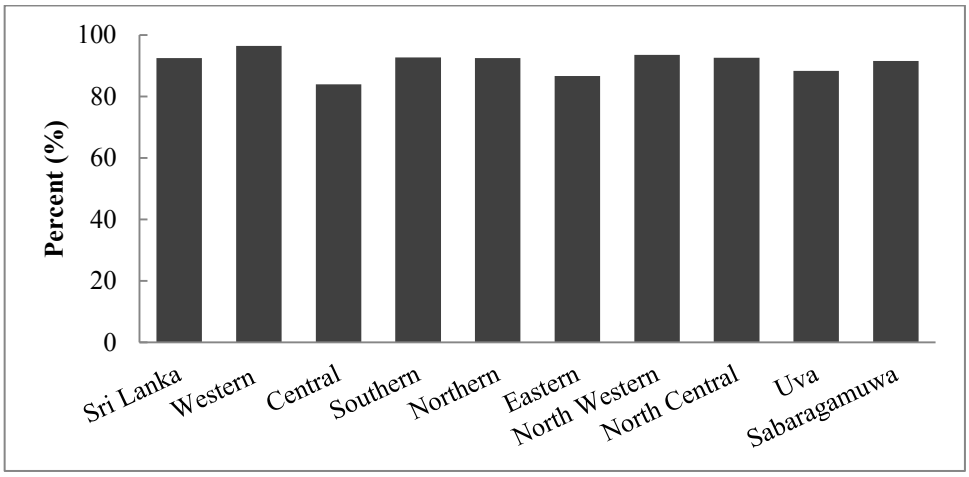

Figure 2.14: Literacy rates by province

Source: CBSL (2005b)

Note: Northern Province excludes Mannar, Kilinochchi and Mullaithivu districts

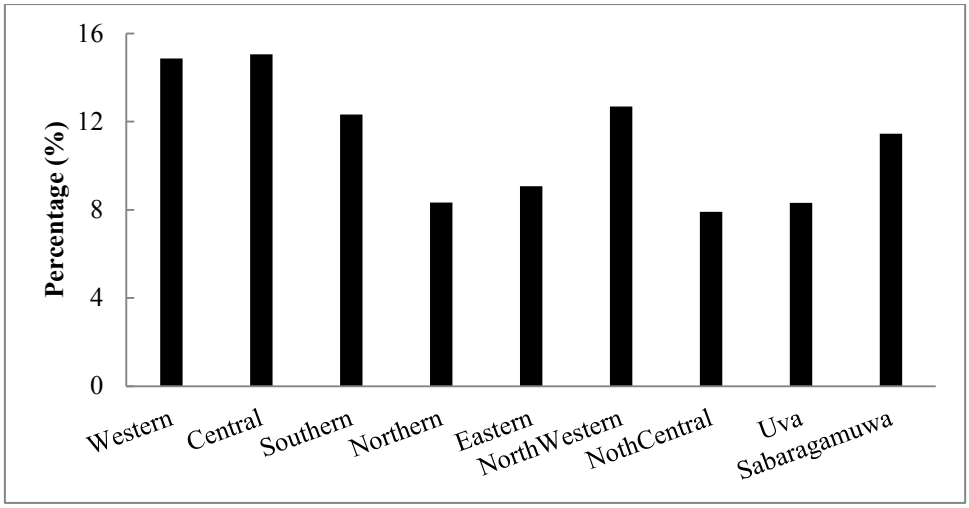

Figure 2.15: Schools in each province as a percentage of total schools 2002

Source: DCS (2002d)

Provincial monthly per capita expenditure levels varied within a range from Rs. 2,564 in Uva Province to Rs. 5,922 in Western Province, compared to the national average of Rs.3,936 according to the CFS survey conducted in 2003/04 (CBSL, 2005b). This indicates some widening of differences in relative expenditure levels among provinces when compared with the 1996/97 survey (CBSL, 1999). Patterns of expenditure are fairly similar across provinces where the non-food expenditure share is higher than the food expenditure share (Figure 2.16).

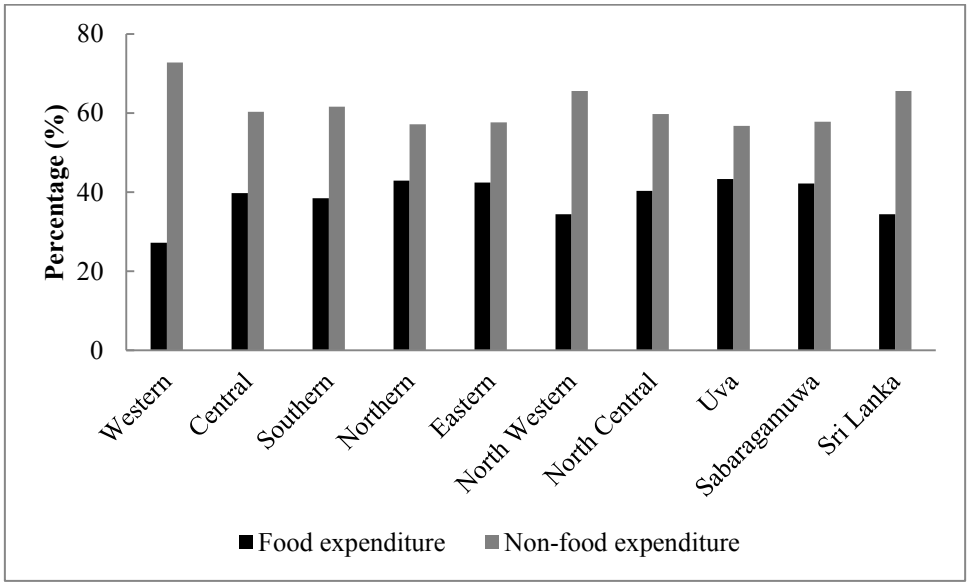

Figure 2.16: Distribution of expenditure share by province 2003/04

Source: CBSL (2005b)

Note: Northern Province excludes Mannar, Kilinochchi and Mullaithivu districts

The lowest relative expenditure share on food was recorded in Western Province (27 per cent), while highest was recorded in Uva Province (43 per cent). The CBSL (2005b) indicates that the importance of the food expenditure share fell across provinces from 1996/97 to 2003/04, yet, six provinces spent over 40 per cent of their expenditure on food.

Monthly per capita expenditure, income, and monthly household income of all the provinces are reported in Table 2.27. Only Western Province exceeds the average national monthly per capita income. Uva Province recorded the lowest monthly per capita income and monthly household income.

Table 2.27: Monthly household/per capita income and expenditure 2003/04

Province	Monthly per capita expenditure	Monthly per capita income	Mean monthly household income	Median monthly household income
Western	5,922	5,999	15,549	10,817
Central	3,089	3,222	8,521	5,973
Southern	3,222	3,060	8,340	6,408
Northern[a]	3,255	3,208	9,232	6,335
Eastern	3,136	2,905	8,136	5,162
North Western	4,012	3,872	9,591	6,876
North Central	3,159	3,814	9,489	6,313
Uva	2,564	2,570	6,789	4,737
Sabaragamuwa	2,793	2,894	7,425	5,419
Sri Lanka	**3,936**	**3,968**	**10,391**	**6,893**

Source: CBSL (2005b)

Note: [a] Northern Province excludes Mannar, Kilinochchi and Mullaithivu districts

Household income consists of both monetary and non-monetary income received by all the members of the household; it can be earned or received through donations. Table 2.28 shows the average monthly household income as a percentage share by main source of income in different provinces. Income from wages and salaries, agricultural activities, non-agricultural activities, and other cash income are identified as monetary income. The non-monetary income is the estimated value of goods and services received in kind and consumed within the survey reference period. Eighty-six per cent of the income was received as monetary income

in 2006/07. A major part of the monetary income was recorded from wages and salaries and it varied around 25 (North Central Province) to 50 per cent (Eastern Province) of the total household income.

Table 2.28: Percentage shares of average monthly household income by main source of income 2002/03 and 2006/07[a]

Province	Average monthly household income by main source of income (Percentage)				
	Wages and salaries	Agricultural activities	Non-agricultural activities	Other[4]	Non-monetary income[5]
Sri Lanka	**35.83**	**11.20**	**17.15**	**21.00**	**14.82**
Western	40.41	4.37	17.91	21.48	15.83
Central	33.83	18.23	13.88	20.94	13.13
Southern	34.47	14.80	13.99	21.46	15.27
North Western	32.76	13.04	20.11	19.80	14.29
North Central	24.65	10.82	24.16	26.43	13.93
Uva	28.91	21.71	13.63	20.28	15.46
Sabaragamuwa	34.98	21.65	17.44	11.82	14.11
Northern	47.7	9	16	19.4	7.8
Eastern	49.6	8.1	12.1	16.2	13.9

Source: DCS (2003, 2008b)

Note: [a] percentage shares of Northern and Eastern provinces are obtained from the household income and expenditure survey conducted in Northern and Eastern Provinces in 2002/2003 and percentage shares of all the other provinces are obtained from the household income and expenditure survey conducted in Northern and Eastern Provinces in 2006/2007.

[4] Other cash income includes pension payments, disability payments, local and foreign transfers, windfall income such as lottery wins, compensations etc.

[5] The non-monetary income includes home grown fruits and vegetables, firewood, home-consumed quantities of the product of agricultural activities, other goods or concession values received from employer or other parties, and estimated rental value of owner occupied housing units or freely occupied housing units.

Some important conclusions can be drawn from the socio-economic indicators of all the regions. In a nutshell, Western Province appears to be the most developed region in terms of all the indicators, followed by North Western, Central and Southern Provinces. Uva, Sabaragamuwa, Northern and Eastern Provinces are the least developed and poverty ridden regions. Northern and Eastern Provinces are less developed as a consequence of the three-decade civil conflict that prevailed in the area, but since the end of the conflict they are developing rapidly. Apart from those two provinces, Uva Province can be considered the poorest region in the country, and has the highest proportion of the population involved in agricultural activities.

2.6 Chapter summary

This chapter reviewed the Sri Lankan economy and its agriculture in order to provide the background for the study. It has been noted that Sri Lanka was a relatively affluent agriculture-dominated open economy at the time of its independence, with the best prospects for successful development in Asia. The post-independence development policy in Sri Lanka has been guided by different economic and political philosophies that changed from time to time. They have shifted from open free market policies (up to 1959) to rigid ISI (1960-1977), and export-oriented liberalisation (after 1977). Since 1977, the fundamental direction of policy has not changed, yet there have been differences in the degree and scope of liberalisation measures under different administrations. These changes in the policy regimes have led to changes in the relative contributions and significance of the sectors, and qualitative changes within them. As a result, the character of agriculture, manufacturing and services has changed considerably.

Analysis of the performance of the agriculture sector and its policy evolution revealed that the agriculture sector's contribution has steadily declinined over the decades with the expansion of the manufacturing and services sectors. However, it still continues to play a key role in the economy as a major source of employment generation and livelihood support for the rural population. Within the agriculture sector, the output share of export-oriented plantation crops has been declining, while the output share and contribution of the non-plantation sector has been increasing. Pre-liberalisation agricultural policies seemed to favour the domestic agriculture sector. They taxed export agricultural crops and provided subsidies to domestic

agricultural crops mainly in terms of input subsidies. Taxes on export crops were abolished during the post-liberalisation period and focused mainly on food self-sufficiency.

A comparison of socio-economic indicators of the nine provinces suggest that Sri Lanka is experiencing a regionally imbalanced economic growth and increasing disparities among the regions despite the implementation of strategies targeting regional development. In the next chapter, the current literature on CGE studies on agriculture in developing countries will be reviewed.

Chapter 3

Literature Review on Agricultural Sector-Focused CGE Applications in Developing Countries

There is a large body of literature on the role of agriculture in economic development, and previous researchers have adopted different empirical methods for the analysis of agricultural policy that come under two broad categories, econometric/partial equilibrium analysis and general equilibrium analysis methods. Reviewing all these past studies would be a tedious task. Instead, this chapter mainly focuses on the application of CGE modelling on the agricultural sectors of developing countries.

This chapter begins by providing an overview of agricultural policy analysis. Section 3.1, briefly examines various modelling approaches used for this purpose. Then, in Section 3.2, this chapter tries to answer the question of why the CGE approach is the best modelling technique for assessing economy-wide impacts of agricultural policies. Section 3.3 highlights some limitations of CGE modelling. In Section 3.4, a survey of agriculture focused CGE studies, particularly in developing countries, is conducted. CGE applications on the Sri Lankan economy are discussed in Section 3.5. The final section presents concluding remarks.

3.1 An overview of agricultural policy analysis

Agricultural policy analysis always demands a baseline situation against which the policy intervention can be assessed. In the natural sciences, this baseline setting is given by controlled experiments where the result of experiments influenced by an intervention can be compared to the outcome of those experiments without any intervention. In the case of agricultural policy, a more general approach would be to examine policy impacts before the introduction of the policy and afterwards. This methodology runs into a counterfactual problem that, in examining the post-policy effects, not everything else has been kept constant. We cannot be sure what fraction of the total consequences is due to the policy change and the amount of all the other changes occurring simultaneously. As Matthews, O'Toole, and Jensen (2003) described, forming a model for the agricultural sector, or for the whole economy, focusing on the agricultural sector is one way of setting up a condition which can be used as a

baseline to assess the consequences of a policy change. If we can determine the main relationships that operate within the sector, we can use this knowledge to examine how the agricultural system would react to a shock in an exogenous variable, such as price or technology, as these models represents simplifications of reality. Thus, these models can be used as a laboratory where policy experiments can be conducted and their real impact can be assessed.

There are many ways of constructing models in agricultural economics. Models can be distinguished based on their structure, for example, synthesis models, econometric models, programming models, partial equilibrium models, input-output models, and general equilibrium models. Models can also be distinguished based on their scope, for example, single commodity, multi-market, sector specific or national economy models. Either way, results of these models should not be taken as firm predictions, but need to be interpreted by taking into consideration, the model's structure and assumptions (Matthews, et al., 2003). Partial equilibrium analysis has been the most common approach in applied economics until recently. The advantage of this approach lies in its empirical simplicity. There is an important distinction between partial and general equilibrium modelling. In partial equilibrium models, the focus is on detailed modelling of a particular sector or part of the economy.

As Bandara (1991) and Carry (2008) point out, the partial equilibrium approach can be used to analyse policy issues occurring from a shock whose effects are restricted to a specific industry or, rather, where the impacts on other industries can be considered to be small enough to be ignored in practice. However, its capacity is limited in terms of handling matters arising from general shocks that affect prices and outputs of other industries as well. In order to focus on a particular sector, all other prices in the economy are implicitly assumed constant and no feedback effects between the sector and the rest of the economy are clearly modelled. General equilibrium models, on the other hand, are capable of conceptually portraying all the relationships in an economy, although they pay more attention to modelling some sectors than others. This framework provides a logically consistent way to look at policy issues which involve more than one economic agent, since it contains all commodities and factors markets together with decision-making agents. Such models, often called Applied General Equilibrium (AGE) models or Computable General Equilibrium (CGE) models, are increasingly used for agricultural policy analysis. In an economy-wide model, demand and supply of each

commodity depends on all relative prices in the economy. A general equilibrium analysis can take into account all these interactions clearly, unlike in partial equilibrium models.

The CGE/AGE models are descendants of the disaggregated, fixed-coefficient models traditionally used in drawing up consistent plans and examining related issues of resource allocation. They are used to tackle a wide range of problems in the development field. These models attempt to use general equilibrium theory as an operational tool in empirically oriented analyses. Bandara (1991) describes the difference between theoretical general equilibrium analysis and CGE/AGE analysis. According to him, the main focus of theoretical GE literature is on the existence and uniqueness of equilibrium, while numerical experience is emphasised in CGE approach. As Shoven and Whalley (1984) mention, the CGE approach converts the Walrasian general equilibrium structure (formalised in the 1950s by Kenneth Arrow, Gerard Debreu, and others) from an abstract representation of an economy into realistic models of actual economies. These models use empirical data from real economies and use them to evaluate policy decisions. Leif Johansen developed the first operational AGE model in the late 1950s. Since then, a number of CGE models have been designed to address a wide range of policy issues such as choice of development strategy, income distribution, trade policy, structural adjustments to external shocks, tax-policy, and long-term growth and structural changes. AGE models incorporate the macroeconomics of the national economy, specifying key determinants as endogenous variables, while allowing any degree of sectoral disaggregation that is suitable for the analysis of intersectoral shifts (Carri, 2008; Hartel, 1999).

As explained by Lofgen and Robinson (Lofgren & Robinson, 2003, as cited in Matthews, et.al., 2003), constructing a GE model involves a series of six steps:

1. Identify the decision-making agents in the model economy. Normally, these encompass producers, consumers, and perhaps “macro” agents such as the government and the rest of the world.
2. Specify what motivates the agents. In general, one assumes profit-maximizing producers and utility-maximizing consumers.
3. Specify the institutional structure of the economy and the signals to which agents respond.

Typically, one assumes competitive markets, with consumers and producers subject to budget constraints- they cannot spend more than they receive. In this environment, the only signals that actors need to see are prices and wages.

4. Specify constraints faced by the agents. Producers have production or cost functions that reflect available technology, and consumers have initial endowments of resources that define their incomes.

5. Specify "system constraints" that the economy faces, but which are not seen as signals by individual agents. For example, aggregate supplies of labour, capital, and land are usually assumed to be fixed, as well as macro constraints such as the current account balance on foreign trade.

6. Specify "balance conditions" that define market equilibrium, for example, supply-demand balance in commodity and factor markets.

3.2 Why use GE analysis in agriculture-related issues?

An important question regards the relevance of CGE analysis for agriculture. With food and agriculture having an ever-shrinking share of GDP and consumer expenditure, why should one go to the trouble of constructing an economy-wide model to analyse policies in these sectors in preference to other available models? There are several important advantages offered by this approach to agricultural policy analysis (Carri, 2008; Hartel, 1999; Matthews, et al., 2003). Probably the most important advantage of the CGE approach is its comprehensive nature. Because the agriculture sector is embedded in an overall model of the economy, it is imperative to capture the feedback and indirect effects which evolve because of economic interdependencies between sectors. Moreover, economy-wide CGE models can be of use for the analysis of policy changes that cut across both agricultural and non-agricultural sectors.

When policy analysis in the farm sector is considered, inter-industry linkages become very important. It is very difficult to distinguish the commodities and sectors affected by a given policy and the rest of the economy. Sayan and Demir (1998) analysed the degree of interdependence between agriculture and non-agriculture industries in Turkey. They suggested that, when backward linkages from agriculture to non-agriculture are disregarded, agricultural multipliers are reduced by about 20 per cent. Capturing non-farm linkages is important as farm households' earning is diversified. Since they often have significant wage-earning interests in

sectors other than agriculture, their welfare depends on much more than changes in agricultural activity. Therefore, it is important to capture the inter-industry linkages through CGE/AGE models.

Secondly, general equilibrium models make sure that they maintain the resources and accounting consistency. Preserving these accounting identities is as important as behavioural assumptions specified in the model as they influence the range of possible outcomes. Chambers (1995) used a GE approach to analyse the incidence of different agricultural policy instruments related to agricultural subsidies in the presence of distortionary income taxation. The results suggested that partial equilibrium calculations of the cost and benefits of farm programmes systematically overstate the benefits farmers receive from these programmes by ignoring the linkages, such as higher factor costs, higher taxes, and impact on government revenue requirements.

The third most important advantage of the CGE approach is its focus on the household. As in any other area of policy analysis, agricultural policy analysis pays increasing attention to the distributional consequences of a particular policy change. There has been a growing concern in recent years to evaluate the potential outcomes of the Doha Development Agenda which would intensively liberalise agricultural trade and whether this would have a bigger effect on poor households in developing countries. Traditional agricultural economics analysis mainly focuses on commodities and associated factor returns. In contrast, household disaggregation can be incorporated explicitly into CGE models.

CGE models begin with households as a primary concept. Households supply factors of production and consume goods and services. Welfare in the model is computed directly in terms of household utility rather than summation of producer, consumer, and tax payer surplus. If enough data are available for the construction of the data base for the model, then factor incomes of households can be mapped to household types and household incomes. When a policy change is simulated, changes in these factor incomes can be captured and welfare changes for individual household types can be calculated directly. As Hertel (1999) explains, the attention on people, services, resources, and the environment, instead of just commodities, is crucial as the share of farm household income generated outside of agriculture increases.

Fourthly, CGE models may incorporate the ability of regional disaggregation based on the data availability. Regional disaggregation is often advantageous in capturing the impacts of agricultural and resource policies. Such disaggregation can occur at sub-national level and would be able to reflect the geographic dimension of impact from economy-wide policies and/or analysing policies which are implemented differently across regions like public investment. For example, Briones (2009) disaggregated the Philippines into four regions to analyse the impacts of removal of trade protection in agriculture. These regions differ in economic structure due to the country's geography and uneven historical patterns of development. The results suggested that implementation of tariff reforms in agriculture will contract some import-competing sectors in lagging regions, but improve welfare across all regions, and productivity growth in agriculture can offset these contractionary effects.

Fifthly, CGE models can have a global coverage. Many policy makers are in search of answers to global economic policy questions. In this case global AGE analysis is often the most appropriate instrument. The impacts of negotiations under the Uruguay Round Agreement and Doha Development Agenda on different regions of the world were comprehensively analysed using global AGE models (Goldin & Knudsen, 1990; Martin & Winters, 1996). Similarly, in some cases global modelling is desired if the region undertaking the policy shock is large in world market terms so that its results are expected to be widespread.

Lastly, the general equilibrium framework provides valuable insights into the political economy of agricultural policies. For example, there is a strong movement of relative rates of protection to shift as countries develop. Poor countries tend to tax agriculture and subsidise industry, whereas wealthier countries subsidise agriculture relative to industry (Carri, 2008; Hartel, 1999). Anderson (1995) used an AGE model to explain what causes this particular pattern of intervention. The findings suggested that structural differences prevailing between rich and poor countries were the main reasons that determined the differences in protection patterns.

3.3 Limitations and hidden challenges of CGE modelling

General equilibrium modelling has become respected amongst policy analysts in developing countries in the recent past. However, there is still substantial debate regarding the significance and appropriateness of using CGE models for such policy analysis. Bandara (1991) summarised some of the main criticisms of CGE models in the literature, arguing, that despite these criticisms, such models are useful in providing valuable insights into important policy problems.

Firstly, some opponents disagree with CGE modelling for having unrealistic neo-classical assumptions, such as perfect competition and production functions characterised by constant returns to scale. However, some CGE modellers (Brown, Deardorff, & Stern, 1995; Harris, 1984; Roson, 2006) have been able to incorporate assumptions other than traditional assumptions into CGE models. Furthermore, different CGE models are developed to deal with different policy issues. Therefore, it is not essential to incorporate all the structural rigidities and market distortions into a model at all times. Another criticism is the absence of the role of money in these models. Traditional CGE models are real models, which are primarily interested in real variables in the economy. Again, there are attempts in incorporating the monetary sector into CGE models (Mahjabeen, 2008; Robinson, 1991). The methods used to model the long-run process of development in CGE models have also been questioned. This led to the development of dynamic CGE models. Furthermore, possibly the most important criticism is associated with data and parameter values used in models.

Reliability of data used is being questioned, as there are many problems related to consistency and adequacy of data in the less developed countries (LDC). In addition, some parameter values such as elasticities rely on best guess values in the absence of econometric estimations. Development of a Social Accounting Matrix (SAM) for LDCs as the base data for the CGE models provides the solution for the inadequacy of consistent data in current models, and, appropriateness of best guesses can be determined through sensitivity analysis. The final criticism is that the difficulty of explaining the estimated results from a simulation makes CGE models unattractive. These models are perceived as giant black boxes which do not assist in explaining what happens inside. To respond to this criticism, model builders must be able to provide a detailed explanation of how their results are obtained. One way to respond to such

criticisms is to undertake back-of-the envelope computations following policy simulations, so that the modeller can prove the results following the economic theory (Parmenter & Meagher, 1985).

It is clear from the previous discussion that CGE modelling methodology has been able to deal with many weaknesses and overcome them. As a result, CGE models are now well suited to analyse a wide range of policy issues in developing countries in the short-run and medium-run, and generate valuable insights into policy issues being analysed. Whalley (1985) emphasises the need to move from general to special purpose models if general equilibrium is to become more policy relevant. He explains that particular attention should be paid to parameter specification and the way in which policies are modelled. Hertel (1999) examined and discussed those hidden challenges which have often limited the impact which general purpose GE models have had on agricultural policy issues.

Most of the early AGE models considered agriculture (along with forestry and fisheries) as a single aggregate sector producing one homogenous product. This type of aggregation was necessary in order to allow complete commodity coverage at a relatively uniform level of aggregation. However, when it comes to analysing agricultural policies, more detail is required as interventions vary widely across farm commodities with some receiving a great deal of support while others are free of intervention. By grouping together all these products into one single aggregate, little can be said that would carry any weight with agricultural policy makers. Gehlhar and Frandsen (1998, as cited in Hartel, 1999, p. 8) show how aggregation of agricultural sectors alter major qualitative findings with respect to APEC (the Asia Pacific Economic Cooperation) trade liberalisation, as aggregation instigates a tendency to create false competition between countries producing fundamentally different products. Therefore, AGE models attempting to deal with the overall effects of farm and food programmes should disaggregate sufficiently to isolate distinct types of commodity market intervention.

A second important attribute of general purpose models, which has restricted their applicability to agricultural issues, is their inability to differentiate land from other capital inputs. Nonetheless, the existence of land in the agricultural production function is crucial. It is possibly the most distinguishing feature of the agricultural sector in the economy. As land usually represents the major form of wealth holding for the farm population, the impact of

public policy on farm prices and hence returns to landowners is of paramount importance to farmers and agricultural policy makers. Therefore, if one wishes to model the agricultural sector, disaggregation of factors of production including land is important. There are other important modelling issues arising from heterogeneity of land in production. The ability of a given hectare of land to produce a distinct farm product differs with the agronomic and climatic conditions. These characteristics all combine to determine the yield, given a certain level of non-land inputs. A CGE model should try to capture the essence of such characteristics without being forced to develop a full-blown model of agricultural production.

Another very common limitation is the specification of key behavioural parameters in farm and food systems. CGE modellers should be able to capitalise on econometrically estimated data and behavioural information. If the model's parameters lack sufficient empirical justifications, they can often generate implausible results. For example, when consumer demand is considered, while there is a strong tendency for food products to be price and income inelastic, individual elasticity values diverge broadly among food groups, with consumer demands for grains being fairly unresponsive to price and income, while livestock products are more responsive. Capturing these differences in consumer demand elasticities is important as they are critical in determining the incidence of changes in policies like price policies.

The time frame preferred for a simulation also has inferences for a variety of characteristics which are vital to the result of the experiments being conducted. As Hertel (1999) states, in the very short-run, crop production has little room for adjustment, and lack of stocks make supply shocks trigger wide fluctuations on commodity prices. As a result, there is considerable motivation for stock holding for non-perishable crop products. In the longer-run, the importance of stocks is diminished, since continued accumulation or decumulation quickly becomes impractical based on the nature of the global agricultural economy. Factor mobility assumptions and model closure also have important implications based on the time horizon. For example, in their review of alternative modelling approaches and the implications for the incidence of agricultural policy in India, de Janvry and Sadoulet (1987) explored the question of labour market closure. They investigated the implications of two extreme specifications of assuming flexible wages and full employment on the one hand, and fixed real wages and unemployment on the other, as well as an intermediate case in which wages were partially

indexed to the cost of living. They concluded that labour market closure plays a major role in determining the incidence of technological change in agriculture on the rural population, especially the landless poor.

After several decades of rapid development and applications to many different areas of economic analysis, general equilibrium models are maturing. Increased collaboration with economists working on partial equilibrium and other econometric studies in the areas of communication of key assumptions and parameters in a form which others can interpret and evaluate, and more widespread use of systematic sensitivity analysis would be an avenue for improvement in AGE analyses of agricultural policies over the coming decade. Nevertheless, CGE modelling still has potential for giving unique insights into policy, and there is potential for developing new methodologies to address its limitations. Hertel (1999) suggests some key features that successful AGE applications related to agricultural and resource policies in the future should increasingly exhibit. They are, appropriate institutional and behavioural characteristics of the sector in question are taken into account; key policies are modelled clearly, for example, quantitative restrictions, price ceilings and floors; key behavioural parameters are declared and linked to econometric work in the literature; results are explained in terms of means and standard deviations from sensitivity analysis that takes parametric uncertainty into account; principal findings are broken down systematically and explained; and, finally, results can be easily replicated and key assumptions changed by the reviewer.

3.4 Applications of agriculture-related CGE modelling

Applications of CGE models comprise a variety of countries and regions and policies. Further advances have incorporated money, financial and asset markets to link the microeconomically focused Walrasian CGE models to Keynesian macroeconomic models, and the development from single-period models appropriate for comparative static analysis to multi-period dynamic models. The most common issues of interest for the application of CGE modelling in the LDCs' context are macroeconomic adjustment issues, external shocks, foreign aid and capital inflow issues, agricultural development and industrialisation issues, trade liberalisation and spatial trade issues, rural-urban migration and urbanisation issues, welfare analysis and income distribution issues, and environmental issues (Bandara & Coxhead, 1999; Carri, 2008). CGE

models can be classified into different groups based on several attributes such as theoretical structure, solution techniques, model closure rules, and policy issues that they address.

Many developing countries have implemented extensive agricultural policy reforms over the past few decades including removal of quotas and price controls, changes in international trade barriers, and the commercialisation and privatisation of state marketing boards for key crops. These reforms have often resulted in criticism from groups arguing that they harm poor farmers and poor households. The general equilibrium framework has mainly been used in analysing economy-wide agricultural trade liberalisation policies after the implementation of the Uruguay Round. There has been increasing attention given by development economists to the simulation of domestic markets in developing countries as a means of dealing with what is being perceived as an unfavourable external economic environment. The purpose of this section is to review various applications of CGE modelling, specifically in relation to agriculture, based on the policy issues that they address.

3.4.1 Productivity and other external shocks

In earlier debates on economic development, agriculture's role was somewhat controversial. While some groups stressed the importance of agriculture, others placed a greater weight on the conception of a modern industrial sector. However, the conclusions of these discussions often implied that the long-run growth process must be a balanced one where agricultural productivity is a necessary condition for industrial growth. The distinction between output and productivity growth is important, since these do not necessarily have similar impacts. However, literature is not always clear on this distinction (Schneider & Gugerty, 2011). In some cases output and productivity increase together. In other cases they can vary inversely with different consequences. A new technology, for example, can have a variety of impacts with different consequences for output, profit, and employment. If the technology reduces the inputs needed in the production process, production cost will reduce, raising profits, output may not be affected, and employment could be reduced. If instead technology raises yields, output and employment will increase, but profits will not necessarily increase. If the technology raises the labour productivity, wage rates will increase probably at the expense of the quantity of labour employed, and with indecisive effects on profits and output. If the new technology allows the cultivated area to be expanded, it might lead to increase in output,

employment and profit, but is likely to lower yield (Irz, Lin, Thirtle, & Wiggins, 2001; Schneider & Gugerty, 2011; Thirtle, Irz, Lin, McKenzie-Hill, & Wiggins, 2001).

The evidence suggests that agricultural growth through improved agricultural productivity may cause lower and more stable food prices, better wages for the rural poor, increased demand for consumer goods and services, and stimulate growth in the non-farm economy (Adelman, 1975; de Janvry & Sadoulet, 2002). There are several analyses underscoring the importance of agricultural technology and productivity in economic growth and poverty alleviation using partial equilibrium and econometric analysis, but they ignore the concept of intersectoral impacts of technical progress (Datt & Ravallion, 1998; Mellor, 1999; Self & Grabowski, 2007; Thirtle, Lin, & Piesse, 2003).

Bautista (1986) developed a multi-sectoral general equilibrium model to investigate the effects of productivity increases in Philippine agriculture. This model emphasised not only agricultural sectors, but also other production sectors with which it closely interacts. Furthermore, the model incorporated the distinction between rural and urban households in their income generation and consumption patterns. The study simulated the impacts of productivity increases in three agricultural sectors; food crops, export crops, and the livestock and fishing sectors, and the food-manufacturing sector on sectoral prices and outputs, rural and urban income, trade balance and national income. The consequences of productivity increases were then evaluated against the values from a reference growth path of the economy with no changes in basic period values of the other exogenous variables and parameters of the model. The simulations implied a ten per cent increase in total productivity separately in the four sectors, and increased productivity in all sectors simultaneously. The cause of the productivity increase was assumed to be a result of technological change and/or improved infrastructure.

Accordingly, increased productivity in the food crops sector resulted in a fall in food prices but promoted the food-manufacturing sector. This caused adverse impacts on rural household income, while improving urban income. Ultimately it provided a positive effect on the trade balance and national income. Productivity improvements in the export crop sector resulted in a decline in sector prices, while improving sector production. Both rural and urban households benefitted, as did macroeconomic aggregates. In contrast to the previous results, the livestock and fishery sectors experienced increases in sectoral prices and production. Rural households

benefitted, while urban households lost. The trade balance and national income were negatively affected, implying trade-offs between rural welfare and some macroeconomic aggregates. Increased productivity in the food-manufacturing sector stimulated growth in production of that sector, and in the food crop sector as well. This had favourable impacts on both household incomes and national income. Results of simultaneous productivity increases in all four sectors showed moderate positive impacts on household income, while there were significant impacts on macroeconomic variables. Based on those results, the author argues that increasing agricultural productivity does not necessarily result in reduced rural income, but is more likely to benefit urban households.

Mitra and Tendulkar (1986) also used a six-sector general equilibrium model to assess internal and external exogenous shocks in India. In this model, agriculture was represented by a single sector and the model assessed the impacts of weather-related agricultural peaks, especially the drought that prevailed during the 1973/74 to 1983/84 period. Counterfactual simulation indicated that cumulative effects of weather-related agricultural shocks resulted in worsening of macroeconomic indicators like GDP, savings, investment and the capital stock.

Coxhead and Warr (1991) investigated the distributional effects of technical progress in agriculture using a CGE model for the Philippines. This model assumed that agricultural production takes place in two different environments with fixed land resources of different quality. It differentiated agricultural producers with (sector 1) and without (sector 2) access to resources complementary to the new technology, notably irrigation. Furthermore, the model structure allowed both the rate and factor biases of technical change to differ between environments. There were seven illustrative groups of households distinguished both by their asset ownership and consumption behaviour. Three forms of technical change were simulated in the analysis: (a) factor neutral; (b) labour-saving, capital-using; and (c) labour-using, land-saving. It was assumed that the nature and the magnitude of these shocks were indicative of individual technical innovations in developing country agriculture. The results highlighted three important issues in determining the distributional effects of technical progress. These were the price-setting mechanism for inter-sectorally mobile factors, prior differences in land quality, and factor biases in technical progress. Factor neutral technical change occurring in both agricultural sectors caused output and factor demands to rise in both sectors. At constant output prices, technical change increased the income of the owners of factors used relatively

intensively in agriculture, labour and land. Thus, landlords gained the most among households, with lesser gains to farmers (who own some land, labour and capital) and to labourers. In the case of unbalanced technical progress, most of the additional income generated directly from technical progress was captured by landowners in the sector where such progress occurred. A technical change which substitutes capital for labour with no increase in output in sector 1 triggered a reduction in real wages in the same sector. Households owning only labour lost, while real incomes of households that did not depend on labour showed a slight increase. A labour-using, land-saving shock caused an increase in returns to both fixed factors. It produced a redistribution of income from landlords to labourers.

Coxhead and Warr (1995) used the same model to trace the effects of differential rates of technical progress in the two sectors on income distribution of the factors owning household groups, poverty and economic welfare within a small open economy. They extended the earlier model to capture the effects of technical progress on the distribution of real expenditure among household groups and by different expenditure classes within household groups. Furthermore, they attempted to capture the implications of varying key parameter values, structural assumptions and policy settings. Values for technical change parameters were calculated from the Philippine agricultural data. The short-run overall rate of technical change in the irrigated agriculture sector exceeded that of the non-irrigated agriculture by a factor of about 20. Simulations represented open agricultural trade and agricultural trade under restrictions. In the case where agricultural commodities are freely traded, output and mobile factor demand rose where technical change has been rapid (irrigated sector). Because of that, cost of production in sector 2 (non-irrigated agriculture) increased as the technical progress in this sector was not adequate to offset the reduction in profits. Therefore, output and returns to land diminished. The production of manufacturing and services sectors also declined as a result of increased cost of production. The changes in household poverty results revealed relatively large poverty reductions among labourers and landlords and farmers owning land in the irrigated agriculture sector. Poverty increased among owners of capital specific to manufacturing sector and landlords in the non-irrigated agriculture sector. Effects of technical change with trade restriction were generated by holding agricultural trade fixed and allowing their prices to be determined entirely in the domestic market. Under this scenario, the price of agricultural output fell substantially causing reductions in returns to factors used relatively intensively in agriculture and increases in returns to factors used relatively intensively in non-

agriculture. This benefitted all households as consumers, but triggered serious problems for household groups who derived their income mainly from ownership of low quality agricultural land. The results clearly show that reduced poverty from technical progress is substantially greater when agricultural trade is unrestricted at a constant world price.

Coxhead and Warr (1993) examined the distributional effects of technical change in the Philippines' agriculture using a 41-sector, 50-commodity Agricultural Policy Experiments (APEX) GE model. This model incorporated regional features assuming three of these industries are multi-output regional agricultural industries, each jointly producing 12 agriculture producer goods. The elasticities of product transformation were estimated econometrically for each region to reflect differences in regional production conditions. The rest of the industries were non-agricultural industries producing an individual good. Short-run productivity growth estimated for the Philippines' agriculture during 1969-1984 was used to calculate the overall technical change in each region. These overall rates were then used to evaluate the economic impacts and income distribution. This was based on the assumption that rates of technical change in irrigated agriculture were the same in all three regions and similarly for the non-irrigated agriculture. The results of the study suggested that around 30 per cent of the growth of per capita output was due to technical progress in agriculture alone. All household groups benefitted in real terms and the poorest group benefitted proportionately the most. Income inequality was reduced by this technical change. The authors explain that technical change in Philippine agriculture raises incomes, reduces poverty and improves the income distribution. Furthermore, they argue that income distributional aspects of technical change depend on differential changes in returns to primary factors of production, the distribution of returns between factors of production that are mobile across industries and the relationship between changes in the prices of final consumer goods and expenditure patterns of different income classes.

Arndt, Jensen, Robinson, and Tarp (2000) explored impacts of improvements in agricultural productivity and reductions in marketing costs in Mozambique. The model they used explicitly incorporated detailed marketing margins and separated household demand for home-produced and marketed goods. Even though land is an important factor of production, only agricultural labour, non-agricultural labour and capital were considered as factors of production. Land was considered abundant and embedded in returns to capital due to unavailability of data. The

model assumed full employment of available resources. Three experiments were conducted in order to evaluate potential benefits from increases in productivity of the agricultural sector and improvements to marketing networks. The first experiment simulated a uniform 30 per cent improvement in productivity across all agricultural sectors. It was found to have aggregate welfare improvement and expansionary effects on the economy especially in the rural sector. However, exports decreased more than imports in real terms causing mild depreciation of the real exchange rate. The second experiment was the reduction in marketing margins and it also led to increases in welfare causing both producers and consumers to gain. Gains were spread evenly across the economy. Yet, the impact on trade was the converse of the first experiment. Exports gained more than imports leading to slight appreciation of the real exchange rate. The third experiment combined the first two simulations, and the results revealed significant synergistic effects supporting the hypothesis that prior improvements in marketing infrastructure allow the economy to reap greater benefits from improvements in productivity.

de Janvry and Sadoulet (2002) explored the implications of agricultural technology adoption on world poverty. To capture the relative magnitudes of direct and indirect effects of technological change, they used a CGE approach for archetype economies representing poor countries in Africa, Asia and Latin America. The study found that price and income effects of agricultural productivity growth is an important instrument for poverty reduction, but the gains from direct and indirect effects are different across households in poverty depending on the particular regional context. The results showed that the dominant effect of technological change in agriculture on poverty was through direct effects by raising the welfare of poor farmers in Africa, indirectly by improvements in agricultural employment effects in Asia and effects of linkages with other sectors in Latin America.

Dorosh, El-Said, and Lofgren (2002, 2003) presented a CGE model for Uganda with the objectives of quantifying the linkages between agriculture, other sectors in the economy, and the macro-economy as agriculture is a dominant sector in the Ugandan economy, and to assess the implications of various external shocks and investments in the Ugandan economy. The model focused on regional variations in agricultural production and household income by taking into consideration six agricultural zones. Simulations were conducted to analyse the impacts of changes in world coffee prices, agricultural productivity shocks, reductions in agricultural marketing costs and changes in foreign capital inflows. The results showed that

the decline in world coffee prices produced broad ranging effects leading to real exchange rate depreciation, discouraging production of non-tradable agriculture but encouraging production of industrial tradables. Broader increases in agricultural productivity and reductions in marketing costs had more potential to raise rural incomes in Uganda with largest gains in regions where home consumption was lower. The authors suggest that agricultural growth can raise rural incomes in Uganda if markets perform well and producer incentives are maintained.

3.4.2 Price policy

Agricultural price policy has been actively used by virtually all governments to seek a wide variety of resource allocation and income distribution objectives. The analysis of price policy has been conducted through a variety of classes of models according to the nature of the question asked. The principle classes of models are farm and household models, partial equilibrium models, multi-market models and different types of economy-wide models including linear programming, econometric and CGE models. Mellor (1978) explained that price policy should be studied in general equilibrium models in order to consider the important employment, wage and non-agricultural growth effects. Since then, many CGE models have been developed to analyse several agricultural policy questions.

De Melo (1978) developed a CGE model for the Sri Lankan economy quantitatively assessing the effects of selected alternative agricultural policies and other development strategies on growth, employment, distribution of income and the satisfaction of "basic human needs" for the lower income groups. The model distinguished seven economic sectors and seven factors. Agricultural policy interventions investigated included elimination of the rice subsidy and the tax on agricultural exports, import substitution in agriculture, land reform, increased government investment in agriculture and technical change in agriculture. The results suggested that rice subsidy elimination and technical change in agriculture have strong favourable impacts on GDP and improve income of the poorer groups but elimination of export taxes and investment favouring agriculture[6] had adverse impacts. The skewing of

[6] In this experiment it is assumed that the government had the direct control over 15 per cent of total investment which it used as supplementary investment for agriculture. The effect of this policy was to cause fast capital accumulation in agriculture (more than doubling over the ten year period) and slower capital growth in non-agricultural sectors.

investment towards agriculture did not promote faster growth of the agricultural sectors and led to sharp decline in agricultural terms of trade. Withdrawal of investment from non-agricultural sectors, which are themselves capital incentives, had a negative impact on the growth and resulted in increased prices in those sectors. Furthermore, the study suggested that land reforms[7] should not be used as a discrete policy with the aim of improving income distribution. Different variants of this policy were shocked based on changes in amount of land and capital transfers. In all variants of this experiment, an apparent trade-off between growth and equity could be observed. The redistribution of agricultural land and capital to the poor reduced the rich/poor and urban/rural income gap, but it also reduced the rate of capital formation and GNP growth.

de Janvry and Subbarao (1984, 1986) employed a CGE model to analyse the relative impacts of price and technology policy changes on output, income distribution and consumption in India. The model was composed of seven production sectors of which five were agricultural. Households were grouped into seven social classes characterised by contrasted sources of income incorporating both rural and urban groups. Keynesian closure was applied to the model with infinitely elastic supply of labour at fixed nominal wage rates in all sectors of the economy. The study examined the impacts of output changes with flexible and fixed pricing, food subsidies and irrigation. The authors showed the importance of increasing food production in India to improve income distribution. They recognise the importance of understanding the choice of instrument to be used in inducing output expansion. The results showed that the largest gain for the poor with the most progressive impact on the distribution of income and growth effects on other sectors was obtained when output increased with flexible prices. Moreover, it was found that price support programmes were highly regressive for the distribution of real income causing sharp losses in purchasing power of urban and rural poor in the short-run. Therefore, the study concludes that agricultural output can be comparatively stimulated through price incentives, while the social cost of this approach is excessively high. When this cost is compared with the cost of irrigation development to achieve a similar level of output growth and consumer welfare, it is clear that the latter provides more benefits. They argue that decentralisation of irrigation and technological change towards new areas, and opposing the power of farm lobbies in fixing prices which capture the

[7] In this experiment the ownership of agricultural land and part of the associated capital stock was transferred from large farmers and estates to small farmers.

gains from technological change is imperative to sustain the strong agricultural production performance and to improve welfare of the poorer population.

de Janvry and Sadoulet (1987) compared six GE models that address price policies. The models were for India, Peru, Mexico, Egypt, Korea and Sri Lanka. Six types of policy experiments were analysed in terms of their inter-sectoral, interclass and inter-temporal effects. They examined the questions of output increase under different price regimes, price incentives under short-run and long-run, investment priorities in agriculture versus industry, and food subsidies with different targeting options and sources of financing. This study revealed that those interventions generate complex income effects across social groups and time periods, with few occasions where net gains were experienced by all groups. The authors suggest there are five structural features that determine the poverty alleviation effects of these policies. They are (a) sufficient access to land for the small farmers to make them net sellers of crops if they are to benefit from increasing output with price supporting programmes or an open economy (b) technical advances targeted at the cropping patterns of small farmers if they differ from those of large farmers (c) labour market conditions that make agricultural wages sensitive to changes in the marginal value product of labour, requiring the reabsorbing of surplus labour (d) downward-flexible prices that allow translation of the bulk of productivity gains in agriculture into lower food prices and higher real incomes for net buyers, and (e) an industrial sector capable of responding to changes in effective demand created by productivity-enhancing investments in agriculture.

McCarthy and Taylor (1980) developed a GE model for Pakistan to analyse probable impacts of food policy changes. The model distinguished six income classes and focused on food and nutrition. The policy options simulated included elimination of a wheat subsidy, increases in wages and government expenditures, an increase in the fertiliser subsidy and land reforms. The elimination of the wheat subsidy drove up the cost of living with the heaviest burden falling on the poor with an overall drop in calorie intake. The overall impact on the economy was contractionary, leading to a drop in real GNP. The impacts of an increase in fertiliser subsidy with a commitment by the government to absorb enough of the additional crop output were expansionary, with a higher level of real GNP and increase in caloric intake by all consumer groups. In terms of land reforms, land holdings of the upper 20 per cent of the rural population were transferred to the lower 40 per cent of the rural population. This caused an

increase in the calorie intake of the rural low income class and expansionary impact on the real GDP. The upper rural class was the only group to lose as their real income fell.

It has long been recognised that trade and macroeconomic policies have a negative effect on relative producer price incentives in the agricultural sector. The existence of such an incentive bias against agriculture was confirmed in the late 1980s by a major WB research project which analysed data from the early 1960s to the mid-1980s and employed partial equilibrium modelling methodology. The project concluded that reductions in trade distortions should be pursued in economic reforms so that they would improve agricultural price incentives (Krueger, Schiff, & Valdes, 1988). Many studies were conducted to investigate agricultural policy bias using a general equilibrium framework to capture feedback effects from the policy interventions. WB researchers also reanalysed the issue of whether there is trade policy bias against poor agricultural farm households in developing countries using the GTAP (Global Trade Analysis Project) data base. All studies related to policy bias arrived at a similar conclusion as whatever policy biases prevailed against agriculture were largely eliminated during the 1990s (Anderson & Martin, 2005; Robinson & Ahmed, 2008).

Ali (1989) employed a 14-sector CGE model to analyse different agricultural policy options for Bangladesh. The overall model was static and then it was made dynamic by incorporating changes in the labour force and capital stock, and changes in the demand pattern. The model assumed that total investment is endogenous and equal to the total investments of the private and government sectors. A SAM for 1984/85 was used as the data base for the model. Households were disaggregated into six groups. Of the six groups, four were in the urban areas representing landless labourers/farmers, medium farmers, urban informal and urban formal groups. The rural household groups comprised of small farmers, rural informal households, large farmers and rural formal household groups. There were two types of labour in the model; agricultural labour and other labour. Agricultural labour was mobile across all the agricultural sectors, while other labour was mobile across the other sectors. Movement from agricultural to other labour was made possible in the dynamic component of the model.

The policies analysed included price policies; both input price support through fertiliser subsidy and output price support to the rice farmers in the form of guaranteed floor price, food grain distribution by means of a ration subsidy, land reforms in the form of redistribution of

land only to farmers who owns land and extended to cover the landless, technical change in the agricultural sector, and increase in migrant workers' remittances. To compare the results under alternative policies, macroeconomic performance indicators such as gross production, sectoral composition, private and government investment, consumption and agricultural employment, and welfare measures such as income and consumption were used. It was found that agricultural output, agricultural employment and net prices to the farmers increased in most cases.

Narayana, Parikh, and Srinivasan (1991) constructed a ten-sector AGE model of the Indian economy called AGRI model to investigate a number of policy options that affect agricultural output and income and to measure the spill-over effects of those policies on the rest of the economy. The model consisted of several sub-models. Those were supply sub-models representing the agricultural sector and non-agricultural sector, a demand sub-model representing private final consumption expenditure and a policy sub-model indicating the role played by government. One important feature of this model was the estimation of a number of behavioural functions econometrically using time series data. The reference period for the model was 1970-2000. Policy changes relative to the reference period were introduced in 1980 and their impacts studied over the period from 1980 to 2000. The policies analysed included public distribution policies, foreign trade and aid policies, rural works programme, terms of trade policies, fertiliser subsidy policy and irrigation development policies.

Aggregate indicators which reflect economic development, individual well-being and social welfare were compared among different simulation scenarios[8]. It was found that agricultural trade liberalisation would increase average income, but would make the poor worse off. Under the terms of trade policies, increases in domestic prices of agriculture through policy, led to changes in tariff and tax rates reducing government revenues which, in turn, reduced investment. The impacts associated with reduced investment would offset any favourable effect of increased prices. Variants of fertiliser subsidy demonstrated only a small improvement in the value of aggregate agricultural output as a response to increased fertiliser

[8] GDP (both aggregate GDP and sectoral GDP) is used as the main indicator for economic growth, the level of food energy and protein intake per capita by persons in each expenditure class and equivalent income for each class are used as indicators for individual well-being, and distribution of the population according to their equivalent income is used as the indicator for social welfare.

use in the short-run. However, there was a significant response of individual crops to fertiliser use. Fertiliser price subsidy stimulated immediate agricultural production, but the long-run macroeconomic consequences with a lower GDP outweigh those short-run gains, and the rural poor gain while the urban poor lose. Land extent under cultivation, fertiliser use, and crop yields increased as a result of investment in irrigation. Furthermore, real GDP from agriculture went up substantially (eight per cent) as one would expect. Both rural and urban populations benefitted.

Based on the results, the authors agree that agricultural growth does respond to policy. They concluded that policy options like a better price for agriculture, greater emphasis on irrigation, and cheaper fertiliser – all lead to increased agricultural output, but not all these policies can be recommended (Narayana, et al., 1991, p. 276). The results show that in stimulating agricultural growth, the development of irrigation and new varieties play a more important role than output pricing and input subsidy as irrigation promotes not only growth of agricultural output, but also the aggregate growth.

Storm (1993) analysed a number of agricultural policies including pricing policies and other policy instruments using a nine-sector CGE model to assess how the rest of the economy is affected by the performance of the agricultural sector and to explore agriculture-industry interaction in India. The model consisted of both static and dynamic components and an agricultural sub-model. Several short-run experiments were conducted to trace the short-run impact of agricultural performance on the non-agricultural growth and to select a potentially desirable medium-term policy package to be implemented in the dynamic version of the model. The short-run agricultural pricing policy experiments conducted fell into three categories, fertiliser subsidy experiments, food grain procurement experiments through procurement, and minimum support pricing and food distribution experiments through food rations[9]. Dynamic simulation experiments incorporated the effect of the major drought experienced by India, consequences of increased demand for Indian exports, impact of reallocating public investment from agriculture towards non-agriculture, and effects of pursuing an 'industry-first' investment policy financed by an increase in direct taxation of agricultural income.

[9] This study conducted almost 30 short run simulation experiments. For details see Storm (1993).

Based on the short-term simulation results, the author suggested that any attempt to raise agricultural production through agricultural price policy would have limited impact on agricultural production while causing considerable economy-wide effects in terms of raising inflation rates and redistributing income in favour of agriculturists. Reductions of subsidy rates on fertiliser and food grains had negative impacts on promoting the use of fertiliser in the country, protecting consumers from high food grain prices, and protecting producers from volatile output prices and high input prices.

Jensen, Robinson, and Tarp (2002) presented a comparative analysis of the extent to which indirect taxes, tariffs and exchange rates influenced relative price incentives for agricultural production in developing countries during the 1990s. This study tried to compare its outcomes with results of empirical studies from the 1980s using partial equilibrium methodologies which strengthen the idea that those policies in many developing countries encouraged a major incentive bias against agriculture. The study developed single-country CGE models for 15 developing countries with almost no differences in model specification across the countries. The degree of dependence on trade in agricultural goods was not related to the relative size of the agricultural sector in the country. The country-specific data sets differ in a couple of dimensions, including the disaggregation of production sectors, the disaggregation of primary factors of production, and inclusion of marketing costs and home consumption of own production. For example, the data set for Tunisia was the least disaggregated with 19 production sectors of which only two were agricultural and the data set for Mexico accounted for 71 production sectors of which 57 were agricultural.

Jensen, et al. (2002) analysed the results of two sets of simulations. The first set included simulations to measure the impact of tax and tariff structures and the impact of eliminating current account deficits or surpluses by analysing scenarios that cumulatively eliminate production taxes/subsidies, consumption taxes/subsidies, export taxes/subsidies, and import tariffs. In contrast to the previous findings, the results showed only very few signs of price incentives against agricultural production. In fact, some countries strongly favoured agriculture. The second set of simulations included the impact of traditional ISI policies on relative agricultural price incentives. These policies included non-agricultural import tariffs, agricultural export taxes, and overvalued exchange rates. The authors suggested that these policies can affect relative price incentives in strongly divergent directions depending on

country-specific characteristics. For example, the impact of agricultural export taxes depends on agricultural export shares. On the contrary, the impact of non-agricultural import tariffs depends strongly on relative agricultural trade shares. Therefore, it emphasises the need to incorporate country-specific characteristics into the GE framework when analysing how taxes and exchange rate policies shape relative price incentives for agricultural production. The authors further suggested that overstating agricultural biases in previous studies may be due to the utilisation of partial equilibrium methodology that missed intersectoral linkages and feedback effects from changes in income and relative prices which could be captured by GE framework.

Bautista, Robinson, Tarp, and Wobst (2001) employed a general equilibrium analysis to assess the effects of industrial protection, agricultural export taxes, and overvaluation of the exchange rate on the balance between agricultural and non-agricultural sectors in developing countries. The study used a 28-sector model of Tanzania for 1992, which is a highly agricultural, trade-dependent developing country, to derive the results. The model simulated the effects of a 25 per cent import tariff on all non-agricultural goods and of a 25 per cent tax on all agricultural exports under flexible and fixed exchange rates by constructing various measures of the agricultural terms of trade. The results were then compared with earlier partial equilibrium measures of similar studies in developing countries[10]. The authors argued that trade policies have a significant but much lower negative impact on relative prices in agriculture than would be indicated by partial equilibrium measures. The results showed that imposition of a non-agricultural tariff with a fixed exchange rate led to a much stronger deterioration in the terms of trade compared with a flexible exchange rate scenario. The imposition of an export tax on all agricultural sectors with a fixed exchange rate led to a much lower deterioration relative to the flexible exchange rate scenario. Furthermore, the authors suggested that partial equilibrium measures miss much of the action operating through indirect product and factor market linkages, while overstating the strength of linkages between changes in the exchange rate, and prices of traded goods on the agricultural terms of trade.

Similarly, Robinson, and Ahmed (2008) developed a static, single-country CGE model of Ethiopia to measure the effective rate of protection in a GE framework which incorporated

[10] The findings are compared with the results of Krueger, et al. (1988) and Bautista and Valdes (1993).

price incentive biases in the Ethiopian economy. The authors contend that price incentives are GE issues with important feedback effects from policy interventions through inter-sectoral linkages, degrees of tradability, and changes in income, that all affected relative output prices and factor returns. The results revealed that indirect taxes and tariffs were basically neutral. Traded agriculture was moderately discriminated against by indirect taxes and tariffs, while that sector benefitted from complete elimination of import tariffs. The findings were similar to the results of Bautista, et al. (2001).

3.4.3 Trade policy

The Uruguay Round obligations and the current Doha Round of agricultural trade discussions have boosted the significance of understanding how trade reform will influence the global economy, especially the well-being of the poor. While agriculture continues to be the major stumbling block in the ongoing trade negotiations, progress was made towards reaching a consensus on a road map for agricultural liberalisation (Anderson & Martin, 2005). Agriculture is of major importance for poor people in developing countries who depend on this sector as their main source of income and sustenance. Therefore, improving agricultural market access opens up opportunities for developing the farming sector and presents possibilities for enhancing the livelihoods of the poor, just as it can trigger many hardships for them (Hartel, 2006). This has caused an intense debate about whether removal of trade protection benefits the poor or not.

Evaluation of the likely impact of agricultural trade reform is inevitably multifaceted and has to be supported by modelling tools, either partial equilibrium models or general equilibrium models which stipulate appropriate interactions between the agricultural sectors and the rest of the economy (Litchfield, McCulloch, & Winters, 2003; van Tongeren, van Meijl, & Surry, 2001). CGE models have become a valuable device in analysing a number of different trade policy issues as they allow producing disaggregated results at the microeconomic level, within a consistent macroeconomic framework (Hassine, Robichaud, & Decaluwe, 2010). These models have been used to investigate economic effects of trade policies such as tariffs and NTBs in a range of settings. Some are multi-country models that focus on analysing the effects of global trade policies such as Uruguay Round Agreements. Others focus on analysing commercial policies of a single country, where depending on whether the country is a

developed or developing economy, the modelled trade issues and policies can be quite diverse. Most of the studies focus on investigating poverty alleviation impacts of the trade liberalisation issue. In this section, various applications of CGE modelling in relation to agricultural trade policy issues are discussed.

Loo and Tower (1990) used a highly aggregated CGE model to investigate the impacts of changed agricultural policies in low-income, less-developed countries on several aspects of their economic performance: welfare, revenue and food consumption. The model was calibrated for a representative low-income, less-developed country. They calculated the optimum combinations of different types of policies and showed how cost/benefit ratios and tax policies can be utilised for the maximisation of the success of agricultural liberalisation policies. For that purpose, the model was used to calculate

1. Cost/benefit ratios for incremental policy reforms;
2. Optimum welfare, maximum revenue and maximum nutritional export tariffs;
3. Optimum export taxes for alternative degrees of willingness to trade-off welfare and nutrition;
4. The sensitivity of optimum welfare export taxes to the degrees of foreign aid;
5. Debt repayment, which reform of agricultural export tax policy would make possible without reducing a developing country's welfare (Loo & Tower, 1990, p. 307).

The model demonstrated that agricultural liberalisation will be most successful when import restrictions consist of tariffs and vice versa when it consists of fixed import quotas.

Liu, Yao, and Greener (1996) used a CGE model to demonstrate the potential costs and benefits of different agricultural policy reforms in the Philippines for the year 1987. It differed from other CGE models in that it placed special emphasis on the food and agricultural sectors and their ability to capture the effects of policies not only at the national level but also at different market levels and different locations. This was done by disaggregating the country into two regions (North and South) with different farming systems and incomes, and further disaggregating the economy into three different market levels: farm-gate, intermediate (wholesale), and retail. Consumers in each region were classified by the geography: rural/urban and income/endowment totalling to eight consumer groups. The government sector

was also considered as a consumer. Three sets of policies on supply (increase in sales of rice, increase in floor price of rice and combination), demand (increase in income support, reduction of rural income tax and both), and trade (reduction of import and export tariffs, devaluation of Peso and combination) were then simulated. Compared with the changes in supply and demand side policies, the changes in trade polices yielded much more profound impacts on the economy. Based on these results, the authors argue that although various trade liberalisation measures produce more positive effects on food production and consumption, poverty alleviation and economic growth, any single policy reform incurs intolerable costs. Hence, combining trade liberalisation policies with tax reforms and target income support would achieve greater economic efficiency and alleviate poverty without incurring sizeable external debts.

Bautista and Thomas (2000) used an agriculture-focused CGE model for Zimbabwe for the year 1991 to examine the income and equity effects of trade liberalisation in isolation and in conjunction with potentially complementary changes in fiscal and land policies. The policy experiments included trade policy reform, land reform, maize market liberalisation and income tax adjustment. The simulation results showed that significant improvements in aggregate household income and its distribution were accompanied by large increases in agricultural GDP revealing the crucial role of agriculture in achieving equitable growth in Zimbabwe. Furthermore, the findings suggested that the land reform schemes specified in the model represent a less effective instrument compared to trade policy reform combined with other complementary policy measures. Trade liberalisation by itself and accompanied by other policies led to an appreciable increase in total GDP and agricultural GDP other than land reforms.

Weerahewa (2006) analysed the economy-wide impacts of various policy packages on rice and related markets using an aggregated general equilibrium models with five sectors and two factors of production. The study tried to investigate the link between rice market liberalisation and household welfare in Sri Lanka. This model divided the households into eight groups based on the provinces. The study revealed that in contrast to the general belief that protectionism is pro-poor, an import ban on rice reduced household income and welfare even in the provinces where agriculture is the prominent activity. Further analysis indicated that removal of import tariff on rice, along with removal of the import tariff on fertiliser and/or

subsidy payments on other agricultural sectors could improve economic efficiency and household welfare across provinces.

Increased trade can also increase the access to new technologies that can in turn have a significant influence on productivity. High trade barriers, both tariff and non-tariff in nature, often prevent access to some technologies or goods altogether, thereby hampering productivity growth (Hartel, 2006). The productivity-boosting effects of trade have been widely documented in both macro and case studies mainly using econometric models. Few CGE analyses have also attempted to explore the effects of likely trade liberalisation on productivity.

Salami (2006) used a 25-sector CGE model to examine effects of agricultural land productivity improvements on the Iranian economy assuming that domestic and international trade liberalisation would increase market access. Three different policy scenarios were examined in terms of multiple goals such as domestic production, prices, employment, GDP and household welfare. The model represented an ORANI-type model with one representative household, where household demands for commodities were derived from maximisation of a Cobb-Douglas utility function. The three policy scenarios analysed, were an increase in world prices of some specified commodities on the Iranian economy, a ten per cent increase in exports of specified export-oriented products as a result of increased market access opportunity following Uruguay Round AoA, and ten per cent improvement in agricultural land productivity. All the simulations were conducted in the short-run environment.

The simulation results indicated that enhancing agricultural productivity while implementing trade policy reform caused an expansion in the agricultural sector which, in turn, led to expansion of food-manufacturing and services sectors, while mitigating the problem of unemployment. Based on these results the author concludes that a policy package that consists of improvement in land productivity, removing input subsidies and expanding exports seems to be appropriate to increase domestic output, increase real GDP, improve real household income and enhance labour employment for Iran.

Hassine, Robichaud, and Decaluwe (2010) looked at the issue of whether trade reforms support the poor, and whether agricultural productivity growth boosts the potential gains from

trade by devising a CGE model for Tunisia which included technology transfer and endogenous productivity effects from trade openness in agriculture. The main feature that distinguished this model from earlier CGE analyses of trade liberalisation and poverty was that international trade was allowed to endogenously enhance agricultural productivity through technology transfer. The study incorporated econometric evidence of trade-productivity linkages into the GE framework to capture the additional poverty reduction that could be expected from the ongoing growth effects of agricultural trade reform. In order to do this, the study used a Latent Class Stochastic Frontier Model (LCSFM) to evaluate the contribution of international trade to productivity growth through the speed of technology transfer first, and then the estimated productivity effects induced from higher levels of trade were combined with the general equilibrium analysis of trade liberalisation to evaluate the income and price changes. Finally, these effects were used to infer the impacts on poverty and inequality following the top-down approach.

Two liberalisation scenarios were considered by simulating their impacts with and without endogenous productivity change. The first case was a complete elimination of agricultural trade barriers, while the second case represented full liberalisation of both agricultural and non-agricultural barriers. The model was then applied to Tunisian data for 2001 using a SAM. The authors recognised that poverty declined under agricultural and full trade liberalisation and this decline was much more pronounced when the productivity effects were included. The results indicated that poverty would fall by about 11 and 27 per cent under the above-mentioned liberalisation scenarios, respectively, and these were increased to 19 and 38 per cent when productivity impacts were considered.

Cororaton and Corong (2009) employed a CGE model to assess the poverty and income distribution implications of trade reform that is focused on agriculture and major food items in the Philippines. They developed a dynamic-recursive CGE model calibrated to the SAM for the Philippines economy for the year 2000, and a microsimulation model was used to analyse different policy shifts. This study had two objectives. Firstly, it assessed the poverty and income distribution implications of continuous reduction in protection on key food items in the Philippines. This represented the special products provision under the World Trade Organisation (WTO). The simulation results demonstrated that trade reform in agriculture and major food items had favourable effects on factor prices and brought about a significant

reduction in consumer prices. Real household income increased, while poverty and income inequality declined. These findings therefore imply that maintaining existing trade protections on agriculture and major food items which drive food prices up will not solve the problem of poverty and income inequality in the Philippines. The second objective of this study was to evaluate the poverty and income distribution implications of improved rice productivity. The impact on poverty and income distribution was traced through economy-wide effects, as well as effects on factor prices, commodity prices, household income and welfare, and income distribution and poverty. The simulation results in this report clearly indicated that higher rice productivity increased domestic output and reduced imports. Most importantly, it reduced the domestic price of rice and therefore benefitted poor households in lower income brackets.

3.4.4 Multi-country models

In parallel with the globalisation of economic activity and global orientation of policy discussions, the focus of economic research is also globalising. This has led to the development of large-scale, multi-country or global models to examine global impacts of agricultural and trade policies. These global models of agricultural trade have a long and renowned history. van Tongeren, van Meijl, and Surry (2001) provide a comparative assessment of alternative modelling approaches for global agricultural and trade policy analysis considering partial and general equilibrium models. It reviews a total of 16 global models with an exclusive agricultural and trade policy focus which includes both comparative static and dynamic models. Until the Uruguay Round, agricultural trade policies were subjected to few multilateral disciplines.

The GTAP model made possible a significant expansion of AGE-based approaches to trade liberalisation issues across countries. The introduction of the GTAP model and data base represented a significant advance, as it put trade policy analysts on a common ground. For several years, these GTAP-based models have been at the heart of the economic assessments of the trade liberalisation scenarios under the agricultural agreement in the Doha Round. Obviously, not all models lead to similar results, but most simulations suggest that developing countries will be major gainers under the Doha Agreement. Bouet, Bureau, Decreau, and Jean (2005) used a multi-sector, multi-region CGE model especially to assess the consequences of agricultural trade liberalisation under the Doha Round negotiations. This model distinguished

30 sectors and 11 country groups. It used the GTAP data base for accounting matrices and incorporated protection data and data on farm support. This model established baseline equilibrium for year 2001 and a trade liberalisation scenario representing the Doha Agreement that was used to shock the baseline equilibrium. The simulations consisted of changes in tariffs, suppression of export subsidies, and cuts in trade-distorting domestic support. The results showed that multilateral liberalisation would increase world prices. The quantities of agricultural products traded internationally would grow owing to decreases in tariffs. The results further suggested that the impact of the Doha AoA was much lower compared to other studies. It was found that a larger number of developing countries would experience a loss in welfare. The developed countries that reduced their own distorting support would be the main winners in terms of welfare.

Hertel, Anderson, Francois, and Martin (2000, 2004) analysed the patterns of production, consumption, trade, and protection as well as other structural features of the global economy as they are likely to influence the welfare impacts of liberalising agricultural and non-agricultural trade. This study used a modified version of the GTAP model and assumed cuts in protection in all agriculture, mining, manufacturing and services sectors. The distributions of gains from sectoral protection reductions were quite different for different sectors. In the case of agricultural liberalisation, the rates of protection were highest in the industrialised economies and they were the ones to capture the majority of absolute gains from liberalisation of food markets. However, when the gains were measured relative to initial income, developing countries were among the winners from reductions in agricultural protection.

Anderson, Martin, and Mensbrugghe (2005) used the WB's linkage model of the global economy (global linkage model), which is a recursive dynamic model, to study the impact of removing all merchandise trade distortions including agricultural subsidies would have on food and agricultural production, trade and income. The motivation of this study was to follow the results of Jensen, et al. (2002) described in the previous section. As Jensen, et al. (2002) concluded that anti-agricultural biases in trade and sectoral policies for a sample of 15 developing countries had disappeared in the mid-1990s, this study attempted to uncover what happens to other developing countries. Therefore, this study tried to answer the question of what would be the consequences for agricultural markets and farm income in 2015 if all countries were to bring down their trade distortions simultaneously. It used the GTAP version

6.5 data base. The simulation results suggested that agriculture was where the greatest gains from liberalisation would occur. Global liberalisation of agriculture and food markets accounted for 63 per cent of the total global gains. Global trade liberalisation would benefit the poorest groups, mainly farmers and unskilled labourers in developing countries. In particular, this would cause farm output, employment and net farm income to be enhanced in developing countries except in the South Asian region. Yet, this would have many adverse terms of trade impacts on many developing countries.

After the initiation of GTAP-based modelling of agricultural trade policy using the standard framework, individual researchers began to bring in agricultural specificity into the standard model to better capture the precise features of the agricultural economy relevant to the research question addressed. Keeney and Hertel (2005) documented the introduction of such a specificity to the standard GTAP modelling framework to create the special version named GTAP-AGR that would better portray linkages between international trade, and the farm and food economy. The new features include segmentation of factor markets; farm and non-farm, crop-livestock interactions through minimising feedstuff formulations; and separability between food and non-food in consumption with supporting econometric-based parameter estimates from the literature. This modified model was then used to analyse multilateral trade liberalisation of agricultural markets, and the results were compared with GTAP model results. The results were quite similar with respect to trade predictions, but distinct differences could be observed when variables of greater interest to the farm sector, such as agricultural employment and farm household welfare, were considered. The authors suggested that future model developments should focus on improving both the representation of agricultural features and the modelling of policies. Incorporation of appropriate econometrically estimated parameters for agricultural production in developing countries is also a prioritised area for future work.

3.5 CGE analysis on the Sri Lankan economy

The interest in application of multi-sectoral modelling was initiated in Sri Lanka in the 1970s after the compilation of an I-O table for the year 1968 by the UNDP (Dasanayaka, 2000). In his book, Dasanayake (2000) mentions that three researchers attempted to build models using this I-O table. The first was a multi-sectoral I-O model by Narapalasingham in 1970, the

second was a ten-sector linear programming model by Jayawardane in 1970, and the last was an agriculture-based linear programming model by Sirisena in 1976.

The construction of the SAM for the Sri Lankan economy (Pyatt, Roe, Round, & Lindley, 1977), which provided a detailed data base, was the key motive behind the upsurge of multi-sectoral modelling efforts in Sri Lanka. A ten-sector optimisation model was developed by Anandalingham (1983) to explore the impacts of different development strategies on sectoral resource allocation of the economy. Using the same data base, a multi-sectoral, inter-temporal optimisation model was developed in 1986 to investigate the optimal development path for Sri Lanka (Dasanayaka, 2000).

The first researcher to build a CGE model for Sri Lanka was De Melo (1978). This was based on the 1970 SAM data base for Sri Lanka. The theoretical structure of this model fits into the class of traditional WB CGE models. This was a static model and it was updated over time through a set of inter-temporal linkages to capture the dynamic aspects of the economy. The model distinguished seven economic sectors, seven factors of production, six consumer groups, firms and government. The seven factors of production included capital stock, land stock and various categories of labour. Among them, land, capital and skilled labour were assumed to be sector-specific factors and different unskilled types of labour were categorised as variable factors. Households were grouped based on their social class as urban and rural, rich and poor. The sectoral production functions were expressed by a two-level constant elasticity of substitution (CES) production function with constant returns to scale at each level. Household consumption was modelled with a spliced linear expenditure system (SLES). There were two different sets of demand equations to represent urban and rural consumption. The population growth rate, capital stock adjustment and household mobility among socioeconomic groups were introduced in order to integrate dynamic aspects into the model.

Agricultural policy interventions investigated included elimination of the rice subsidy and the tax on agricultural exports, import substitution in agriculture, land reform, increased government investment in agriculture, and technical change in agriculture. Effects of other non-agricultural government policies, such as a fixed exchange rate, a reduction in the urban wage for unskilled labour, equalisation of indirect taxes and nationalisation of firms, were also investigated here. Apart from those, five comprehensive development strategies chosen from

the evolution of development policies in Sri Lankan history, namely, economic strategy, a green revolution strategy, a modified green revolution strategy, a socialist strategy, and industrialisation strategy were investigated using the same model. Both comparative static and dynamic results were discussed in terms of multiple goals including GNP growth, increase in capital stock, employment, living standards, rich/poor income gap and basic needs.

The results suggested that the elimination of the rice subsidy, land reform, and technical change in agriculture policies yielded improvements in GNP growth, employment and total welfare of households in the long-run. Elimination of export taxes and increased government investment in agriculture resulted in negative impacts on GNP and income distribution in the long-run. The study claimed that import substitution in agriculture was not suitable as a distinct policy intervention as it could increase the prices of protected commodities and lower the standard of living. However, if import substitution could be combined with endogenous land expansion, a more favourable growth effect could be obtained. In terms of development strategies, green revolution strategy would be more appropriate as it encouraged expansion of industrial sectors while lowering cost of living in the medium term. This model has been used for two other studies by De Melo (1979, 1982), but the key simulations have been the same.

Blitzer and Eckaus (1986) developed a neo-classical CGE model for Sri Lanka focusing on energy-economy interactions. This model investigated the impact of energy cost and prices on key macroeconomic variables and industrial structure especially feedback effects of energy costs and demands on the rest of the economy. There were 11 sectors in this model including three energy sectors, crude oil, electricity and traditional fuel. The Leontief form was specified for all intermediate demand and the Cobb-Douglas functions were used to specify the relationship between output and primary factors. Two consumer groups were identified in the model (urban and rural) and the extended linear expenditure system was used to model their behaviour. The base year for the model was 1983, and it was used to carry out simulations to cover the 1983-1989 period.

Three simulations were conducted in this study. The first case reflected the reported plans and forecasts of the government. This was used as the benchmark to measure the impacts of other scenarios. In the other two cases, world oil prices were regarded as increasing faster than the benchmark scenario. These higher world prices were not passed onto domestic consumers in

the second case, while they were passed on to the domestic purchasers in the third case. Results of the base case showed GDP increased at five per cent per year. However, some results were inconsistent when compared with official projections. In the second and third cases, reduction in domestic income and energy and other types of consumption can be observed and these contractionary effects were prominent in the third case. The most significant macroeconomic result was that investment levels in the third case were only slightly lower than the base case. This permitted faster growth than in the second case despite the decline in output-capital ratios due to higher energy costs.

Another CGE model for Sri Lanka was developed in 1987 to discover the experience of stabilisation and adjustment programmes in LDCs, and to find an alternative to the conventional International Monetary Fund (IMF)-WB stabilisation approach at that time. This was more of an aggregated model with four production sectors: (a) food, agriculture, and processing and export agriculture (b) manufacturing (c) mining and construction, and (d) services, trade and transport. There were four income classes and two types of consumer groups. This had been used to address the issue of macroeconomic adjustment experience in Sri Lanka during the 1970s and 80s by counterfactual simulations. The main objective of those simulations was to derive outcomes of different possible government economic policies and investigate the feasibility of alternative adjustment mechanisms (Dasanayaka, 2000; Jayawardena, Maasland, & Radhakrishnan, 1987).

Bandara (1989) developed a neo-classical comparative static model for Sri Lanka to capture the implications of various external shocks. The model highlighted the role of relative prices and substitution possibilities in determining commodity trade flows and their effects on economic structure and distribution of factor income. The equation system of the model followed the ORANI model of the Australian economy (Dixon, Parmenter, Sutton, & Vincent, 1982). The main data base for the model was the 1981 I-O table. There were 24 industries, each producing a unique commodity. Furthermore, there were three different household groups and labour categories having a one-to-one relationship as urban, rural and estate, based on the location. Expenditure elasticities of demand were estimated in the study using the Ordinary Least Square (OLS) method. This model had been used to experiment with the historical magnitudes of terms of trade shocks and capital inflows during the 1978-1982 period.

The short-run results of the model demonstrated that the adjustments to the terms of trade shock alone would have involved major structural changes including reductions in overall absorption and real wages. The terms of trade shock had contradictory effects with a substantial reduction in domestic absorption, real household income, and real wages in the economy, while providing stimulus to the major tradable industries and contractionary impacts on non-tradable industries. The combined effects on the macroeconomic variables and industrial structure demonstrated that the terms of trade shock would have been much stronger than the effects of foreign capital inflows. This model used only labour and capital as major factors of production and it did not focus on incorporating land as a factor of production. Furthermore, the study did not distinguish different household income groups even though it attempted to discover the impacts of terms of trade shocks on income distribution. This model had been used for another study by Bandara (1995), but the simulations were the same.

The CGE model developed by the Centre for International Economics (CIE) (1991) was closely related to the model developed by Bandara (1989) with respect to the structure and solution method. However, this was a more disaggregated model with 35 industries and three primary factors. The 1986 I-O table for Sri Lanka updated to year 1989 was the main data base for this model. This model had been designed to assess the effects of a range of policy changes on growth and composition of the Sri Lankan economy. Policies such as incentives to import-competing industries (elimination of tariffs), increases in world market prices for the two major export commodities in the economy-tea and garments- and reductions in foreign aid were simulated in the short-run. The results suggested that the reduction in tariff levels for import-competing commodities and both the external shocks improved the competitiveness of the economy. They caused considerable effects on export industries, particularly, they made exporting industries more competitive, while formerly highly protected import-competing industries were disadvantaged. Increases in world market prices of tea and garments resulted in an improvement in the relevant industry, while causing reduction in the competitiveness of other exporting industries.

Heart (1994) investigated the economic implications of implementing a major development programme “the Mahaweli Programme” in Sri Lanka. This was done mainly through inclusion of an additional production sector to represent the functions of the project based on the data base developed in Bandara (1989) and then investigating the direct and indirect impacts of

various aspects of changes associated with the implementation of the project. There were three consumer groups, urban, rural and estate, sharing an identical demand structure. The baseline equilibrium was set up in order to measure the impacts of the project in 1981.

Three simulations were conducted. Case 1 represented the situation where the Mahaweli Programme was implemented, with endowments equal to the input requirements of the programme being given to the households and the government. In case 2, net increases in the government endowment were being distributed to the households in addition to case 1. It was assumed that the programme was not implemented in case 3. Instead, additional endowments of the consumption good, equal in value to the increase in endowments in 1 and 2 were given to the households and government. The impact of the programme on households was measured in terms of a utility index representing a weighted average of current consumption and savings. The study suggested that the implementation of the project was beneficial in terms of household welfare and employment generation, but resulted in a deterioration of the terms of trade of Sri Lanka. When households were considered as a whole, case 2 yielded the highest welfare. It is important to note that actual implementation of the Mahaweli Programme was already underway by 1981. Therefore, the baseline equilibrium was influenced to some degree by the programme. Since there was no possible way to isolate and eliminate those effects, the study ignored these effects assuming that they were negligible.

There have been of few attempts to link trade liberalisation to environmental impacts in Sri Lanka. Somaratne (1998) developed a CGE model for Sri Lanka to analyse the link between trade liberalisation and its environmental implications with respect to land degradation in the non-plantation agricultural sector (SL model). This model followed the same structure as the CIE model but in a more disaggregated form and integrated on-site and off-site impacts of land degradation. Land was considered as mobile between crop industries within upland, midland and lowland regions in this study. Real wages and balance of trade were assumed to be fixed. The interesting policy results derived from this model were that trade liberalisation does not have any negative impact on the non-plantation agricultural sector in terms of land degradation.

Based on this model, Somaratne (2000) analysed the macro- and micro-economic effects of policy induced on-site and off-site land degradation effects of tariff policy liberalisation within

the policy framework of the GATT/Uruguay Round AoA, the South Asian Preferential Trade Agreement (SAPTA) and the South Asian Free Trade Agreement (SAFTA). Three policy simulations were considered here. They were partial tariff reduction in the non-plantation agricultural sector, total removal of tariff in the non-plantation agricultural sector, and across-the-board partial tariff reduction. The study found that tariff policy liberalisation would create positive economic and environmental benefits for the economy under the specific context fostering economic growth. The results suggested that tariff liberalisation can lead to a higher real GDP. However, greater growth benefits can be gained with across-the-board tariff liberalisation in all import-competing sector-specific policies. The results in terms of sector outputs proposed that export-oriented products benefitted from liberalisation, while import-competing sectors contracted. Furthermore, tariff liberalisation encouraged a shift of lands in an environmentally friendly direction, from erosive non-plantation crops to less erosive plantation crops.

Weerahewa, Kotagama, and Thrikawala (1998) compared partial equilibrium and CGE approaches to analyse trade and environmental issues as a case study of potato trade liberalisation in Sri Lanka and to suggest optimal tariff rates. They found that the CGE model predicted trade liberalisation is environmentally friendly if potato cultivation is comparatively more erosive and the partial equilibrium approach may predict the opposite, even if potato cultivation is comparatively more erosive. Furthermore, the CGE approach suggested the optimal tariff rate for Sri Lanka was zero. Based on these findings, the authors agree the CGE approach is best for this type of analysis.

Bandara and Coxhead (1999) examined the economic and environmental implications of trade liberalisation in Sri Lanka using a CGE model. They also used a more disaggregated form of the CIE model and incorporated erosion and land degradation specifically in the tea sector, tea being one of the important export crops in the model. There, they modelled the impacts of an across-the-board tariff reduction of 25 per cent and a technical progress in the tea sector. The results indicated that both types of change increased the demand for land in tea, which was the relatively less erosive sector and thus has environmental as well as economic benefits for the Sri Lankan economy. The study also revealed reducing tariffs increased the output of export-oriented industries and decreased that of import-competing sectors. This is consistent with the findings of Somaratne (2000). Furthermore, it was found that tariff reduction reduced

aggregate soil erosion by 0.7 per cent. Other research by Bandara, Chisholm, Ekanayake, and Jayasuriya (2001) on the environmental cost of soil erosion in Sri Lanka showed conclusively that economic losses from soil erosion in Sri Lanka were significant. Trade liberalisation reforms increased national income and marginally decreased soil erosion. Finally, complementary policies which directly target soil erosion, such as tax/subsidy incentives, were needed to minimise social losses from soil erosion.

Kandiah (1999) constructed a CGE model incorporating the financial sector for the Sri Lankan economy to investigate the effects of financial liberalisation. Series of simulations were conducted to examine the impacts of partial and full interest rate reforms and trade policy reforms combined with interest rate reform for both the short and long run on Sri Lankan economy. The results indicated that interest rate reform has a significant impact on growth and employment in the economy. The combined effects of trade and interest rate reforms produced better economics performances.

Another CGE model for Sri Lanka was developed by Naranpanawa (2005). This multi-household model (SLGEM-P) was developed in order to examine the link between trade liberalisation and poverty. In addition, the model included a poverty line. As a prerequisite for the model, a SAM was constructed for the base year 1995 for the Sri Lankan economy and it was used as the main data base. The study conducted trade policy simulations to identify the impacts of trade liberalisation in manufacturing and agricultural industries on absolute and relative poverty at household level. Three simulations were carried out in the study. The first simulation was to analyse effects of total removal of prevailing tariff on manufactured goods. The second simulation was total reduction of prevailing tariffs on agricultural goods, and the third one was total removal of tariffs across-the-board.

Short-run results of the study revealed that trade liberalisation generated positive results with respect to macro indicators like economic growth, aggregate employment and balance of trade. Moreover, trade liberalisation tended to reduce inflation in the economy and the cost of living. Long-run results indicated that simulation 1 and 3 were expected to enhance real GDP growth and real private consumption substantially, suggesting a positive aggregate welfare improvement. In contrast, simulation 2 produced marginal results in both the long-run and

short-run, suggesting agricultural trade liberalisation plays a less important role in achieving growth objectives in Sri Lanka.

Based on the results, the authors argued that trade liberalisation of manufacturing industries were more pro-poor than that of agricultural industries in general. Largely, results implied that trade reforms widen the income gap between the rich and the poor promoting relative poverty in contrast to the popular trickling down effects of trade-induced growth within the developing country context. It is important to note that there are significant differences in the case of poverty and inequality in different regions of the country. Therefore, this study would have produced much more accurate results if the study had taken into account those regional disparities and analysed the trade policy issues in a regional CGE model. Furthermore, one should take into account that the data base used in the study could not capture some of the NTBs, such as quantity restrictions operated in some agricultural imports, before drawing any conclusions from the study results.

Bandara and Naranpanawa (2007) employed the CGE model developed by Naranpanawa (2005) to investigate the effects of the Indian Ocean Tsunami (IOT) on macroeconomic variables and likely effects of a reconstruction package on the Sri Lankan economy. Two sets of simulations were conducted. The first set examined the effect of IOT on macroeconomic variables and industry output levels, while the second set examined the demand effects of the reconstruction aid package. The results indicated that real GDP declined while the Consumer Price Index (CPI) increased. The fishing sector was the most affected sector in the economy recording a 19 per cent decline in the output. When the effects of the reconstruction package were considered, decreased export volumes and increased import volumes can be seen as the adjustment of domestic absorption to accommodate an increase in foreign aid. Therefore, many export-oriented industries contracted while some non-tradable industries expanded. These results suggested that it was important to consider the combined effects of the IOT and the reconstruction package. It emphasised that while the IOT has produced negative economic effects on the economy, the reconstruction package would stimulate the economy. However, it is important to note that these results depend on the magnitude of shocks selected, closure, and the quality of the data base used.

3.6 Concluding remarks

This chapter has reviewed the literature on the application of CGE modelling on agricultural policy analysis in developing countries. In the beginning, the appropriateness of CGE modelling in analysing economic impacts of agricultural policies was highlighted in comparison with other widely used modelling approaches. The CGE model is more likely to capture the feedback effects of policy shocks and represent inter-industry linkages which are lacking in partial equilibrium methods. This chapter has also presented a review of CGE studies on Sri Lanka, highlighting the important features and limitations of these studies. These studies mainly focused on trade liberalisation, structural adjustment programmes and environment-related issues. Very few studies place emphasis on agriculture-related issues in Sri Lanka, with no study focusing on this at the regional level. Table 3.1 summarises the applications of CGE modelling in Sri Lanka.

The survey of CGE models of Sri Lanka has provided the basis for developing a CGE model with new features for Sri Lanka in this study. In the next chapter we describe the theoretical structure of the CGE model developed for the Sri Lankan economy.

Table 3.1: Applications of CGE modelling in Sri Lanka

No	Authors	Supply side		Demand side		Base year	Main database and value of parameters	Policy shocks	Main conclusions
		Production function	No. of sectors	Demand function	No. of sectors				
1.	De Melo (1978)	Nested Cobb-Douglas	7	SLES	6	1970	SAM data base for 1970 Other parameters from published sources	1. Elimination of rice subsidy 2. Elimination of export tax 3. Technological change in agriculture 4. Land reform 5. Increase in investment in agriculture	Policies 1 and 3 have favourable impact on GDP and income of poorer groups
2.	De Melo (1982)	Nested Cobb-Douglas	7	SLES	6	1970	SAM data base for 1970 Other parameters from published sources	1. Socialist strategy 2. An economic strategy 3. Green revolution 4. Industrialisation	Factor-neutral green revolution strategy is the most desirable strategy for a country which encourages expansion of industrial sectors and reduces relative cost of living in the medium term.

No	Authors	Supply side		Demand side		Base year	Main database and value of parameters	Policy shocks	Main conclusions
		Production function	No. of sectors	Demand function	No. of sectors				
3.	Blitzer and Eckaus (1986)	Cobb-Douglas	11	ELES	2	1983	I-O data base Other published sources	1. Base run 1 per cent annual increase in world oil prices 2. 5 per cent annual increase in world oil prices assuming increased oil prices are not passed on to the domestic economy. 3. Increasing world oil prices assuming increased oil prices passed on to the domestic economy.	Base run solution shows contradictions with the official projections. Policy application 2 shows reduction in domestic income leading to contraction in energy and other types of consumption. Policy application 3 also exhibits contractionary effects.
4.	Bandara (1989)	Nested Leontief and CES functions	24	LES	3	1981	I-O data base and other published data. Expenditure elasticities were estimated	1. Terms of trade shock (TOT) 2. Foreign capital inflows during 1978-1982	Adjustments to the TOT shock involve reductions in overall absorption and real wages. Foreign capital inflows have positive effect on the economy and reduce such pressures.
5.	CIE (1992)	Nested Leontief and CES functions	35	LES	1	1989	Updated I-O data base and parameters from other sources	1. Elimination of tariff from 1990 levels 2. 5 per cent increase in world prices of tea and garments 3. A 50 per cent reduction in foreign aid	All policy scenarios improved competitiveness of the economy having positive impact on exporting industries and some negative impacts on import-competing industries

No	Authors	Supply side		Demand side		Base year	Main database and value of parameters	Policy shocks	Main conclusions
		Production function	No. of sectors	Demand function	No. of sectors				
6.	Heart (1994)	Nested Leontief and CES functions	6	Nested Cobb-Douglas	3	1981	I-O data base and other data used in Bandara (1989)	1. Investment on Mahaweli Development Programme with endowments received by the households 2. Investment on Mahaweli Development Programme with endowments imputed to government 3. project not implemented; instead households receive an additional endowment	Implementation of the Mahaweli Programme led to increase in employment and reduction in consumer prices while deminishing the terms of trade of Sri Lanka with reference to the rest of the world.
7.	Bandara (1995)	Nested Leontief and CES functions	24	LES	3	1981	I-O data base and other published data. Expenditure elasticities were estimated	Investigate combined effects of terms of trade shock and foreign capital inflows to the economy	TOT shock could have had severe contractionary effects despite the positive effects of capital inflow
8.	Somaratne (1998)	Nested Leontief and CES functions	40	LES	1	1992	CIE data base and other published sources. Parameters from CIE model	1.Policies to measure economy-wide impacts of trade policy liberalisation 2. Evaluate on-site and off-site environmental cost of land degradation.	Trade liberalisation does not have any damage on the non-plantation agricultural sector with reference to land degradation

No	Authors	Supply side		Demand side		Base year	Main database and value of parameters	Policy shocks	Main conclusions
		Production function	No. of sectors	Demand function	No. of sectors				
9.	Weerahewa et.al (1998)	N/A	N/A	N/A	N/A	N/A	N/A	1. Comparison of partial and general equilibrium approach And suggest optimal tariff rate	Recommends the use of CGE for this scenario. Trade libaralisation is environmentally friendly in potato cultivation is more erosive. Optimal tariff rate is zero.
10.	Somaratne (2000)	Nested Leontief and CES functions	40	LES	1	1992	CIE data base and other published sources. Parameters from CIE model	1. Partial tariff reduction in non-plantation agriculture sectors 2. Total removal of tariff in non-plantation agriculture sectors 3. Across-the-board tariff reduction in all import-competing sectors	All policy applications show that tariff policy liberalisation would create positive economic and environmental benefits for the economy
11.	Bandara and Coxhead (1999)	Nested Leontief and CES functions	37	LES	1	1989	1989 Updated I-O data base and parameters from other sources	1. 25 per cent across-the-board tariff reduction 2. Technical progress in tea sector.	Both the scenarios provide environmental and economic benefits. Both cases raise real GDP and real consumption.

No	Authors	Supply side		Demand side		Base year	Main database and value of parameters	Policy shocks	Main conclusions
		Production function	No. of sectors	Demand function	No. of sectors				
12.	Kandiah (1999)	Nested Leontief and CES functions	15	LES	1	1989	1989 I-O data base and other published sources	1. Short-term effects of partial interest rate reform 2. Long-term effects of partial interest rate reform 3. Short-term effects of full interest rate reform 4. Long-term effects of full interest rate reform 5. Combined effects of trade liberalisation (25 per cent across-the-board) with interest rate reform	Interest rate reform has significant impacts on growth and employment in the economy. Partial liberalisation has less impact on the major macro-economic variables such as GDP, employment, real wage and aggregate household consumption in both short- and long term. Macro-economic performances and industry outcomes are pronounced when interest rate reform is combined with trade liberalisation.
13.	Naranpanawa (2005)	Nested Leontief and CES functions	38	LES	5	1995	1995 I-O data base and other published sources	1. Total removal of prevailing tariff on manufactured products 2. Total reduction of prevailing tariffs on agricultural products 3. Total removal of tariffs across-the-board	Trade liberalisation of manufacturing industries is more important for poverty alleviation than that of agricultural industries. On the other hand, trade reforms may widen the income gap between the rich and the poor promoting relative poverty

No	Authors	Supply side		Demand side		Base year	Main database and value of parameters	Policy shocks	Main conclusions
		Production function	No. of sectors	Demand function	No. of sectors				
14.	Weerahewa (2006)	N/A	5	N/A	8	2000	2005 I-O data base and other published sources	1. Removal of import tariff on rice 2. Removal of subsidy on other agriculture 3. Combination of 1 & 2 4. 10 per cent increase in world market price for rice 5. Combination of 1 & 4 6. Removal of import tariff on rice and fertiliser 7. Combination of 2 & 6 8. No trade in rice and paddy (rice self-sufficiency)	Removal of import tariffs alone would not improve welfare of households unless combined with other policies.
15.	Bandara and Naranpanawa (2007)	Nested Leontief and CES functions	38	LES	5	1995	1995 I-O data base and other published sources	1. 65 per cent reduction in capital stock in the fishing industry 2. 15 per cent reduction in demand for tourism 3. 10 per cent reduction in capital stock in dwellings 4. 2 per cent reduction in efficiency in trade and transport sectors	IOT has produced negative economic effects on the economy- the reconstruction package would stimulate the economy

Chapter 4

Theoretical Structure of the CGE Model Developed for the Sri Lankan Economy

The two previous chapters have laid the foundation for developing a comparative static CGE model for the Sri Lankan economy to capture the impacts of domestic agricultural policies. The model is based on ORANI-G (Horridge, 2007) and derives a great deal from ORANI: A multi-sectoral model of the Australian economy (Dixon, et al., 1982). The main purpose of this chapter is to present the main features of the model.

The chapter is arranged as follows. Section 4.1 summarises the general features of the model. Production functions for each producing sector are explained in Section 4.2. Section 4.3 describes the production of fixed capital in the economy. Section 4.4 explains household demand functions for separate household groups in the model. Export demand functions are illustrated in Section 4.5 and government demand functions are outlined in Section 4.6. Section 4.7 explains the relationships between several sets of commodity prices. Section 4.8 presents household consumption and income equations. Section 4.9 presents equations that allocate investment across several industries. Market clearing equations are discussed in Section 4.10 and equations for imports, exports and balance of trade in Section 4.11. Section 4.12 represents other equations, such as price indices and wage indexation. The concept of regional disaggregation is summarised in Section 4.13. Section 4.14 summarises the solution method using GEMPACK software. Section 4.15 describes the tests used for model validation. Section 4.16 summarises the systematic sensitivity analysis process conducted. Finally, Section 4.17 provides a summary of the chapter.

4.1 General features of the model

The model provides a demonstration of each industry's demands for labour, capital and land, and various intermediate inputs from both domestic and imported sources. The industries in this model are assumed to maximise profit subject to constant returns to scale production functions. A Leontief production function specifies the relationship between industry inputs and outputs for each industry. Aggregation of domestic and imported intermediate inputs is

expressed by a CES production function. The aggregation of primary factors and the aggregation of different types of labour are also based on CES production functions.

Unlike the ORANI model which has only a single representative consumer, this model has nine household groups representing nine provinces in the country. Consumers' utility maximisation is driven by the Stone-Geary linear expenditure system. Consumers maximise utility subject to their income levels. To model this, we have followed the multiple household version of ORANI-G by Horridge (2004). Due to lack of data on margin services (wholesale and retail trade, and transport) which are required to transfer commodities from their sources to their users, the model does not include margins. Hence, it follows the non-margin version of the ORANI model; ORANIG-NM and margins are modelled as direct flows (Horridge, 2002).

4.2 The production function for current output

It is assumed that there is a one-to-one association between industrial sectors and commodities in this model. Therefore, it is implied that there is no multiproduction setting in any of the industrial sectors. This means, for example, the paddy industry produces only commodity paddy and commodity paddy is produced only by the paddy industry. There are two major types of industries, namely agricultural and non-agricultural (including manufacturing and services). For the purpose of this study, the economy is divided into 40 producing industries and there are three primary factors: land, labour and capital. This aggregation has been selected to highlight the features of the agricultural sector. Table 4.1 summarises the producing industries and commodities in the model.

Each industry uses intermediate inputs and three primary factors, land, labour and capital. Producers are assumed to be price takers in both input and output markets. The producers choose their inputs so as to minimise their cost of production. The production function for all the industries is a nested three level CES production function as depicted in Figure 4.1. At the top level, the production function is characterised by a Leontief production function with fixed proportions of intermediate inputs, an aggregate of primary factors (capital, labour and land), other cost tickets and subsidies. At the second level, the aggregation between domestic and imported intermediate inputs and the aggregation of primary factors (aggregated labour, capital and land) are described by a CES production function. At the third level, the

substitution possibilities among seven labour categories are described by a CES production function. It is assumed that no substitution takes place between intermediate inputs and primary factors or between intermediate inputs of different input-output classes.

Table 4.1: Industry and commodity classification

Industries/commodities	
1. Tea growing	21. Flour milling
2. Rubber growing	22. Food, beverages and other
3. Coconut growing	23. Textile, footwear and leather products
4. Paddy	24. Garment industry
5. Vegetables	25. Wood and wood products
6. Fruit	26. Paper and paper products
7. Highland crops	27. Chemicals and fertiliser
8. Potatoes	28. Petroleum industry
9. Minor export crops	29. Plastic and rubber products
10. Tobacco	30. Other manufacturing
11. Betel and areca nuts	31. Electricity, gas and water
12. Miscellaneous agricultural products	32. Construction
13. Plantation development	33. Hotels and restaurants
14. Firewood	34. Tourist shops and travel agents
15. Forestry	35. Trade and transport
16. Livestock and fisheries	36. Post and communications
17. Tea processing	37. Banking, insurance and real estate
18. Rubber processing	38. Ownership of dwellings
19. Coconut processing	39. Public administration and defence
20. Rice milling	40. Other personal services

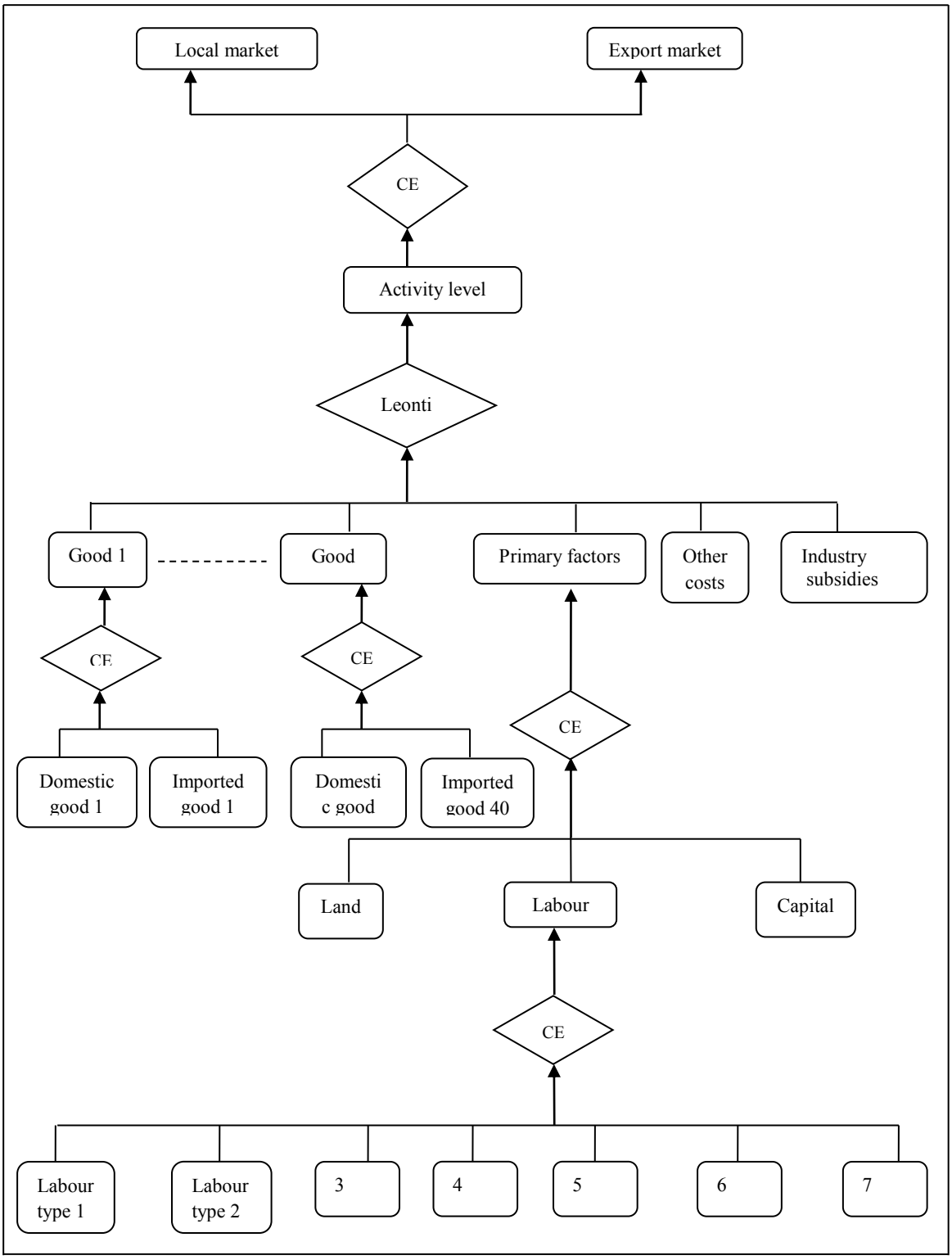

Figure 4.1: Structure of production

Source: Horridge (2007)

The Leontief production function represents the simplest production technology with fixed proportions of inputs determining output. It is a mathematical version of Wassily Leontief's I-O table which has been used widely for inter-industry analysis. In the input-output production technology, any substitution between any pair of inputs is not permitted. However, with the CES production function, substitution possibilities between inputs can occur.

Here, the pair-wise substitution elasticities (σ) are constants and are equal to $1/(1+\rho)$, where ρ is the substitution parameter which determines the value of the σ. CES is more suitable for the production technology than the traditional Cobb-Douglas production function as the substitution elasticity is restricted to one in the latter (Chung, 1994).

4.2.1 Industry inputs and activity level

All the producing industries have a single product. For each industry, we assume that the top level production technology is given by

$$\underset{i=1.....g+3}{Leontief}\left\{\frac{X_{ij}}{A_{ij}}\right\} = A_j Z_j \qquad j = 1.....h \qquad (4.1)$$

where

X_{ij} = effective input of good or factor *i* into current production

Z_j = industry *j*'s activity level

A_{ij} = input *i* augmenting technical coefficient

A_j = all-input augmenting technical coefficient

i = inputs to current production

A_{ij} is the input-output coefficient showing the minimum effective input of i required to support a unit of activity in industry j.

While there is no chance of substitution between primary factors and intermediate inputs, there are possibilities for substitution between different types of primary factors and between domestically produced and imported inputs within the same input-output category. As depicted in the equation (4.1), there are $g+3$ inputs. For the first g of these inputs (i.e. for

intermediate inputs) there are two sources of supply, namely domestically produced and imported. The Armington assumption is used to allow for imperfect substitutability between those sources (Armington, 1969). To capture this idea of imperfect substitutability, it is assumed that units of a given input, differentiated by source are combined to produce an effective input using a CES production technology as described by the equation

$$X_{ij} = \underset{s=1,2}{CES}\left\{\frac{X_{(is)j}}{A_{(is)j}}, \rho_{ij}, b_{(is)j}\right\} \qquad (4.2)$$

$$X_{ij} = \left[b_{(id)j}\frac{X_{(id)j}^{-\rho_{ij}}}{A_{(id)j}} + b_{(im)j}\frac{X_{(im)j}^{-\rho_{ij}}}{A_{(im)j}}\right]^{\frac{-1}{\rho_{ij}}} \quad i = 1,.....,g \qquad j = 1,.....,h$$

where,

$X_{(id)j}$ = input of *i* from domestic source to current production in industry *j*

$X_{(im)j}$ = input of *i* from imported source to current production in industry *j*

$A_{(is)j}$'s are positive coefficients to allow for technical change

$b_{(is)j}$ are non-negative parameters where *s=d,m*

and ρ is greater than -1 but not equal to zero

The remaining three inputs distinguished in equation (4.1) are primary factors (subscript g+1), other cost tickets (g+2) and industry subsidies (g+3). In the case of primary factors, labour, fixed capital and agricultural land are combined to form effective units of primary factor inputs according to the equation,

$$X_{(g+1)j} = \underset{s=L,K,N}{CES}\left\{\frac{X_{(g+1,s)j}}{A_{(g+1,s)j}}, \rho_{(g+1,s)j}, b_{(g+1,s)j}\right\} \qquad (4.3)$$

$$X_{ij} = \left[b_{(g+1,L)j}\frac{X_{(g+1,L)j}^{-\rho_{(g+1)j}}}{A_{(g+1,L)j}} + b_{(g+1,K)j}\frac{X_{(g+1,K)j}^{-\rho_{(g+1)j}}}{A_{(g+1,K)j}} + b_{(g+1,N)j}\frac{X_{(g+1,N)j}^{-\rho_{(g+1,j)}}}{A_{(g+1,N)j}}\right]^{\frac{-1}{\rho_{(g+1,j)}}}$$

$j = 1,.....,h$

where

$X_{(g+1,s)j}$ = input of primary factor type *s* to the production in industry *j*

where s = labour (L), capital (K) and land (N)

$A_{(g+1,s)j}$'s are positive coefficients to allow for technical change

Labour input is further disaggregated into 7 skill categories. The effective input of labour into industry j is given by the equation

$$X_{(g+1,L)j} = \underset{m=1,\ldots 7}{CES}\left\{X_{(g+1,L,m)j}\right\}$$

$$X_{(g+1,L,)j} = \left[\sum_{m=1}^{M} b_{(g+1,L,m)j} X_{(g+1,L,m)j}^{-\rho_{(g+1,L)j}}\right]^{\frac{-1}{\rho_{(g+1,L)j}}} \qquad (4.4)$$

$$j = 1,\ldots\ldots,h$$

where, $X_{(g+1,L,m)j}$ is the input of labour from category m used in current production in industry j. This relationship allows the idea of imperfect substitutability between different labour categories to be depicted.

It is assumed that producers are competitive and efficient. Given the input and output prices at any given level of activity, the producers select the combination of inputs which minimises their costs. It is assumed that producers treat all factors of production as variable. Under the cost minimisation assumption choose the input levels

X_{ij}	= effective intermediate and primary inputs	$i = 1,\ldots\ldots,g+3$
$X_{(id)j}$	= intermediate inputs, domestic and imported	$i = 1,\ldots\ldots,g \quad s = d,m$
$X_{(g+1,s)j}$	=overall labour input, capital, and land	$s = L,K,N$
$X_{(g+1,L,m)j}$	=labour by different skill groups	$m = 1,\ldots..M$

To minimise

$$\sum_{i=1}^{g}\sum_{s=1}^{2} P_{(is)j} X_{(is)j} + \sum_{m=1}^{M} P_{(g+1,L,m)j} X_{(g+1,L,m)j} + \sum_{s=2}^{3} P_{(g+1,s)j} X_{(g+1,s)j} + P_{g+2,j} X_{g+2,j} + P_{g+3,j} X_{g+3,j} \qquad (4.5)$$

subject to equations (4.1 to 4.4) where Z_j and P's are treated as exogenous variables. In (4.5), $p_{(is)j}$ is the price of commodity *i* (for $i = 1,...,g$) from source *s* (for $s = d,m$) to industry *j*. $P_{(g+1,L,m)j}$ is the price of occupational type labour m. $p_{(g+1,s)j}$, $s = K,N$ are the rental price to industry *j* of capital and agricultural land. The *j* subscript appears because we assume that units of capital and land are industry specific. $P_{g+2,j}$ and $P_{g+3,j}$ are the price of other cost tickets and price production subsidies, respectively.

4.2.1.1 Input demand functions

The solution to the above cost minimisation problem can be found in stages. First, tracking equations (4.1) and (4.2), for each *i*, $i = 1,.....,g$, $X_{(id)j}$ and $X_{(i,m)j}$ will be selected so as to minimise

$$\left.\begin{array}{l} P_{(id)j}X_{(id)j} + P_{(im)j}X_{(im)j} \\ \text{Subject to} \\ A_j A_{ij} Z_j = CES_s(X_{(is)j} / A_{(is)j}) \end{array}\right\} \qquad (4.6)$$

That means, the effective input of good *i*, $A_j A_{ij} Z_j$ required to maintain the activity level Z_j will be supplied by the cost minimising combination of imported and domestic inputs of good *i*. Following Dixon, et al. (1982), the percentage change mode of intermediate input demand functions after solving the above cost minimisation problem appear in (4.7). The lower-case letters represent the percentage changes of the upper-case lettered variables.

$$x_{(is)j} = z_j - \sigma_{ij}\left(p_{(is)j} - \sum_{s=1}^{2} S_{(is)j}\, p_{(is)j}\right) + a_j + a_{(is)j} \qquad (4.7)$$

To interpret (4.7), first consider the case in which there is no technical change. In this case, if there is no change in the relative prices of good *i* from alternative sources, an increase in Z_j will lead to an equivalent increase in each of the $X_{(is)j}$. This indicates the assumption of constant returns to scale. However, if $P_{(id)j}$ rises relative to the price of imported good, then

$X_{(id)j}$ will increase less rapidly than Z_j. There will be substitution against the domestic source of good *i* in favour of imports. When the technical change is taking place, a Hicks-neutral change across all inputs (i.e. a change in A_{ij}) implies that *j*'s requirement for all intermediate inputs will fall.

4.2.1.2 Demands for other cost tickets and industry subsidies

Of the remaining inputs, $g+1$, $g+2$ and $g+3$, the demands functions for $g+2$ and $g+3$ can be written as

$$x_{(g+2)j} = z_j + a_j + a_{g+2,j} \tag{4.8}$$

$$x_{(g+3)j} = z_j + a_j + a_{g+3,j} \tag{4.9}$$

4.2.1.3 Demand for primary factors

After gaining demand functions for other cost tickets and production subsidies, demand for primary factors can be obtained. That is the second stage of the cost minimisation problem explained in (4.5). Industry *j* will choose its primary factor inputs labour, capital and land to minimise cost as

$$\sum_{m=1}^{M} P_{(g+1,L,m)j} X_{(g+1,L,m)j} + P_{(g+1,K)j} X_{(g+1,K,j)} + P_{(g+1,N)j} X_{(g+1,N)j} \tag{4.10}$$

subject to (4.1) and (4.3).

Demand for labour by occupation groups is given as

$$x_{(g+1,L,q)j} = x_{(g+1,L)j} - \sigma_{(g+1,L,q)j} \left[p_{(g+1,L,q)j} - \sum_{q=1}^{M} S_{(g+1,L,q)j} p_{(g+1,L,q)j} \right] \tag{4.11}$$

$q = 1,..,7$ and $j = 1,.....,h$

Equation (4.11) relates each industry's demands for labour of a particular group to the industry's demands for labour in general and to the costs of the different types of labour. If there is no change in the relative prices of different types of labour, then the occupational composition of industry *j*'s workforce remains unchanged. If $p_{(g+1,L,q)j}$ increases relative to a weighted average of all the occupational wage rates payable by industry *j*, then *j*'s use of labour of type *q* will increase more slowly than *j*'s use of labour in general.

Demand for labour in general, capital and land is given by

$$x_{(g+1,v)j} = z_j - \sigma_{(g+1)j}\left(p_{(g+1)j} - \sum_{v=1}^{3} S_{(g+1,v)j}\, p_{(g+1,v)j} \right) + a_{(g+1,v)j} \qquad (4.12)$$

Unlike the rentals in capital and agricultural land, the price of labour $P_{(g+1,L)j}$ is not exogenous to the cost minimising problem. It is the cost to industry *j* of a unit of labour or the ratio of total labour costs in industry *j* to the industry's aggregate labour input. Therefore, the percentage change form of general price of labour is given by

$$p_{(g+1,L)j} = \sum_{m=1}^{7} p_{(g+1,L,m)j} S_{(g+1,L,m)j} \qquad (4.13)$$

4.2.2 Activity level and output

After the derivation of input demand functions, the output supply function of industry *j* can be derived. As there is a one-to-one relationship between the industries and commodities in the model, total output is equal to the activity level of the industry *j*. This can be written as,

$$X^{(0)}_{(id)j} = Z_j \qquad (4.14)$$

In percentage-change form,

$$x^{(0)}_{(id)j} = z_j \qquad (4.15)$$

4.3 Production of fixed capital

The production of fixed capital is illustrated by a nested production function. A Leontief production function explains the relationship between effective inputs at the top level, and a CES function combines two sources of inputs, domestic and imported, at the bottom level (Figure 4.2).

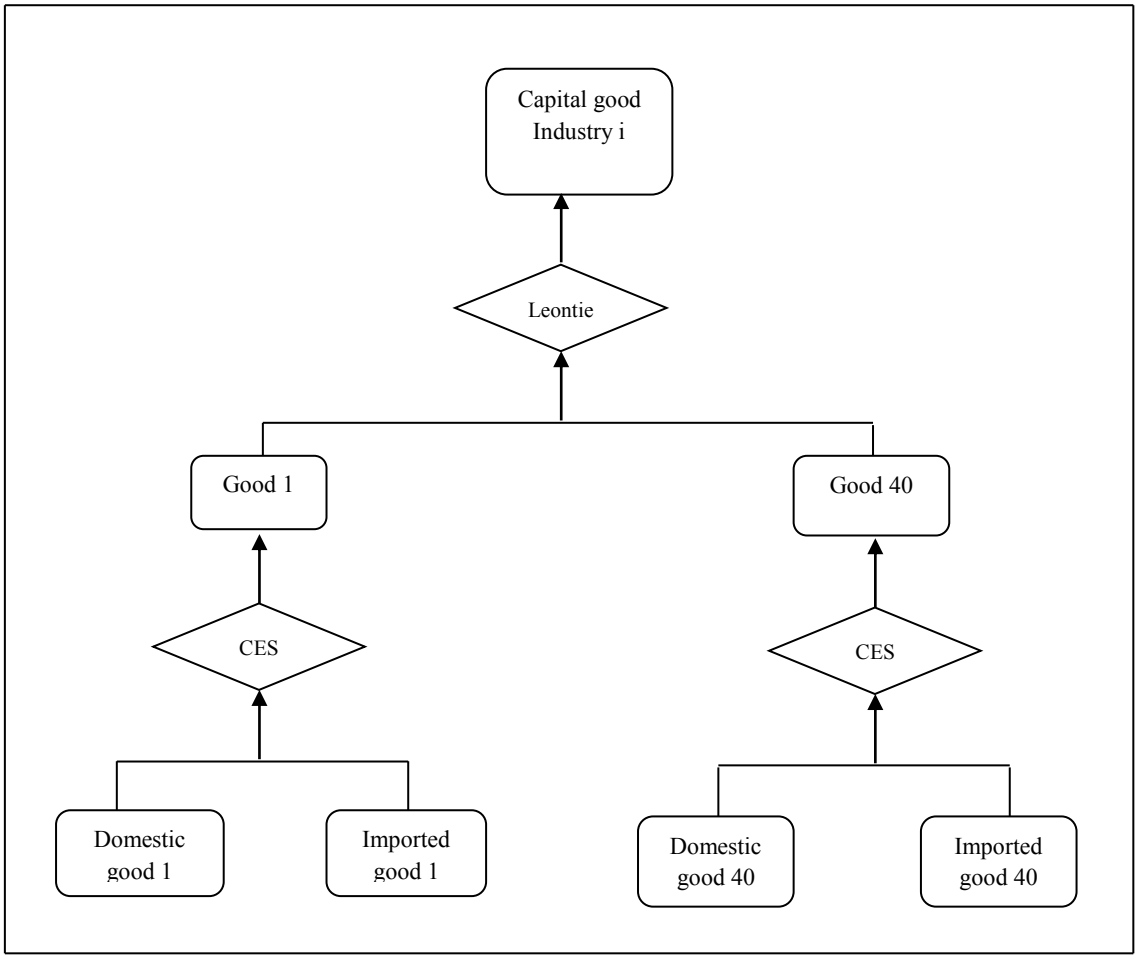

Figure 4.2: Structure of investment

Source: Horridge (2007)

Assume that a unit of fixed capital for the use of industry *j* can be produced according to the production technology,

$$A_j^K Y_j = \underset{i=1,\ldots,g}{Leontief} \left\{ \frac{X_{ij}^K}{A_{ij}^K} \right\} \qquad (4.16)$$

Y_j = number of units of fixed capital created for industry j

X_{ij}^K = direct effective input of good i to creating capital for industry j

A_j^K and A_{ij}^K are positive coefficients to be used to simulate various changes in the technology of making units of capital for industry j

The effective inputs X_{ij}^K, $i = 1,....,g$ are defined by

$$X_{ij}^K = \underset{s=i,d}{CES}\left(X_{(is)j}^K\right) \qquad (4.17)$$

where,

$X_{(id)j}^K$ = inputs of good i from domestic source

$X_{(im)j}^K$ = inputs of good i from imported source

Production of fixed capital requires only intermediate inputs. It does not require any direct inputs of primary factors, other cost tickets or industry subsidies. Furthermore, it is assumed that fixed capital is created competitively and efficiently and producers of capital for industry j treat input prices as beyond their control. Hence, for any given level of capital creation Y_j, they choose

$X_{(is)j}^K$, $\quad i = 1,....,g \quad s = d, m$

To minimise

$$\sum_{i=1}^{g}\sum_{s=1}^{2} P_{(is)j}^K X_{(is)j}^K \qquad (4.18)$$

Subject to (4.16) and (4.17), where $P_{(is)j}^K$ is the price of good i from source s, when it is used as an input for creating capital for industry j. Solving the cost minimisation problem yields the percentage change version of the equation as follows:

$$x_{(is)j}^K = y_i - \sigma_{ij}^K\left(p_{(is)j}^K - \sum_{s=1}^{2} S_{(is)j}^K p_{(is)j}^k\right) \qquad (4.19)$$

$S^K_{(is)j}$ in this equation is the share of good *i* from source *s* in the total cost of good *i* used for capital creation in industry *j*. σ^K_{ij} is the elasticity of substitution between domestic and imported good *i* as inputs for capital creation.

Equation (4.19) can be interpreted as if there are no changes in the relative prices of good *i* from different sources, then a 1 per cent increase in y_i results in a one per cent increase in $x^K_{(is)j}$, for all *i* and *s* representing the assumption of constant returns to scale. When we consider the case of the price of imported inputs rising relative to the price of domestically produced inputs, then $x^K_{(is)j}$ will increase less rapidly than y_i, since there is a substitution against the imported inputs in favour of domestic inputs. The strength of substitution is determined by σ^K_{ij}.

4.4 Household demand

Contrasting to the ORANI model, the households are divided into nine groups on the basis of geographical area, specifically based on the provinces of Sri Lanka. It is assumed that there are Q_k number of households in each household group *k*. A utility-maximising model expresses household demands in the model. Households are assumed to be utility-maximising agents, consuming both domestic and imported goods. The utility function used in the model is in the form of the Stone-Geary utility function/ Linear Expenditure System (LES). This facilitates the substitution between composite commodities. Substitution between imported and domestic consumer goods by each household group is allowed by using a CES functional form (Figure 4.3).

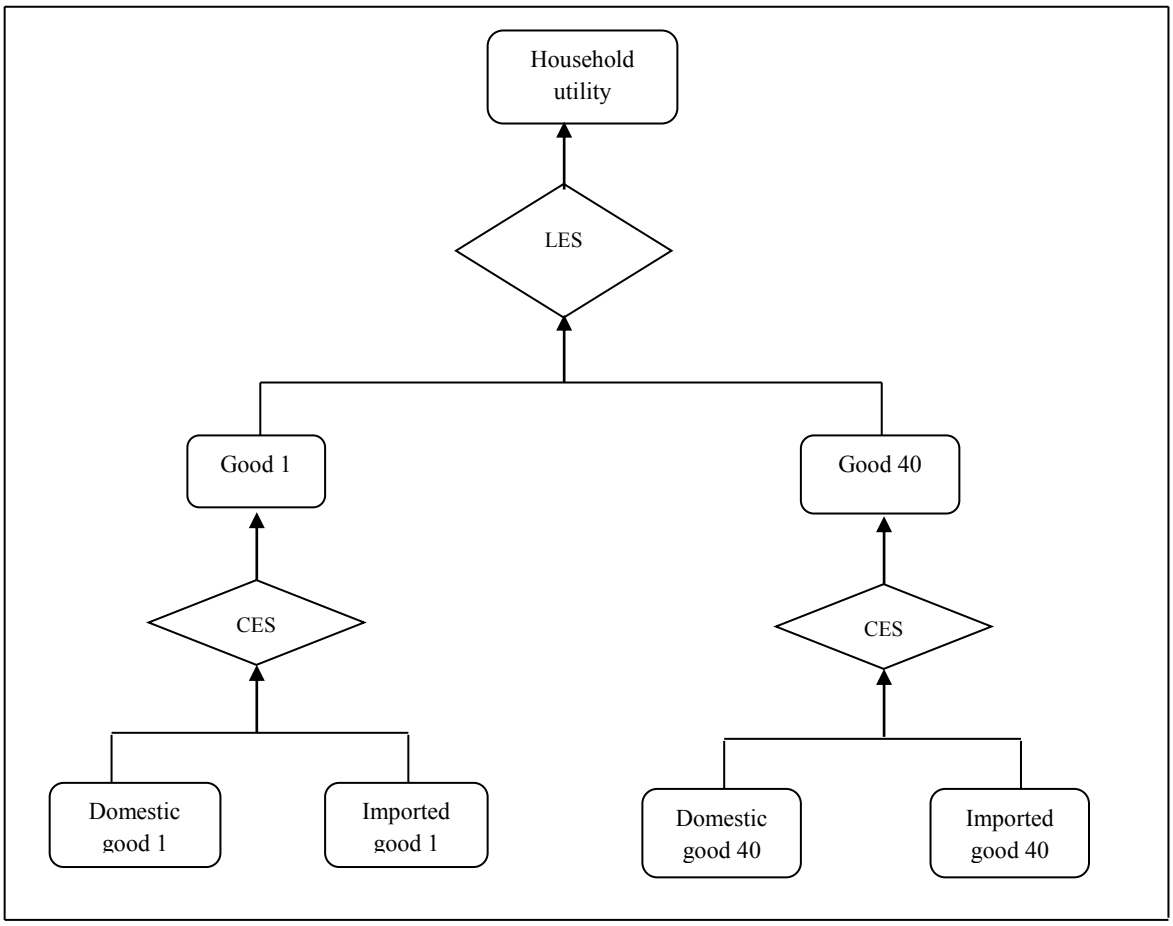

Figure 4.3: Structure of consumer demand

Source: Horridge (2007)

It is assumed that the consumption bundle of effective inputs for the average household in group k, X_{ik}^{H} / Q_k, where k $k = 1,...,9$ representing the household group and Q_k is the number of households in group k and $i = 1,..., g$ is chosen to maximise

$$U\left[\overline{X}_{1k}^{H},.....,\overline{X}_{gk}^{H}\right] \qquad (4.20)$$

Subject to

$$\overline{X}_{ik}^{H} = \underset{s=1,2}{CES}\left[\overline{X}_{(is)k}^{H}\right], \qquad i = 1,..., g \qquad (4.21)$$

and

$$\sum_{s=1}^{2}\sum_{i=1}^{g}\overline{P}_{(is)k}^{H}\overline{X}_{(is)k}^{H}=C_k \tag{4.22}$$

where,

$$\overline{X}_{ik}^{H}=X_{ik}^{H}/Q_k, \qquad i=1,...,g \tag{4.23}$$

$$\overline{X}_{(is)k}^{H}=X_{(is)k}^{H}/Q_k, \qquad i=1,...,g \tag{4.24}$$

and

$$\overline{P}_{(is)k}^{H}=P_{(is)k}^{H}Q_k, \qquad i=1,...,g \tag{4.25}$$

$X_{(is)k}^{H}$ and $P_{(is)k}^{H}$, $i=1,...,g$, $s=d,m$ are the quantities consumed and prices paid by household group *k* for units of good *i* from source *s*, with $s=d$ referring to domestic sources and $s=m$ referring to imported sources. C_k is the aggregate consumer budget for household group *k*. Solving the maximisation problem using the LES yields the household demands for goods and the prices paid by the household that can be given in the percentage change form as

$$x_{(is)k}^{H}=x_{ik}^{H}-\sigma_{ik}^{H}\left[p_{(is)k}^{H}-\sum_{s=1}^{2}S_{(is)k}^{H}p_{(is)k}^{H}\right] \tag{4.26}$$

$$p_{ik}^{H}=\sum_{s=1}^{2}S_{(is)k}^{H}p_{(is)k}^{H} \tag{4.27}$$

$$x_{ik}^{H}-q_k=\varepsilon_{ik}(c_k-q_k)+\sum_{r}\eta_{(ir)k}p_{rk}^{H} \tag{4.28}$$

$S_{(is)k}^{H}$ is the share of commodity *i* from source *s* in the total consumer spending on commodity *i*. σ_{ik}^{H} is the elasticity of substitution between domestic and imported commodity *i*. ε_{ik} and $\eta_{(ir)k}$ are defined as expenditure and own (and cross) price elasticities. ε_{ik} measures the effects on per household consumption of effective units of good *i* as a result of a one per cent increase in average household expenditure. $\eta_{(ir)k}$ measures the effects on per household consumption of

effective unit of good *i* as a result of one per cent increase in the general price of commodity *k*. The general price index is defined in (4.27).

4.5 Demand for exports

Export demand functions describe the foreign demands for domestically produced goods. To model export demands commodities in the model, we split goods into two groups, namely, traditional export commodities and non-traditional export commodities: (i) individual export commodities for which export demand is inversely related to that commodity's price (these commodities are identified as traditional export commodities in the model); (ii) remaining commodities defined as collective exports for which export demand is inversely related to the average price of all collective export commodities (these commodities are identified as non-traditional commodities in the model).

It is assumed that the demand for Sri Lankan exports is given by

$$X^{E}_{(id)} = F^{E}_{(Qi)} \left[\frac{P^{E}_{(id)} / PHI}{F^{E}_{(Pi)}} \right]^{\gamma_i} \qquad (4.29)$$

where

$X^{E}_{(id)}$ = volume of exports of good *i*

$P^{E}_{(id)}$ = price per unit of export of good *i*

PHI = exchange rate

$P^{E}_{(id)} / PHI$ = price in foreign currency

$F^{E}_{(Qi)}$ = shift variable which represents a horizontal (quantity) change in the demand schedule

$F^{E}_{(Pi)}$ = shift variable which represents a vertical (price) change in the demand schedule

γ_i = foreign elasticity of demand

The percentage-change form of (4.29) is given by,

$$x^E_{(id)} - f^E_{(Qi)} = \gamma_i (p^E_{(id)} - phi - f^E_{(Pi)}) \qquad (4.30)$$

4.6 Government demand

The only remaining element of final demands is government demand. Government demands both imported and domestically produced goods and services. It is assumed that government buys goods and services only and has no direct demands for labour or other primary factors. Instead it buys from service industries which employ primary factors. Therefore, the government demand is given by

$$X^G_{(is)} = C_R h^G_{(is)} F^G_{(is)} \qquad i = 1,....,g \qquad s = d,m \qquad (4.31)$$

$$C_R = \frac{C}{\xi^H} \qquad (4.32)$$

where,

$X^G_{(is)}$ = government demand for good *i* from source *s*

C_R = real aggregate household expenditure

$F^G_{(is)}$ = shift variables

$h^G_{(is)}$ = ratio between overall shift in government demand and real aggregate household consumption

ξ^H = CPI

The percentage-change form of the above equations is as follows,

$$x^G_{(is)} = c_R + h^G_{(is)} + f^G_{(is)} \qquad (4.33)$$

$$c_R = c - \xi^H \qquad (4.34)$$

Setting the parameter $h^G_{(is)}$ at one and shift variable $f^G_{(is)}$ at zero allows government demand to move in line with real household expenditure. When $h^G_{(is)}$ parameters are set at zero it allows

government demand to be determined exogenously. This brings the possibility of introducing various exogenous shifts in government demand.

4.7 The price system

The ORANI model uses several sets of commodity prices: purchaser's prices, basic values, prices of capital units, FOB foreign currency export prices and CIF foreign currency import prices. This section demonstrates the association between these groups of domestic prices, along with their relation to the foreign currency price of exports and imports. There are two initial assumptions used to set out the system of pricing. They are,

1. There are no pure profits in any economic activity (producing, importing, exporting, etc.)

2. Basic values are uniform across users and across producing industries in the case of domestic goods, and importers in the case of imported goods. Basic values for domestic goods are the prices received by producers excluding sales taxes. For imports, the basic values are the prices received by the importers. Sales taxes associated with deliveries from the ports to domestic users are excluded, but import duties are included in the basic values.

Based on those two assumptions, the basic value of output of industry *j* is equal to the total payments for inputs by industry *j*, which is implied by the assumptions of no pure profits.

This is given by the equation,

$$\sum_{i=1}^{g} P_{(id)}^{(0)} X_{(id)j}^{(0)} = \sum_{i=1}^{g}\sum_{s=1}^{2} P_{(is)j} X_{(is)j} + \sum_{m=1}^{M} P_{(g+1,L,m)j} X_{(g+1,L,m)j}$$
$$+ \sum_{s=K}^{N} P_{(g+1,s)j} X_{(g+1,s)j} + P_{g+2,j} X_{g+2,j} + P_{g+3,j} X_{g+3,j} \qquad j = 1,....,h \tag{4.35}$$

The notation used in this equation is the same as in previous sections.

The percentage-change form can be written as,

$$\sum_{i=1}^{g}(p_{(id)}^{(0)}x_{(id)j}^{(0)})H_{(id)j}^{(0)} = \sum_{i=1}^{g}\sum_{s=1}^{2}(p_{(is)j}x_{(is)j})H_{(is)j} + \sum_{m=1}^{M}(p_{(g+1,L,m)j}x_{(g+1,L,m)j})H_{(g+1,L,m)j}$$
$$+\sum_{s=K}^{N}(p_{(g+1,s)j}x_{(g+1,s)j})H_{(g+1,s)j} + (p_{g+2,j}x_{g+2,j})H_{g+2,j} + (p_{g+3,j}x_{g+3,j})H_{g+3,j} \quad (4.36)$$

The H's are revenue and cost shares. $H_{(is)j}$, $H_{(g+1,L,m)j}$, $H_{(g+1,s)j}$, $H_{g+2,j}$ and $H_{g+3,j}$ are the shares of the total cost of industry *j* accounted for by inputs of commodity *i* from source *s*, by inputs of labour from different occupation groups *m*, by inputs of capital and land, by other cost tickets and by production subsidies, respectively. Due to the assumption of constant returns to scale, both revenue and cost per unit of output are independent of the activity level. They are influenced only by the changes in prices and technology. Therefore, all quantity terms are dropped in this equation leaving only prices and technology terms. The resulting equation can be written as,

$$\sum_{i=1}^{g}p_{(id)}^{(0)}H_{(id)j}^{0} = \sum_{i=1}^{g}\sum_{s=1}^{2}p_{(is)j}H_{(is)j} + \sum_{m=1}^{M}p_{(g+1,L,m)j}H_{(g+1,L,m)j} + \sum_{s=2}^{3}p_{(g+1,s)j}H_{(g+1,s)j}$$
$$+p_{g+2,j}H_{g+2,j} + p_{g+3,j}H_{g+3,j} + a_j + \sum_{i=1}^{g+3}a_{ij}H_{ij} + \sum_{s=1}^{3}a_{(g+1,s)j}H_{(g+1,s)j} \quad (4.37)$$

This equation indicates that when there is no technical change, weighted average of the percentage changes in the basic prices of outputs is equal to the weighted average of the percentage changes in the relevant purchasers' prices of inputs.

For the creation of fixed capital, the price of capital is given by,

$$\Pi_j Y_j = \sum_{i=1}^{g}\sum_{s=1}^{2}P_{(is)j}^{K}X_{(is)j}^{K} \qquad j = 1,....,h \qquad (4.38)$$

This equation imposes the zero pure profit condition: the value of new capital equals the cost of its production.

In percentage-change form,

$$\pi_j = \sum_{i=1}^{g}\sum_{s=1}^{2} p^K_{(is)j} H^K_{(is)j} \qquad j = 1,....,h \qquad (4.39)$$

$\prod_j$ is the price of a unit of fixed capital and Y_j is the level of fixed capital created in industry *j*. At this point, it is essential to be familiar with the difference between $\prod_j$ and $P_{(g+1,s)j}$. As introduced in section 4.2, $P_{(g+1,s)j}$ is the cost of using or renting a unit of capital for industry *j* and $\prod_j$ is the cost of buying or producing a unit of capital for industry *j*. This equation denotes that percentage change in the cost of a unit of capital in industry *j* is a weighted average of the percentage changes in the price of inputs. The weights are cost shares.

For imports, the basic price is equal to the CIF price plus tariffs.

$$P^{(o)}_{(im)} = P^m_{im}\Phi G_{(im,0)} \qquad i = 1,....,g, \qquad (4.40)$$

where,

$P^{(o)}_{(im)}$ = Basic price of imported good *i* (the price received by Sri Lankan importers, excluding transport and other margin costs involved in transferring imports from Sri Lankan ports to final users)

P^m_{im} = Foreign currency CIF price of imported units of good *i*

Φ = Exchange rate

$G_{(im,0)}$ = Power of tariff in rupees per unit of imported good *i* equal to $(1+T_{(m,i)})$

In percentage-change form it becomes,

$$p^{(0)}_{(im)} = (p^m_{(im)} + \phi) + \zeta_{(im)} t_{(M,i)} \qquad (4.41)$$

where,

$\zeta_{(im)}$ = The share in basic price of (im) accounted for by the foreign currency price in Sri Lankan rupees $(p^m_{(im)} + \phi)$ including tariffs

$t_{(M,i)}$ = Power of tariff which is equal to (1+t)

Similarly, the relationship between prices of domestic goods and export prices is given by,

$$P^{E}_{(id)}\Phi = P^{(0)}_{(id)}G_{(Ei)} \qquad i = 1,....,g, \qquad (4.42)$$

where,

$P^{E}_{(id)}\Phi$ = Sri Lankan currency paid by foreigners for units of good (*id*) at Sri Lankan ports. That is the foreign currency FOB price $P^{E}_{(id)}$, converted to local currency through the exchange rate Φ

$P^{(0)}_{(id)}$ = basic price of good (*id*)

$G_{(Ei)}$ = The power of export tax per unit export of (*id*) which is equal to ($1+T_{(E,i)}$). If there is an export subsidy, $G_{(Ei)}$ is equal to ($1-T_{(E,i)}$)

The percentage-change form of the equation is expressed as,

$$p^{E}_{(id)} + \phi = p^{(0)}_{(id)} + \zeta_{t(Ei)}t_{(E,i)} \qquad (4.43)$$

Finally, the following set of price equations relates the various purchasers' prices paid by domestic users of good *i* (industries, households, and government) from source *s* for current production, capital creation, and household consumption to its basic value.

$$P^{u}_{(is)j} = P^{(0)}_{(is)}G_{(is,ju)} \qquad (4.44)$$

where G's represent power of tax or one plus tax rate (or one less the subsidy). For example, $G_{(is,ju)}$ is the power of tax associated with the sale of good *i* from source *s* to industry *j* for purpose *u*.

$$P_{(is)j} = P^{(0)}_{(is)}G_{(Ip,is)j}, \qquad i = 1,....,g, \qquad s = d,m \qquad j = 1,....,h, \qquad (4.45)$$

$$P^{K}_{(is)j} = P^{(0)}_{(is)}G_{(K,is)j} \qquad i = 1,....,g, \qquad s = d,m、 \qquad j = 1,....,h, \qquad (4.46)$$

The equations above link the prices paid in industry *j* for good *i* from source *s* to be used for the purpose *u* (that is for current production and capital formation) to the sum of the basic value of good (*is*) and the relevant taxes. The next two equations portray the purchasers' price of good (*is*) used by the households and government.

$$P^{H}_{(is)j} = P^{(0)}_{(is)} G_{(H,is)k} \qquad i = 1,....,g, \qquad s = d,m \tag{4.47}$$

$$P^{G}_{(is)j} = P^{(0)}_{(is)} G_{(G,is)} \qquad i = 1,....,g, \qquad s = d,m \tag{4.48}$$

The percentage-change forms of the equations are as follows.

$$p_{(is)j} = p^{(0)}_{(is)} + \zeta_{t(Ip,is)j} t_{(Ip,is)j} \tag{4.49}$$

$$p^{K}_{(is)j} = p^{(0)}_{(is)} + \zeta_{t(K,is)j} t_{(K,is)j} \tag{4.50}$$

$$p^{H}_{(is)k} = p^{(0)}_{(is)} + \zeta_{t(H,is)k} t_{(H,is)} \tag{4.51}$$

$$p^{G}_{(is)k} = p^{(0)}_{(is)} + \zeta_{t(G,is)} t_{(G,is)} \tag{4.52}$$

$G_{(Ip,is)j}$, $G_{(K,is)j}$, $G_{(H,is)k}$ and $G_{(G,is)}$ are the power of tax on current production, capital formation, household consumption and government consumption.

4.8 Household income and consumption

It is assumed that the household sector owns the primary factors of production. Therefore, household income is assumed to be comprised of primary factor incomes. Hence, household income is given by

$$Y^{H} = \sum_{j=1}^{h}\sum_{m=1}^{M} P_{(g+1,L,m)j} X_{(g+1,L,m)j} + \sum_{j=1}^{h} (P_{(g+1,k)j} X_{(g+1,k)j} + \sum_{j=1}^{h} P_{(g+1,N)j} X_{(g+1,N)j} \tag{4.53}$$

The consumption function of the household *k* is given by

$$C_k = F_k^H F^H Y^D \qquad (4.54)$$

where, Y^D is the disposable income, F_k^H is the ratio of household *k*'s consumption to aggregate household expenditure and F^H is the ratio of aggregate household expenditure to total household disposable income. When T_Y is assumed to be the flat rate of tax on total household income, the household disposable income is calculated as

$$Y^D = Y^H (1 - T_Y) \qquad (4.55)$$

Then the consumption function can be written as

$$C_k = F_k^H F^H Y^H (1 - T_Y) \qquad (4.56)$$

The disposable income of household *k* is described as

$$Y_k^D = \prod_{k=1}^{9} \left[Y^H (1 - T) \right]^w \qquad (4.57)$$

The aggregate household expenditure is set by

$$C = \sum_{k=1}^{9} C_k \qquad (4.58)$$

The linearised versions of the above equations are as follows.

$$y^H = \sum_{j=1}^{h} \sum_{m=1}^{M} (p_{(g+1,L,m)} x_{(g+1,L,m)}) J_{(g+1,L,m)j}^H + \sum_{j=1}^{h} p_{(g+1,K)j} x_{(g+1,K)j} J_{(g+1,K)j}^H$$
$$+ \sum_{j=1}^{h} p_{(g+1,N)j} x_{(g+1,N)j} J_{(g+1,N)j}^H \qquad (4.59)$$

$$c_k = f_k^H + f^H + y^H - \left(T_Y \big/ 1 - T_Y \right) t_Y \qquad (4.60)$$

$$y_k^D = \sum_{k=1}^{9} w [y^H - (T_Y \big/ 1 - T_Y)] t_Y \qquad (4.61)$$

$$c = \sum_{k=`}^{9} c_k \psi_k \qquad (4.62)$$

where, w's are the shares of household k's income in total household income and ψ_k is the share of household k's consumption in total household consumption.

4.9 The allocation of investment across industries

Section 4.3 described the technology for creating units of capital. The investment theory introduced in the ORANI model does not attempt to explain aggregate private investment in fixed plant, machinery and buildings. The model only explains how this investment is allocated across using industries.

The first step in allocating investment across industries is to note that current net rate of return on fixed capital in industry j, $R_j(0)$ depends on rate of depreciation, d_j, which is assumed as fixed, the rental cost of capital $P_{(g+1,K)j}$, and cost of a unit of capital in industry j $\prod_j$.

$$R_j(0) = \frac{P_{(g+1,K)j}}{\prod_j} - d_j \qquad (4.63)$$

Here, it is assumed that capital in industry j takes one period to install. This period can be some number of years for different industries. Exact calendar time is not important since the model is a static one.

The industry j's rate of return in one period's time will have the form

$$R_j(1) = R_j(0)\left(\frac{K_j(1)}{K_j(0)}\right)^{-\beta_j} \qquad (4.64)$$

This shows the relationship between expected rate of return $R_j(1)$ and the ratio of current level of capital stock $K_j(0)$, and the level of capital stock at the end of one period $K_j(1)$. β_j is a positive parameter. This shows that investors are cautious in assessing the effects of expanding the capital stock in industry j.

The next step is to assume that total private investment expenditure I in the economy, is allocated across industries so as to equate the expected rates of return. This is applied only for those industries for which investment is explained within the model. This means that there exists some rate of return Ω, such that;

$$\left(\frac{K_j(1)}{K_j(0)}\right)^{-\beta_j} R_j(0) = \Omega, \qquad j \in J \qquad (4.65)$$

where J is a subset of [1,2,….,h] which contains the identifying numbers of those industries where investment is treated as endogenous. Most of the time, J would exclude industries that are dominated by government activity.

Then, it is assumed that only current capital stock and current level of investment affect the capital stock at the end of one period.

$$K_{(j)}(1) = K_{(j)}(0)(1 - d_j) + Y_j \qquad j = 1,....,h, \qquad (4.66)$$

Further, it is assumed that effects of past investment decisions are fully integrated in the current capital stock. Equation (4.67) defines the private investment budget as the sum of investment expenditure across those industries.

$$I = \sum_{j \in J} \Pi_j Y_j \qquad (4.67)$$

Finally, it is considered that the rate of return theory used above is not appropriate for those industries $j \notin J$. The following equations are used for such industries.

$$Y_j = (I_R)^{h_j^K} F_j^{(K)} \qquad j \notin J \qquad (4.68)$$

where

$$I_R = I / \Xi^K \qquad (4.69)$$

where,

Ξ^K = ORANI capital-goods price index

I_R = real level of private investment

$F_j^{(K)}$ = shift variable

In percentage-change form, investment allocation equations may be expressed as follows:

$$r_j(0) = Q_j(p_{(g+1,K)j} - \pi_j) \qquad j = 1,....,h, \qquad (4.70)$$

$$-\beta_j\left(k_j(1) - k_j(0)\right) + r_j(0) = \omega \qquad j \in J \qquad (4.71)$$

$$k_j(1) = k_j(0)\left(1 - G_j\right) + y_j G_j \qquad j = 1,....,h, \qquad (4.72)$$

$$\sum_{j \in J}\left(\pi_j + y_j\right)\lambda_j = \left(\sum_{j \in J}\lambda_j\right) i \qquad (4.73)$$

$$y_j = h_j^K i_R + f_j^K \qquad j \notin J \qquad (4.74)$$

$$i_R = i - \xi^K \qquad (4.75)$$

Where, Q_j is the ratio of gross rate of return in industry j to the net rate of return. G_j is the ratio of gross investment in industry j to its future capital stock. λ_j is the share of total aggregate fixed investment accounted for by industry j.

4.10 Market clearing equations

This section details the equations which guarantee that demand equals supply for domestically produced commodities and for the primary factors of production. The equations for domestic commodities are,

$$X_{(rd)}^{(0)} = \sum_{j=1}^{h} X_{(rd)j} + \sum_{j=1}^{h} X_{(rd)j}^{K} + \sum_{k=1}^{9} X_{(rd)k}^{H} + X_{(rd)}^{G} + X_{(rd)}^{E} \qquad r = 1,....,g, \qquad (4.76)$$

where,

$$X_{(rd)}^{(0)} = \sum_{j=1}^{h} X_{(rd)j}^{(0)} \qquad r = 1,....,g, \qquad (4.77)$$

Equation (4.77) equates supply $X_{(rd)}^{(0)}$ and the demand for each of the domestically produced goods (*rd*), $r = 1,.....,g$. Total supply is equal to the sum over industry outputs of (*rd*). Total demand is comprised of demand for intermediate inputs to current production $X_{(rd)j}$, demand for inputs to the creation of capital equipment $X_{(rd)j}^{K}$, demand for consumption goods $X_{(rd)k}^{H}$, government purchases $X_{(rd)}^{G}$ and export demand $X_{(rd)}^{E}$. It is important to note the absence of imported products. This is explained by the fact that ORANI treats imports of good *i* as a separate product from domestically produced *i*.

Market clearing equations for primary factors are,

$$L_m = \sum_{j=1}^{h} X_{(g+1,L,m)j} \qquad m = 1,....,M, \qquad (4.78)$$

$$K_j(0) = X_{(g+1,K)j} \qquad j = 1,....,h, \qquad (4.79)$$

$$N = X_{(g+1,L)j} \qquad j = 1,....,h, \qquad (4.80)$$

Equation (4.78) equates the supply of labour of skill m, L_m to the demand for it. It implies that labour is homogenous within each skill group and is shiftable between industries. To simulate full-employment, L_m can be set exogenously at their full-employment levels. Equation (4.79) equates supply and demand for capital in each industry. Capital is assumed to be industry specific and non-shiftable between industries. Equation (4.80) confirms the equity between the demand for, and supply of, agricultural land in each industry. It is assumed that the land is non-shiftable between industries as in the case of capital.

Percentage-change forms of the equations are

$$x_{(rd)}^{(0)} = \sum_{j=1}^{h} x_{(rd)j} B_{(rd)j} + \sum_{j=1}^{h} x_{(rd)j}^{K} B_{(rd)j}^{K} + \sum_{k=1}^{9} x_{(rd)k}^{H} B_{(rd)k}^{H} + x_{(rd)}^{G} B_{(rd)}^{G} + x_{(rd)}^{E} B_{(rd)}^{E} \qquad (4.81)$$

$$x_{(rd)}^{(0)} = \sum_{j=1}^{h} x_{(rd)j}^{(0)} B_{(rd)j}^{(0)} \qquad r = 1,....,g, \qquad (4.82)$$

$$l_m = \sum_{j=1}^{h} x_{(g+1,L,m)j} B_{(g+1,L,m)j} \qquad m = 1,....,M, \qquad (4.83)$$

$$k_j(0) = x_{(g+1,K)j} \qquad j = 1,....,h, \qquad (4.84)$$

$$n_j = x_{(g+1,L)j} \qquad j = 1,....,h, \qquad (4.85)$$

B's appearing in the equation (4.81) are the shares of domestically produced goods which are occupied by the various types of demands. The B's in equation (4.82) are production shares and B's in equation (4.83) are employment shares.

4.11 Aggregate imports, exports and the balance of trade

Aggregate demand for imported good r, $r = 1,....,g$, is indicated by $X^{M}_{(rm)}$ and worked out as

$$X^{M}_{(rm)} = \sum_{j=1}^{h} X_{(rm)j} + \sum_{j=1}^{h} X^{K}_{(rm)j} + \sum_{k=1}^{9} X^{H}_{(rm)k} + X^{G}_{((rm)} \qquad r = 1,....,g, \tag{4.86}$$

Aggregate value of imports M, in foreign currency cost is given by,

$$M = \sum_{r=1}^{g} P^{M}_{(rm)} X^{M}_{(rm)} \tag{4.87}$$

In percentage-form, these equations are,

$$x^{M}_{(rm)} = \sum_{j=1}^{h} x_{(rm)j} B^{IP}_{(rm)j} + \sum_{j=1}^{h} x^{K}_{(rm)j} B^{K}_{(rm)j} + \sum_{k=1}^{9} x^{H}_{(rm)k} B^{H}_{(rm)k} + x^{G}_{((rm)} B^{G}_{(rm)} \tag{4.88}$$

$$m = \sum_{r=1}^{g} (p^{M}_{(rm)} + x^{M}_{(rm)}) M_{(rm)} \tag{4.89}$$

where, $M_{(rm)}$ is the share of aggregate foreign currency cost of commodity imports which is accounted for by imports of good *r*. B's appearing in equation (4.88) are the shares of good *r* accounted for by current production, capital creation, household consumption and government consumption in total imports of good *r*, respectively.

Similarly, the aggregate foreign currency receipts E, from commodity exports is described by

$$E = \sum_{r=1}^{g} P^{E}_{(rd)} X^{E}_{(rd)} \tag{4.90}$$

Percentage-change form is,

$$e = \sum_{r=1}^{g} (p^{E}_{(rd)} + x^{E}_{(rd)}) E_{(rd)} \tag{4.91}$$

where, $E_{(rd)}$ is good *r*'s share in aggregate export revenue.

Finally, the balance of trade on commodity account is given by

$$B = (E - M) \tag{4.92}$$

This gives,

$$100\Delta B = Ee - Mm \tag{4.93}$$

Note that ΔB is the change in B, not the percentage change. That is because B can either be negative or positive. This is the only variable in the model which requires units.

4.12 Macro indices and wage indexation

During the previous explanations on government demands and investment allocations, ξ^H and ξ^K were introduced as the percentage changes in the consumer and capital-goods price indices. ξ^H is defined as follows,

$$\xi^H = \sum_{s=1}^{2}\sum_{i=1}^{g} w_{(is)}^H p_{(is)}^H \tag{4.94}$$

$w_{(is)}^H$ = Share of aggregate consumer spending devoted to good *i* from source *s*

ξ^H = Weighted averages of the percentage changes in the purchasers' prices of consumer goods

The capital-goods price index is explained by

$$\xi^H = \sum_{j \in J} \bar{\lambda}_j \pi_j \tag{4.95}$$

where, $\bar{\lambda}_j = \lambda_j / \sum_{j \in J} \lambda_j$, that is the share of total private investment expenditure accounted for by industry *j*.

Other helpful macroeconomic indices consist of aggregate employment (L), aggregate capital stock in base-period value units (K(0)) and the ratio of real private investment expenditure to real private consumption (F_R). Percentage changes in these are given by,

$$l = \sum_{m=1}^{M} l_m \psi_{Lm} \tag{4.96}$$

$$k(0) = \sum_{j=1}^{h} k_j(0) \psi_{Kj} \tag{4.97}$$

and,

$$f_R = i_R - c_R \tag{4.98}$$

where, ψ_{Lm} is the share of skill m in total employment and ψ_{Kj} is the share of capital of type *j* (value at base-period prices) in the total value of fixed capital for the economy. The next equations allow wages ($p_{(g+1,L,m)j}$), prices of other cost tickets $p_{(g+2,j)}$ and production subsidies $p_{(g+3,j)}$ to be indexed to the CPI.

$$p_{(g+1,L,m)j} = h_{(g+1,L,m)j}\xi^H + f_{(g+1,L)} + f_{(g+1,L)j} + f_{(g+1,L,m)} + f_{(g+1,L,m)j} \tag{4.99}$$
$$m = 1,....,M, \quad j = 1,....,h,$$

$$p_{(g+2,j)} = h_{g+2,j}\xi^H + f_{g+2,j} \qquad j = 1,....,h, \tag{4.100}$$

and,

$$p_{(g+3,j)} = h_{g+3,g}\xi^H + f_{g+3,j} \qquad j = 1,....,h, \tag{4.101}$$

where, *f*'s are shift variables and *h*'s are parameters. Full wage indexation can be attained via setting $h_{(g+1,L,m)j}$ at one for all *m* and *j* and all the *f*'s in (4.99) at zero. The shift variables add flexibility to the equation. Overall changes in real wages and variations in industrial wages can be generated by manipulating the *f*'s.

The GDP can be expressed from both the income side and the expenditure side. GDP calculation from the income side consists of total payments to factors of production and total tax collection, while GDP from expenditure side takes account of total household

consumption, total investment, total government and other expenditure and total exports less imports. The latter relationship can be given by the expression

$$GDP = \sum_k C_k + \sum_j Yj + \sum_i X_{is}^G + (E\phi - M\phi) \qquad (4.102)$$

This can be expanded in terms of prices and quantities.

$$GDP = \sum_{i=1}^{g}\sum_{s=1}^{2}\sum_{k=1}^{9}(P_{(is)k}^H X_{(is)k}^H) + \sum_{i=1}^{g}\sum_{s=1}^{2}\sum_{j=1}^{h}(P_{(is)k}^K X_{(is)k}^K) + \sum_{i=1}^{g}\sum_{s=1}^{2}(P_{(is)}^G X_{(is)}^G)$$
$$+ \sum_{i=1}^{g}(P_{(id)}^E X_{(id)}^E) - \sum_{i=1}^{g}(P_{(im)}^M X_{(im)}^M \phi) \qquad (4.103)$$

The percentage-change form is written as,

$$gdp = \sum_{i=1}^{g}\sum_{s=1}^{2}\sum_{k=1}^{9}(p_{(is)k}^H + x_{(is)k}^H)S_{gdp,k}^H + \sum_{i=1}^{g}\sum_{s=1}^{2}\sum_{k=1}^{9}(p_{(is)j}^K + x_{(is)j}^K)S_{gdp,j}^K + \sum_{i=1}^{g}\sum_{s=1}^{2}(p_{(is)}^G + x_{(is)}^G)S_{gdp,is}^G$$

$$+ \sum_{i=1}^{g}(p_{(id)}^E + x_{(id)}^E)S_{gdp,i}^E - \sum_{i=1}^{g}(p_{(im)}^M + x_{(im)}^M + \phi)S_{gdp,i}^M \qquad (4.104)$$

where, S 's are the shares of each final demand categories in total GDP.

Finally, we derive equations for average nominal wage and for real wage in percentage change form. Average wage is the weighted sum of the wage rates across different occupational groups and real wage is the average wage divided by the CPI. The expressions for the above are given respectively as

$$p_{(g+1,L)} = \sum_{j=1}^{h}\sum_{m=1}^{M} p_{(g+1,L,m)j} w_{(g+1,L)mj} \qquad (4.105)$$

$$realwage = p_{(g+1,L)} - \xi^H \qquad (4.106)$$

4.13 Theoretical structure of regional disaggregation

Along with the development of national CGE models, the development of regional CGE models has shown significant progress. There are two broad approaches used for generating regional results in CGE modelling: the tops-down approach and the bottoms-up approach (Dixon & Rimmer, 2003). This section provides the rationale for selecting the most appropriate method for representing regional disaggregation in this study; that is the tops-down approach.

Tops-down approach

The tops-down approach was initiated by Leontief, Morgan, Polenske, Simpson, and Tower in 1965 by disaggregating results from an input-output model to the fifty US states. Their method was revised to CGE modelling by Dixon, Parmenter, and Sutton in 1978 by disaggregating results from a CGE model to the six Australian states (Dixon & Rimmer, 2003, p. 1).

This is the simplest approach to regional modelling. It involves disaggregation of national level results into regional levels using relevant regional shares. The main feature of this approach is the division of the commodities in the model into two groups: national and local commodities. National commodities include commodities that are traded extensively across regions. Local commodities include commodities produced and consumed within regions. The regional output levels of those two groups are derived using different assumptions. For national industries, it is assumed that output growth in each region moves in line with the output growth of that industry at national level. That is, the growth of a national industry in a region is independent of economic activities in that region. In contrast, outputs of local commodities in each region are derived from local demands. Thus, outputs of these commodities in each region can be different from the outputs of the corresponding commodities at the national level.

This approach is subject to some limitations. The first limitation is the dichotomy between local and national commodities which may lead to distorting effects on regional results. Secondly, the assumption that industry technology is the same across the region, and national industries in all regions move in line with national industries at the national level can overlook

the importance of differences between regions. Thirdly, changes in regional outputs of national and local commodities are considered to be independent of resource constraints. Therefore, a possible crowding-out effect of the growth of a regional industry on other regional industries can be ignored. Finally, it is less capable of modelling region-specific supply effects, as the tops-down approach does not contain theory of regional variation in prices. It is useful mainly to disaggregate regional effects of shocks to the economy at national level (Horridge, 2007, p. 55; Pham, 2003, p. 7).

Bottoms-up approach

The bottoms-up approach explains economic activity at the regional level and obtains national results by aggregation of regional results. In this approach, the regions are considered as a group of distinct trade economies. Each region is represented via a separate CGE model and all multi-regional CGE models link through trade and primary factor flows. Both prices and quantities can vary independently by the region in these multi-regional models. Because of this, these models have the capacity to shed light on policies that affect relative costs across regions. However, data requirements for the bottoms-up models are enormous. Bottoms-up models require precise judgements about initial values for interregional trade flows. They also impose extensive computational burdens (Dixon & Rimmer, 2003, p. 10). There are several bottoms-up models constructed for developed countries like Australia (for more details see Pham, 2003).

By reviewing advantages and disadvantages of both regional modelling approaches, we select the tops-down approach as the appropriate choice for regional disaggregation of results in this study for the following reasons.

1. The tops-down approach is adequate for analysing regional impacts of economy-wide shocks.
2. The difficulty in finding appropriate data to develop independent regional CGE models for all the regions in Sri Lanka.

Regional disaggregation for the present model

The theoretical framework described in the previous sections creates the model that is capable of producing results at national level. To get a better understanding of the implications of many policies to the economy, regional disaggregation may be required. For example, policy makers in a country might be interested in the implications of certain policies at regional level as well as national level before they are implemented. This section describes the theory behind the regional disaggregation in the model, which is the tops-down approach. The method used here for disaggregation is an adaptation of that proposed by Leontief, Morgan, Polenske, Simpson, and Tower in 1965 (LMPST) (Dixon, et al., 1982). Here, we illustrate the modified LMPST approach that we employ.

The LMPST method used with ORANI

Regional ORANI computations can be conducted in a three-part way. The first part consists of projecting the economy-wide effects of the exogenous shock under consideration. The economy-wide activity levels in industries producing national commodities are assigned to the regions in exogenously given proportions in the second part; and in the third part, a system of commodity balance equations for each region is set up and solved to forecast regional outputs of local commodities. The notational principles implemented here include the use of

U to identify the set of all commodities;
K to identify the set of all industries;
N to identify the set of industries producing national commodities (i.e. national industries);
M to identify the set of industries producing local commodities (i.e. local industries);
H to identify the set of national commodities;
L to identify set of local commodities;
R to identify the number of regions.

The definition of symbols for the regional concept follows the definition for the corresponding economy-wide concept. For example, we use the variable $x_{(id)}^{(0)r}$ to denote the percentage change in the output of domestic commodity *i* in region *r*. This follows its economy-wide variable which we define earlier in the text, $x_{(id)}^{(0)}$, supply of commodities. For the purpose of

clarity, we use the following superscripts to identify intermediate production and final demands as opposed to the symbols we use earlier in the text.

Current production (1)
Capital formation ($K = 2$)
Household consumption ($H = 3$)
Exports ($E = 4$)
Other final demands ($G = 5$)

It is important to note that ORANI's industry and commodity classifications are such that no industry produces both national and local commodities.

4.13.1 The regional allocation of activity levels in national industries

Activity levels of national industries are allocated as

$$Z_n^r = Z_n G_n^r \text{ for all } n \in N \text{ and } r = 1,...,R \qquad (4.107)$$

where, G_n^r is the base-period proportion of the aggregate output of industry *n* which is produced in region *r*. Since it is a constant, equation (4.107) means

$$z_n^r = z_n \text{ for all } n \in N \text{ and } r = 1,...,R \qquad (4.108)$$

If there is a one per cent increase in the economy's aggregate output in a national industry, then output of this industry is assumed to increase by one per cent in each region.

4.13.2 The regional balance equations for local commodities

It is assumed that the aggregate output of any local commodity in a region be equal to aggregate demand for the commodity in the region.

$$X_{(id)}^{(0)r} = \sum_{n \in N} A_{(id)n}^{(1)} Z_n^r + \sum_{m \in M} A_{(id)m}^{(1)} Z_m^r + \sum_{n \in N} A_{(id)n}^{(2)} Z_n^r + \sum_{m \in M} A_{(id)m}^{(2)} Z_m^r + X_{(id)}^{(3)r} + X_{(id)}^{(5)r} + \sum_{u \in U} A_{(id)}^{(u1)4} X_{(ud)}^{(4)r} \qquad (4.109)$$

$i \in L$ and $r = 1,...,R$

where, $A^{(h)}_{(id)k}$ is the direct input of domestically produced commodity *i* required per unit output (*h*=1) or capital formation (*h*=2) in industry *k*.

The percentage-change form of this can be written as

$$x^{(0)r}_{(id)} = \sum_{n \in N}\left(a^{(1)}_{(id)n} + z^r_n\right)B^{(1)r}_{(id)n} + \sum_{m \in M}\left(a^{(1)}_{(id)m} + z^r_m\right)B^{(1)r}_{(id)m} + \sum_{n \in N}\left(a^{(2)}_{(id)n} + z^r_n\right)B^{(2)r}_{(id)n} + \sum_{m \in M}\left(a^{(2)}_{(id)m} + z^r_m\right)B^{(2)r}_{(id)m}$$
$$+ x^{(3)r}_{(id)}B^{(3)r}_{(id)} + x^{(5)r}_{(id)}B^{(5)r}_{(id)} + \sum_{u \in U}\left(a^{(u1)4}_{(id)} + x^{(4)r}_{(ud)}\right)B^{(u1)4r}_{(id)}$$

$i \in L$ and $r = 1,...,R$ (4.110)

where the B's are sales shares. It is assumed that there is no technical change for simplification purposes. Further simplification is possible if we assume that

$$B^{(us)khr}_{(id)} = B^{(u.)khr}_{id} S^{(h)r}_{(us)k} \qquad (4.111)$$

It says in the base-period that the relative quantities of good *(id)* used in facilitating the domestic and import components of each industry in each region indicate the relative values of these components. Then suppose (4.7) and (4.19) are valid at regional level, in the absence of technical change, we get

$$\sum_{s=d}^{m} x^{(1)r}_{(us)k} B^{(us)k1r}_{(id)} = z^r_k B^{(u.)k1r}_{(id)} \qquad (4.112)$$

$i \in L$, $u \in U$, $k \in K$ and $r = 1,...,R$

and

$$\sum_{s=d}^{m} x^{(2)r}_{(us)k} B^{(us)k2r}_{(id)} = z^r_k B^{(u.)k2r}_{(id)} \qquad (4.113)$$

$i \in L$, $u \in U$, $k \in K$ and $r = 1,...,R$

On setting technical change variables at zero and using (4.112) and (4.113), we could simplify (4.110) to get

$$x_{(id)}^{(0)r} = \sum_{n\in N}\left(B_{(id)n}^{(1)r} + \sum_{u\in U} B_{(id)}^{(u.)n1r} \right) z_n^r + \sum_{m\in M}\left(B_{(id)m}^{(1)r} + \sum_{u\in U} B_{(id)}^{(u.)m1r} \right) z_m^r \tag{4.114}$$

$$+ \sum_{n\in N}\left(B_{(id)n}^{(2)r} + \sum_{u\in U} B_{(id)}^{(u.)n2r} \right) y_n^r + \sum_{m\in M}\left(B_{(id)m}^{(2)r} + \sum_{u\in U} B_{(id)}^{(u.)m2r} \right) y_m^r + x_{(id)}^{(3)r} B_{(id)}^{(3)r} + x_{(id)}^{(5)r} B_{(id)}^{(5)r} + \sum_{u\in U} B_{(id)}^{(u1)4r} x_{(ud)}^{(4)r}$$

$i \in L$, $r = 1,.....,R$

4.13.3 Regional investment

It is assumed that investment in any industry is allocated to the regions in the same proportions as current output. This can be expressed as

$$Y_n^r = Y_n G_n^r, \qquad n \in N,\ r = 1,.....,R \tag{4.115}$$

and

$$Y_m^r = Y_m Z_m^r / Z_m, \qquad m \in M,\ r = 1,.....,R \tag{4.116}$$

The $G_n^{r,}$, $n \in N$ are considered as constant so the percentage-change forms are as follows

$$y_n^r = y_n, \qquad n \in N,\ r = 1,.....,R \tag{4.117}$$

and

$$y_m^r = y_m + z_m^r - z_m \tag{4.118}$$

4.13.4 Household consumption at regional level

It is assumed that there is an association between regional consumption and regional labour income. Distinctly, it is assumed that

$$X_{(us)}^{(3)r} = f_{(us)}^r\left(X_{(us)}^{(3)}, V^r / V\right) \qquad u \in U,\ s = d,m,\ r = 1,.....,R \tag{4.119}$$

where, V^r is the total wage bill in region *r* and V is the economy-wide aggregate wage bill. The percentage-change form is

$$x_{(us)}^{(3)r} = \alpha_{(us)}^r x_{(us)}^{(3)} + \gamma_{(us)}^r \left(v^r - v\right) \qquad u \in U,\ s = d,m,\ r = 1,.....,R \tag{4.120}$$

where, $\alpha^{r}_{(us)}$ is the elasticity in region *r* of consumption of good (us) with respect to aggregate consumption of that good, and $\gamma^{r}_{(us)}$ is the elasticity in region *r* of the consumption of good (us) with respect to the share of region r in the economy's aggregate wage bill. For the computations, it is assumed that

$$\alpha^{r}_{(us)} = 1$$

and

$$\gamma^{r}_{(us)} = \varepsilon_{(us)}\gamma, \qquad 0 \le \gamma \ge 1, u \in U,\ s = d, m,\ r = 1,.....,R$$

where, γ is a user-specified parameter, the value of which reflects the dependence of aggregate regional consumption on regional income, and $\varepsilon_{(us)}$ is the economy-wide household expenditure elasticity of demand for good *u* from source *s*.

The wage bill variables can be expressed in terms of wage rates and industry-specific employment levels. The regional wage-bills, V^{r}, are

$$V^{r} = \sum_{k \in K} P^{(1)}_{(g+1,L)k} X^{(1)r}_{(g+1,L)k} \qquad r = 1,.....,R \qquad (4.121)$$

Here we assume that wage rates do not vary regionally. In percentage-change form, this becomes

$$v^{r} = \sum_{k \in K} \left(p^{(1)}_{(g+1,L)k} + x^{(1)r}_{(g+1,L)k} \right) W^{r}_{k} \qquad r = 1,.....,R \qquad (4.122)$$

where, W^{r}_{k} is the share of industry *k* in the aggregate wage bill of region *r*. Then, the economy-wide wage bill is

$$V = \sum_{k \in K} P^{(L)}_{(g+1,L)k} X^{(L)}_{(g+1,L)k} \qquad (4.123)$$

In percentage-change form,

$$v = \sum_{k \in K} \left(p^{(L)}_{(g+1,L)k} + x^{(L)}_{(g+1,L)k} \right) W_{k} \qquad (4.124)$$

where, the weights W_k are industries' shares in the aggregate wage bill for the economy.

To decide regional employment, we presume that the percentage change in employment per unit of output in industry *k* in each region *r* is similar to the percentage change in employment per unit of output in industry *k* for the nation. That is,

$$x_{(g+1,L)k}^{(L)r} - z_k^r = x_{(g+1,L)k}^{(L)r} - z_k \qquad k \in K\,,\ \ r = 1,.....,R \qquad (4.125)$$

By using all the above equations we get,

$$x_{(us)}^{(3)r} = x_{(us)}^{(3)} + \varepsilon_{(us)}\gamma\left[\sum_{k\in K}\left(W_k^r - W_k\right)\left(p_{(g+1,L)k}^{(L)} + x_{(g+1,L)k}^{(L)}\right) + \sum_{m\in M} W_m^r\left(z_m^r - z_m\right)\right] \qquad (4.126)$$

$$u \in U\,,\ s = d,m\,,\ r = 1,.....,R$$

4.13.5 Other final demand at the regional level

The following relationship describes the regional allocation of other final demand.

$$X_{(us)}^{(5)r} = X_{(us)}^{(5)} Q_{(us)}^{(5)r}\,, \qquad u \in U\,,\ s = d,m\,,\ r = 1,.....,R \qquad (4.127)$$

where, $Q_{(us)}^{(5)r}$ is the share of the total other final demand for commodity *u* from source *s* which is accounted for by region *r*. The percentage-change form of (4.127) is,

$$x_{(us)}^{(5)r} = x_{(us)}^{(5)} + q_{(us)}^{(5)r} \qquad u \in U\,,\ s = d,m\,,\ r = 1,.....,R \qquad (4.128)$$

It is not generally assumed that $Q_{(us)}^{(5)r}$ as constant and exogenous changes in its regional allocation can be modelled through this. The default setting is, nevertheless, $q_{(us)}^{(5)r} = 0$.

4.13.6 International exports from regions

We basically assume fixed regional sourcing for international exports. Therefore, it is expressed as

$$X_{(u,d)}^{(4)r} = X_{(u,d)}^{(4)} Q_{(u,d)}^{(4)r} \qquad u \in U\,,\ \ r = 1,.....,R \qquad (4.129)$$

where, $Q_{(ud)}^{(4)r}$ is the share of region *r* in the aggregate supply of domestic commodity *u* for export. This is treated as fixed, so the percentage-change form is

$$x_{(u,d)}^{(4)r} = x_{(u,d)}^{(4)} \qquad (4.130)$$

4.13.7 The commodity composition of local industries

The implemented version of ORANI has local industries which are single-product industries.

Therefore, the regional outputs of local industries are expressed as

$$Z_m^r = X_{(md)}^{(0)r}, \qquad r = 1,.....,R,\ m \in M,\ m' \in L, \qquad (4.131)$$

where, m' is the local commodity produced by the local industry m.

The percentage-change form of this is

$$z_m^r = x_{(md)}^{(0)r} \qquad (4.132)$$

4.14 Solution method

To solve the model described in the previous sections, we transform it to a computable programme and then impose shocks on the model and evaluate their impacts on the economy. For this purpose, we use the General Equilibrium Modelling Package (GEMPACK) (Codsi & Pearson, 1988) developed at the Centre of Policy Studies, Monash University. This is a general purpose economic modelling software system used for general and partial equilibrium models. The simulations are carried out using GEMPACK version 10. The main steps of the simulation procedure are illustrated in Figure 4.4.

The first step is the specification of the model's equations using TABLO language. Some times when the model is large, the number of variables and equations specified in the model are reduced through condensation (or omitting specified variables which can be exogenous and unshocked). The information on condensation is listed in another instruction file, a stored input file (STI). If there are no errors in the TABLO input file, the run-TABLO programme will convert the TAB and STI files into a FORTRAN source file (FOR). This FORTRAN file contains the model-specific code necessary for a solution programme. Secondly, the compilation and linking phase use a FOR file to produce the executable programme EXE which can be used to solve the model specified in the TABLO and STI files. Thirdly, simulations are conducted using an EXE file by running RUN TG PROGRAM. The inputs

needed for this step are a data file (DAT) containing I-O data and behavioural parameters, and a command file (CMF) specifying the model closure, respective data base, solution methods and shocks. Finally, each simulation produces a solution file (SL4). This can be viewed through viewSOL programme or parts can be selected and printed with GEMPIE programme or results can be decomposed and analysed with AnalyseGE programme.

Many of the model's equations are non-linear. However, the model can be solved by representing it as a series of linear equations relating the percentage changes in model variables following Johansen's linearisation approach. Johansen's one-step solution procedure can lead to linearisation errors. Particularly, the larger the change in model variables, the greater is the proportional error in the projections. This could be minimised by solving the model using a multi-step solution process. Therefore, we used the Gragg 2-4-6 multi-step procedure to solve our model.

4.15 Model validity tests

GEMPACK provides the opportunity to detect the problems in the model using some validity tests. These tests include a price homogeneity test, a real homogeneity test and a test to check whether GDP from the income and expenditure sides change by the same amount (Horridge, 2007). The price homogeneity test ensures that there is no monetary illusion in the model. It says that economic agents respond to changes in relative prices, but not to changes in the general level of prices. To perform this test we shock an exogenous variable measured in domestic currency units which is called a numeraire (exchange rate or the CPI). For example, if we shock the numeraire by one per cent while keeping all the other exogenous variables unchanged, we would expect to see that all domestic prices and flows increase by one per cent and all the real variables remain unchanged.

The real homogeneity test is a test of constant returns to scale imposed on the production structure of the model. Therefore, if we shock all real exogenous variables by one per cent, all endogenous real variables should also move by one per cent leaving the prices unchanged. The GDP test confirms that the change in GDP from both the income side and expenditure sides due to a shock are the same. An unbalanced data base or errors in equations could disturb this equality.

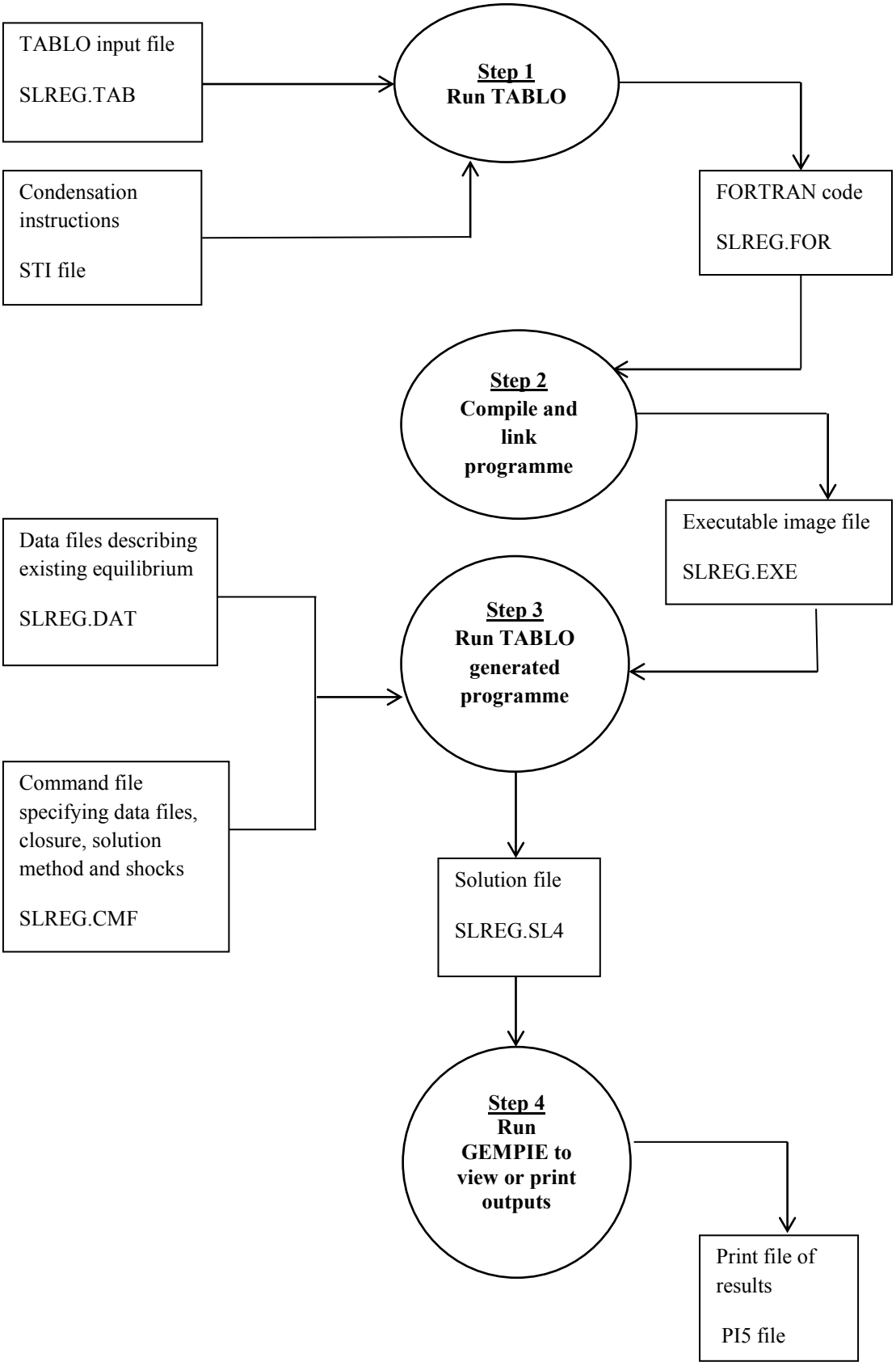

Figure 4.4: Simulation procedure using GEMPACK

Source: Horridge (2007)

4.16 Systematic sensitivity analysis (SSA)

Conducting a systematic sensitivity analysis is very important to test the robustness of the simulation results under different parameter values which are either estimated or taken from literature. It is well known in the field of econometrics that any model outcome can be sensitive to the specification of functional form and the parameter values, and some researchers have even questioned the empirical validity of CGE results (see, for example, McKitrick, 1998). CGE models use several behavioural parameters. Most of these parameters are borrowed from other studies. Therefore, the main objective of conducting a sensitivity analysis is to examine the reliability of results, in particular, to see whether the results are sensitive to different parameter values and/or shocks.

Many previous CGE studies on Sri Lanka have not been subjected to sensitivity analysis to identify the sensitivity of the model results. Only the model developed by Naranpanawa (2005) used SSA related to Sri Lanka.

A Gaussian quadrature (GQ) procedure (for details, see Arndt, 1996; Arndt & Pearson, 1998) is used to conduct SSA. The GQ approach views main exogenous variables as random variables with associated distributions and produces estimates of means and standard deviations of model results. The RUNGEM programme of GEMPACK software is used to conduct the SSA by generating the best possible choice of parameter within a specified range, run simulations, and uses the results to get estimates of means and standard deviation for all endogenous variables in the model. Among the two Gaussian quadratures in RUNGEM, we adopt the Stroud's quadrature method. The results of the SSA are presented in Chapter 6.

4.17 Chapter summary

This chapter explains the theoretical structure of the CGE model, which is a single-country, comparative static CGE model of ORANI tradition. The model incorporates multi-households and regional extension. The tops-down approach has been used for the purpose of regional extension due to its ability to disaggregate results of economy-wide policy shocks down to the regional level, and the availability of regional data for Sri Lanka.

All the equations in the core model, including demand, supply, and miscellaneous equations are listed in Table 4.2. All these equations are in the linear percentage-change form. All the variables in relation to these equations are defined in Table 4.3. A possible list of exogenous variables is given in Table 4.4. Table 4.5 details the coefficients and parameters used in the core model. Tables 4.6, 4.7 and 4.8 list the equations, variables and coefficients, and parameters used in the regional extension.

Table 4.2: Equations of the CGE model of Sri Lanka in linear percentage-change forms

Identifier	Equation	Subscript range	Number
(4.7)	Intermediate input demand $x_{(is)j} = z_j - \sigma_{ij}\left(p_{(is)j} - \sum_{s=1}^{2} S_{(is)j}\, p_{(is)j}\right) + a_j + a_{(is)j}$	$i = 1,.....,g$ $s = d, m$ $j = 1,.....,h$	2gh
(4.8)	Demand for other cost tickets $x_{(g+2)j} = z_j + a_j + a_{g+2,j}$	$j = 1,.....,h$	h
(4.9)	Industry subsidies $x_{(g+3)j} = z_j + a_j + a_{g+3,j}$	$j = 1,.....,h$	h
(4.11)	Demand for labour by occupation groups $x_{(g+1,L,q)j} = x_{(g+1,L)j} - \sigma_{(g+1,L,q)j}\left[p_{(g+1,L,q)j} - \sum_{q=1}^{9} S_{(g+1,L,q)j}\, p_{(g+1,L,q)j}\right]$	$m = 1,.....,M$ $j = 1,.....,h$	Mh
(4.12)	Demand for primary factors $x_{(g+1,v)j} = z_j - \sigma_{(g+1)j}\left(p_{(g+1)j} - \sum_{v=1}^{3} S_{(g+1,v)j}\, p_{(g+1,v)j}\right) + a_{(g+1,v)j}$	$v = 1,2,3$ $j = 1,.....,h$	3h

Identifier	Equation	Subscript range	Number
(4.13)	Price of labour $p_{(g+1,L)j} = \sum_{m=1}^{9} p_{(g+1,L,m)j} S_{(g+1,L,m)j}$	$j = 1,.....,h$ $m = 1,.....,M$	h
(4.14)	Supply of commodities by industry $x_{(id)j}^{(0)} = z_j$	$i = 1,.....,g$ $j = 1,.....,h$	gh
(4.19)	Demands for inputs to capital creation $x_{(is)j}^{K} = y_i - \sigma_{ij}^{K}\left(p_{(is)j}^{K} - \sum_{s=1}^{2} S_{(is)j}^{K} p_{(is)j}^{k} \right)$	$i = 1,.....,g$ $j = 1,.....,h$ $s = d, m$	2gh
(4.26)	Household demands for good i by source s $x_{(is)k}^{H} = x_{ik}^{H} - \sigma_{ik}^{H}\left[p_{(is)k}^{H} - \sum_{s=1}^{2} S_{(is)k}^{H} p_{(is)k}^{H} \right]$	$i = 1,.....,g$ $s = d, m$ $k = 1,.....,9$	2gk

Identifier	Equation	Subscript range	Number
(4.27)	General price of each commodity to household $p_{ik}^{H} = \sum_{s=1}^{2} S_{(is)k}^{H} p_{(is)k}^{H}$	$i = 1,.....,g$ $k = 1,.....,9$	gk
(4.28)	Household demands for commodities, undifferentiated by source $x_{ik}^{H} - q_k = \varepsilon_{ik}(c_k - q_k) + \sum_r \eta_{(ir)k} p_{rk}^{H}$	$i, r = 1,.....,g$ $k = 1,.....,9$	gk
(4.30)	Export demand functions $x_{(id)}^{E} - f_{(Qi)}^{E} = \gamma_i (p_{(id)}^{E} - phi - f_{(Pi)}^{E})$	$i = 1,.....,g$	g
(4.33)	Government demand functions $x_{(is)}^{G} = c_R h_{(is)}^{G} f_{(is)}^{G}$	$i = 1,.....,g$ $s = d, m$	2g
(4.34)	Aggregate real household expenditure $c_R = c - \xi^{H}$		1

Identifier	Equation	Subscript range	Number
(4.37)	Zero pure profits in production $\sum_{i=1}^{g} p_{(id)}^{(0)} H_{(id)j}^{0} = \sum_{i=1}^{g}\sum_{s=1}^{2} p_{(is)j} H_{(is)j} + \sum_{m=1}^{8} p_{(g+1,L,m)j} H_{(g+1,L,m)j} + \sum_{s=2}^{3} p_{(g+1,s)j} H_{(g+1,s)j}$ $+ p_{g+2,j} H_{g+2,j} + p_{g+2,j} H_{g+2,j} + p_{g+3,j} H_{g+3,j} + p_{g+3,j} H_{g+3,j}$ $+ a_j + \sum_{i=1}^{g+3} a_{ij} H_{ij} + \sum_{s=1}^{3} a_{(g+1,s)j} H_{(g+1,s)j}$	$j = 1,.....,h$	h
(4.39)	Zero pure profits in capital creation $\pi_j = \sum_{i=1}^{g}\sum_{s=1}^{2} p_{(is)j}^{K} H_{(is)j}^{K}$	$j = 1,....,h$	h
(4.41)	Zero pure profits in importing $p_{(im)}^{(0)} = (p_{(im)}^{m} + \phi) + \zeta_{(im)} t_{(M,i)}$	$i = 1,.....,g$	g
(4.44)	Zero pure profits in exporting $p_{(id)}^{E} + \phi = p_{(id)}^{(0)} + \zeta_{t(Ei)} t_{(E,i)}$	$i = 1,.....,g$	g

Identifier	Equation	Subscript range	Number
	Zero pure profits in distribution of goods to domestic users	$i = 1,.....,g$,	2gh
(4.49)	$p_{(is)j} = p_{(is)}^{(0)} + \zeta_{t(Ip,is)j} t_{(Ip,is)j}$	$j = 1,....,h$,	
(4.50)	$p_{(is)j}^{K} = p_{(is)}^{(0)} + \zeta_{t(K,is)j} t_{(K,is)j}$	$s = d, m$	2gh
		$i = 1,.....,g$,	
		$j = 1,....,h$,	
		$s = d, m$	
	Zero pure profits in distribution of goods to domestic users (cont.)	$i = 1,.....,g$	2gk
(4.51)	$p_{(is)k}^{H} = p_{(is)}^{(0)} + \zeta_{t(H,is)k} t_{(H,is)}$	$k = 1,.....,9$ $s = d, m$	
(4.52)	$p_{(is)}^{G} = p_{(is)}^{(0)} + \zeta_{t(G,is)} t_{(G,is)}$	$i = 1,.....,g$,	2g
		$s = d, m$	
	Household income		1
(4.59)	$y^{H} = \sum_{j=1}^{h} \sum_{m=1}^{M} (p_{(g+1,L,m)} x_{(g+1,L,m)}) J_{(g+1,L,m)j}^{H} + \sum_{j=1}^{h} p_{(g+1,K)j} x_{(g+1,K)j} J_{(g+1,K)j}^{H} + \sum_{j=1}^{h} p_{(g+1,N)j} x_{(g+1,N)j} J_{(g+1,N)j}^{H}$		

Identifier	Equation	Subscript range	Number
(4.60)	Household consumption function $c_k = f_k^H + f^H + y^H - \left(T/_{1-T}\right)t_Y$		k
(4.61)	Household disposable income by household group $y_k^D = \sum_{k=1}^{9} w[y^H - (T/_{1-T})]t_Y$		k
(4.62)	Aggregate household consumption $c = \sum_{k=`}^{9} c_k \psi_k$		1
(4.70)	Rates of return on capital in each industry $r_j(0) = Q_j(p_{(g+1,K)j} - \pi_j)$	$j = 1,....,h,$	h
(4.71)	Equality of rates of return across industries $-\beta_j\left(k_j(1) - k_j(0)\right) + r_j(0) = \omega$	$j \in J$	J
(4.72)	Capital accumulation $k_j(1) = k_j(0)\left(1 - G_j\right) + y_j G_j$	$j = 1,....,h,$	h

Identifier	Equation	Subscript range	Number
	Investment budget		1
(4.73)	$\sum_{j \in J} (\pi_j + y_j) \lambda_j = \left(\sum_{j \in J} \lambda_j \right) i$		
	Equations for handling exogenous investments	$j \notin J$	h-J
(4.74)	$y_j = h_j^K i_R + f_j^K$		
	Real private investment expenditure		1
(4.75)	$i_R = i - \xi^K$		
	Demand equals supply for domestically produced products	$r = 1, \ldots\ldots, g$	g
(4.81)	$x_{(rd)}^{(0)} = \sum_{j=1}^{h} x_{(rd)j} B_{(rd)j} + \sum_{j=1}^{h} x_{(rd)j}^K B_{(rd)j}^K + \sum_{k=1}^{9} x_{(rd)k}^H B_{(rd)k}^H + x_{(rd)}^G B_{(rd)}^G + x_{(rd)}^E B_{(rd)}^E$		
	Output of total commodities (rd)	$r = 1, \ldots\ldots, g$	g
(4.82)	$x_{(rd)}^{(0)} = \sum_{j=1}^{h} x_{(rd)j}^{(0)} B_{(rd)j}^{(0)}$		

Identifier	Equation	Subscript range	Number
(4.83)	Demand equals supply for labour of each skill group $l_m = \sum_{j=1}^{h} x_{(g+1,L,m)j} B_{(g+1,L,m)j}$	$m = 1,....,M,$	M
(4.84)	Demand equals supply for capital $k_j(0) = x_{(g+1,K)j}$	$j = 1,....,h,$	h
(4.85)	Demand equals supply for agricultural land $n_j = x_{(g+1,L)j}$	$j = 1,....,h,$	h
(4.88)	Import volumes $x^M_{(rm)} = \sum_{j=1}^{h} x_{(rm)j} B^{IP}_{(rm)j} + \sum_{j=1}^{h} x^K_{(rm)j} B^K_{(rm)j} + \sum_{k=1}^{9} x^H_{(rm)k} B^H_{(rm)k} + x^G_{((rm)} B^G_{(rm)}$	$r = 1,.....,g$	g
(4.89)	Foreign currency value of imports $m = \sum_{r=1}^{g} (p^M_{(rm)} + x^M_{(rm)}) M_{(rm)}$		1

Identifier	Equation	Subscript range	Number
	Foreign currency value of exports		1
(4.91)	$e = \sum_{r=1}^{g} (p_{(rd)}^{E} + x_{(rd)}^{E}) E_{(rd)}$		
	Balance of trade		1
(4.93)	$100\Delta B = Ee - Mm$		
	Consumer price index		1
(4.94)	$\xi^{H} = \sum_{s=1}^{2} \sum_{i=1}^{g} w_{(is)}^{H} p_{(is)}^{H}$		
	Capital goods price index		1
(4.95)	$\xi^{K} = \sum_{j \in J} \overline{\lambda}_{j} \pi_{j}$		
	Aggregate employment		1
(4.96)	$l = \sum_{m=1}^{M} l_{m} \psi_{Lm}$		

Identifier	Equation	Subscript range	Number
(4.97)	Aggregate capital stock $k(0) = \sum_{j=1}^{h} k_j(0)\psi_{Kj}$		1
(4.98)	Ratio of real investment to real consumption $f_R = i_R - c_R$		1
(4.99)	Flexible handling of wages by occupation and industry $p_{(g+1,L,m)j} = h_{(g+1,L,m)j}\xi^H + f_{(g+1,L)} + f_{(g+1,L)j} + f_{(g+1,L,m)} + f_{(g+1,L,m)j}$	$m = 1,....,M,$ $j = 1,....,h,$	Mh
(4.100)	Indexing the prices of other cost tickets $p_{(g+2,j)} = h_{g+2,j}\xi^H + f_{g+2,j}$	$j = 1,....,h,$	h
(4.101)	Indexing the prices of subsidies $p_{(g+3,j)} = h_{g+3,j}\xi^H + f_{g+3,j}$	$j = 1,....,h,$	h

Identifier	Equation	Subscript range	Number
	GDP		1
(4.104)	$gdp = \sum_{i=1}^{g}\sum_{s=1}^{2}\sum_{k=1}^{9}(p_{(is)k}^{H} + x_{(is)k}^{H})S_{gdp,k}^{H} + \sum_{i=1}^{g}\sum_{s=1}^{2}\sum_{k=1}^{9}(p_{(is)j}^{K} + x_{(is)j}^{K})S_{gdp,j}^{K} + \sum_{i=1}^{g}\sum_{s=1}^{2}(p_{(is)}^{G} + x_{(is)}^{G})S_{gdp,is}^{G}$		
	$+\sum_{i=1}^{g}(p_{(id)}^{E} + x_{(id)}^{E})S_{gdp,i}^{E} - \sum_{i=1}^{g}(p_{(im)}^{M} + x_{(im)}^{M} + \phi)S_{gdp,i}^{M}$		
	Average nominal wage		1
(4.105)	$p_{(g+1,L)} = \sum_{j=1}^{h}\sum_{m=1}^{M} p_{(g+1,L,m)j} w_{(g+1,L)mj}$		
	Real wage		1
(4.106)	$realwage = p_{(g+1,L)} - \xi^{H}$		
Total number of equations	$9gh + 15h + 2Mh + 6gk + 10g + 2k + M + 16$		

According to the data base, $g, h = 40$, $k = 9$, $M = 7$

Table 4.3: Variables of the core model

Variable	Subscript range	Number	Description
$x_{(is)j}$	$i = 1,.....,g$ $j = 1,....,h$ $s = d,m$	$2gh$	Demands for inputs from domestic and foreign sources for current production
$x^{K}_{(is)j}$	$i = 1,.....,g$ $j = 1,....,h$ $s = d,m$	$2gh$	Demands for inputs from domestic and foreign sources for capital creation
$x^{H}_{(is)k}$	$i = 1,.....,g$ $s = d,m$ $k = 1,...,9$	$2gk$	Demands for commodities from domestic and foreign sources by households
x^{H}_{ik}	$i = 1,.....,g$ $k = 1,...,9$	gk	Demand for effective commodities by different household groups
$x^{E}_{(id)}$	$i = 1,.....,g$	g	Export volume
$x^{G}_{(is)}$	$i = 1,.....,g$ $s = d,m$	$2g$	Demands for commodities from domestic and foreign sources by government
$p^{(0)}_{(is)}$	$i = 1,.....,g$ $s = d,m$	$2g$	Basic prices of domestically produced goods and imported goods
$x_{(g+1,L,m)j}$	$j = 1,....,h$ $m = 1,....,M$	Mh	Demands for labour by occupational group and industry
$x_{(g+1,v)}$	$j = 1,....,h$ $v = M,K,N$	$3h$	Demands for labour in general, capital, and land by industry
$x_{(g+2)j}$	$j = 1,....,h$	h	Demands for other cost tickets
$x_{(g+3)j}$	$j = 1,....,h$	h	Demands for production subsidies
$x^{(0)}_{(rd)}$	$r = 1,.....,g$	g	Supply of domestic commodities
$x^{M)}_{(rm)}$	$r = 1,.....,g$	g	Supply of imported commodities
$p_{(is)j}$	$i = 1,.....,g$ $j = 1,....,h$ $s = d,m$	$2gh$	Purchasers' price of produced inputs for current production

Variable	Subscript range	Number	Description
$p^{K}_{(is)j}$	$i=1,.....,g$ $j=1,....,h$ $s=d,m$	$2gh$	Purchasers' price of produced inputs for capital creation
$p^{H}_{(is)k}$	$i=1,.....,g$ $s=d,m$ $k=1,...,9$	$2gk$	Purchasers' prices of commodities for household consumption from different sources
p^{H}_{ik}	$i=1,.....,g$ $k=1,...,9$	gk	Purchasers' prices of effective commodities by different household groups
$p^{E}_{(id)}$	$i=1,.....,g$	g	Foreign currency prices of exports in FOB terms
$p^{G}_{(is)}$	$i=1,.....,g$ $s=d,m$	$2g$	Purchasers' prices of commodities for government consumption from domestic and foreign sources
$p^{M}_{(im)}$	$i=1,.....,g$	g	CIF prices of imports in foreign currency
$p_{(g+2,j)}$	$j=1,....,h$	h	Price of other cost tickets
$p_{(g+3,j)}$	$j=1,....,h$	h	Price of other production subsidies
$p_{(g+1,L,m)j}$	$j=1,....,h$ $m=1,....,M$	Mh	Wages for labour by occupational group and industry
$p_{(g+1,v)j}$	$j=1,....,h$ $v=M,K,N$	$3h$	Prices of labour in general, capital, and land paid by industries
$t_{(Ip,is)j}$	$i=1,.....,g$ $j=1,....,h$ $s=d,m$	$2gh$	Power of tax on produced inputs for current production
$t_{(K,is)j}$	$i=1,.....,g$ $j=1,....,h$ $s=d,m$	$2gh$	Power of tax on produced inputs for capital creation
$t_{(H,is)k}$	$i=1,.....,g$ $s=d,m$ $k=1,...,9$	$2gk$	Power of tax on households

Variable	Subscript range	Number	Description
$t_{(G,is)}$	$i = 1,.....,g$ $s = d,m$	$2g$	Power of tax on government
$t_{(E,i)}$	$i = 1,.....,g$	g	Power of tax on exports
$t_{(M,i)}$	$i = 1,.....,g$	g	Power of tax on imports
$f^{E}_{(Pi)}$	$i = 1,.....,g$	g	Price shift in export demand
$f^{E}_{(Qi)}$	$i = 1,.....,g$	g	Quantity shift in export demand
$f^{G}_{(is)}$	$i = 1,.....,g$ $s = d,m$	$2g$	Shift terms for government
$f_{(g+2,j)}$	$j = 1,....,h$	h	Shift terms for prices of other cost tickets
$f_{(g+3,j)}$	$j = 1,....,h$	h	Shift terms for prices of production subsidies
$f_{(g+1,L)}$		1	Overall wage shift variable
$f_{(g+1,L)j}$	$j = 1,....,h$	h	Industry specific wage shifter
$f_{(g+1,L)m}$	$m = 1,....,M$	M	Occupation specific wage shifter
$f_{(g+1,L,m)j}$	$j = 1,....,h$ $m = 1,....,M$	Mh	Occupational and industrial wage shifter
f^{K}		1	Investment shifter
f^{H}_{k}	$k = 1,...,9$	k	Shift term for consumption of household k
f^{H}		1	Ratio of household consumption to total household disposable income
z_j	$j = 1,....,h$	h	Activity level
y_j	$j = 1,....,h$	h	Capital creation by industries
π_j	$j = 1,....,h$	h	Costs of units of capital
$k_j(0)$	$j = 1,....,h$	h	Current capital stock in each industry
$r_j(0)$	$j = 1,....,h$	h	Current rate of return on fixed capital
$k_j(1)$	$j = 1,....,h$	h	Future capital stock in each industry
$k(0)$		1	Aggregate capital stock

Variable	Subscript range	Number	Description
ω		1	Economy-wide expected rate of return on capital
i		1	Aggregate private investment expenditure
i_R		1	Aggregate real private investment expenditure
ξ^K		1	Aggregate investment price index
c_k	$k = 1,...,9$	k	Nominal household consumption
q_k	$k = 1,...,9$	k	Number of households in each household group
c		1	Aggregate household expenditure
y^H		1	Total household income
y_k^D	$k = 1,...,9$	k	Income of household k
$t_{(Y)}$		1	Tax rate on household income
l		1	Aggregate employment
l_m	$m = 1,....,M$	M	Employment by occupational group
m		1	Value of imports in foreign currency
e		1	Foreign currency value of exports
ϕ		1	The exchange rate
ΔB		1	The balance of trade
c_R		1	Real aggregate household consumption
ξ^H		1	CPI
n_j	$j = 1,....,h$	h	Total supply of land
$h_{(is)}^G$	$i = 1,.....,g$ $s = d, m$	$2g$	Ratio of government demand to real private consumption
gdp		1	GDP from expenditure side
$p_{(g+1,L)}$		1	Average nominal wage
$realwage$		1	Real wage
$x_{(id)j}^{(0)}$	$i = 1,.....,g$ $j = 1,....,h$	gh	Output by commodity and industry

Variable	Subscript range	Number	Description
a_j	$j = 1,....,h$	h	All-input augmenting technical change
a_{ij}	$i = 1,.....,g+3$ $j = 1,....,h$	$(g+3)h$	Input-*i*-augmenting technical change
$a_{(is)j}$	$i = 1,.....,g$ $j = 1,....,h$ $s = d, m$	$2gh$	Input-*is*-augmenting technical change
$a_{(g+1,v)j}$	$j = 1,....,h$ $v = K, L, N$	$3h$	Labour, capital, and land augmenting technical change
f_R		1	Ratio of real investment to real consumption
Total Variables $16gh + 8gk + 21g + 3Mh + 27h + 22 + 2M + 4k$			

According to the data base, $g, h = 40$, $k = 9$, $M = 7$

Table 4.4: A possible list of exogenous variables

Variable	Subscript range	Number	Description
$p^{M}_{(im)}$	$i = 1,.....,g$	g	CIF prices of imports in foreign currency
a_j	$j = 1,....,h$	h	All-input augmenting technical change
a_{ij}	$i = 1,.....,g+3$ $j = 1,....,h$	$(g+3)h$	Input-*i*-augmenting technical change
$a_{(is)j}$	$i = 1,.....,g$ $j = 1,....,h$ $s = d,m$	$2gh$	Input-*is*-augmenting technical change
$a_{(g+1,v)j}$	$j = 1,....,h$ $v = K,L,N$	$3h$	Labour, capital, and land augmenting technical change
$k_j(0)$	$j = 1,....,h$	h	Current capital stocks
n_j	$j = 1,....,h$	h	Total supply of land
ω		1	Economy-wide expected rate of return on capital
ϕ		1	The exchange rate
$t_{(Y)}$		1	Tax rate on household income
f^{H}_{k}	$k = 1,...,9$	k	Shift term for consumption of household k
f^{H}		1	Ratio of household consumption to total household disposable income
$t_{(E,i)}$	$i = 1,.....,g$	g	Power of tax on exports
$t_{(M,i)}$	$i = 1,.....,g$	g	Power of tax on imports
$t_{(H,is)k}$	$i = 1,.....,g$ $s = d,m$ $k = 1,...,9$	$2gk$	Power of tax on households
$t_{(G,is)}$	$i = 1,.....,g$ $s = d,m$	$2g$	Power of tax on government

Variable	Subscript range	Number	Description
$t_{(Ip,is)j}$	$i = 1,....., g$ $j = 1,...., h$ $s = d, m$	$2gh$	Power of tax on produced inputs for current production
$t_{(K,is)j}$	$i = 1,....., g$ $j = 1,...., h$ $s = d, m$	$2gh$	Power of tax on produced inputs for capital creation
q_k	$k = 1,...,9$	k	Number of households in each household group
$f^E_{(Pi)}$	$i = 1,....., g$	g	Price shift in export demand
$f^E_{(Qi)}$	$i = 1,....., g$	g	Quantity shift in export demand
$f^G_{(is)}$	$i = 1,....., g$ $s = d, m$	$2g$	Shift terms for government
l		1	Aggregate employment
$f_{(g+2,j)}$	$j = 1,...., h$	h	Shift terms for prices of other cost tickets
$f_{(g+3,j)}$	$j = 1,...., h$	h	Shift terms for prices of production subsidies
$f_{(g+1,L)j}$	$j = 1,...., h$	h	Industry-specific wage shifter
$f_{(g+1,L)m}$	$m = 1,...., M$	M	Occupation-specific wage shifter
$f_{(g+1,L,m)j}$	$j = 1,...., h$ $m = 1,...., M$	Mh	Occupational and industrial wage shifter
$h^G_{(is)}$	$i = 1,....., g$ $s = d, m$	$2g$	Ratio of government demand to real private consumption
f_R		1	Ratio of real investment to real consumption
Total $7gh + 12h + Mh + 2gk + 11g + 6 + 2k + M$			

Table 4.5: List of coefficients and parameters of the core model

Coefficient/ Parameter	Description
σ_{ij}	Elasticity of substitution between domestic and imported sources of good *i* to use as an input for current production of industry *j*.
$S_{(is)j}$	Share of intermediate input in total cost of good *i* for use in current production by industry *j*.
$\sigma_{(g+1,L,q)j}$	Elasticity of substitution between different occupational categories of labour in the production of industry *j*.
$S_{(g+1,L,q)j}$	Share of different occupational categories in the total cost of labour in industry *j*.
$\sigma_{(g+1)j}$	Elasticity of substitution between primary factors in the production of industry *j*.
$S_{(g+1,v)j}$	Shares of primary factors in the total cost of primary factors used by industry *j* for current production.
σ_{ij}^{K}	Elasticity of substitution between domestic and imported good *i* for capital creation in industry *j*.
$S_{(is)j}^{K}$	Share of good *i* from source *s* in the total cost of capital creation.
σ_{ik}^{H}	Elasticity of substitution between domestic and imported good *i* consumed by household group *k*.
$S_{(is)k}^{H}$	Share of good *i* from source *s* in household *k*'s total consumption expenditure of good *i*.
ε_{ik}	Own-price elasticity of demand for good *i* in household *k*.
$\eta_{(ir)k}$	Cross-price elasticity of demand for good *i* in household *k*.
γ_{i}	Export elasticity of demand for domestically produced good *i*.
$h_{(is)}^{G}$	An indexing parameter which establishes the relationship between movement in aggregate real private consumption and government consumption
$H_{(is)j}$	Share of intermediate inputs of good *i* from source *s* in the total cost of industry *j*.
$H_{(g+1,L,m)j}$	Share of industry *j*'s costs accounted for by inputs of labour category *m*.

Coefficient/ Parameter	Description
$H_{(g+1,s)j}$	Shares of industry *j*'s cost accounted for by inputs of labour in general, capital, and land.
$H_{g+2,j}$	Value of other cost tickets as a share of total costs of industry *j*.
$H_{g+3,j}$	Value of production subsidies as a share of total costs of industry *j*.
H_{ij}	Share of technological coefficients.
$H^{K}_{(is)j}$	Share of good *i* from source s in the total cost of capital creation in industry *j*.
$\zeta_{(im)}$	Share of the basic price of imported good *i* accounted for by the foreign currency price including tariffs.
$\zeta_{t(Ei)}$	Share accounted for by the export tax for unit of domestically produced good *i*.
$\zeta_{t(u,is)j}$	Value of sales taxes in the purchasers' price of good *i* from source *s* for intermediate production (Ip) and for capital creation (K).
$\zeta_{t(H,is)k}$	Value of sales taxes in the purchasers' price of good *i* from source *s* for consumption expenditure of household *k*.
$\zeta_{t(G,is)}$	Value of sales taxes in the purchasers' price of good *i* from source *s* for government consumption.
$\left(T/_{1-T}\right)$	Taxes on household income as a fraction of net household income.
w	Share of household *k*'s income in total household disposable income.
ψ_k	Share of household *k*'s consumption in total consumption.
$J^{H}_{(g+1,L,m)j}$	Share of labour income in total household income.
$J^{H}_{(g+1,K)j}$	Share of capital income in total household income.
$J^{H}_{(g+1,N)j}$	Share of land income in total household income.
Q_j	Ratio of gross to net rate of return in industry *j*.
β_j	Elasticity of expected marginal return on capital in industry *j*.
G_j	Ratio of industry *j*'s gross investment to its future capital stock.
λ_j	Share of total aggregate fixed investment accounted for by industry *j*.

Coefficient/ Parameter	Description
$B_{(rd)j}$	Share of the total sales of domestically produced good *(rd)* accounted for by sales to industry *j* as an input for current production.
$B^{K}_{(rd)j}$	Share of the total sales of domestically produced good *(rd)* accounted for by sales to industry *j* as an input for capital formation.
$B^{H}_{(rd)k}$	Share of the total sales of domestically produced good *(rd)* accounted for by sales to industry *j* as an input for household consumption.
$B^{G}_{(rd)}$	Share of the total sales of domestically produced good *(rd)* accounted for by sales to industry *j* as an input for government consumption.
$B^{E}_{(rd)}$	Share of the total sales of domestically produced good *(rd)* accounted for by sales to industry *j* as an input for exports.
$B^{(0)}_{(rd)j}$	Share of industry *j* in the economy's output of good *(rd)*.
$B_{(g+1,L,m)j}$	Share of total employment in occupation category *m* which is accounted for by industry *j*.
$B^{IP}_{(rm)j}$	Share of total imports of good *(rm)* accounted for by industry *j* for current production.
$B^{K}_{(rm)j}$	Share of total imports of good *(rm)* accounted for by industry *j* for capital creation.
$B^{H}_{(rm)k}$	Share of total imports of good *(rm)* accounted for by industry *j* for household consumption.
$B^{G}_{(rm)}$	Share of total imports of good *(rm)* accounted for by industry *j* for government consumption.
$M_{(rm)}$	Share of exports of good *r* in aggregate imports.
$E_{(rd)}$	Share of exports of good *r* in aggregate export earnings.
E	Total foreign currency value of exports.
M	Total foreign currency value of imports.
$w^{H}_{(is)}$	Weights in the CPI equation.
ψ_{Lm}	Share of labour type *m* in total employment in the economy.
$\bar{\lambda}_{j}$	Share of capital employed in j^{th} industry in the total capital stock.
$h_{(g+1,L,m)j}$	Wage indexation parameter which sets up the relationship between

Coefficient/ Parameter	Description
	movements in the wage rate of labour type m and model's CPI.
$h_{g+2,j}$	Indexation parameter which sets up the relationship between movements in the price of other cost tickets and model's CPI.
$h_{g+3,g}$	Indexation parameter which sets up the relationship between movements in the price of production subsidies and model's CPI.
$S^{H}_{gdp,k}$	Share of household *k*'s consumption in total GDP.
$S^{K}_{gdp,j}$	Share of industry *j*'s investment in capital formation in total GDP.
$S^{G}_{gdp,is}$	Share of government's consumption in total GDP.
$S^{E}_{gdp,i}$	Share of total exports in total GDP.
$S^{M}_{gdp,i}$	Share of total imports in total GDP.
$w_{(g+1,L)mj}$	Weights in the nominal wage equation.

Table 4.6: Equations for regional disaggregation

Identifier	Equation	Subscript range
(4.108)	Activity levels of national industries $z_n^r = z_n$	$n \in N$ $r = 1,\ldots,R$
(4.114)	Aggregate output of any local commodity $x_{(id)}^{(0)r} = \sum_{n\in N}\left(B_{(id)n}^{(1)r} + \sum_{u\in U} B_{(id)}^{(u.)n1r}\right) z_n^r + \sum_{m\in M}\left(B_{(id)m}^{(1)r} + \sum_{u\in U} B_{(id)}^{(u.)m1r}\right) z_m^r$ $+ \sum_{n\in N}\left(B_{(id)n}^{(2)r} + \sum_{u\in U} B_{(id)}^{(u.)n2r}\right) y_n^r + \sum_{m\in M}\left(B_{(id)m}^{(2)r} + \sum_{u\in U} B_{(id)}^{(u.)m2r}\right) y_m^r + x_{(id)}^{(3)r} B_{(id)}^{(3)r} + x_{(id)}^{(5)r} B_{(id)}^{(5)r} + \sum_{u\in U} B_{(id)}^{(u1)4r} x_{(ud)}^{(4)r}$	$i \in L$ $r = 1,\ldots,R$
(4.132)	The commodity composition of local industries $z_m^r = x_{(md)}^{(0)r}$	$m \in M$, $m' \in L$ $, r = 1,\ldots\ldots,R$
(4.120)	Household consumption at regional level $x_{(us)}^{(3)r} = \alpha_{(us)}^r x_{(us)}^{(3)} + \gamma_{(us)}^r \left(v^r - v\right)$	$u \in U$, $s = d, m$, $r = 1,\ldots\ldots,R$
(4.122)	Regional wage-bills $v^r = \sum_{k\in K}\left(p_{(g+1,L)k}^{(L)} + x_{(g+1,L)k}^{(L)r}\right) W_k^r$	$r = 1,\ldots\ldots,R$
(4.126)	Regional employment $x_{(us)}^{(3)r} = x_{(us)}^{(3)} + \varepsilon_{(us)}\gamma\left[\sum_{k\in K}\left(W_k^r - W_k\right)\left(p_{(g+1,L)k}^{(L)} + x_{(g+1,L)k}^{(L)}\right) + \sum_{m\in M} W_m^r\left(z_m^r - z_m\right)\right]$	$u \in U$, $s = d, m$, $r = 1,\ldots\ldots,R$

Identifier	Equation	Subscript range
(4.128)	Other final demand at the regional level $x_{(us)}^{(5)r} = x_{(us)}^{(5)} + q_{(us)}^{(5)r}$	$u \in U$, $s = d, m$ $r = 1, \ldots\ldots, R$
(4.130)	International exports from regions $x_{(u,d)}^{(4)r} = x_{(u,d)}^{(4)}$	$u \in U$, $r = 1, \ldots\ldots, R$

Table 4.7: Variables of regional disaggregation

Variable	Description
$x_{id}^{(0)r}$	Output of local commodity in region *r*
$a_{(id)n}^{h}$	Direct input of domestically produced commodity *i* required per unit of output (*h=1*) or capital creation (*h=2*) in industry *k*
z_{n}^{r}	Output of national industry *n* in region *r*
z_{m}^{r}	Output of local industry *m* in region *r*
y_{n}^{r}	Capital creation of national industry *n* in region *r*
y_{m}^{r}	Capital creation of local industry *m* in region *r*
$x_{(us)}^{(3)r}$	Household demand for commodity *u* from source *s* which is accounted for by region *r*
v^{r}	Total wage bill in region *r*
$x_{(g+1,L)k}^{(L)r}$	Labour used for current production of all industries in region *r*
$x_{(us)}^{(5)r}$	Government demand for commodity *u* from source *s* which is accounted for by region *r*
$x_{(ud)}^{(4)r}$	Export demand for commodity *u* from source *s* which is accounted for by region *r*

Table 4.8: List of coefficients of the regional disaggregation

Coefficient/ Parameter	Description
$\alpha^{r}_{(us)}$	Elasticity in region *r* of consumption of good (*us*) with respect to aggregate consumption of that good.
$\gamma^{r}_{(us)}$	Elasticity in region *r* of the consumption of good (*us*) with respect to the share of region *r* in the economy's aggregate wage bill.
$\varepsilon_{(us)}$	Economy-wide household expenditure elasticity of demand for good *u* from source *s*.
$q^{(5)r}_{(us)}$	Share of government demand for domestically produced commodity *u* which is accounted for by region *r*.
W^{r}_{k}	Share of industry *k* in the aggregate wage bill of region *r*.
W^{r}_{m}	Share of local industry *m* in the aggregate wage bill of region *r*.
$B^{(h)r}_{(id)n}$	Share of total sales of domestically produced national commodity (*id*) accounted for by sales to region *r* as an input for current production (*h=1*), capital formation (*h=2*).
$B^{(h)r}_{(id)m}$	Share of total sales of domestically produced local commodity (*id*) accounted for by sales to region *r* as in input for current production (*h=1*), capital formation (*h=2*).
$B^{(3)r}_{(id)}$	Share of the total sales of domestically produced local good *(id)* accounted for by sales to region *r* as an input for household consumption.
$B^{(u1)4r}_{(id)}$	Share of the total sales of domestically produced local good *(id)* accounted for by sales to region *r* as an input for exports.
$B^{(5)r}_{(id)}$	Share of the total sales of domestically produced local good *(id)* accounted for by sales to region *r* as an input for government consumption.