

Effect of the change in the EU international banana marketing
regime on inequality and welfare in St. Lucia (1995-2005)

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ABSTRACT

Banana production was central to the economy of St. Lucia prior to the liberalization of international banana marketing. The potential for change in inequality and welfare following this liberalization was examined using household expenditure survey and income tax filer data. The non-parametric bootstrap method was used to conduct statistical inference on the Gini coefficient to assess the change in inequality, at the national level between 1995 and 2005. It was concluded that the change in the Gini coefficient was not statistically significant so this analysis does not provide statistical support for a change in inequality following the liberalization. Lorenz curves were constructed with the income tax data, and then distribution free statistical inference performed on them, indicating that there were statistically significant improvements in welfare for the poorest 20 percent of these income distributions, after the liberalization (1998-2007). For more robust results in the future, attention should be given to the development of long term data collection.

RÉSUMÉ

La production de la banane était la plus importante activité pour l'économie de Ste. Lucie, avant de la commercialisation internationale des bananes. Utilisant des données provenant d'une enquête sur les dépenses des ménages et sur l'impôt sur le revenu des particuliers le potentiel que l'état d'inégalité et du bien-être en Ste. Lucie ait à changer été fut déterminé. Une méthode non-paramétrique d'autoamorçage servit à tirer des inférences à partir du coefficient de Gini quant aux changements à l'inégalité à l'échelon national entre 1995 et 2005. Comme le changement du coefficient de Gini ne fut pas significatif, cette analyse ne porta aucun d'appui statistique à l'idée que le niveau d'inégalité ait changé après la libéralisation. Choisisant les contribuables comme sous-ensemble de la population, une inférence non-paramétrique appliqué à des courbes de Lorenz indiqua que des améliorations significatives au bien-être des 20% plus pauvres se manifesta durant la période suivant la libéralisation (1998-2007). Afin d'obtenir des résultats plus robustes à l'avenir, le développement d'un régime de collecte des données à long terme doit être visé.

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Dedication

To my seven year old son Andrae Lerone Lewis

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LIST OF ACRONYMS

ACP	African Caribbean and Pacific States
CARICOM	Caribbean Community
COMB	Common Market Organisation for Bananas
CSO	Central Statistical Office
EC	Eastern Caribbean
ECCB	Eastern Caribbean Central Bank
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GLcurve	Generalized Lorenz Curve
IID	Independently and Identically Distributed
IMF	International Monetary Fund
MoA	Ministry of Agriculture
STABEX	Système de Stabilisation des Recettes d'Exportation
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WTO	World Trade Organization

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Chapter 1 Introduction

1.1 Socio Economic Importance of Banana to the Caribbean

During the 1960s, banana became one of the important crops for a number of Caribbean islands and for several decades, contributed significantly to employment and generated a secure income for producers. It also had a strong positive multiplier effect on other sectors of the economy (International Monetary fund (IMF), 2002; Perville, 2003). The economic success of banana in the Caribbean was made possible in part, due to its relationship with European countries. Without this support, it would have been difficult for Caribbean producers to survive since they never had enjoyed the same economies of scale as their South American rivals; the majority (69%) of banana farms in Dominica, St. Lucia and St. Vincent were about 1 acre in size (Patin, 1996) and most were situated on hilly terrain. Additionally, higher freight charges, due to smaller volumes, made Caribbean bananas uncompetitive in terms of price (Laurent, 2003).

In 1998, however, under the new European Union (EU) regime this changed and producers were forced to contend with lower prices. For example, over the ten year period from 1990-2001 the differential in import prices (CIF) to the UK between Caribbean and South American producers was reduced from 31% to 17%¹. The higher price paid for Caribbean bananas coupled with their lower quality made it difficult for producers to compete and production began to fall. Production fell by 50% on the islands of St. Lucia, Grenada, Dominica and St. Vincent to 140,500 tonnes over the 10 year period from 1990-2000 as farmers abandoned their fields (Payne, 2006). It is estimated that in 1992, on these islands the banana industry employed 56,000 persons (out of a combined labour force of 190,000). However, by 2002 the collapse of the banana industry was responsible 17% of the regions' unemployment (Perville, 2003)².

¹ Calculated from (Laurent, 2003)

² See Perville (2003) for details on this calculation

1.2 World Banana Trade

The main import markets for bananas are North America, the European Union (EU) and Japan, although the Russian Federation and China are becoming increasingly important. Three companies: Dole, Chiquita and Delmonte dominate world banana trade (Food and Agriculture Organisation (FAO), 2002). Prior to the 1990's, production occurred mainly in Latin America and the Caribbean. Latin American bananas were destined for North America while those from the African, Caribbean, and Pacific regions (ACP) were exported to Europe. Currently, production in Asian countries such as China, Indonesia and India, has surpassed that of Latin America and the Caribbean combined. Production in Africa has not increased much and is mainly for domestic consumption (van de Kastele, 1998, UNCTAD, 2005). Bananas exported to North America were always sold in an open market, while those sold in Europe have had different trading regulations which are discussed in the following section.

1.3 The EU Banana Trading Regime

Prior to the formation of the Single European market in 1993, bananas were imported into the Europe according to individual county rules. For example, members such as France got their bananas from their overseas territories such as Guadeloupe, Martinique and ACP countries such as Cameroon and Cote d'Ivoire. The UK secured its supply from the Caribbean, while Italy had supplies from Somalia. Each of these had their own tariff regulations for banana imports while Germany used a zero tariff quota system (Kersten, 1995; Sutton, 1997). After its formation, the EU Common Market Organization for Bananas (COMB - EC Banana Regime)³ was established to govern the banana trade in the EU. This aim of the regime was to maintain support for former EU member colonies in the ACP and to prevent internal

³ For a detailed discussion of the regime see van de Kastele, (1998), and Kersten, (1995) and <http://www.fao.org/docrep/007/y5102e/y5102e06.htm>.

conflict among the newly formed body. The EU regime kept prices⁴ higher for ACP producers than under the free market, making it difficult for Latin American bananas to gain a foothold. These higher prices meant importers of ACP bananas did not have to pay import duties and that their suppliers received the EU domestic price, which was higher than the international price (Anderson, 2003). Some of the main arguments brought against the EU regime related to the inefficiency and consumer losses. An analysis of the regime by Borrel and Yang (1990), found that for every dollar of benefit that the banana policy brought to the producers in the ACP countries, the regime harmed non-ACP countries almost exactly one dollar, and in the process harmed EU consumers by more than thirteen dollars. The system was thus described as being highly inefficient. From the money gained from the higher price that consumers were asked to pay in order to support farmers in the developing world, only a small proportion of it was actually received by the producer (Kresten, 1995). Lending support to this is the argument by Sutton (1997) who opined, that Britain was more concerned with the arrangement for bananas as a form of subsidizing the British shipping business than supporting producers in the Caribbean.

In 1998, the WTO ruled that this EU regime was discriminatory. When the dispute was finally settled, a two step approach was agreed upon leading to the eventual liberalization of the EU banana market by 2008. First, the EC agreed to replace its quota system by a tariff-only system, no later than 1 January 2006. When it was introduced, the tariff was set at EURO 176 per tonne for Most Favoured Nations MFN suppliers including a duty free quota of 775,000 tonnes for ACP states (FAO, 2006). The second step was that the tariff preference granted to ACP countries would be eliminated after 2008.

Those not in favour of the Regime could find support in the argument of Alexandraki and Lankes (2004) who showed St. Lucia to be among the ten countries, most exposed to losses from preference erosion. This was attributed

to the strong dependency of the St. Lucian economy on banana exports at that time.

From 1993, when the previously mentioned banana regime came into effect, revenue from Caribbean banana exports began to decline. Following the 1998 ruling this trend worsened. For the period, 1992-2002, revenue from banana exports fell from US\$139 million to US\$43.3 million (Perville, 2003). Meanwhile, Latin American countries gained a greater share of the European market, and in fact by 2005, large suppliers in Latin America diverted exports from the US to Europe, causing a fall in import prices in Europe and a rise in prices in the US (FAO, 2006). This shift in the export and import pattern is revealed in Table 1.1. In 1986, there were 6 Caribbean islands (St. Lucia, St. Vincent, Suriname, Jamaica and Grenada) among the top 10 suppliers to the UK accounting for 84% of UK imports (of the top ten). By 1995, there were 5 Caribbean countries, (66% of the top 10) and in 2005, there were only 4(33% of the top 10). Dominica, Grenada and St. Vincent, were eliminated from the top ten leaving only Belize, St. Lucia and the Dominican Republic that had been relatively unimportant in the 1980's.

Table: 1.1 Shifts in UK banana imports by country of origin from 1986-2005.
Calculated from FAOSTAT database

Country	Banana (tonnes) '000 Year -1986	Country	Banana (tonnes) '000 Year -1995	Country	Banana (tonnes) '000 Year -2005
St. Lucia	109	St. Lucia	100	Cameroon	158
Dominica	46	Jamaica	84	Costa Rica	137
St. Vincent	40	France	69	Dominican Republic	114
Suriname	35	St. Vincent	47	Colombia	100
Colombia	29	Costa Rica	46	Belize	66
Jamaica	22	Belize	41	Brazil	36
Ireland	14	Suriname	36	Belgium	32
Belize	12	Honduras	33	St. Lucia	28
Grenada	8	Dominica	32	Netherlands	28
France	7	Belgium- Luxembourg	28	Côte d'Ivoire	28
Total	322	Total	516	Total	727
Caribbean	272	Caribbean	299	Caribbean	208
<i>Caribbean as % of total</i>	84%	<i>Caribbean as % of total</i>	66%	<i>Caribbean as % of total</i>	33%

1.4 Adapting to the New Regime

The islands' attempts to adapt to the new trading environment produced mixed results. For example, Grenada invested in an Organic Banana farm costing approximately US\$3 million. Success was limited⁵ and the farm was converted to conventional production within two years of its establishment. The islands tried to improve productivity by investing in irrigation, feeder roads, husbandry practices, marketing and production of Fair Trade bananas. They also received considerable support from the EU to help in their agricultural diversification efforts, however, these have had limited success and alternative crop(s) to replace bananas have not been identified (Laurent, 2003). The regional market is growing with bananas exported from St. Lucia and St. Vincent being imported into Barbados and Trinidad (Table 1.2). However, expansion has been relatively slow because of a limited availability of inter-island freight carriers.⁶

Table: 1.2 Imports ('000 tonnes) of banana by Barbados and Trinidad from St. Lucia and St. Vincent (2002-2005)

Trinidad imports from:			Barbados imports from:	
Year	St. Lucia	St. Vincent	St. Lucia	St. Vincent
2005	97	1265	315	1920
2004	42	1410	Not available	Not available
2003	12	1101	1274	1690
2002	Not available	1043	415	1837

Source: FAO trade statistics

⁵ Personal observation: There were a series of labour disputes on the farm, and production did not reach desired level, due to lack of technical expertise to cope with disease and the local demand for conventional bananas was stronger and more secure.

⁶ Personal observation: there was a Conference scheduled in Guadeloupe in September from 11-13 2008 to titled; *Caribbean Coastal and Inter-island shipping (Cabotage) Challenges and projects* to discuss this constraint), which is evidence of its priority and concern in the region.

In the particular case of St. Lucia, before the 1998 World Trade Organization (WTO) ruling, banana was an important contributor to the country's GDP. Banana exports contributed 10.3% of GDP in 1990, but by 2006 it had declined to 1.9% of GDP (IMF, 1999, IMF 2008). The number of banana farmers fell from 10,000 in the 1990s, to 4,800 by 2000. Only 2000-3000 are expected to remain in production after the industry has adjusted fully (IMF, 2004). The situation with regards to the effect of the fall in banana production in St. Lucia can best be summarized from the following quote:

“The remaining famers ... are old and conservative... The truth is the decline of bananas has already done most of its damage to the St. Lucian economy and society. Many farmers have gone out of the business or turned to growing of marijuana: accordingly their sons have not been able to inherit a functioning business and many have drifted off to Castries the capital: crime has grown and also become more professional in association with the growing use of St. Lucia as a transshipment point for drugs produced in South America and sold to North America”..... (Payne, 2006 p: 33)

A total of 30,000 persons were estimated to be employed directly or indirectly in banana production in the 1980s-1990s (IMF, 2002). The Central Statistical Office of St. Lucia (KAIRI, 2006) reports that there was a significant increase in unemployment because of the reduction in banana exports and that the level of unemployment was higher among older farmers for whom it was difficult to access jobs in other sectors. These increased levels of unemployment undoubtedly affect the household income of St. Lucians. The government of St. Lucia anticipated negative effects and with the aid of STABEX funds, from the EU, implemented programs to ameliorate the banana industry. Social recovery programs such as adult education and a farmers pension scheme were also undertaken (IMF, 2002).

The table below summarizes the events that occurred in the history of banana production in St. Lucia.

Table 1.3 Timeline of major events in banana production in St. Lucia from 1960 -2006

1960's	Banana introduced to Caribbean for commercial production
1970 -early 1990	Green Gold ((period of growth high revenue generation)
1993	Implementation of EU preferential access for products from ACP countries
1998	WTO ruling against EU preferential market access arrangement for ACP Bananas Significant drop in production and revenue from banana production
1998-2006	Continued decline in production and revenue, amid efforts to restructure the industry

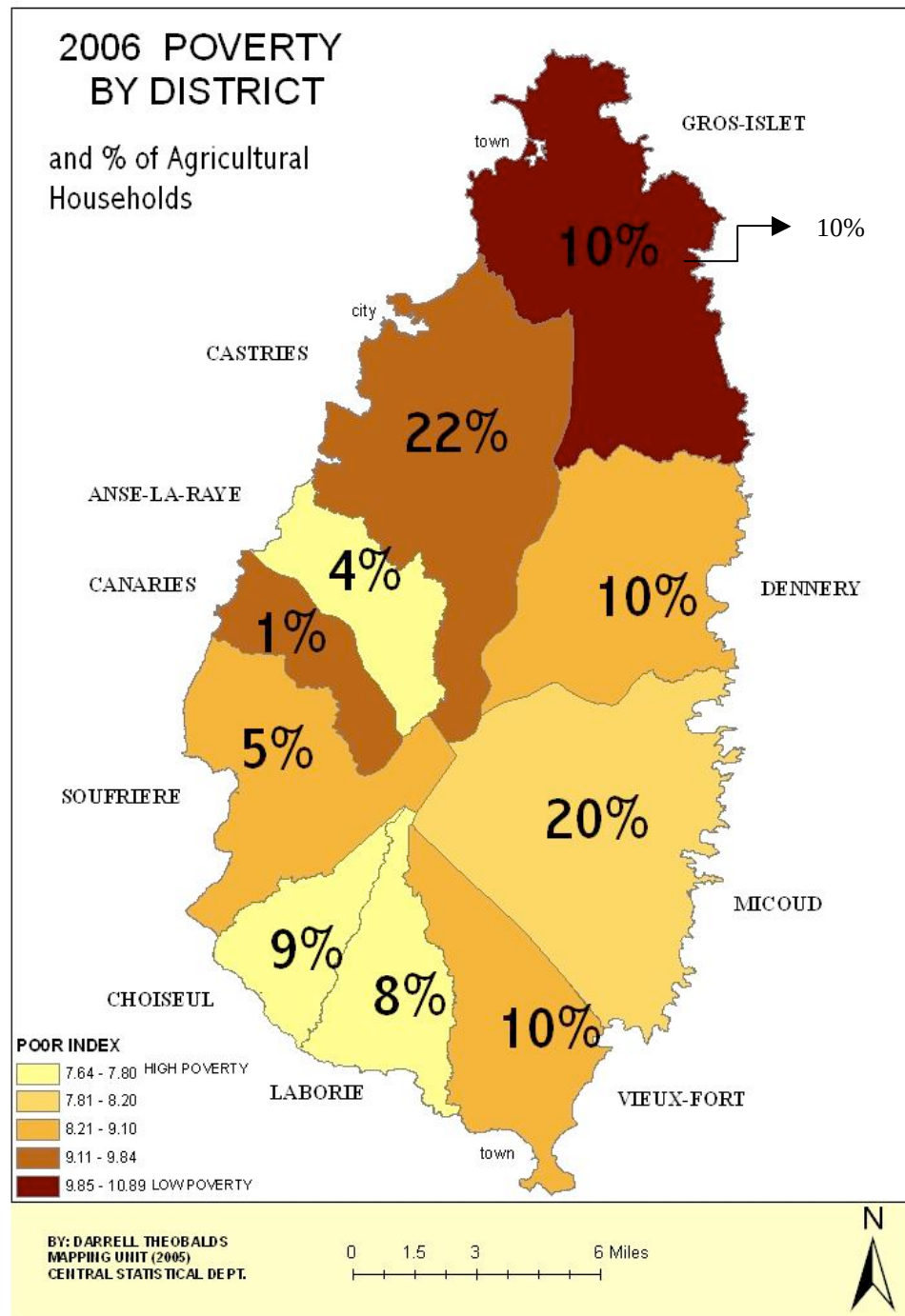
1.5 The Research Problem

During the past 10 years, a series of reforms were undertaken in the international banana trade that will lead to its eventual liberalization. In the Caribbean, this was accompanied by reductions in the volume of bananas exported, and increases in unemployment. From the above discussion, it is evident that the effect was profound on the island of St. Lucia. Studies were conducted to gauge the likely impact of the liberalization of the banana market on developing countries prior to its implementation.⁷ Previous work on inequality in St. Lucia was based two household surveys of 1995 and 2005. As mentioned earlier, the Gini index was calculated for the expenditure distribution and suggests a reduction in inequality. This seems surprising in light of the high levels of unemployment arising from the decline in the banana industry,

⁷ See FAO (2004) Trade and Policy Technical Notes for comprehensive comparison of the studies that calculate the effect of tariff equivalent on ACP exports and EU imports, Guyomard (1999) and Perville (2003).

occurring during this period. However, this same study (KAIRI, 2006) pointed out that the level of poverty increased particularly in the banana producing areas of Micoud. Figure:1.1 shows the level of poverty in the districts based on the 2005 survey, along with the percentage of agricultural households. (The two areas with highest levels of poverty, Anse-la Raye and Canaires, were not banana growing areas since soil and climatic conditions were not suitable and were always poor).

Figure 1.1 Map of St. Lucia showing poverty by district and percentage of agricultural households



Source: http://www.stats.gov.lc/mapping_page/map_index.htm
Government of St. Lucia Central Statistical Office

It is possible that different sections of the population, for instance those living in the capital Castries and those at upper and lower end of the income

distribution were affected differently by the changes and that this was masked by the single numeric value of the Gini coefficient. A related question that arises is: what is the statistical significance of this change in the Gini coefficient? This question has not yet been answered. Previous work on poverty established the probability of being poor based on the results of the 2005 survey, using logistic regression. It was found that employment, housing conditions, family size, and education and living in rural areas increased the likelihood of being poor (KAIRI, 2006). However, it appears that no research has been done to assess the statistical significance of changes in *income* inequality or changes in welfare in St. Lucia following the liberalization of banana marketing.

Thus, the effect of the banana liberalization on income inequality remains unclear. The loss of income from employment in the banana industry seems to have had an impact on income distribution. Qualitative studies point to the absence of work in the banana industry as the root cause and can be summarized in this quote, *"Since banana decline there is no work., when there was banana there was money, but that ain't so now.... Now we cannot get work."* (KAIRI, 2006 pg: 64). However, thesis will not attempt to establish a direct causal relationship between this liberalization and changes in income distribution, because of limited data. However, it can provide a definitive response to the question of how inequality and welfare have changed in St. Lucia following the liberalization of the world banana market.

1.6 Research Questions

1. Was there a change inequality measured by household expenditure in St. Lucia following the new liberalization of banana marketing?
2. What are the changes in welfare in St. Lucia between 1995 and 2007?
3. For a subset of the population who are the tax payers, how has income inequality changed in St. Lucia between 1998 and 2007?

1.7 Summary

There are four other chapters in this thesis. A review of St. Lucia's economy begins Chapter 2. A discussion on the possible impacts of liberalization on inequality is then presented, followed by a discussion on the methods that could be used to measure changes in inequality and welfare. In particular, the Gini coefficient is discussed along with ways to conduct statistical tests on it, using the non-parametric bootstrap. The use of the Lorenz curve and the Generalized Lorenz curve (GL curve) to determine changes in welfare are also discussed. A method involving the use of Kernel density functions to estimate changes in the Lorenz and GL curves is then presented. This is followed by a discussion on a distribution free inference approach for testing the difference between Lorenz ordinates of different distributions. Chapter 3 outlines the methods selected to determine the changes in inequality and welfare. The methods proposed involve the calculation of bootstrap standard error of the Gini coefficient, which can then be used to derive bootstrap confidence intervals. Also proposed is the method based on the computation of an asymptotically correct standard error for the Gini coefficient, along with the calculation of a test statistic for hypothesis testing of the difference between two biased corrected Gini coefficients, for different distributions. Lorenz curve and GL curve analyses are proposed as the method for examining changes in welfare. A non-parametric test on the Lorenz ordinates is also proposed to determine the statistical significance of the changes observed. The penultimate chapter presents the results of the bootstrap tests on the Gini coefficient and the distribution free statistical inference on the Lorenz ordinates, for the bottom 20% of the distributions. Finally, Chapter 5 includes a summary of the main findings, a discussion about the limitations of the thesis and suggestions for future research.

CHAPTER 2 LITERATURE REVIEW

This chapter begins with an overview of the St. Lucian economy and the possible impact of liberalization on income distributions. This is followed by a review of literature on measures of inequality and social welfare and how stochastic dominance is useful in assessing changes in welfare and inequality. It also includes a discussion on the bootstrap and its use in determining when changes in the most commonly used measure of inequality, the Gini coefficient, are considered statistically significant.

2.1 The Economy of St. Lucia

St. Lucia is an island state situated in the Eastern Caribbean. It has an area of 620 km² of which 4.9% is categorized as arable land. It has a population of 168,000 that was estimated to be growing at a rate of 2%, in 1997. However, the latest estimate in 2006 indicated that growth rate declined to 1.4 % (IMF, 2008). St. Lucia has a GDP per capita of US\$5,546 and is considered to be a middle income country (World Bank, 2008), with a small open economy and highly dependent on foreign trade to sustain economic growth (Lazare et al., 2001). The inflation rate for 2004 was 1.4% increasing to 3.9% in 2005 and falling to 2.3% in 2006. In 2008, the unemployment rate was 15.7% down from 21% in 2004 (Central Statistical Office (CSO) St. Lucia, 2008). Almost a quarter (24.1%) of the population was categorized as poor (those living below the poverty line⁸) in 1995, rising to 28.8% in 2005. The proportion of poor households moved from 18% in 1995 to 21% in 2005. Even so the Gini coefficient, which measures inequality in the population, was 0.5 and 0.42 in 1995 and 2005 respectively, suggesting a decrease in inequality (KAIRI, 2006). The poverty gap⁹ increased from 8.6% in 1995 to 9% in 2005. The working poor were employed in agriculture and manufacturing and the decline in the banana and the manufacturing or assembly sectors have been

⁸ The poverty line in St. Lucia is set at US\$1.27 per day and is the minimum amount of money necessary to meet basic survival needs food, clothing shelter, (KAIRI, 2006).

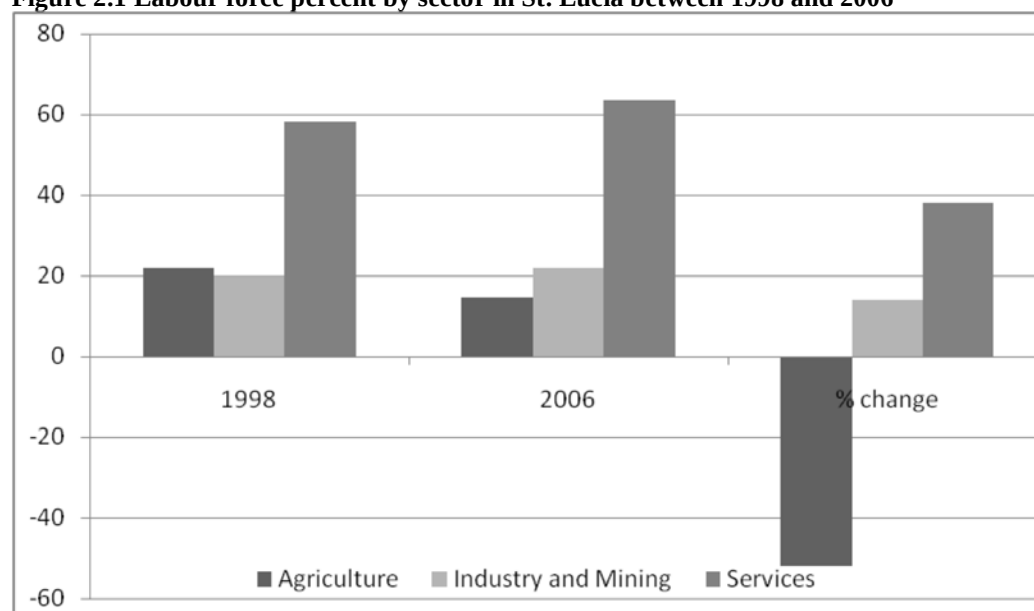
⁹ The poverty gap measures the mean distance below the poverty line as a percentage of the poverty line, where this mean is taken over the whole population

identified as the main reasons for the increasing incidence of poverty (KAIRI, 2006).

2.1.1 Macro Economy

Historically, agriculture was the most important economic activity in St. Lucia, utilizing the largest proportion of the country's labour force. However, as discussed earlier, from the beginning of the 1990s, the importance of agriculture declined and with this, there was a decrease in the number of persons employed in the sector. The largest percentage change in the utilization of the country's labour force occurred in the agricultural sector, which decreased by 52%, while industry and mining and services increased by 14% and 32% respectively¹⁰. Figure 2.1 describes this structural shift in employment. This is corroborated by agricultural census reports which reported that, whereas in 1976, 75% of households reported that agriculture was the main source of the household income, in 1998, this was true for only 25% of households (Ministry of Agriculture (MoA), 2007).

Figure 2.1 Labour force percent by sector in St. Lucia between 1998 and 2006



Source:

(IMF, 2006:2008)

¹⁰ Calculated from data in (IMF,2006; IMF, 2008)

Lazare et al, (2001) divided the macroeconomy of St. Lucia into three distinct periods, 1986-1989, a high growth period, 1990-1994, with lower growth of 2.1% and the period 1994-1998 described as being markedly slow, averaging only 1.7%. The high growth of the first period was driven by growth in the tourism and agricultural sectors. Among the three periods, agriculture's contribution was highest in this period because of the expansion in banana production and increases in foreign exchange earnings associated with banana exports. The favourable exchange rates between the Pound Sterling and the Eastern Caribbean (EC) dollar also contributed. During this period, construction, and communication services were also important, having expanded on average by 22% and 26% respectively (Lazare et. al, 2001).

The economic slow down of the second period was attributed to the decline in the agricultural sector due to uncertainty surrounding the banana industry. The formation of the European Single Market replaced the Pound Sterling with the European Exchange Rate Mechanism, which was less favourable to the banana farmers as they received lower real prices. As a consequence, there was a reduction in foreign exchange earnings. However tourism improved as did foreign direct investment (FDI).

During the third period the poor performance of the banana industry was responsible for the comparatively low growth. The value added by the industry declined (-21%) in 1994 and (-23%) in 1997. The reduction of exports and the increase of imports of goods and services served to widen the current account deficit. However tourism and communication gave a positive contribution. (FDI) increased at that time, and this together with the use of STABEX¹¹ funds and borrowing were used to boost capital inflows.

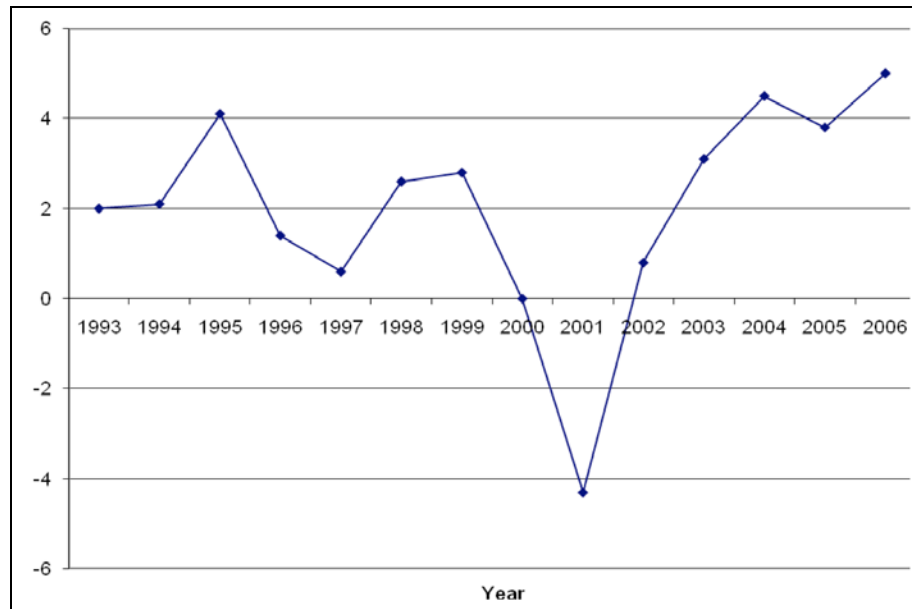
Similarly, a fourth period can be categorized from 1998 to the present. This is characterized by a decline in GDP followed by a small recovery and subsequent decline. Figure 2.2 shows the growth rate of GDP from 1993 to

¹¹ STABEX fund was established in 1975 under Lomé I to aid African Pacific and Caribbean (ACP) countries, address their development challenges and is funded by the European Union. Specifically, its purpose is to help stabilize export earnings by limiting the drop in income from certain products exported to the European Union by paying a compensation financial transfer which preserved the real value of the export transaction (Koehler, 1997 and Spore, 1990)

2006. It highlights the initial decline in GDP and its subsequent increase from 2001-2006. The decline in GDP was due to continued decreases in revenue from banana exports, while the growth experienced from 2001 was related to activities in the construction and service industry, geared towards the preparation for the Cricket World Cup held in the Caribbean in 2006. The current account deficit was 18% of GDP in 2003 and peaked at 33.3% in 2007 (ECCB, 2008).

In 2008, economic activity slowed down due to decreases in manufacturing and construction. Tourism experienced a small recovery of 2.2% compared with a decline of almost 8% in 2007. The economy was also negatively affected by the global economic crisis (IMF, 2009; Ministry of Finance, 2009). The performance of agriculture was a highlight of the economy. This was due to strong recovery in banana production from a 10.7% decline in 2007, to an increase of 26.5% (38,369 tonnes) in 2008, (Ministry of Finance, 2009). Despite this, the economy is likely to perform poorly in the near future. Annual real GDP growth is expected to be -2.5% in 2009, and -0.4%, in 2010, showing positive growth only in 2011, when it is forecast to be 1.8%. In July 2009, the Eastern Caribbean Currency Union of which St. Lucia is a member predicted a contraction of 2.9% for its members due to a fall in construction and tourism both of which rely on foreign funds (FDI and visitor receipts.).

Figure 2.2 Annual growth rates (percent) of GDP in St. Lucia (1993-2006)

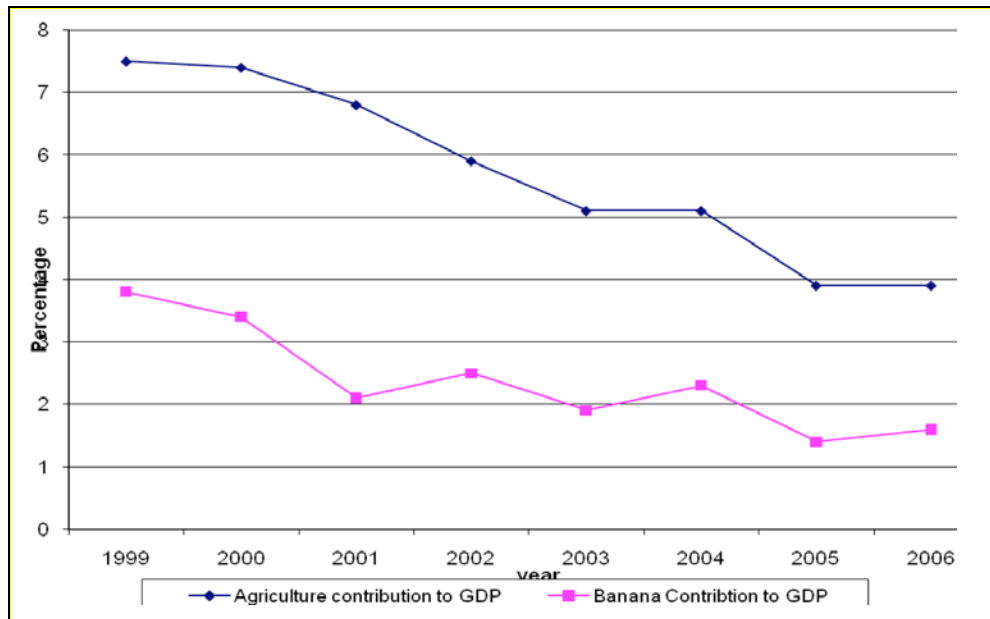


Source: Central Statistical Office St. Lucia
http://www.stats.gov.lc/na_main/GDP%20Growth.pdf

2.1.2 Agriculture in St. Lucia

The agricultural sector in St. Lucia is comprised of crop, livestock production and fisheries. But the crop production sector is the most important and banana was traditionally the most important crop. In 1990, agriculture contributed 13.8% to GDP and 70% of this came from banana production. By 2005, then ongoing negotiations with the EU, over conversion of its banana import regime from a multi-quota and tariff regime to a single tariff structure in 2006, served to further increase uncertainty in the industry (CSO, 2005). In 2006, agriculture's contribution fell to 2.3%, and banana production accounted for 40% of this.

Figure 2.3 Contributions of Agriculture and Banana to the GDP of St. Lucia



¹²Source: (CSO, St. Lucia)

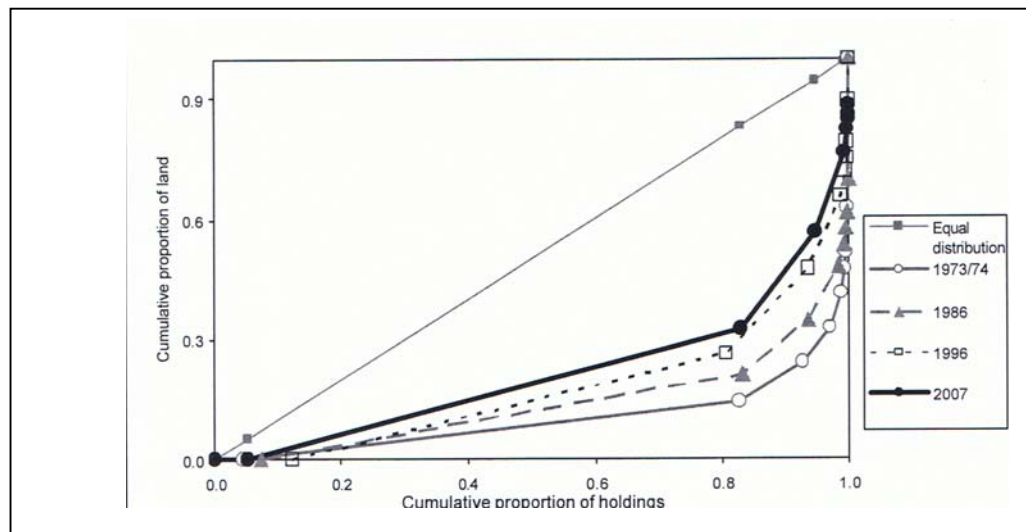
The decrease in banana production also translated into a direct loss of tax revenue for the government, because of reduced income earned from the export tax on banana, which is set at 5% of gross export sales. An indirect loss was experienced in the paper board industry due to the decreased need for banana packaging containers. The volume (boxes are recorded by weight) produced went from 24,000 tonnes in 2002 to 11,000 tonnes in 2006 (IMF, 2006). In the first quarter of 2008 there was a 15% drop in production, again due to reduced demand for boxes, used to package banana for export (ECCB, 2008).

The lack of confidence in agriculture was reflected in its decreasing ability to attract credit from commercial sector. In 2005, credit to the agriculture sector contracted for the fourth consecutive year, falling to 7% of total loans to \$26.5 million. This is in contrast to loans for tourism which increased from 12% in 2002 to 18% in 2005 (ECCB, 2005; 2008; CSO, 2005).

2.1.3 Agricultural Households and Land Distribution

According to the 2007 Agricultural Census of St. Lucia there were 32,919 agricultural households representing 21% of total households. This represents a decline in agricultural households of 26%, compared to 1986 highlighting again the declining importance of agriculture. There was however, improvement in land distribution as shown from the Lorenz curves below. More individuals now owned a greater proportion of land compared to forty years ago (Ministry of Agriculture (MoA), 2007). One explanation may be that land tenure in St. Lucia, like many Caribbean islands, was associated with the colonial era when there were large plantations, or estates as they were referred to. Over time these estates were broken up into smaller plots and this trend continues today. The MoA census (2007) reports that in 1996, there were 39 farms of 100 acres or more and by 2007 there were only 11, representing a change of 71.1%.

Figure 2.4 Lorenz curve for land distribution 1973-2007



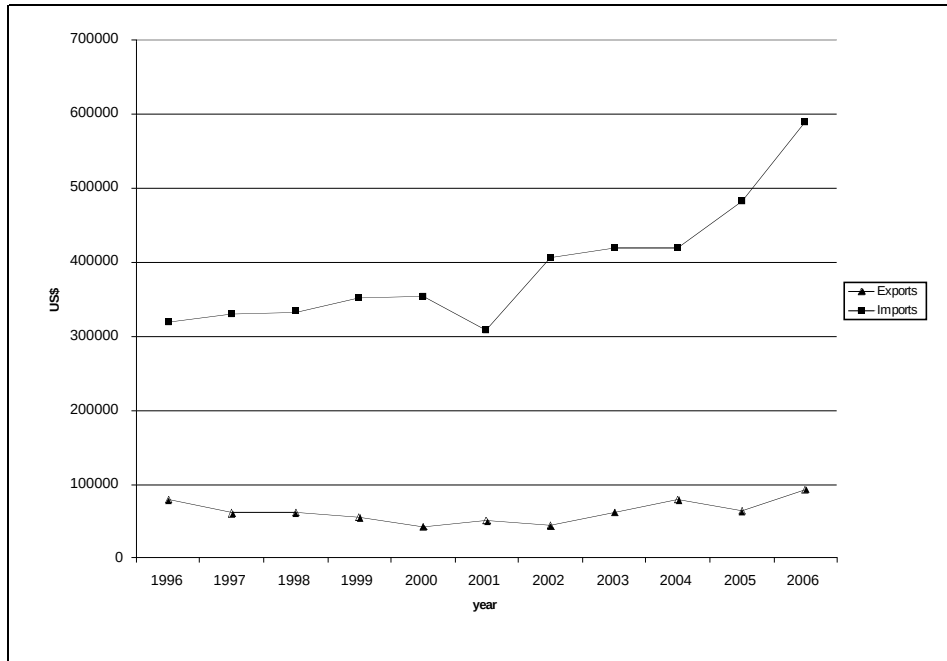
Source : (CSO, 2007 p : 8)

2.1.4 Trade

Trade is important to St. Lucia; on average more than 60% of government current account revenue was received from taxes on international trade on goods and services between 1999 and 2006. The balance of trade

deficit has become progressively wider from 1996-2006 especially from 2001 as seen from Figure 2.5, here values are in nominal terms

Figure 2.5 Pattern of trade in St. Lucia from 1996-2006 in US\$('000)



Source: IMF, 2002 and 2008

The destination for St. Lucia's exports changed between 2002 and 2006 (Table 2.1) and can be primarily attributed to the decline in banana export. Exports to the United Kingdom accounted for about half (52.2%) of St. Lucia's total exports in 2002 while exports to Caribbean (CARICOM) countries represented about one third. However, by 2006, the trend was virtually reversed with exports to CARICOM accounting for almost half (42.9) of total exports while those to the UK had dropped to 33.6%. Banana, beer and boxes (packaging for banana) remain the three most important items exported regionally. The growing importance of regional trade was not only due to loss of markets in the UK and Europe, but can also be attributed to the movement towards liberalization within the region. In 1991, CARICOM countries agreed to reduce their Common External Tariff from 45% to 28% by 1998 (Stotosky,

2000)¹³. Among Caribbean countries, Barbados and Trinidad are the most important to St. Lucia.

Table 2.1: The relative importance (percent) of export destinations for St. Lucia (2002-2006)

Export Destination	2002	2003	2004	2005	2006
United Kingdom	52.2	42.6	46	18.9	33.9
CARICOM	33.5	43.3	42.7	65.4	42.9
Barbados (as percentage of CARICOM)	10.9	10.9	10.4	10	1.2
Trinidad (as percentage of CARICOM)	4.1	11.1	11.8	36.1	37.4

Source: (IMF, 2008)

The preceding account of the economy of St. Lucia showed that its performance was intertwined with the performance of the banana industry up to 2007. Subsequently, in 2008, and early 2009, it appears that global contractions also played a major role in the performance of the economy. Liberalization may have been followed by changes in the level of inequality in St. Lucia, since many persons were rendered unemployed by the demise of the banana industry. The loss of employment and subsequent re-employment in other sectors might have also changed the level of inequality and well-being. Empirical evidence suggests that the impact of liberalization on inequality and welfare is not always conclusive; the issues surrounding this will now be discussed.

2.2 The Impact of Trade liberalization on Income Distribution-Empirical Evidence

The impact of liberalization on inequality and poverty has been examined by methods based on the Global Trade Analysis Project (GTAP), general equilibrium models, the Social Accounting Matrix, household surveys, or a combination (Reimer 2002). But as Milanovic (2005) suggests it is difficult to

¹³ Although their work did not contain empirical arguments, the authors provided preliminary evidence which showed that when the tariffs were reduced, the regional trade would increase.

make generalizations on whether or not the methods used are more likely or not to show one result versus another because of the heterogeneity among countries. Empirical evidence on the effect of trade liberalization on income distribution is for the most part, inconclusive. The reasons could be related to data itself, model specification, for example involving omitted variables along with how openness is defined (Ravaillion, 2004; Milanovic 2002). It is therefore difficult to say *a priori* what the impact of liberalization should be, since several factors have to be examined. These include the share of households' income which is derived from factor inputs affected by the liberalization, prices in consumer markets, along with fiscal and financial measures (Reimer, 2002; Anderson, 2003; Winters et.al 2004).

Anderson, (2003) used the GTAP to show that with full trade liberalization by rich countries, both developed and underdeveloped countries would gain. Sarnitsart (1995) also used the GTAP and found that if free trade was adopted in Thailand that income equality would improve. Bourguignon, (1990) used household surveys and conducted a cross-country analysis of twenty small and medium developing countries to estimate the effect of trade on income distribution. He found that liberalization can have a negative impact on income inequality. Alexandraki and Lankes (2004 pg; 27) concluded that if trade preferences are removed, small island economies are likely to face "serious adjustment challenges." Albert (2005) acknowledged that the impact of liberalization on income distribution may vary, but concluded that trade liberalization was indeed responsible for rising global inequality. Berry (2005) argued that the increase in inequality observed in developing countries which implemented trade liberalization policies can be explained by the growing difference in wages between more and less skilled workers.

Gourdon et al, (2008) found that when trade liberalization took place in countries that were well-endowed with capital and highly skilled workers, there were increases in inequality, while in countries endowed with unskilled workers, that is those with mainly primary level education and arable land, there were

decreases in inequality. But in countries where many people had no education (i.e., not even primary education) they found that inequality increased.

In many developing countries like St. Lucia, the effects of open trading regimes have been mixed. This is because the benefits of trade are related to the level of infrastructure, development, strength of local institutions, including property rights and completeness of markets. Information asymmetry, unresponsive bureaucratic structures and having a dependent position in the world market also impact the outcome of trade liberalization policies (Cornia, 2005; World Bank, 2006). The review above suggests clearly that it is difficult to forecast how the income distribution in St. Lucia has changed due to liberalization of the banana market.

2.3 Assessment of Changes in Inequality

Generally, the assessment of the changes in income distribution can be used to show if inequality increased or decreased over time and in which sectors either the poor or rich benefited most from those changes. Changes in welfare can be used to determine if a society is better or worse off over time. In the following section, a review of literature measuring changes income inequality and also in welfare is presented. This includes a discussion of indices of inequality, such as the Gini and the Atkinson, followed by discussion on the social welfare function and its relationship with inequality. The reason for examining both follows Deaton, (1997) who states that in this way one avoids the error of interpreting measures of inequality as measures of welfare. It is possible to have inequality decrease and also have social welfare increase, for example if the rich get poorer but the overall standard of living increases. The concept of stochastic dominance is then introduced along with Lorenz and Generalized Lorenz (GL) dominance and how they are used to measure changes in inequality and welfare respectively. The Kernel estimator is discussed showing how it can be used to estimate the density function for the Lorenz and GL curves. The use of the density function to examine how

changes in income and welfare affect certain groups within the population, over time is also presented. The method for testing of statistical significance of changes observed follows. A brief summary concludes the chapter.

2.3.1 Desirable Properties of Measures of Inequality

Inequality in an income distribution can be measured using variety of indices. These include the variance, the coefficient of variation, the relative mean deviation, and the Gini coefficient, among others. Yntema (1933) provides a detailed discussion of each of these indices. Measures of inequality should, in addition to having a single value, (which would lead to an unambiguous conclusion when comparing the inequality between different distributions) have finite values, preferably between 0 and 1, since this facilitates easy interpretation (Yntema, 1933). Other criteria include that they should;

- Satisfy the Pigou-Dalton principle of transfer. This means that the transfer of some amount of income from a poor person to a rich person in a way that preserves the mean of the distribution should increase the value of the measure.
- Be decomposable. If the population is divided into sub-groups it should be possible to determine how much of the inequality of the population is due to within-group inequality and between group inequality.
- Be scale independent. If all incomes were to increase or decrease the measure of inequality should not change, all other things being equal.
- Have anonymity. The measure does not change if only the names of the persons are changed, such that it does not matter who has what (Deaton and Muellbauer, 1980).
- Be bounded. It must include its endpoints.
- Unit free, so that it is comparable across countries and over time and is unaffected by the number of units (individuals or households) in

which income is measured (Hoy et al, 2001, Yntema, 1933; Atkinson 1970; Frank 1977).

2.4 *Measuring Inequality and Welfare*

Inequality can be measured using income data, expenditure data or consumption data for individuals or households. In the case of St. Lucia, expenditure data have been used to measure the inequality because income data were under reported or unreported. This highlights one of the advantages of using expenditure data over income data in developing countries. Some people refuse to cooperate when asked to provide income data and when they do it is subject to measurement error (Deaton, 1997). Another problem associated with the use of income data in developing countries is farm income, which is typically important for the poor and near poor, but often not captured in survey forms (Ravallion, 2001). Largely, due to this type of measurement error in income data, expenditure data have been used as an indicator of inequality in developing countries, like Jamaica (King and Handa, 2000) and in Burkina Faso (Fafok et.al, 2001).

A standard of living measure for welfare analysis considers expenditure on all goods and services consumed by the individual or household valued at appropriate prices, and includes consumption of goods produced by the household such as the food produced on farms or kitchen gardens (Deaton, 1997; Ravallion, 2001).

“Most analysts using household data for developing countries in making welfare comparisons have preferred current consumption to income as an indicatory of living standards. Variability is probably the main reason.”
(Ravallion 1997 p; 13).

Consumption data is also useful when the permanent income hypothesis (PIH) is considered. According to the PIH, households seek to maintain constant consumption over time by minimizing the adverse impact of inter-

temporal shocks through dissavings or borrowing. Thus, while income may fall due to agricultural seasonality (rain fed agriculture in poor countries) the consumption pattern may remain relatively unchanged and thus the standard of living remains virtually unaffected. This is done through the use of savings and family or community pooling of resources (Deaton 1997; Ravillion, 1992). While the very poor generally have limited access to these resources, the use of expenditure data can still capture relative differences households' ability to maintain current and future standards of living. This is because differences in consumption can reflect differences in the ability to maintain current living standards.

The use of other types of data apart from income data does have disadvantages. For example, consumption data are also subject to measurement error (though not as severely as income data) in developing countries where households are both producers and consumers. This is because householders often have difficulty in accounting for what is actually produced and what is actually consumed (Deaton, 1997). Another problem is that while consumption data are a good measure of the current standard of living, as mentioned above, and can also give an indication of long-term living standards, these data are noisy. For example, two households, one young and one old, could have different life-time wealth but show the same consumption on the date of the survey. The same level of welfare may be inferred, when in fact because of the difference in life-cycle, their future consumption pattern is likely to differ due to their respective patterns of wealth and savings (Ravillion 1992). For this reason, income data is better than consumption data when studying the long term standard of living, when savings are positive because the savings level affects the consumption level in the future. If savings are negative, then consumption data is preferred because of the opportunity to share resources among family and community (Ravillion, 2001).

Changes in relative prices may pose a problem for inequality measures derived from consumption data. The reason is that households react differently to price changes since rich and poor spend different a proportion of their

income on various goods and services. The price change may cause inequality to increase or decrease for certain sections of the population. For example, Muellbauer (1974) showed that when these relative price changes are not considered, inequality was underestimated.

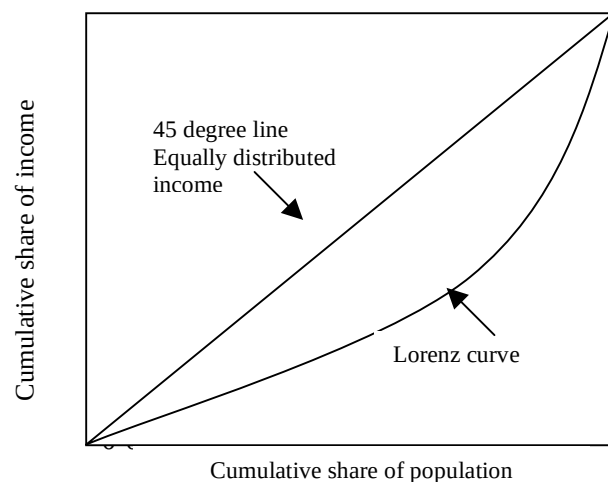
When expenditure data are used instead of income data, Deininger and Squire (1996) showed that there is a 6.6 percentage difference between the Gini obtained from expenditure data than that obtained from income data. Li et al (1998); King and Handu (2000) followed their recommendation and added 6.6 percentage points to their Gini as their inequality measure was also expenditure based.

The preceding section summarized the features of inequality measures and discussed the issues relating to the use of consumption, expenditure or income data to calculate inequality measures. Some of these measures, such as the Gini coefficient, the Atkinson index and the Lorenz curve will be presented next.

2.5 Lorenz Curves

The Lorenz curve gives a graphical representation of the distribution of income, measuring the proportion of income against the proportion of the population earning that income. The 45 degree line represents an equally distributed income. Inequality is often depicted by the Lorenz curve (Figure 2.6). The Lorenz curve may be defined as: $L(y, p), p \in [0, 1]$ (and y is income and p is the proportion of persons with this income).

Figure 2.6 Lorenz Curve



The information in the Lorenz curve can be summarized by the Gini coefficient which is a number equivalent to twice the area between the 45 degree line and the Lorenz curve. Following Davidson (2008a) when the cumulative distribution function for an income distribution is denoted $F(\cdot)$; the Lorenz curve is defined implicitly as:

$$L(F(y)) = \frac{1}{\mu} \int_0^y z \, dz \quad (1)$$

Here μ is mean income of the CDF, assuming there are no negative incomes. L is non-negative, increasing, and convex and maps the interval $[0, 1]$ into itself.

2.6 The Gini Coefficient

The Gini coefficient measures the level of inequality in a given population. It is the most widely used measure of inequality and may be represented on the Lorenz curve as 1 - twice the area between the line of perfect equality and the Lorenz curve. It lies between zero and one, with values closer to zero indicating higher equality. The Gini coefficient (G) can be defined as (Davidson, 2008a)

$$G = 1 - 2 \int_0^1 L(y) dy \quad (2)$$

Here L is the (Lorenz curve). The Gini satisfies the conditions listed earlier that are desirable for inequality measures. One drawback is that it is not additively decomposable. It therefore does not permit comparison of inequality within the same income category. To conduct analysis it is necessary to first define the categories of income and then use the Gini to measure the changes between these predefined categories. It is more useful for giving directional change in distribution than describing changes within the distribution. According to Deininger and Springer (1996) to compensate for this the information on quantiles is usually reported along with the Gini coefficient. The Gini also

attaches more weight to transfers in the center of the distribution, so it is a good measure of inequality when one is interested in examining how middle income earners are affected by a policy that affects the income distribution. So for example, if one wanted to attach more weight to transfers at the lower end of the distribution then the standard deviation of logarithms would be a more appropriate measure (Atkinson, 1970). Another consideration is that the Gini coefficient can give the same value for two income distributions whose Lorenz curves cross even if the overall shape of their distribution of income is different. In this case, the value of the Gini coefficient alone cannot be used to tell which curves are more egalitarian.

Another issue to consider when using the Gini coefficient is its apparent stability over time. Li, et. al., (1998) found that the Gini coefficient in many countries was generally stable over time. Their study was based on 49 developed and developing countries over the period 1947-1994. Adjustments were made for differences in the definition of income (per capita vs. household, income vs. expenditure data). Analysis of variance of the Gini coefficients was done to examine the variance according to time, country, and definition of income and expenditure. The country variable accounted for 90% of the variance in the Gini coefficients in their sample and was the only statistically significant variable. Less than 1% was explained by time. Their results point to cross country differences as the source of the variation with very little is attributed to inter-temporal difference. This may be because within country factors that affect income inequality such as education and access to credit do not change drastically from year to year. Thus, while it is useful for cross country comparisons it may be limited when examining inter-temporal changes within a country.

2.7 *Social Welfare Function and Inequality*

While the Gini coefficient and the Lorenz curve are used to measure and depict the level of inequality in society, normative judgments about the nature of the economy can be made through welfare analysis.

The study of social welfare falls under welfare economics, in which one is concerned with making normative judgments about what is good or bad for the individuals in the society and with the optimal allocation of resources so that social welfare is maximized. The criterion of Pareto Optimality can be used to help make these judgments, and it states that a situation or economy is Pareto Optimal if there is no alternative that can make citizens better off without making someone worse off. Thus, Pareto Optimality is the preferred situation for a society.

Choosing a Pareto Optimal solution depends on the choice of a Social Welfare Function (SWF). The SWF can be considered as an aggregation of individual utility functions which represent household or individual preferences for alternative social states (Deaton and Muellbauer, 1980). Each individual's preferences are represented by a utility function, written as a function of per capita income or consumption. The SWF permits judgments about choices the society can make to improve the well-being of its members. Assuming there are additively separable and symmetric functions of individual incomes (y), the value of the social welfare function (V) is (Deaton, 1997 p 134)

$$W = V(y_1, y_2, \dots, y_n) \quad (3)$$

Here (n) is the number of individuals. The function is non-decreasing in y and there is greater welfare when V is increasing in each of its arguments and there are Pareto improvements. Other properties of social welfare functions are that it has anonymity, (who has what does not matter), and more equal distributions are preferred to less equal distributions. The principle of transfer applies so that the transfer of income from a rich person to a poor person

should increase social welfare as long as the transfer is not large enough to cause a reversal in their relative positions (Deaton, 1993).

As an alternative the Kaldor-Hicks principle can be used to judge if a policy intervention increases welfare even though it is not a Pareto improvement. It states that an outcome is more efficient if undertaking it would increase the income of at least one person, while disadvantaging another, so long as the gain to the winner is enough to compensate the loser. The Kaldor-Hicks principle implies that a more efficient outcome can leave some people worse off. No payment is actually necessary.

2.8 Atkinson's Inequality Index

Atkinson (1970), proposed an inequality index that estimates changes in both equality and welfare. It is based on what he defined as the concept of equally distributed equivalent income. This is the level of income per capita, which if distributed equally to everyone would produce the same level of welfare as the current distribution. It is calculated as shown below, where (n) is the number of observations, (x_i) is the income earned by the i th group and (μ) is the mean income.

$$A = 1 - \frac{n}{1} \left[\sum_{i=1}^n \left(\frac{x_i}{\mu} \right)^{(1-\varepsilon)} \right]^{(1/1-\varepsilon)} \quad (4)$$

The parameter ε can take on values from 0 to infinity however it usually ranges from 0.5 to 2. ε Indicates the society's preference for inequality so as ε increases the society has greater preference for income transfers to the lower end of the distribution. The Atkinson index lies between 0 and 1 and a larger number indicates greater inequality (Kawachi, 2000). Normative judgments about the distribution, for any class of social welfare functions that are increasing and concave in income can be made. For example, it allows one to state if the society is better off or worse off as a result of the changes in

income distribution. Another advantage over the Gini is that it is decomposable allowing the analysis of within group inequality in the distribution.

Other indices such as the Theil index can be used to measure welfare. However calculation of these measures necessitates parametric assumptions about the distributions, and sometimes these lead to faulty inference because of poor fit with the data to a particular functional form. Nonparametric methods can be used, and these are robust to errors because a functional form is not imposed on the distribution (Kennedy, 2003). The analysis of dominance of Lorenz curves is one of the ways of determining if there are changes in inequality while avoiding this situation.

2.9 *Lorenz Dominance*

Lorenz dominance refers to the situation where one Lorenz curve B is everywhere above Lorenz curve A, and the means of the two distributions must be equal (Arora and Jain, 2006). The Lorenz curve B dominates A and there is less inequality in B than in A. The dominating Lorenz curve is a more egalitarian distribution since, by the principle of transfers the lower curve can be transformed into the higher through equalizing transfers. This dominance feature is used to rank distributions in terms of inequality. However, if the curves cross the distributions cannot be ranked because neither of them dominates (Deaton, 1996 and Davidson, 2008a).

2.10 *The Generalized Lorenz Curve*

Lorenz curves can only be compared if the distributions have the same mean. The Generalized Lorenz curve is used to make comparisons of distributions with different means overcoming the restrictiveness of the Lorenz curves. According to Shorrocks (1983) the Lorenz curve can be converted to the Generalized Lorenz Curve, $GL(y,.)$. The cumulative distribution function CDF of income (y) is ordered in terms of increasing incomes and the ordinates of the Lorenz curve multiplied by the average of the distribution. This scales

the Lorenz curve up by the amount of the means, so that distributions with different means can be compared. The horizontal axis of the GL curve still represents the fraction of the population, but the vertical axis shows the cumulative share times the mean and represents the levels of incomes. According to Davidson (2008a) the GL curve is defined as

$$GL(F(y)) = \int_0^y z dF(z)dz. \quad (5)$$

2.11 Generalized Lorenz Dominance

When comparing two distributions A and B whose CDFs are F_A and F_B there is Generalized Lorenz Dominance of B by A for any argument (y) when the CDFs of A lies everywhere above that of B, that is A has a higher social welfare than B. This means the poorest percent in B will have *more* than the poorest percent in A. Thus B is the dominating distribution. This GL curve can be used to rank distributions according to welfare when the means are not the same and they do not intersect. As defined by Davidson (2008a) for two independent distributions there is Generalized Lorenz dominance of B by A when

$$\forall GL(p) = GL_A(p) - GL_B(p) \geq 0 \text{ for all } p \in (0,1) \quad (6)$$

Here (p) is the cumulative fraction of the population of the respective distributions. When making comparisons according to GL curve dominance, Shorrocks' theorem is used to decide which curve is dominant. If the GL curves of one curve dominates the other and mean income is higher then, the welfare is higher in the dominating curve. As long as the curves do not cross an unambiguous welfare ranking is possible.

2.12 Crossing Generalized Lorenz Curves

GL curves are used when the Lorenz curves cross to rank distributions. However ranking according to dominance of one curve over the other is not

possible if GL curves cross, since Shorrocks' theorem cannot be applied (Figure 3.1 a and b).¹⁴

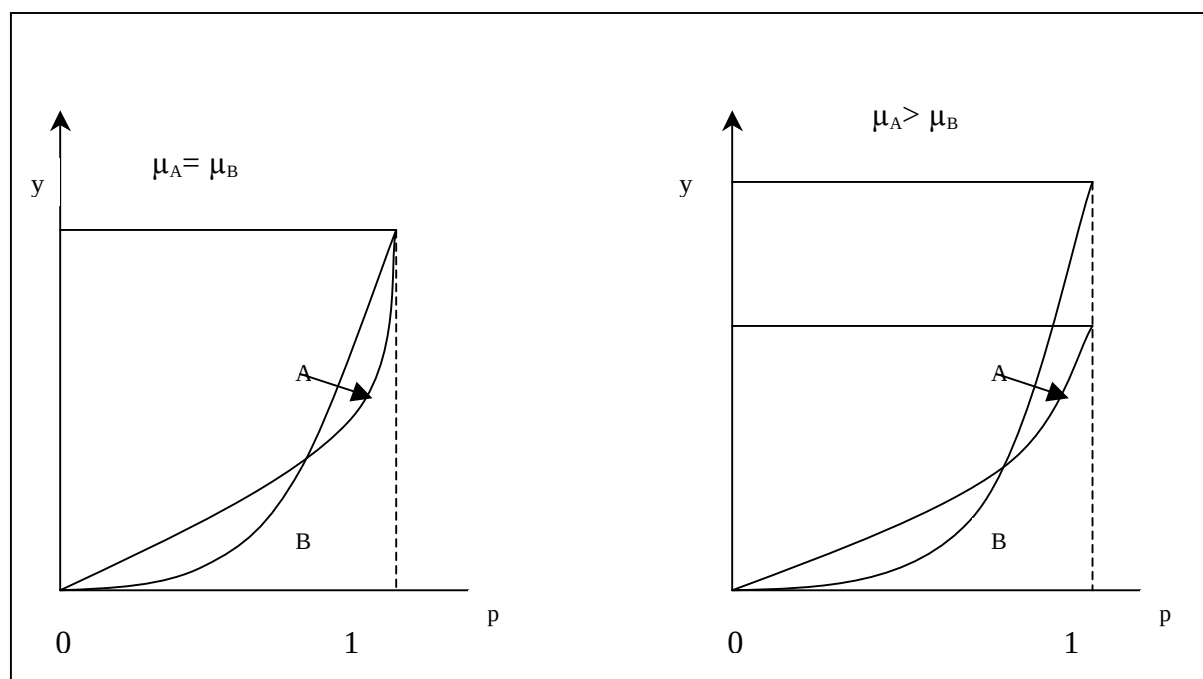


Figure 2.7 Crossing Generalized Lorenz Curves

In this case, restrictions have to be placed on the form of the social welfare function so that the trade off between more income (efficiency) and equality is considered. The ranking is thus achieved by examining the means (Utilitarian criterion), the variance or by the Rawlsian criterion (Dardanoni and Lambert, 1996). When the Utilitarian criterion it is applied, the distribution with the higher mean income, as evident by the higher end-point on the Lorenz curve graph is preferred (Shorrocks 1983; Bellù 2005c). Alternatively, when ranking according to the Rawlsian criterion (inequality-aversion), (Dardanoni and Lambert, 1996; Ballu, 2005c) the incomes of the poor are given more weight than other income brackets. The preferred distribution is the one where

¹⁴ http://www.fao.org/docs/up/easypol/307/swa_crsgenlc_003en.pdf (pg:4)

the incomes of the poor are highest, so that the GL curve that dominates the lowest incomes is preferred. Thus, the conflict of efficiency versus equity is resolved depending on the point of view of the analyst. However, it can be resolved more objectively for the class of SWFs for which the third derivative is positive. This means that the SWF satisfies the principle of diminishing transfers, which states that an increase in social welfare brought about by a transfer of a given amount of income from a richer to a poorer person, both of whom are in the lower part of the distribution, increases the social welfare more than a transfer of the same amount of income from a richer person to a poorer person both of whom are the upper part of the distribution (Bullu, 2005c; Dardanai and Lambert, 1996).

If the means of crossing GL curves are equal then the Utilitarian criterion is not useful. Instead the variance is compared. If the variance of B is less than the variance of A, then distribution B is preferred to A, for all SWF with

$$\frac{\partial w}{\partial y} > 0, \frac{\partial^2 w}{\partial y^2} < 0 \text{ and } \frac{\partial^3 w}{\partial y^3} > 0. \quad (7)$$

When means are unequal and GL curves cross once, the mean-variance criterion can be used to rank the distributions (Bellù: 2005c). He outlines three conditions that must be satisfied for ranking to be possible. These are that:

1. the GL curve of the income distribution **B** crosses the GL curve of the income distribution **A** from above:
2. the mean of income of **B** is less than the mean income of **A** ($\bar{b} < \bar{a}$)
3. the inequality specifying the mean-variance condition is satisfied: $\sigma_B^2 < \sigma_A^2 - (\bar{a} - \bar{b})(2z - \bar{a} - \bar{b})$, the variance of B is sufficiently less than the variance of A, where z is the maximum income of the two distributions

Thus, if the conditions are satisfied i.e. the mean of income B is less than A B is preferred if the variance of B is sufficiently less than A by all SWF of the form (7), Rankings are not possible if the variance condition or mean-variance criterion do not hold.

2.13 Stochastic Dominance

Davidson in (2008b) defines stochastic dominance as a set of relations that may hold between a pair of distributions applied to the ranking of income distributions, but it can also be used in financial economics. There are different degrees of stochastic dominance. There is first order stochastic dominance and second order increasing to the n th order. To determine if there is stochastic dominance of one distribution over another, the cumulative distribution functions are formed first. If there are two cumulative distribution functions F_A and F_B , first order stochastic dominance of B over A for an argument y , denoting an income level, is defined as $F_A(y) \geq F_B(y)$. This means that for this level of income (y) the proportion of individuals in the distribution A with incomes no greater than y is not less than the proportion of these individuals in distribution B. If A dominates B at say a chosen poverty line (z) there is more poverty in the distribution of A than in B and A is referred to as the dominated distribution (Davidson, 2008a).

2.14 Second Order Stochastic Dominance

When the concept of stochastic dominance is used to examine changes welfare, essentially this means that one looks for the existence of second order stochastic dominance of one distribution over the other. Following Davidson (2008b) $D^s(y)$ is used to denote stochastic dominance of order (s). D is found by repeatedly integrating the CDF of the distributions A and B from 0 to y . The sequence commences at D^1 which is the CDF of A, D^2 is the integral of D^1 and this continues to higher orders of dominance ($S= 1,2, 3, \dots$). When there is second order stochastic dominance of A by B then there is a preference for a mean preserving progressive transfer of income that increases welfare (Shorrocks, 1983). In other words, society favours a more equitable

distribution. Second order stochastic dominance of A can be defined (Davidson, 2008b) as

$$D^2(y) = \int_0^y D(z) dz \quad (8)$$

Distribution B dominates distribution A at second order stochastic dominance if the following conditions hold,

$$D_A^2(y) \geq D_B^2(y) \text{ for all } y \quad (9)$$

Comparing GL curves is the same as determining the existence of second order stochastic dominance of one distribution over another (Shorrocks, (1983) and discussed by Davidson, (2008a)¹⁵. Thus one can check for either Generalized Lorenz dominance or second order stochastic dominance when investigating a change in welfare.

2.15 P- approach to Stochastic Dominance

The p-approach to dominance expresses dominance in terms of quantiles of the distribution (Davidson, 2008a). The quantile function is the inverse of the CDF corresponding to F expressed as $F^{-1}(p) = \inf\{y | F(y) \geq p\}$, $0 \leq p \leq 1$ (Arora and Jain, 2005) and p is an ordinate value between 0 and 1. The GL curves $GL(p)$ are defined by Davidson and Duclos (1998) as

$$GL(p) = \int_0^{Q(p)} y dF(y) \quad (10)$$

The p-approach is useful when comparing Lorenz curves at particular quantiles. It is used to compare the two distributions up to the p ordinate. For example, p could be the poverty line (z) (Davidson and Duclos, 1998). The disadvantage of focusing on quantiles, when comparing distributions for stochastic dominance is that by using only part of the available information, tests could be inconsistent (Barret and Donald, 2003).

¹⁵ Working paper

2.16 Alternatives Methods for Examining Income Distributions

The methods for studying income distributions may be parametric or non-parametric. The parametric method involves fitting the empirical distribution to one of several density functions, such as the Pareto, lognormal or log-logistic, obtaining the CDF and then making inferences about the distribution based on the chosen form (Salvatore, 2006). However as discussed earlier, Beach and Davidson (1983) showed that it is possible avoid making arbitrary judgments about the form of its empirical distribution and still make statistical inferences about changes in inequality. Their method was non-parametric. Another non-parametric method involves the use of the kernel density. The kernel density method can be used to estimate the density of the income distribution (Dixon and Maré, 2006). Based on this, standard errors and confidence intervals can be calculated to determine which changes in the distribution are statistically significant.

2.16.1 The Kernel Density Method

This is a non-parametric method for estimating the density of functions of distributions of income, consumption or welfare (Deaton, 1996). When a distribution is assumed to have a particular functional form, the density can be characterized by its parameters such as the mean and standard deviation for the normal distribution. In cases where no functional form is apparent, or to eliminate the risk of choosing the incorrect form, a histogram can be used as a guide to the shape of the function. It can also be used as a crude estimator of the density function. The bins which are the rectangles in the histogram, the bin width and the left most starting point are the parameters used in the calculation (Greene, 2006). The use of the histogram is not the best option because histograms are not smooth and therefore, difficulty will arise when trying to use this method to estimate continuous functions. The estimate from the histogram also differs according to bin width (unit interval) and the endpoints of the bin (length of interval of all the bins). See Kennedy (2003) for a detailed discussion. These shortcomings are overcome by using

the kernel estimator. When plotted, the y-axis usually represents the density of the income distribution. When the kernel function is denoted (K) and its bandwidth by (h), the estimated density at any point x is

$$f(x) = \frac{1}{n} \sum_{i=1}^n K\left(\frac{x - x_i}{h}\right) \quad (11)$$

Here n is the number of observations ($x_1, \dots, x_n$). There are several kernel estimators¹⁶ as listed in Greene (2006). However, the functional form is not as important as the bandwidth chosen because if the bandwidth is too small, the density will be under-smoothed and if the bandwidth is too large there will be over smoothing. Additionally, the bandwidth might need to be varied for different parts of the distribution or a different estimator used for the tail than for the body (Kennedy, 2002) as done by Cowell (1998). Starting with a rule of thumb, say choosing the bandwidth that minimizes the mean square integrated error, the bandwidth can be chosen and visually investigated to ensure that it does not over smooth or under smooth (Kennedy, 2006).

2.17 Applications

Holsch's (2002), cross-country analysis examined the effect of different social transfers on the welfare of citizens in five European countries using Generalized Lorenz Curves (GL curves). The household income was used as the unit of measure and adjustments were made using an equivalence scale to allow for the comparison of households of different sizes. Pairwise comparisons of GL curves were then conducted. He inferred that the dominating curve, having a larger mean, indicated a higher welfare position. But his conclusion was only possible if the curves did not intersect. If there was an intersection, a conclusion would be ambiguous and the rank given would be dependent on the specification of the social welfare function or on the restrictions placed on SWF to allow a partial ordering to be obtained (Shorrocks

¹⁶ The Epanechnikov, Normal, Logit, and Uniform, Beta, Cosine, Triangle and Parzen. Each of these has its unique formula of calculation Green 2006 pg: 455.

1983 pg 1)¹⁷ or the tradeoff between a higher mean and inequality. This trade off refers to the situation where there can be higher mean income and higher inequality or lower mean income and lower inequality. According to Holsch's analysis within the range of income prior to the intersection, where one curve clearly dominated the other, the average income and the welfare of that proportion of the population was higher in the dominating curve.

When the difference between the two curves was not evident, a graph was plotted of their difference subtracting the curve with the lower mean from that with the higher mean. This difference was plotted against the quintile of the population. Positive values indicated that the curves did not intersect at any point. In this case, Holsch concluded that there was Lorenz dominance of one curve over the other.

Cowell (1998) used a kernel estimator to investigate the change in income in Brazil between 1981 and 1990. He tried a normal kernel estimator to fit the income distribution. Finding a poor fit, he then used a log-normal transformation and arrived at a better fit. Using these density estimates, he was able to examine the trends in income distribution for income less than \$1000, which was where the mass of the income lay. He concluded that the fall in the peak of the density plot and the shift to the right, reflected rising inequality and growth of mean incomes for the period examined.

Dixon and Maré (2006), investigated the changes in income inequality among an indigenous ethnic group in New Zealand, based on data from two national income surveys. The study examined this change during a period of sustained economic growth from 1997-2003 and described changes using descriptive statistics and the kernel density method. The unit of analysis was the individual and not the household. This is to similar Strudler and Pestsk (2006) who used individual income tax returns to calculate Gini indices in a US study. Dixon and Maré (2006), highlight that the use of the individual is advantageous because there is no need for assumptions about how income is

¹⁷ Shorrocks (1983) proposed two constraints that could allow for rankings to be made, reflecting social preference for more equitable distribution and higher real incomes.

shared within the household. However, the disadvantage is that in households, with unemployed persons, the total income is what matters to the household and this would not be accounted for in the analysis. However, the authors' check for consistency showed that household income showed the same trend as individual income.

The Epanechnikov kernel function with bandwidth of 0.08 was used to estimate the income distributions. The authors under-smoothed the density function so that they would not miss peaks and troughs in the distribution. The density function revealed that from 1997-2003, there was a shift upwards and to the right in the central peak of the distribution indicating that there was growth in the average real income. They also identified increases in income in the mid to high level income brackets. Income densities were calculated for all members of the population eligible to work based on their age, as well as different sub-groups; employed and un-employed, men and women. The bootstrap was used to calculate standard errors. Confidence intervals were constructed around the difference between the kernel density estimates for 1997 and 2003, to test the statistical significance of the changes observed among groups. These tests revealed a statistically significant reduction in the number of people who had zero incomes, interpreted by the authors as a reduction in the number of unemployed indigenous people.

Rostek (2000), also used dominance criteria to rank distributions and examine the relative movements of various income groups within the distribution. Nine European and Scandinavian countries were studied at twenty- seven different points in time, from 1967 to 1995. [The time periods were not all the same for each country but were within the same decades, for example France was studied in for the period 1981-1984 and Norway for 1979-86 and Sweden 1979-86]. The Gini coefficient was calculated at the beginning and ends of each period and gave the direction of the change in inequality. Pairwise comparisons of Lorenz and GL curves between countries were conducted, the results were categorized into conclusive (one curve was clearly above the other), inconclusive (curves crossed) and unambiguous (there was

an increase in inequality and an increase income). Based on Lorenz dominance, 9 out of the 27 periods were conclusive. The author was able to conclude that decreases in inequality were experienced in Finland, Luxembourg, the Netherlands, Sweden and the UK up till the end of 1980. However, by the first half of the 1990s only three countries experienced absolute increases in income level. When the analysis was conducted with the GL curve, 12 cases were conclusive and 3 inconclusive.

Lorenz curves were used to analyze the changes (which proportions of the population had greater changes compared to others) in income within the distribution. First differences of the Lorenz and GL curves were calculated. With this analysis of the densities of the first difference, Rostek goes further than Holsch (2002), who also used first difference to rank GL curves. The advantage is that Rostek was able to give more information than the ranking of the distributions, since the method indicated which the shares of population experienced a change. Moreover, using the kernel density estimates, Rostek was able to describe the changes that took place within the distributions. Specifically, the author identified in the case of Norway, that the middle of the distribution improved but this was at the expense of the tails of the distribution which grew poorer. Thus, in this way too it was possible to identify movements within the distribution that were masked by a simple overall ranking.

To choose the kernel for the density estimation of the first difference curves, the author estimated the density for all seven specifications of the kernel functions (using three bandwidths for each). The Epanechnikov function was chosen for all countries because it had the best fit that is it minimized the mean integrated squared error. From this analysis the author was able to conclude that for Finland the Generalized Lorenz dominance suggested that there was an improvement in its society as whole, while some people within the distribution were made worse off. This construction of the kernel density function of the first difference of the GL Curves also permitted the author to identify groups in the distribution that had welfare gains or losses over time.

The review above indicates that the Gini coefficient is best used to provide a summary indicator of the directional changes in inequality. It further highlights the use of Lorenz and GL curves to evaluate changes in inequality and welfare respectively. The use of the Kernel density method to determine the exact location within the distribution where changes occur was also noted. The use of the bootstrap to estimate the standard error and ultimately the statistical significance of the changes observed was briefly mentioned. In the following section this will be presented in greater detail.

2.18 The Bootstrap

The notations defining the terms used in the description of the bootstrap are as follows:

1. θ Refers to a parameter of the distribution F of a random variable
2. $\theta = t(F)$ Refers to the parameter being a function of F and the operator is t .
3. $\hat{\theta}$ Refers to the parameter estimate (estimator) obtained from a sample of the population.
4. $\hat{\theta} = t(\hat{F})$ Refers to the function of the empirical distribution $\hat{F}$ used to compute parameters
5. $\hat{\theta}^*$ Refers to the bootstrap estimate of the parameter
6. se Refers to the standard error
7. $se_{\hat{F}}^*$ Refers to the bootstrap standard error of the empirical distribution.

The bootstrap, introduced in 1977 by Efron, is a technique used to assess the accuracy of statistical estimates associated with a sampling distribution, often through the calculation of the standard error, bias, confidence intervals or p-values (for the purpose of testing). This can be accomplished by the bootstrap even when no parametric assumptions are made about the data.

A further advantage of the bootstrap is that it can be used even if the data are multimodal or skewed so that linear approximation is not necessary (Chernick, 2007). No analytical expression for the estimator is needed, regardless of the complexity of the computation for deriving it (Efron and Tibshirani, (1993); Boos, (2003); Chernick, (2008)).

The bootstrap is a re-sampling procedure that replicates the procedure by which the original data were collected with replacement. For each re-sampled distribution the statistic of interest is calculated and stored. After the chosen number of replications, the values of the statistic are used to compute a suitable measure such as the standard error. The re-sampling procedure ensures the sampling distributions generated remain IID, (independent and identically distributed). Each of the bootstrap samples has a sample size of n elements and is drawn from the empirical distribution $\hat{F}$.

$$s((x^{*1}), (x^{*2}) \dots x^{*B})) \quad (12)$$

B is the number of the replicates drawn from the original data set X and used to obtain x^* . Here s is the operator used to calculate the statistic. B can be equal to 50 for the calculation of the standard error but usually no more than 200 replications are needed. When it is necessary to construct bootstrap confidence intervals however, a larger number of replications are needed (Efron, 1993). The $(*)$ refers to the re-sampled data set and is called a Monte Carlo approximation of the distribution θ^* . The standard deviation of this distribution is the Monte Carlo approximation to the bootstrap estimator of the standard error for $\hat{\theta}$. This method can be used because according to the law of large numbers, as the number of replications gets very large, the bootstrap standard error¹⁸ approaches the standard error of the empirical distribution.

For an estimator such as the mean, the standard error can be calculated using the standard formula; however for many measures, such as measures of inequality, the calculation of the standard error is not as straight forward (Efron and Tibshirani, 1993). One alternative is to make statistical inferences based

¹⁸ The definition of standard error being the general term for the standard deviation of a summary statistic (Efron & Tibshirani, 1993 pg 40)

on theories of asymptotic normality of the distribution of a statistic. Asymptotic normality means that the distribution of the statistic approaches a normal distribution as the sample size becomes very large. In this method analytic mathematical theory is used to obtain the limiting distribution of the statistic as the sample sizes approaches infinity. Because of the mathematical complexity involved, in most cases using asymptotic theory, it is not easily implemented in practice. The bootstrap is often chosen as the alternative because of its ease of use and accuracy ((Efron and Tibshirani, (1993), Moran, 2003)). In fact, Davidson (2009) also showed that the bootstrap gave a more reliable estimator than that derived through asymptotic approximations. The bootstrap procedure is preferred since it minimizes the error in rejection probability in a fixed sample, and it is considered a superior approach to the estimation of critical values when compared with those obtained from asymptotic theory (MacKinnon, 2007; Davidson, 2008).

2.19 The Plug-in-principle

The bootstrap applies the plug-in-principle to produce and then assesses the standard error, bias, variance, confidence intervals, or prediction error of the estimator (i.e., assess its accuracy) (Efron, 2003). As explained by Efron and Tibshirani, (1993), the plug-in-principle refers to a method of estimating a parameter from a random sample by substituting or plugging in the empirical estimator $\hat{\theta} = t(\hat{F})$ in place of the parameter $\theta = t(F)$. Essentially, applied to the bootstrap, it involves the use of the same estimator that would be used to with the empirical function to obtain the parameter for the bootstrap sample. It gives the best estimator in the non-parametric setting, that is, where there is no (parametric) assumption made about the distribution itself. If F is the probability distribution function we have,

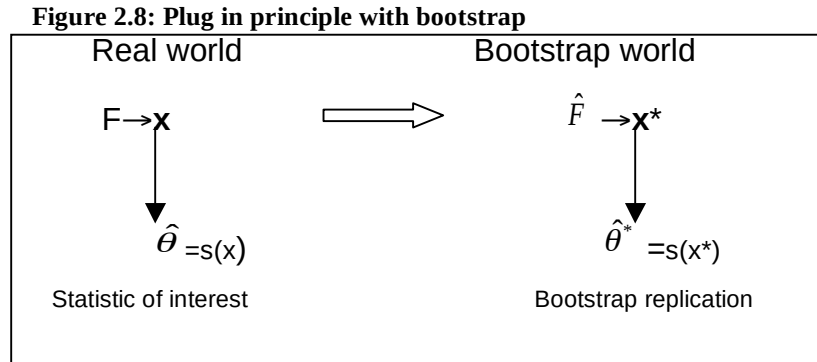
$$F = \{ \mathbf{x}_1, \mathbf{x}_2, \dots, \mathbf{x}_n \}, \text{ and } \hat{F} = \{x_1, x_2, \dots, x_n\}$$

$$\theta = t(F) \tag{13}$$

$$\hat{\theta} = t(\hat{F}) \tag{14}$$

The plug-in-estimate of the parameter equation (13) is equation (14).

Figure (2.7), adopted from (Efron and Tibshirani, 1993; Efron, 2003) summarizes the plug-in-principle applied to the bootstrap. In the diagram to go from the real world to the bootstrap world involves simple substitution of the empirical estimator based on F to obtain the parameter based on $\hat{F}$ which is the vector of bootstrap observations ($\mathbf{x}$) selected n times. This step is indicated by the double line arrow.



Source: (Efron and Tibshirani, 1993 p: 87; Efron, 2003 p: 136)

In the real world, the sample is obtained from the data and used to generate a statistic $\hat{\theta}$. In the bootstrap world $\hat{F}$ gives the bootstrap data vectors ($\mathbf{x}^*$) which are used to generate $\hat{\theta}^*$ the bootstrap test statistic. The variability of the test statistic is used to assess the accuracy of a parameter (Efron, 2003). Following Efron and Tibshirani, (1993) the plug-in-principle can be applied to generate the standard error of the Gini coefficient (G) for an income distribution. If the Gini coefficient is a function of the distribution $G = t(F)$ by the plug-in principle, the estimate of the Gini coefficient is generated using the same function of the empirical distribution

$$\hat{G} = t(\hat{F}) \quad (15)$$

The Gini coefficient is first calculated using the data in the sample, followed by the bootstrap of the Gini coefficient $\hat{G}^*$ and its standard error

$$se_F(\hat{G}^*) \quad (16)$$

Following Efron and Tibshirani, (1993), the standard error of the bootstrap estimate of the Gini coefficient approaches the empirical standard error as the number of replications B gets very large.

$$\lim_{B \rightarrow \infty} se_{\hat{F}}(\hat{G}^*) \rightarrow se(\hat{G}) \quad (17)$$

2.20 Bias

Bias is the difference between the expected value of an estimator and the parameter being estimated, $E[(\hat{\theta})] - \theta$. When the bootstrap is used to assess the bias of an estimator, the bias of $\hat{\theta} = s(x)$, of a real valued parameter ($\theta = t(F)$) is the difference between the expectation of $\hat{\theta}$ and the value of the parameter. This bootstrap estimate of the bias with B replications is (Efron, and Tibshirani, 1993 p 125):

$$bias_B = E_{\hat{F}}(\hat{\theta}^*) - \hat{\theta} \quad (18)$$

The reason for estimating the bias is to improve a biased estimator. One way of correcting for the bias is by subtracting the bias from the estimate itself (Efron and Tibshirani, 1993). Small bias, but more importantly an unbiased estimate where $E_{\hat{F}}(\hat{\theta}^*) = \theta$ are preferable in statistical work. Plug-in estimators usually have small biases compared to the size of their standard errors, and a bias of less than 0.25 standard errors can be ignored (Efron and Tibshirani, 1993).

2.21 Hypothesis Testing and Confidence Intervals

Hypothesis testing can be conducted using the bootstrap p-value (p^*) or by estimating confidence intervals. A confidence interval, with a level of significance of α % implies that the interval will contain the true value of the estimator α %, of the time, in this case the Gini coefficient. The confidence interval can be found by the following, where the se is standard error of the Gini,

$$\hat{G} \pm t \cdot (se_B) \quad (19)$$

Here t is the critical t value from the t distribution and se_B is the bootstrap standard error (Hamilton, 2006).

2.22 The Bootstrap p-value

This is useful for evaluating the strength of the conclusion reached by the confidence intervals analysis. The bootstrap p-value, p^* is the proportion of the bootstrap samples ($\hat{G}^*$) that give a test statistic larger than the ($\hat{G}$). Following Davidson and MacKinnon (2004) and Moran (2005) for one-tailed tests that reject the null hypothesis when ($\hat{G}^*$) is in the upper tail (unusually large), the bootstrap p-value is computed ((Davidson, 2001); (Boos, 2003)) as:

$$p^* = \frac{\# \{G_b^* \geq G\}}{B} \quad (20)$$

This means that the p^* value is estimated by the proportion (represented by the #) of bootstrap samples that give a statistic greater than ($\hat{G}$). If the value is

p^* is smaller than α (α is say 0.05 or 0.01) the null hypothesis

$$H_0: \text{Gini}_{2005} - \text{Gini}_{1995} = 0.$$

is rejected. The inequality sign would be reversed if the test should reject when ($\hat{G}^*$) is in the lower tail. The number of bootstraps for hypothesis testing should be about 2000 (Kennedy, 2006) citing (Efron 1987). MacKinnon (2007) suggests that $\alpha(B+1)$ (where α is the level of significance)¹⁹ should be an integer but say that B should not be less than 999 especially where cost of computation is not an issue.

¹⁹ Davidson and MacKinnon (2001) citing Dufor and Kiviet (1998) explain that because the bootstrap is a Monte Carlo approximation, B must be chosen so that $\alpha(B+1)$ is an integer. Their example suggests that for a value of $\alpha = 0.05$ the largest possible value of B must be 19. Otherwise the test will not be exact.

2.22.1 *Application of the Plug-in-Principle for Calculation of the Gini Coefficient*

For a randomly drawn sample of size n , that is IID, Davidson (2009), showed how to compute asymptotically a correct standard error for the Gini coefficient:

$$\hat{G} = \frac{2}{\hat{\mu}n^2} \sum_{i=1}^n y_{(i)} \left(i - \frac{1}{2} \right) - 1 \quad (21)$$

Where

$y_{(i)}$ = the ordered statistics for income (income data, ordered from smallest to largest)

n = number of observations

i = observation number

$\hat{\mu}$ = average income based on sample

The bias corrected Gini coefficient is calculated by multiplying the above Gini expression above by $(n/n-1)$.

He further outlines the procedure for calculation of the Gini which can be summarized in the following steps

$$1. \text{ Compute the vector: } w_i = \frac{1}{2n} (2i - 1) y_{(i)} \quad (22)$$

$$2. \text{ Calculate the mean of } w_i \quad \hat{I} = \frac{1}{n} \sum_{i=1}^n w_i \quad (23)$$

$$3. \text{ Calculate the bias corrected Gini } \tilde{G} = \left(\frac{n}{n-1} \right) \left(\frac{2\hat{I}}{\hat{\mu} - 1} \right) \quad (24)$$

To compute the variance and standard error the vector v_i is calculated as the partial sums of the income data. The steps are summarized as follows:

$$v_i = \frac{1}{n} \sum_{j=1}^i y_{(j)}$$

$$\text{Note that : } v_1 = (1/n)y_{(1)} \quad (25)$$

$$v_2 = (1/n)(y_{(1)} + y_{(2)})$$

$$v_3 = (1/n)(y_{(1)} + y_{(2)} + y_{(3)}) \quad \text{and so on}$$

Create the following vector and calculate its mean and variance

$$\hat{Z}_i = -(\tilde{G} + 1)y_{(i)} + 2(w_i - v_i) \quad (26)$$

$$\bar{Z} = \sum_{i=1}^n \hat{Z}_i \quad (27)$$

$$\hat{V}(\tilde{G}) = \sum_{i=1}^n (\hat{Z}_i - \bar{Z})^2 \cdot \left(\frac{1}{(n\hat{\mu})^2} \right) \quad \text{and} \quad \hat{se}_G^2 = (\hat{V}(\tilde{G}))^{1/2} \quad (28)$$

To test for the difference between two Gini coefficients Davidson (2009) recommends first to define the standard errors as $\hat{\sigma}_{G1}$ and $\hat{\sigma}_{G2}$. The test statistic for two independent populations used test whether the Gini coefficient is the same is:

$$T = (\tilde{G}_1 - \tilde{G}_2) / (\hat{\sigma}_{G1}^2 + \hat{\sigma}_{G2}^2)^{1/2}. \quad (29)$$

Davidson (2009), suggest hat when his estimate of the standard error of the Gini coefficient is used together with the bootstrap, reliable inferences are obtained and he showed how the bootstrap p-value can be calculated.

2.23 Statistical Inference with Lorenz Curves

Beach and Davidson (1983) suggested that the Lorenz curve should be used for more than descriptive statistics. The same applies to GL Curves. Davidson and Duclos, (1998) used the p-approach to stochastic dominance to conduct statistical tests up to the poverty gap. They were able to show that

generalized Lorenz dominance was statistically significant up to a particular p-value. In their cross country comparison, they were able also able to identify countries for which the difference in poverty level was statistically significant. Their method was distribution free and so required no assumptions about the empirical distributions. Bishop et al (1991) used a similar method to conduct statistical inference on Lorenz curves. This approach of Bishop et, al.,(1991) has the advantage ,similar to Rostek (2002), of providing additional information on the nature of differences in inequality within the two distributions that are being compared. But it goes further than Rostek , since it permits the assessment of the statistical significance of the differences observed. Additionally, one avoids the tedium of fitting of various Kernel estimators to the distributions. Bishop et, al. (1991) derived an asymptotic distribution for the Lorenz ordinates, which are various points along the distribution of income proportions. Statistical comparison is possible because the distribution does not depend on any functional form. The authors developed a formula for the calculation of the Lorenz ordinates and this is based on the following definitions.

- Φ - these are the Lorenz ordinates, $i=1...K$
The ordinates correspond to the number of quantiles (K) that are being used in the comparison between income distributions. For example if every 10 percent is being compared (deciles), ($K=9$) are being compared along the distribution
- p_i Lorenz abscissa, or values along the x-axis of the Lorenz curve (population proportions)
- $F(y)$ Cumulative distribution of income
- ξ Income quantiles (e.g., median income)

For p_i , to calculate the bottom 20% of the distribution, $p_i=0.20$. For deciles of the distribution, then $p_i=0.1, 0.2, 0.3 \dots 0.9$.

The Lorenz ordinates are now expressed as:

$$\hat{\Phi}_i = \frac{\sum_{j=1}^{r_i} Y_j}{\sum_{j=1}^N Y_j} \cong p_i \frac{\hat{\gamma}_i}{\hat{\mu}} \quad (30)$$

This is interpreted as the amount of income earned by the subset of the sample relative to the total amount of income earned by everyone in the sample. It is equivalent to the proportion of the population in question multiplied by the conditional mean divided by the mean of the entire sample.

At this point they rely on the work of Beach and Davidson (1983) to calculate the asymptotic standard errors as:

$$se(\hat{\Phi}_i) = \left(\frac{v_{ii}^L}{n} \right)^{1/2} \quad (31)$$

where:

$$v_{ii}^L = \frac{\hat{p}_i}{\hat{\mu}^2} \left[\hat{\lambda}_i^2 + (1 - p_i)(\xi_{pi} - \hat{\gamma}_i)^2 \right] + \left(\frac{p_i \hat{\gamma}_i}{\hat{\mu}^2} \right)^2 \hat{\sigma}^2 - 2 \left(\frac{p_i^2 \hat{\gamma}_i}{\hat{\mu}^3} \right) \left[\hat{\lambda}_i^2 + (\hat{\mu} - \hat{\gamma}_i)(\xi_{pi} - \hat{\gamma}_i) \right] \quad (32)$$

$\hat{\gamma}_i$ - sample conditional means

$\hat{\lambda}_i^2$ - sample conditional variances

ξ_{pi} - income quantiles

$\hat{\mu}, \hat{\sigma}$ - sample mean and variance of income

The sample estimates that are used these are, the sample mean, conditional means, conditional variances, the income quantiles and the p_i . These give the diagonal elements of the variance-covariance matrix of the Lorenz ordinates that they identified as V_L above.

With this estimation of the Lorenz ordinates and standard errors, comparisons can be made between the Lorenz curves, at various proportions of income p_i , without knowledge of the true income distribution, thereby allowing for distribution-free statistical tests.

2.23.1 Statistical Testing

A test statistic based on the standard normal distribution can be calculated to compare two Lorenz curves at various income proportions p_i . A test statistic is calculated at each proportion to be tested. The null hypothesis is that there is no difference between the two Lorenz ordinates, and the test statistic is calculated as follows:

$$z = (\hat{\Phi}_{1i} - \hat{\Phi}_{2i}) / \left[(\hat{v}_{i1}/N_1) + (\hat{v}_{i2}/N_2) \right]^{1/2} \quad (33)$$

This calculation requires that the distributions are independent though they can have different sample sizes (N_1 and N_2). $\frac{V_{ii}}{n}$ is the variance.

To compare the entire Lorenz curve the null hypothesis tests that the two curves are equal and the test statistic is:

$$\chi_K^2 = (\hat{\Phi}_{1i} - \hat{\Phi}_{2i})' \left[(\hat{V}_{L1}/N_1) + (\hat{V}_{L2}/N_2) \right]^{-1} (\hat{\Phi}_{1i} - \hat{\Phi}_{2i}) \quad (34)$$

In this test the entire variance-covariance matrix is used. The test statistic to compare all ordinates simultaneously has K degrees of freedom, equal to the number of quantiles.

2.24 Summary

This chapter provided a review of the economy of St. Lucia showing that it was affected by the liberalization of the international banana market. The possible impact on inequality, measured by changes in income distribution was discussed and the conclusion reached that because of heterogeneity of countries and methods used to study its impact there can be no *a priori*

conclusion about the impact of liberalization on income distribution. This is supported by empirical evidence which provides varying conclusions on the impact of liberalization on inequality. The methods for studying changes in equality were then discussed, along with the advantages and disadvantages of using expenditure versus income as the unit of measure. The Gini coefficient, Lorenz curve and dominance concepts were also discussed showing how these can be used to measure changes in inequality. The general consensus that observed differences in Gini coefficients should undergo statistical tests, led to the discussion of the bootstrap technique and how it is useful in assessing when changes observed are statistically significant. A discussion on determining the statistical significance of rankings of Lorenz curves was presented. The following chapter will provide a discussion of the methods used to investigate the research questions previously outlined.

CHAPTER 3 RESEARCH METHODS

In this chapter, the methods used to answer the research questions are presented. The data sources, assumptions about the data and descriptive statistics that will be presented are briefly discussed. Then the methods of analysis follow. These are based first, on the calculation of the Gini coefficient, and then its bootstrap standard error which is used to generate a bootstrap test statistic. This test statistic is used to conduct statistical tests on the difference in inequality between expenditure distributions of 1995 and 2005. Secondly, the concepts of Lorenz and generalized Lorenz dominance are employed to rank distributions according to inequality and welfare respectively. Thirdly, statistical inference procedure is utilized to test the equality of the Lorenz curves.

3.1 Sources of Data

At this time, data availability poses a challenge, so no attempt can be made to try and establish a direct causal relationship between changes in income distribution and trade liberalization in St. Lucia. However, it is possible to show how inequality changed, in the period following the liberalization of international banana marketing. This is accomplished by measuring changes in the distribution of income and expenditure.

Two data sets were used in the analysis. The first set of data was obtained from the 1995 and 2005 household surveys conducted by the Central Statistical Office of St. Lucia. These surveys include information on population demographics: members and size of household, and number of dependents under fifteen; level of education, religion, occupation, health and access to health care. It also includes expenditure information on household items such as, clothing, education, food, health and insurance among others. Unlike previous surveys conducted in St. Lucia, these two uses the same survey instrument allowing for comparison. The data however does not constitute a

panel data set. Respondents were selected using a two staged stratified systematic random sample selection process. In the first stage clusters within enumeration districts were selected. In the second stage, ten households were selected from each cluster. The data set for 2005, contains 1222 households (4319 persons) while the 1995 data set contains 600 households (2200 persons). This represents 2.7 and 2 percent of the population respectively.

The second data set contains individual income tax data obtained from the Inland Revenue Department of St. Lucia and contains annual panel data from 1998-2008 for 14,000 persons. However, as explained by Deininger and Squire (1996), this data cannot be used to make conclusions about the state of inequality in the entire country, because it is not a representative sample. It does not permit conclusions to be drawn about the entire population of St. Lucia since the data only covers a subset of the population, which are those persons that are employed and pay taxes. Agricultural workers are exempt from taxes in St. Lucia thus this data cannot be used to make conclusions about overall inequality in St. Lucia as a large section of the working population is omitted. Thus, it will be used to investigate the changes in income inequality from 1998-2008 for tax payers in St. Lucia.

3.2 *Data Assumptions*

The underlying assumption of this study is that the data meet the quality requirements as described by Deininger and Squire (1996). The first is that the data come from household surveys instead of national accounts. Secondly, the data should be representative of the whole population. Household surveys containing only information on, for example, taxpayers or working persons should not be used to make inferences on national inequality which is why conclusions will be limited to taxpayers. Thirdly, data should include detailed coverage of all sources of income for the unit, (individual or household). Fourthly, non-monetary income as well as income earned through wages, pension, and self-employment should be included. Fifth, the definition of expenditure or income should be the same for both surveys ensuring

comparability Deininger and Squire (1996). Finally, the data sets are assumed to be independently and identically distributed.

3.3 Data Treatment

Cursory investigation of the income tax data suggests that there may be measurement error arising from data input and reporting bias (under reporting or over reporting by respondents). In this case as suggested by Cowell et al. (1999) the validity of the dominance results will be tested. To do this, a balanced trim of the distributions, involving the removal of 0.5% and 1% of the observations from each tail of the distribution will be conducted and the results compared. This will account for small amounts of contamination. Both tails are chosen since there is no reason to believe that data contamination is arising from an “economic phenomenon that is more likely to affect one tail of the distribution” (Cowell et al 1999 pg 8).

For some households, total expenditure was recorded as zero. This suggests that the household did not purchase any item, yet this is a bit unrealistic. Since it occurs in a small number of instances, these observations were dropped. Where there is zero income in the income tax data set, there was no information on the unit for that year (Personal communication, Leon)²⁰. This means the individual either did not earn income or did not report it. When Cowell et al (1999) conducted analysis on the sensitivity of their results to the presence of zero incomes they found that dropping or keeping the zero incomes had no effect on the direction of inequality in their study. Following their study, the results will be reported for the analysis of income tax data with and without zero income. The income tax data are adjusted by the consumer price index for 2007 to allow for comparability following Deaton (1997) and Bishop et al. (1991).

²⁰ Marlene Leon Inland Revenue Department Government of St. Lucia April 7 2009

3.4 *Equivalence Scale*

To measure expenditure inequality in St. Lucia, the Gini coefficient for household per capita expenditure, adjusted for size of household, was calculated by the Central Statistical Office for the 1995 and 2005 surveys. An adjustment for size of household was made to account for the fact that in households with children, the needs are different from those without children. It was made using a household equivalence scale. This is an index number used adjust the data so as to compare welfare or real income across households (Deaton and Muellbauer, 1980), based the poverty gap (p) at market prices for a household, with A adults and K children. The equivalence scale is defined as the ratio of expenditures needed for a family unit, relative to expenditures needed for a reference unit (usually a family of four two adults and two children) (Muellbauer, 1977). There are several measures of the equivalence scale and the one used by the CSO is called the square root scale and is equal to the household income divided by the square root of the household size.²¹ The data set thus contains the variable already defined in terms of per capita adult equivalent expenditure.

3.5 *Method of Analysis*

3.5.1 *Descriptive Statistics*

Descriptive statistics such as the mean, median, maximum and minimum values along with the standard errors will be presented for both the survey data and income tax data. Histograms and CDFs will be also being presented. The same descriptive statistics will be presented for the income tax data. The Lorenz curves and Generalized Lorenz curves will be drawn for each year to facilitate visual inspection of the movement in inequality over the time period.

²¹ (<http://www.oecd.org/els/social>).

3.5.2 Hypothesis Testing for the Difference in Gini Coefficients

The method proposed by Davidson (2009) for the calculation of the Gini coefficient, along with its standard error was presented as being advantageous over those computed using a jackknife method, which does not provide reliable estimates for the standard error. Using the data on per capita household expenditure formed by the CSO, the procedure outlined by Davidson (2009) in Chapter 2, will be followed to determine if there is a statistically significant difference between Gini coefficients of 1995 and 2005.

The null hypothesis is:

$$H_0: \text{Gini}_{2005} - \text{Gini}_{1995} = 0.$$

The p-value as described by Davidson (2009) calculated using equation (20) is used to test the strength of result. Rejection of the null hypothesis occurs if the bootstrap p-value is less than α , the chosen level of significance. Following this analysis it is possible to state whether changes in inequality between 1995 and 2005 were statistically significant.

The number of replications is chosen as 1000 in accordance with Kennedy (2006), since a large number is needed to have an accurate calculation of the tails of the distributions and there is no cost to having a large number of repetitions (Deaton, 1993). Since the samples were selected using a two stage stratified random sample, he also advises that the replication process used to calculate the bootstrap estimates reflects the original data generating process.

3.5.3 Analysis with Lorenz and Generalized Lorenz Curves

The second data set containing incomes from 1998-2007 is used. The analysis is based on theory of Lorenz and Generalized dominance. Tests for Lorenz dominance are conducted by comparing the year 1998 with 2001, 2004 and 2007. This is done because as explained earlier the inequality measures

are expected to be relatively stable over short periods of time. When it is difficult to decipher visually, first differences will be calculated as in Bellù (2005c). If the Lorenz curves cross, GL Curves will be used to decide on the dominating curve. If these cross then the procedure outlined by Bellù (2005c), involving the comparison of means and variance, or mean-variance will be conducted to determine the ranking of curves. This method is chosen because the main purpose is to rank the distributions; it has the advantage of being more straightforward than the method involving the calculation of kernel density estimates. The statistical significance of the rankings will be determined using the method of Bishop et al (1991) and Beach and Davidson (1983).

3.6 *Summary*

In this chapter the methods that will be used to answer the research questions are presented. The descriptive statistics that will be used will give a general idea of movement of inequality in the years following the liberalization of banana marketing in St. Lucia. However the main feature of the analysis is the assessment of the statistical significance of these changes observed. The next chapter discusses these results.

CHAPTER 4 RESULTS

This chapter presents the results based on the methods outlined in Chapter 3. The chapter commences with a description of the sample for the household surveys. This is followed by the presentation of the results of the tests for differences between the Gini coefficient of 1995 and 2005. The Lorenz curves for the income tax data are presented next, along with the calculation of the Lorenz ordinates and variances that are used to conduct statistical inference on the changes from 1998-2007 for the poorest 20% of the population. A summary of the main findings is presented at the end of the chapter.

4.1 *Description of Samples*

The average age of the household decreased from 56.7 years in 1995, to 51 in 2005. The average size of the household was about the same in both years 3.8 in 1995, and 3.6 in 2006. However, the average number of children per household decreased from 1.5 per household in 1995 to 1.1 in 2005. The average number of earners per household was almost the same 1.3 in 1995 and 1.2 in 2005.

Table 4.1 Description of sample of households surveyed 1995 and 2005

Gender of Head of Household	2005	1995
Male (%)	56.4	56.7
Female (%)	43.6	43.3
Average Age of Household Head (years)	51	46.6
Average Size of Household	3.6	3.8
Average Children per Household	1.1	1.5
Average Earners Per Household	1.2	1.3

Source: (Karri, 2006)

4.1.2 Education

There were slight changes in the pattern of education between 1995 and 2005. The majority of respondents, 68% in 1995 indicated that primary school was their highest level of school attended. In 2005, it dropped to 60%. The proportion of respondents who indicated that they had reached only secondary school was 22% in 2005, compared to 20% in 1995. Those reporting that they had attained university level education increased to 4.4% in 2005 from 2.9% in 1995. The remaining proportions did not indicate any level formal schooling.

4.1.2 Expenditure Data

The unit of observation is the individual and the unit of measure is expenditure measured in Eastern Caribbean dollars (with EC \$1 worth US\$0.37). The variable representing expenditure is Pcexpae per capita equivalent adult expenditure. The summary statistics for each data set are presented below in Table 4.2. It can be seen the mean per capita adult equivalent expenditure was in 2005 was EC \$520. The survey instrument of 1995 used to collect expenditure data was based on recall. The survey instrument for 2005 survey included a diary in which respondents logged their expenditure and repeated visits were made to households during the data collection period. Deaton (1997) citing Scot and Amenuvegbe (1990) stated that relying on recall often results in downward-biased estimates. It is therefore likely that measurement error due to this recall bias has affected the 1995 values. This may be a possible reason for the small values compared to the 2005 expenditure values.

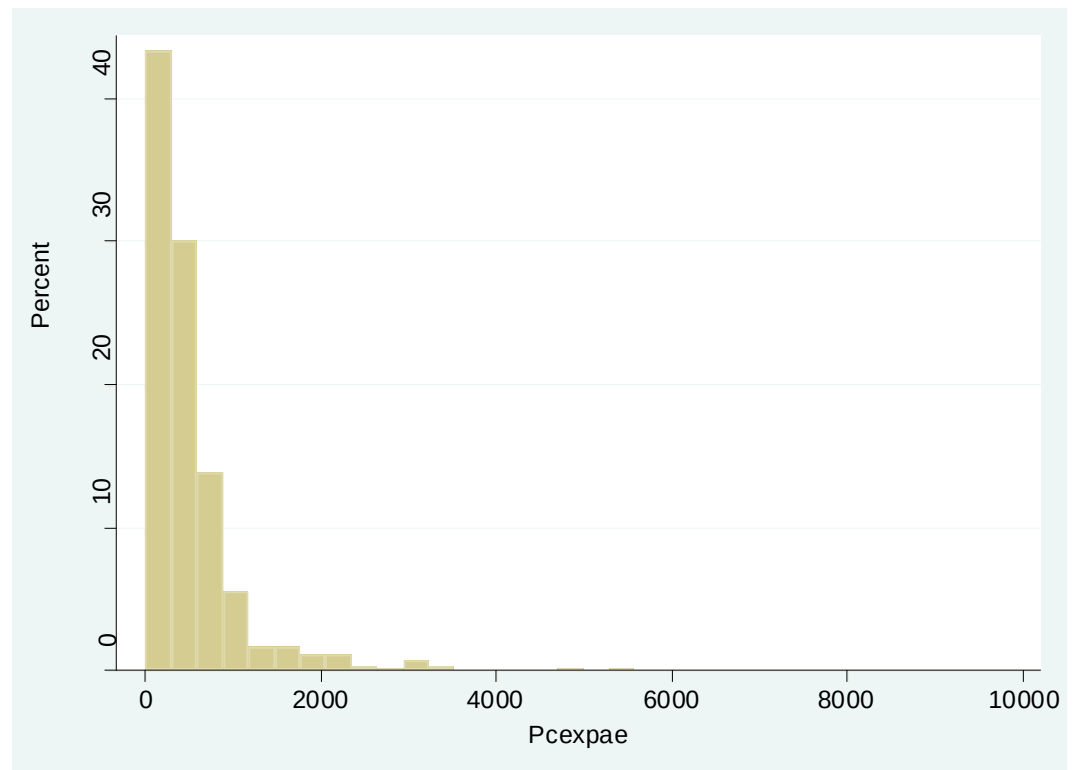
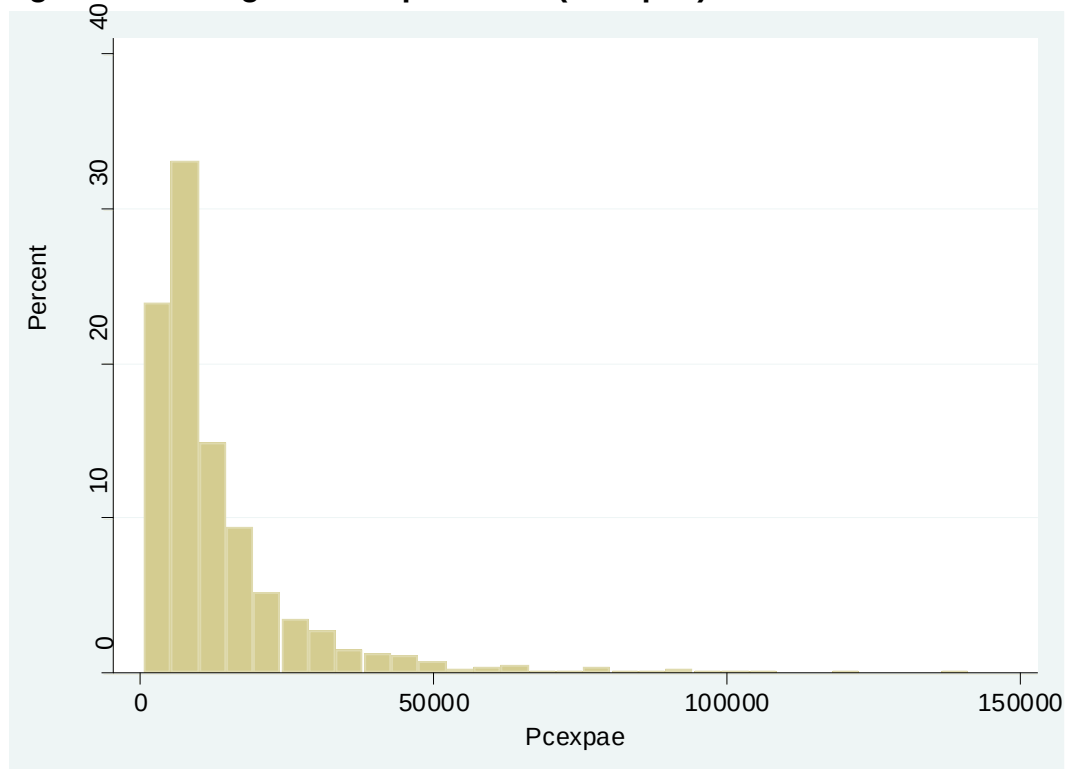
4.1.3 Visual Inspection of Data

The outliers in the data (Appendix 1) also serve to confirm the possibility of measurement error. The frequency histogram for expenditure (pcexpae) displays the data for 1995 and 2005 in Figures 4.1 and 4.2 respectively. From the graphs it can be seen that the majority of the expenditures were under \$2000 in 1995. For 2005, the expenditure was higher with more than half of

expenditures falling in the 0-25,000 range. The difference in average income was shown to be statistically significant at 5% level using the Mann-Whitney *U* test (similar to the t-test but it is used with income data since they are not normally distributed (Bernstein and Bernstein, 1999)) and was calculated using STATA. The results are presented in Appendix (1A)

Table 4.2 Descriptive statistics for household expenditure (Pcexpae) 1995 and 2005

Pcexpae	1995	2005
No of observations	2,324	4,318
Standard Deviation	609.65	10,853.3
Mean EC\$	519.63	10,615.43
Median EC\$	333	7532
Minimum EC\$	0	755
Maximum EC\$	9699	141,320

Figure 4.1 Histogram of expenditure (Pcexpae) for 1995**Figure 4.2 Histogram of expenditure (Pcexpae) for 2005**

4.2 Bootstrap Results for the Gini Coefficient

The results of the bootstrap calculation of the Gini coefficient based on the variable Pcexpae for 1995 and 2005 are presented below. These statistics were calculated with the full set of data, followed by their recalculation after having trimmed 1% and 5% of the observations. The bootstrap is done by resampling with replacement 1000 times. It is done in a two stage process, using the STATA command (Ineqerr) that replicates the original data generating process, which was done using a two stage stratified procedure in which the district was the first stage of the selection process.

Table 4.3 Bootstrap results of Gini Coefficient for 1995 and 2005

	1995	2005	1%trim 1995	5%trim 1995	1% trim 2005	5% trim 2005
Gini	.466	.430	.427	.3501	.395	0.327
Bias	-.00546	-.00342	-.0038	-.0010	-.0016	.0014
Bootstrap standard error	0.0232	0.01624	0.0134	0.0098	.0126	0.0109
95% Confidence lower limit	0.4234	0.3947	0.4023	0.331	0.373	0.3102
95% Confidence upper limit	0.5097	0.4589	0.4510	0.3733	0.4246	0.3505

The estimated Gini coefficients indicate that there was less inequality in expenditure in 2005 compared to 1995. It can be seen that the direction of inequality does not change between 1995 and 2005 even when the data were trimmed at 1% and 5%. Based on the assessment of the 95% confidence intervals, it can be inferred that the difference in the Gini coefficient between 1995 and 2005 is not statistically significant at a 5% level.

The bootstrap replication of the Gini coefficient is presented below and it can be seen that it is fairly normally distributed permitting the use of the Students-t test for hypothesis testing.

Figure 4.3 Bootstrap Histogram of replications of the Gini Coefficient (2005)

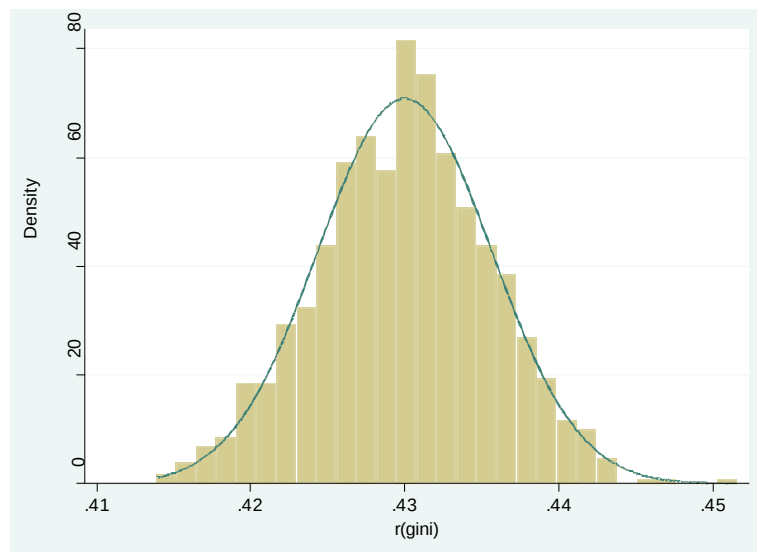
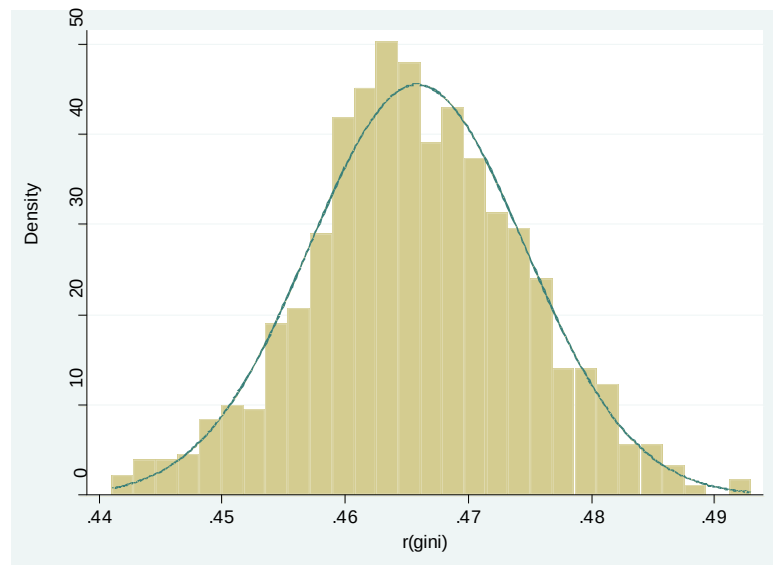


Figure 4.4 Bootstrap Histogram of replications of the Gini Coefficient (1995)



The bias corrected Gini is calculated by multiplying the observed Gini by $(n / (n-1))$. This yields a Gini of 0.466 and 0.430 for 1995 and 2005 respectively. These are used to test the null hypothesis

$$H_0: \text{Gini}_{2005} = \text{Gini}_{1995}$$

$$H_a: \text{Gini}_{2005} \neq \text{Gini}_{1995}$$

The test statistic for the difference between the Gini coefficients is calculated using equation (28)

$$T = (\tilde{G}_{2005} - \tilde{G}_{1995}) / (\hat{\sigma}_{G1}^2 + \hat{\sigma}_{G2}^2)^{1/2}$$

$$T = (0.4300 - .466) / ((0.016)^2 + (0.023)^2)^{1/2}$$

$$T = -1.178$$

For the two tailed test using the Student t-distribution, we fail to reject the null hypothesis at the 5% level. The change in the Gini between 1995 and 2005 is therefore not statistically significant at a 5% level. However, the t-test for the trimmed at 1% and 5% are not consistent with this since the t- values are -1.739 and 2.10 respectively, indicating that it is possible to reject the null hypothesis so that there is a statistically significant difference observed when data are trimmed.

4.6 Descriptive Statistics for Income Tax Data

Summary statistics for the income tax data for 1998, 2001, 2004 and 2007 are presented below in Table 4.4. It can be seen that the variance of the distributions is highest in 1998, followed in descending order by 2007, 2004 and 2001. The decrease in variance indicates that there is less spread in the incomes over the period. The mean income increased progressively between 1998 and 2007 by 47%. While the highest maximum income for all the years was recorded 1998, the maximum income increased progressively from the period 2001 to 2007.

Table 4.4 Summary statistics for income tax data, 1998, 2001, 2004 and 2007

Statistic	1998	2001	2004	2007
N	9721	7981	7420	7100
Max	6,184,058	328,628	563,467	725,298
Min	0	0	0	0
Zeros	21	17	97	6
SD	79,715	21,422	24,543	28,408
Mean	16,746	23,748.01	26,915.40	31,831
Median	10300.00	18442.68	21737.40	26208
Variance	6,354,631,923	458,932,088	602,384,736	807,059,350

The Gini coefficient is presented to give an overall idea of the direction of inequality when the data are trimmed. The pattern is consistent with a general movement towards a reduction in income inequality, and is consistent with what was observed using expenditure data.

Table 4.5 Gini coefficient of income tax data 1998-2007

Year	Gini coefficient
1998	0.553
1998 1% trim	0.491
1998 5% trim	0.449
2001	0.423
2001 1% trim	0.396
2001 5% trim	0.337
2004	0.405
2004 1% trim	0.380
2004 5% trim	0.323
2007	0.402
2007 1% trim	0.371
2007 5% trim	0.291

However, it is of interest to test if there is a statistically significant difference between the coefficients for 1998 and 2007. The null and alternative hypotheses are:

$$H_0: \text{Gini}_{2007} = \text{Gini}_{1998}$$

$$H_a: \text{Gini}_{2007} \neq \text{Gini}_{1998}$$

The analysis in Appendix 2 B shows that these changes in inequality measured by the Gini coefficients are not statistically significant at the 5 % level for the original data and the trimmed data.

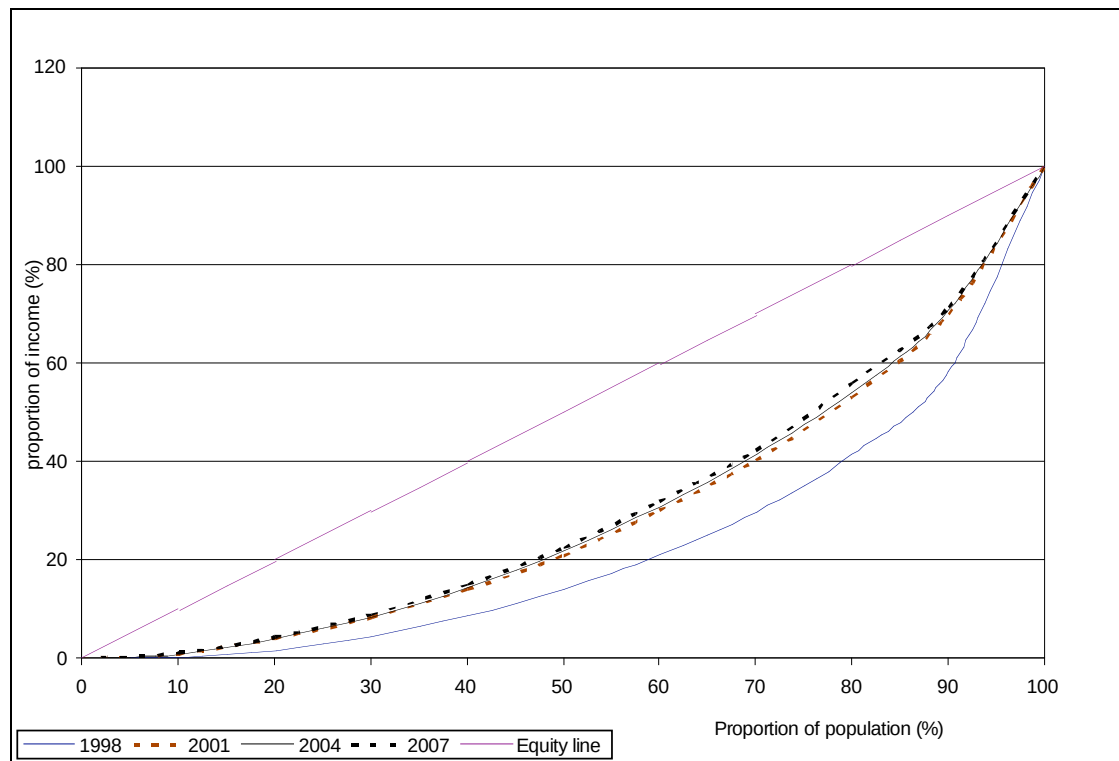
4.7 Lorenz Curves Analysis

The Lorenz curves for 1998, 2001, 2004 and 2007 were calculated using the data adjusted by the CPI with a base year of 1984=100 (Appendix 2). From Figure 4.5, it is evident that there is a general trend towards a more equitable

distribution of income among tax payers, and this is consistent with the findings on the change in inequality using household expenditure data. Pairwise comparisons for the years, 1998-2001, 1998-2004 and 1998-2007 are presented in Appendix 4, and these show that Lorenz curves do not cross. This strengthens the conclusion that from 1998 to 2007 there was a progressive reduction in income inequality among tax payers.

Difference plots of the Lorenz curves were constructed to give the nature of the dominance relationship between the 2004 and 2007 and the 2001 and 2004 distributions, since it was difficult to decipher visually. These difference plots (Appendix 5) reveal that the distribution of 2007 dominates the distribution of 2004, since differences are always positive. This dominating distribution has a higher mean income (EC\$31,831 vs. EC\$26,915) seen from Table 4.3. Assuming that individuals are income seeking and inequality averse, Atkinson's theorem can be invoked because the dominating distribution has higher mean income (Bellu, 2006a). It can be concluded that the 2007 distribution is welfare-superior to the 2004 distribution.

Figure: 4.5. Lorenz curves comparing 1998, 2001, 2004, and 2007



Examination of the Lorenz curves (Figure 4.6), for 2001 and 2004 shows that it is impossible to rank distributions because they appear to cross. This is confirmed by the difference plots Appendix 3 which has both positive and negative values. Because of the crossing of Lorenz curves, GL curves were constructed (Figure 4.7) and as shown they appear to cross at the lower end. However, the difference calculations reveal that this is probably due to the scale of the drawing and in fact the differences are always positive, so there is GL dominance of the 2004 distribution over the 2001 distribution. Based on Shorrocks' theorem, it can be concluded that the 2004 distribution is welfare-superior to the 2001 distribution.

Figure 4.6 Comparison of Lorenz curves for 2001 and 2004

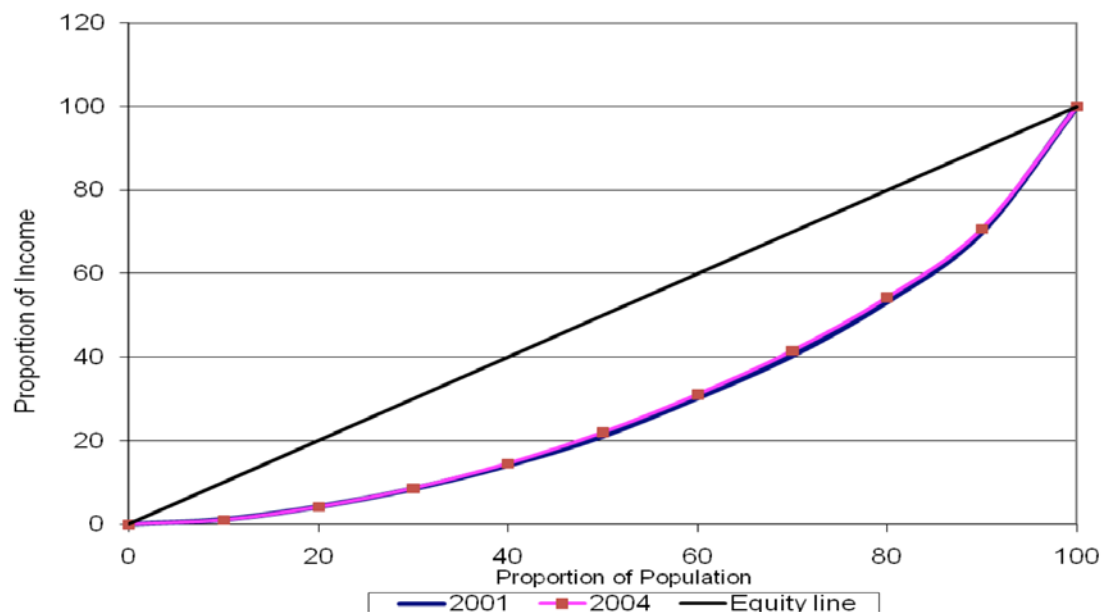
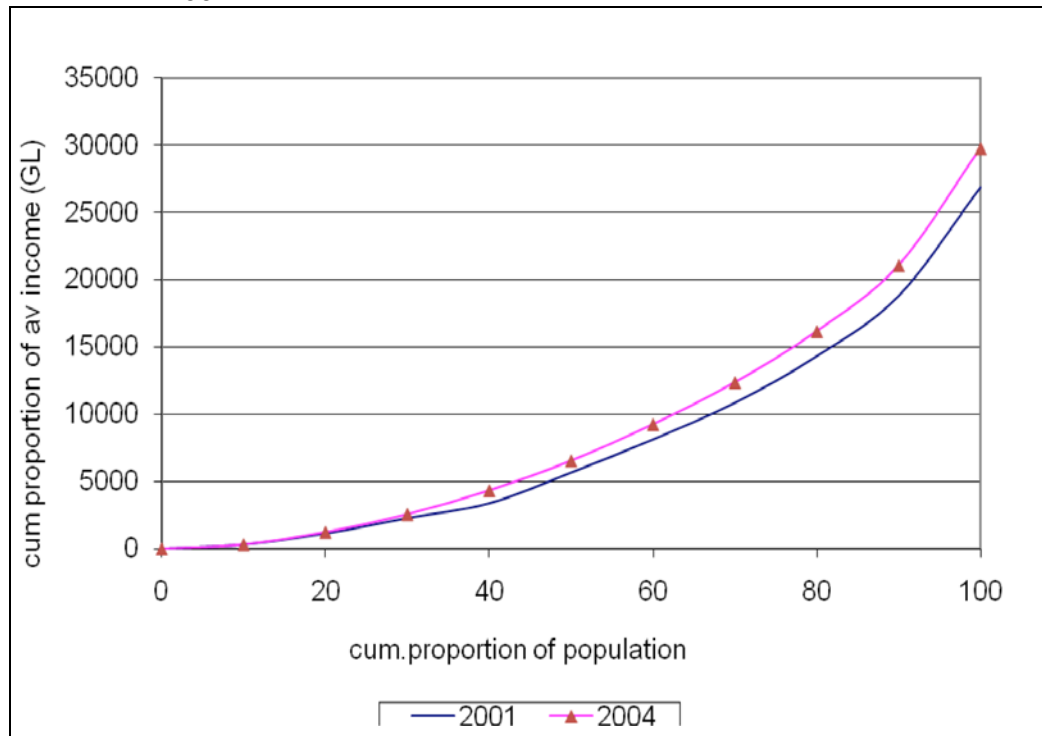


Figure 4.7 Comparison of Generalized Lorenz Curves 2001 and 2004



Based on the above analysis it is possible to conclude that there was a general trend between 1998 and 2007 towards a reduction in inequality among tax payers in St. Lucia. Within this period, this trend is consistent when the distributions of 1998 and 2001, 2001 and 2004 and 2004 and 2007 were compared. Because of the Lorenz and Generalized Lorenz dominance, it can also be concluded that over the time period studied, tax payers experienced improvements in welfare.

4.8 Statistical Inference of Lorenz Curves

Using the method of Beach and Davidson (1983) outlined in Chapter 3, it was possible to examine the nature of the changes in the Lorenz distribution for the bottom 20% of the population. This level was chosen to determine if the changes in the Lorenz curve observed were statistically significant for the poorest members of the distribution of tax payers. The test statistic was computed as in equation (32) and statistical inference based on the Standard

Normal test. The null hypothesis is that there is no difference the Lorenz curves as the for 20% of the population

$$H_0: \text{Lorenz}_{2007(0.2)} = \text{Lorenz}_{1998(0.2)}$$

$$H_a: \text{Lorenz}_{2007(0.2)} > \text{Lorenz}_{1998(0.2)}$$

The income tax data were used to estimate equations used for inference testing. The data were sorted from lowest to highest values, then and the means, variances, conditional means, conditional variances were computed. The Lorenz ordinates were calculated using equation (30). The income values for the quantiles were obtained from STATA output. These values are presented in Table 4.5 and used to compute the variance specified by equation (32). This was then used to calculate the test statistic by using equation (33). The computed value is 5.2. At the confidence level of 5% the using the standard normal tests it is possible to reject the null hypothesis in favour of the alternative hypothesis. That is, the ordinate of the Lorenz curve for 2007 is greater than that for 1998 for the bottom 20% of the population. Based on this evidence, it can be inferred that the welfare of the poorest 20% of the population improved between 1998 and 2007.

The null hypothesis for the test between the Lorenz ordinates for 2001 and 2007 for the poorest 20% of the population is presented below

$$H_0: \text{Lorenz}_{2007(0.2)} = \text{Lorenz}_{2001(0.2)}$$

$$H_a: \text{Lorenz}_{2001(0.2)} > \text{Lorenz}_{2007(0.2)}$$

This test statistic is 0.9, so there is therefore no statistically significant difference at the 5% level between the Lorenz curves of 2001 and 2007. This indicates that there was no change in welfare for the poorest 20% of the population between 2001 and 2007, although welfare improved for the poorest 20% of the population over the period 1998-2007.

4.9 Lorenz Inference

Table 4.6 Calculation of variance and test statistic for Lorenz ordinate 0.2, 1998 and 2007

	1998	2001	2004	2007
p_i	0.2	0.2	0.2	0.2
N_i	1944	1596	1484	1420
Φ				
$\frac{\Phi}{N_i}$	0.0244	0.0473	0.0414	0.0446
ξ_{pi}				
ξ_{pi}	4596	10037	11226	13877
$\hat{\gamma}_i$				
$\hat{\gamma}_i$	2042	5611	6191	7091
$\hat{\lambda}_i^2$				
$\hat{\lambda}_i^2$	1729906	918129	12680721	13032507
σ^2				
σ^2	6354631923	458932088	602384736	807059350
$\hat{\mu}$				
$\hat{\mu}$	16746	23748	29915	31831
V_{ij}^L				
V_{ij}^L	0.017	0.005	0.006	0.008
Z	5.281 for difference between 2007 and 1998			
Z	0.903 for difference between 2001 and 2007			

The calculation of the variance V_{ij}^L and the test statistic are done according to equation (32) and (33) in Chapter 3

4.10 Summary

The results presented in this chapter show that the changes observed in the Gini coefficient, based on household surveys, were not statistically significant at the 5% level. This result was based on the use of the bootstrap technique; in which re-sampling of the empirical distribution was conducted 1000 times to produce bootstrap confidence intervals. These were used to conduct statistical inference, which led to the above stated conclusion. The advantage of this method is that no parametric assumptions need to be made about the distribution. Examination of the Lorenz dominance relationships among distributions the between 1998 and 2007, showed that there were improvements in welfare. Further, using inference tests, (which were also non-parametric), on the Lorenz curves, it was found that for the poorest 20% of income tax payers, this improvement was statistically significant.

Chapter 5 Summary and Conclusion

Summary

In St. Lucia, the liberalization of international banana marketing was marked by a decline in banana production and an increase in unemployment. Having reviewed the literature, the likely effect of trade liberalization on income distribution cannot be predicted *a priori* because of the economic, institutional, political, and social differences among countries. While it was not possible to establish a direct causal relationship between the liberalization of banana marketing and changes in income distribution in St. Lucia, it was possible to examine the changes in inequality and welfare in the period leading up to immediately following liberalization. This was accomplished by using expenditure data from household surveys of 1995 and 2005 and income tax data for the period 1998 to 2007.

Beach and Davidson (1983) urged that inequality measures should not be used simply as descriptive tools. Thus, the overarching goal of this thesis was not only to describe changes in equality and welfare, but also to determine if these were statistically significant. The methods reviewed include the use of an asymptotically derived standard error for the Gini coefficient (Davidson, 2009) which could be used together with the bootstrap to obtain reliable statistical inferences. The application of the bootstrap method is suitable because it is fairly easy to implement, and it can be used regardless of the complexity of the formula to compute the test statistic. Additionally, it is non-parametric; no assumption about the form of the distribution is required. The bootstrap method was used to conduct statistical inferences on the changes observed in the Gini coefficient calculated from the household expenditure data.

The results of the analysis indicate that the changes observed between 1995 and 2005 were not statistically significant. Reemphasizing, a direct relationship cannot be established between the liberalization and the changes in inequality. However, it may be possible that growth in the tourism, and construction industries, , along with increases in FDI helped to reduce the

impact of the adverse liberalization. As mentioned earlier, there was a structural shift in employment with a large percentage of the employed population moving out of agriculture into tourism and manufacturing. Perhaps inefficient farmers were forced out of agricultural production when confronted with a liberalized market. Further, the growth in regional export market for bananas, even while the international market collapsed, could have helped some workers in the banana industry to maintain their incomes. Indeed as mentioned in Chapter 2, there were recent (2008) improvements in the banana industry as a consequence of investments in 2007. Overall, there may have been a diversification of economic activity since 1998, which allowed the level of inequality to remain generally stable.

The qualitative studies referenced earlier shed light on the plight of many unemployed banana farm workers. The findings of this thesis do not contradict their claims. However, it may be that other factors such as higher educational levels helped many former farmers to regain employment and that those who remained unemployed, even eight years after the implementation of the free trade rules, do not account for a large majority of the population. Another factor to consider as discussed earlier (Li et al, 1998), is that the factors that affect income inequality, such as access to loans, credit and institutions remain fairly constant over time within countries. So it is possible that the Gini coefficient did not change much for the period under study because there were no major changes in these areas.

With regards to the subset of the population who were income taxpayers, the Lorenz and GL curve analysis revealed that they experienced improvements in welfare between 1998 and 2007. Furthermore, the distribution free inference technique employed showed that this improvement in welfare was statistically significant for the poorest 20% of the sample. However, it should be emphasized that this sample contains information on only those persons who pay income tax and so it is not a representative sample of the entire population. Thus, it cannot be used to give a conclusive indication of the changes in welfare at the national level in St. Lucia. Additionally, since no

income, including wages, earned from agriculture is taxable, the observed changes in welfare are not directly related to changes in income due to changes in agricultural employment. However, inferences on the Lorenz curves do show clearly that in the period following liberalization, income tax earners in the bottom 20% of the income distribution experienced a statistically significant improvement in welfare.

This thesis has highlighted the importance of reporting statistical inferences on inequality measures. The study by KARIRI (2006) gave the surprising result which showed a decrease in inequality, but an increase in the poverty gap based on their calculation of the Gini coefficient. Thus, the results of this thesis may serve to clarify their findings, since it can be concluded that the level of inequality remained unchanged. This thesis has also shown the relative ease with which the method of Beach and Davidson (1983) could be used to conduct distribution free statistical inferences on Lorenz curves. However, these conclusions could be enhanced by using survey data which contains demographic variables to examine if there are statistically significant changes in inequality for different segments of the population according to age, gender and employment sector.

The limitations of this thesis relate to largely the data. Firstly, the expenditure data were collected using fundamentally different methods. The 2005 data were collected from diaries which logged the respondents expenditure while the 1995 data was collected based on recall. This therefore limits the extent to which comparisons can be made. Secondly, the results are limited by possible sources of measurement error. Consequently policy recommendations are made with caution.

Based on these results, since it appears that inequality was relatively unchanged over the time period examined, an investigation into the reasons why some persons remain unemployed even eight years after the liberalization could be commissioned. They could be retrained through programs geared towards their specific academic level, or receive support through special farmer pension schemes if they have reached the age for retirement. A review of

changes in government's policy during this time could be examined to see if they had an impact on mitigating the possible adverse effects of the trade liberalization in the medium term. This would be useful because little research has been done to that focuses on the impact of the liberalization of bananas on the small islands of the Caribbean. Such studies could be useful in helping to design regional policy initiatives, since these islands (Grenada, St. Vincent, and Dominica) have very similar characteristics. In the future, empirical work on the impact of liberalization of banana marketing on inequality and welfare in St. Lucia and the other small islands of the Caribbean will only be possible if policies are implemented that place greater emphasis on long term data collection and management. Nevertheless, the methodology employed in this thesis suited the current availability of data and provided valuable insight into the changes in inequality in St. Lucia in the period following international banana marketing liberalization. Given the fact that there are similar data constraints in each of these islands, it can be easily replicated in each for cross country analysis.

5.2 Conclusion

This thesis investigated the changes in inequality and welfare in St. Lucia following the liberalization of banana marketing based on household expenditure data and income tax data. At the national level there were no statistically significant changes in inequality between 1995 and 2005. It was found that for a poorest 20% of income tax payers, there were significant improvements in welfare between 1998 and 2007. However a review of secondary data indicated that there were major losses in employment in the period leading up to and immediately after the 1998 WTO ruling. The possible explanations for these results, given the surge in unemployment and its potential impact on the income distribution and inequality include, structural shifts in employment, government policy intervention and growth in regional markets for banana, all of which could have helped maintain income levels in the period reviewed. This chapter also outlined the major limitation of the study which was related to data availability and also proposed areas for future

research which includes cross country analysis among the small Caribbean islands which produce bananas, by replicating the methodology employed in this thesis.

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APPENDIX 1

A.

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

_stack	obs	rank sum	expected
1	4318	19315303	14342237
2	2324	2746100.5	7719166
combined	6642	22061403	22061403

unadjusted variance 5.555e+09

adjustment for ties -6890.7132

adjusted variance 5.555e+09

Ho: $P_{cexpa \sim e}(_stack == 1) = P_{cexpa \sim e}(_stack == 2)$

$z = 66.723$

Prob > z = 0.0000

$P\{P_{cexpa \sim e}(_stack == 1) > P_{cexpa \sim e}(_stack == 2)\} = 0.996$

3 Box plot for 1995 variable (Pcexpae)

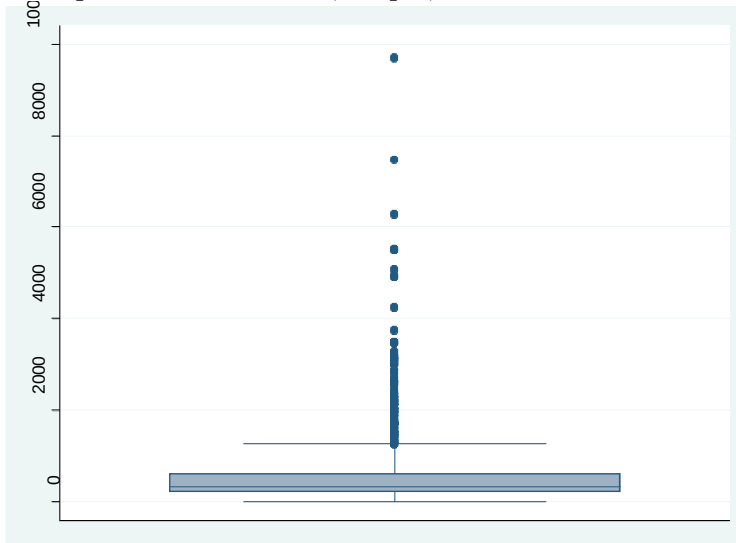
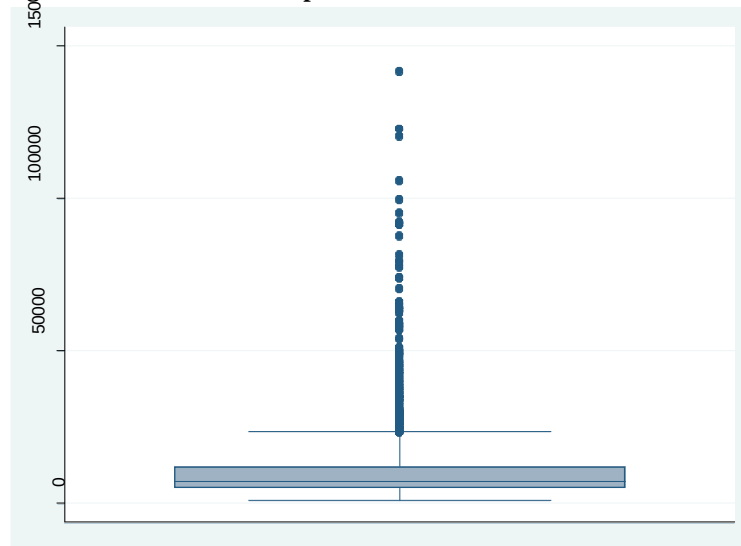
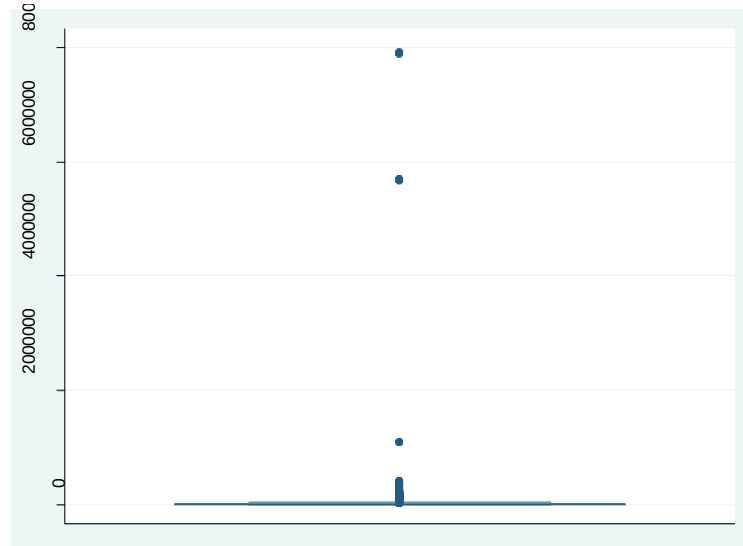


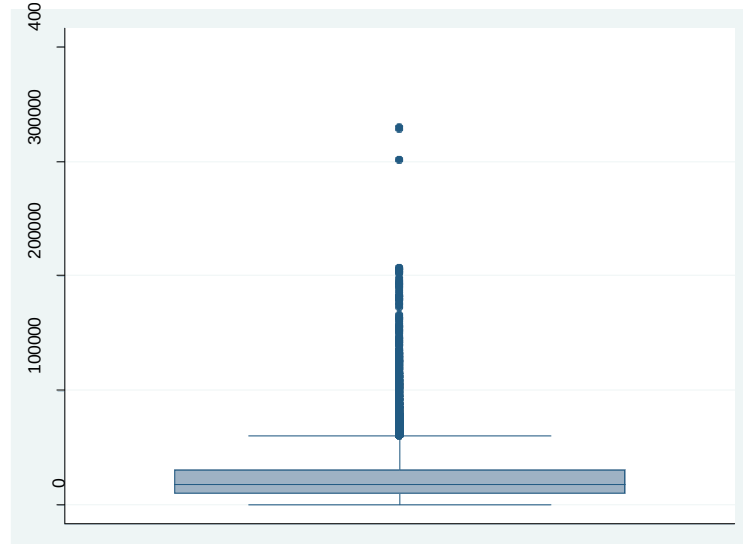
Figure 4 Box Plot for Pcexpae 2005

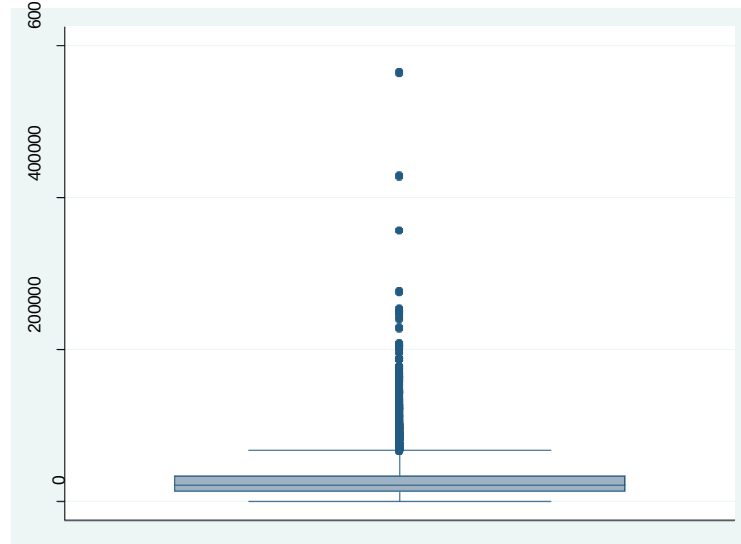
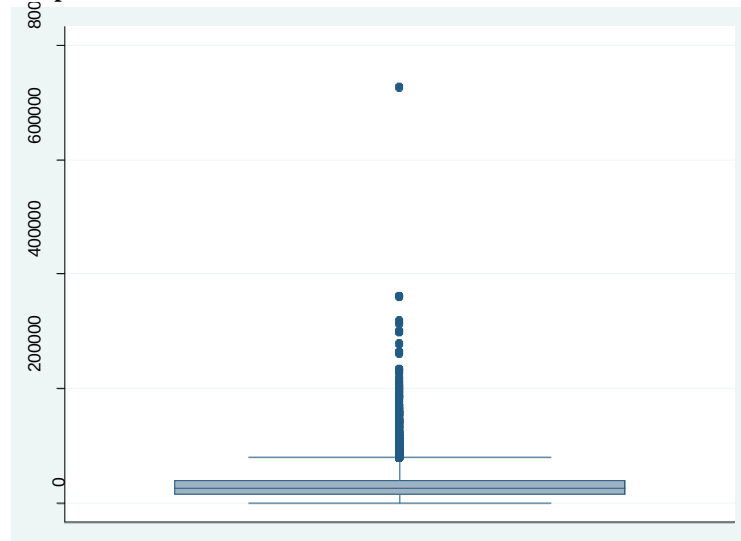


Box Plot for 1998



Box Plot for 2001



Box Plot 2004**Box plot for 2007**

APPENDIX 2

Consumer Price Index Data
Base year 1984=100

year	CPI
1998	156
1999	161.4
2000	166.9
2001	170.4
2002	175.6
2003	177.5
2004	180.1
2005	187.1
2006	193.8
2007	199.2

Calculation of the t-value for income tax data
for 1998 and 2007

<i>no trim</i>	<i>value</i>	
<i>Gini 1998</i>	<i>0.553</i>	
<i>Gini 2007</i>	<i>0.402</i>	<i>-0.15</i>
<i>se 1998</i>	<i>0.0208</i>	<i>0.02</i>
<i>se2007</i>	<i>0.0043</i>	
<i>t value</i>		<i>-7.11</i>
<i>1% trim</i>		
<i>Gini 1998</i>	<i>0.491</i>	
<i>Gini 2007</i>	<i>0.371</i>	<i>-0.12</i>
<i>se 1998</i>	<i>0.002</i>	<i>0.004</i>
<i>se 2007</i>	<i>0.003</i>	
<i>t value</i>		<i>-33.28</i>
<i>5% trim</i>		
<i>Gini 1998</i>	<i>0.449</i>	
<i>Gini 2007</i>	<i>0.294</i>	<i>-0.16</i>
<i>se 1998</i>	<i>0.0025</i>	<i>0.003</i>
<i>se 2007</i>	<i>0.0022</i>	
<i>t value</i>		<i>-46.54</i>

APPENDIX 3

Data used for Construction of Lorenz and GL Curves

The data is based on the STATA generated values of the Lorenz and GL Curves

Data for Lorenz graph

1998	2001	2004	2007	Difference 2007-2004	Difference 2004-2001
0	0	0	0	0	0
0.43	1.13	1.05	1.25	0.2	-0.08
1.92	4.18	4.16	4.46	0.3	-0.02
4.72	8.48	8.62	9.09	0.47	0.14
8.84	14.1	14.56	15.12	0.56	0.46
14.29	21.08	22	22.62	0.62	0.92
21.21	30.25	31.09	32.07	0.98	0.84
29.92	40.37	41.54	42.35	0.81	1.17
41.6	53.28	54.31	56.03	1.72	1.03
58.48	69.95	70.75	71.37	0.62	0.8
100	100	100	100	0	0

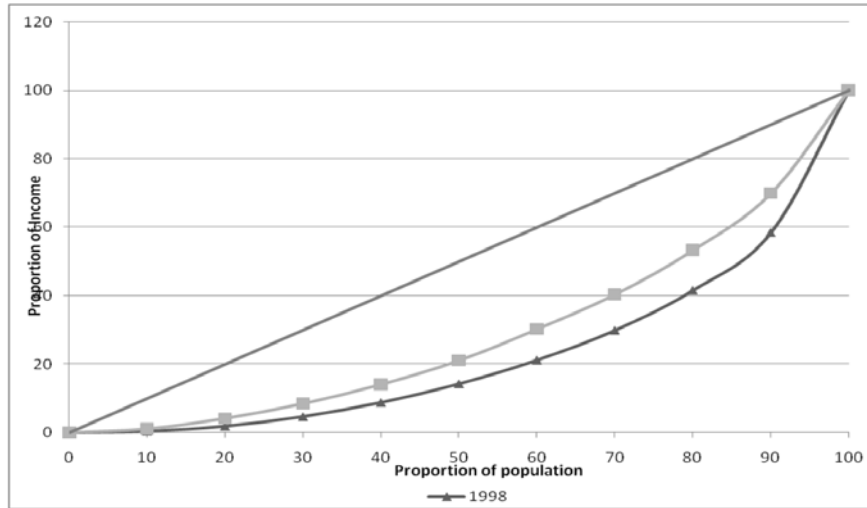
Data for GL curves graph

1998	2001	2004	2007	Difference 2004-2001	Difference 2007-2004
0	0	0	0	0	0
91,24	302.51	312.67	718.85	10.16	406.18
410.44	1123.32	1238.31	1899.57	114.99	661.26
1010.32	2279.06	2566.74	3493.97	287.68	927.23
1890.37	3378.52	4335.7	5472.39	957.18	1136.69
3056.73	5663.78	6548.64	7885.21	884.86	1336.57
4535.90	8124.98	9254.23	11227.52	1129.25	1973.29
6398.42	10845.62	12366.56	14136.85	1520.94	1770.29
8895.54	14312.68	16167.7	17924.13	1855.02	1756.43
12505.91	18791.9	21063.37	22649.66	2271.47	1586.29
21384.44	26863.17	29769.83	28783.44	2906.66	-986.39

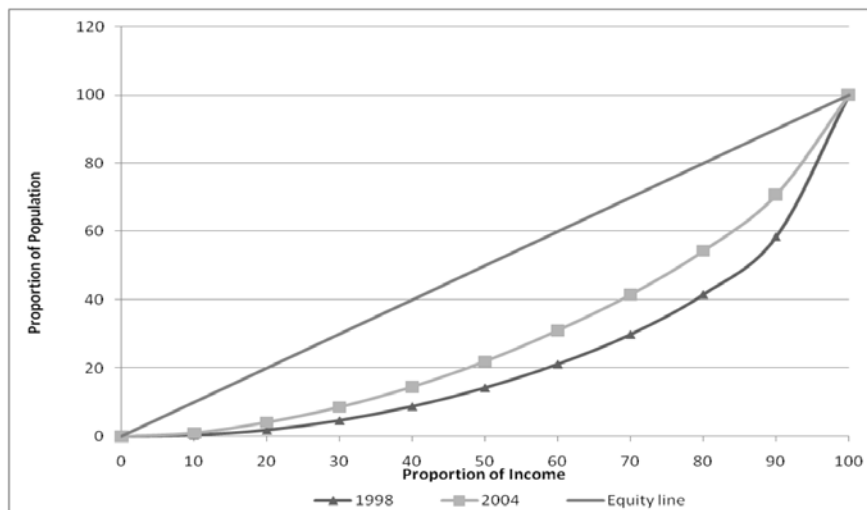
APPENDIX 4

Comparison of Lorenz curves

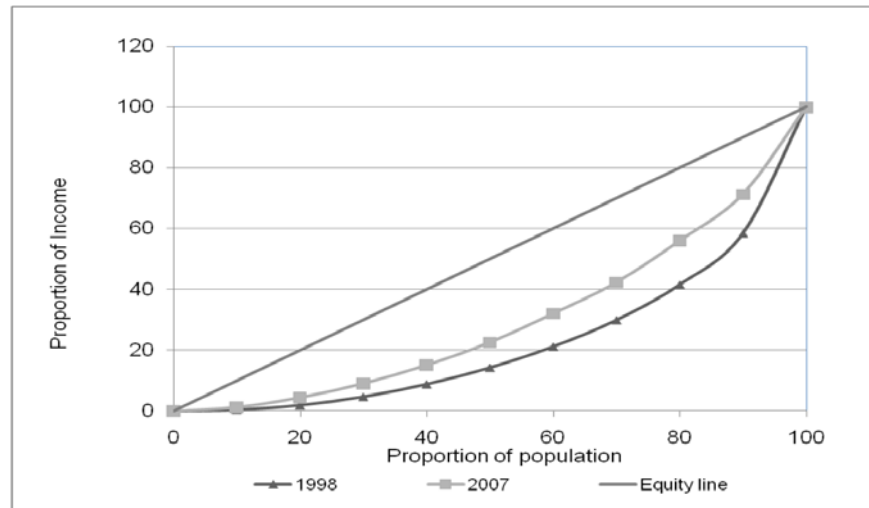
4A: Comparison of Lorenz curves 1998-2001



4B comparison of Lorenz curves 1998 and 2004

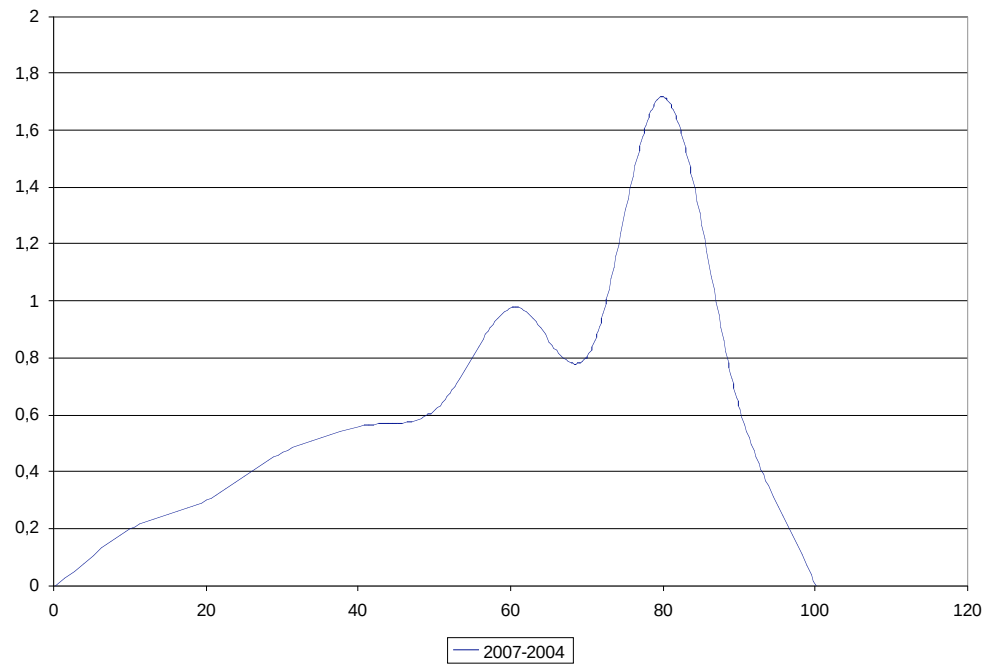


4C Comparison of Lorenz curves 1998 and 2007



APPENDIX 5

5A. Difference Plot for Lorenz Curves 2007 and 2004



5b Difference Plots for Lorenz curves for 2004 and 2001

