

Income Distribution in Barbados

by

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Introduction

The distribution of income is a major indicator of the basic structure of any given economy. In recent times it has been as equally prominent as the growth rate of Gross Domestic Product as a measure of economic performance. Concerns in Barbados about the distribution of income were manifested in policies such as minimum wage legislation, the wage policy in the public sector of giving workers in the lower income categories a larger percentage increase in income than those in the upper income groups and the changing tax structure. The growing emphasis on income distribution was accompanied by increased interest in employment as part of the development process, employment being regarded as the most effective means of changing income distribution in a developing society. The purpose of this exercise is to analyse the distribution of income in Barbados, considering the growth in GDP, and unemployment as well as the effect of taxes and wealth on the distribution of income.

Our study will be based on personal income reported on income tax returns. We are well aware of the shortcomings of this income measure¹, but we submit that it is easier to form a "correct" idea of the income distribution for income tax payers than for the entire nation. Most studies for the Caribbean (e.g. Ahiaram [1966], Henry [1975] for Trinidad and Tobago; Ahiaram [1964] for Jamaica and Straw [1953] for Barbados) examined the

distribution of household income from sample data and so differ from own. The approach of Cox (1979) for Barbados and Andic (1963) for Puerto Rico is similar to the method employed by us. However, we differ in that instead of comparing two years we attempt to compare a series. In so doing we are able to detect when changes did occur and whether these changes were abrupt or gradual over time. The major findings of Cox were (a) the lowest incomes were to be found in agriculture, manufacturing and services - a hypothesis we will not be testing; (b) income inequality was smaller in 1974 than in 1970 - a decrease of 5.16%; (c) the Lorenz curves intersected, implying an increase in inequality among the lower income groups. The latter was confirmed by the construction of the minor concentration ratio.

In the next section we present an overview of the changing pattern of income distribution and how it compares with the growth of Gross Domestic Product and employment creation; that is the "trickle down" theory. This is followed by sections analysing the effect of taxation and wealth on the distributional pattern. We then proceed to examine the changing distribution within the poor classes - an analysis of the minor concentration ratios and partitioned Gini coefficients. Finally, we present a summary of our findings.

Methodology

The familiar measure of income distribution is adopted. The Lorenz curve and the resulting Gini coefficient are used.

With cumulative percentage income plotted on the vertical axis and cumulative percentage recipients on the horizontal axis, the greater the curvature of the Lorenz curve, the greater would be the level of income inequality. The ratio of the area between the line of equal distribution and the Lorenz curve to the area below the line of equal distribution is the Gini coefficient which helps to explain levels of income inequality. The smaller the Gini coefficient becomes the less unequal is the distribution of income.

Hagerbaumer [1977] has suggested the use of another ratio, which although dependent on the Gini coefficient, should be used to explain the redistributive effects for the lower portion (the poor) of the income recipients (vis-a-vis the others). This coefficient is referred to as the minor concentration ratio (See Appendix 1).

In proposing the minor concentration ratio, Hagerbaumer suggests firstly that this ratio provides "a quantification of the position of the poor with respect to their theoretical best position"; secondly the ratio describes "movements of the Lorenz curve with more precision than a single summary measure"; and thirdly that the ratio "focusses on the type of inequality that causes most concern, inequality in the lower portion of the distribution".

Koo et al [1981] partition the Gini coefficients into parts for each income class and suggest that the minor concentration ratio as developed by Hagerbaumer (1977) is arbitrary in selecting the poor (See Appendix 2). Koo et al

further suggest that the minor concentration ratio ignores the distribution of income within income classes. In this paper we use the Koo method to investigate the income distribution among the lower income groups. We posit that an income of \$1,000 per annum in 1951 prices represents the upper limit of the lower income groups (the poor) in the country.

Ishi [1980] uses the Gini coefficients to arrive at a measure of the effects of taxation on income distribution which he calls the equalisation coefficient. It is defined as follows:

$$EC = \frac{G_{bt} - G_{at}}{G_{bt}}$$

where EC = Equalisation coefficient

G_{bt} = Gini coefficient for income before taxation

G_{at} = Gini coefficient for income after taxation

The larger EC becomes the more powerful the redistributational effect of taxation.

We have extended Ishi's approach to total income before and after investment income and have called this coefficient the investment income effect coefficient (IIEC). The investment income effect coefficient is defined as:

$$IIEC = \frac{G_I - G_{BI}}{G_{BI}}$$

G_I = Gini coefficient for total income

G_{BI} = Gini coefficient for total income before investment income

The greater WEC the more adverse is the effect of investment on the distribution of total income.

The data used is that reported by the Department of Inland Revenue from yearly income tax returns as submitted by individuals. One drawback in using this data has been the relatively small number of income classes which have the effect of under-estimating the Gini coefficient or in other words over-estimating the area under the Lorenz curve. Another drawback is the question of under-reporting of income and non-submission of returns which is a problem faced by tax systems which rely on a voluntary reporting mechanism. The final problem is that of sample size which we have assumed to be large enough so that our results would not be unduly biased. Watson [1982] has proposed a method for estimating the Lorenz curve when small samples are used².

Distribution of Income, Unemployment and Per Capita Income

Paukert (1973) and Chow and Papenek (1981) suggested that as development proceeds income distribution becomes less equal since the rapid rate of growth requires policies unfavourable to equitable distribution. They further suggested that only extensive and active government intervention can counteract these tendencies and provide growth with equity.

From the international data comparison given in (Paukert 1973) inequality increases up to a per capita income of US\$500 and thereafter declines (Table 1). In contrast the distribution of income in Barbados has declined consistently over the income ranges. At the lower income level our average Gini ratio was greater and for the higher per capita income range was slightly lower. Whereas the international evidence lends support to the Paukert, Chow and Papenek thesis, the data for Barbados does not substantiate the thesis.

A further examination of the data in Table 1 shows that after the income range US\$100-US\$200 was attained by Barbados, the Gini ratios have been considerably less than those of the other countries and are nearly equal in the highest income ranges. We posit that the emergence of a strong labour union and its emphasis on a better distribution of income and as a result higher wages including production bonuses in the agricultural (sugar) sector was mainly responsible for the better distribution in the 1950's.

Table 1

Gini Coefficients for Personal Income before Tax
Selected by Per Capita GDP

Gross Domestic Product Per Capita * \$US	No of countries	Gini (Averages)	Gini Range
100 - 200	9	.468	.56 - .26
201 - 300	8	.499	.62 - .36
301 - 500	11	.494	.58 - .30
501 - 1000	6	.438	.58 - .38
1001 - 2000	10	.401	.50 - .30
2001 and above	3	.365	.39 - .34
<u>Barbados</u>			
150 - 200 (1950-1954)		.518	.61 - .48
201 - 300 (1955-1959)		.474	.48 - .46
301 - 500 (1960-1962)		.459	
607-980 (1971-1973)		.395	.42 - .39
1310-1987 (1976-1978)		.358	
2406 and above (1979-1981)		.356	.40 - .32

* Based on per capita gross domestic product 1965. Ginis calculated for various years.

Source: Paukert [1973] Table VI.

For a period during the 1970's a wage policy which granted larger percentage increases to the lower income groups was responsible for the less unequal distribution of income. Another cause could have been the increased demand for unskilled labour in the faster growing sectors of the economy (tourism and manufacturing) which placed an upward pressure on wages. The less unequal distribution of income can also be attributed to the increasing ratio of wages and salaries to total income. While investment income was an average 16.7% of total income during 1951 - 1962, the proportion has fallen on average to 4.5% during the period 1971 - 1981 with a low of 2.2% in 1980.

A comparison (Table 2) between Barbados and selected Western Hemisphere countries, shows that the distribution of income was slightly better than that of Jamaica and Brazil, but worse than the distribution in Trinidad and Tobago, Argentina, Venezuela, Puerto Rico and the United States. When compared with the United States, the distribution of income in Barbados in 1980 reached the level which existed in the United States in 1969.

Although income growth was accompanied by a less unequal distribution of income, unemployment increased reaching high levels in the 1970's³. We can only postulate that unemployment affects those in the lower income brackets ("the poor" - the non-reporting group) and that there is job security for those in the higher income brackets.

Table 2

Gini Coefficients - Personal Income before Tax

Barbados and Selected Countries

Countries	Year	Gini	Gini Barbados
Trinidad & Tobago	1957/58	.44	.47
Jamaica	1958	.56	.46
Brazil	1960	.54	.46
Argentina	1961	.44	.46 ¹
Venezuela	1962	.42	.46
Puerto Rico	1963	.44	.46 ¹
United States	1964	.34	.42 ²
	1969	.34	.35 ³

1. Gini for Barbados 1962.

2. Gini for Barbados 1971.

3. Gini for Barbados 1980.

Source: Paukert [1973] Table 6.

Effects of Taxation and National Insurance

The tax function in Barbados is such that the average tax rate increases as income increases. This would imply that the tax elasticity is greater than one for all pretax incomes and therefore the tax system serves either to reduce or to check the inequality of income in Barbados. Before proceeding with the assessment of the tax effect we make two general observations. First, in all classifications of income the Gini coefficient exhibited a downward trend (See Table 3). Second, income from professions as well as investment income moved toward increasing income inequality.

We now turn our attention to the equalising power of the tax system. To accomplish this we focus on the before and after tax income. Overall, income taxes have served to reduce the level of inequality. However, in 1954, 1959 and 1979 the movement in taxes had a perverse effect on the inequality coefficient. The causes of this about turn in 1979 have been identified as the increasing level of deductions (including exemptions), the change (reduction) in the tax rate at the higher end of the scale, as well as higher salaries and greater coverage of income tax payers. (See section on wealth effect for possible causes in 1954 and 1959).

Table 3

Gini Coefficients

	A	B	C	D	E
1951	.318	.445	.488	.418	NA
1952	.340	.436	.485	.432	NA
1953	.341	.433	.484	.417	NA
1954	.311	.586	.613	.535	NA
1955	.335	.417	.472	.405	NA
1956	-	-	-	-	-
1957	.344	.434	.484	.411	NA
1958	.353	.400	.458	.398	NA
1959	.372	.429	.482	.419	NA
1960	.357	.412	.463	.400	NA
1962	.362	.409	.455	.391	NA
1971	.362	.395	.424	.372	.376
1972	.343	.363	.389	.342	.345
1973	.329	.366	.371	.325	.328
1976	.332	.356	.358	.307	.310
1978	.334	.342	.359	.307	.308
1979	.383	.393	.400	.350	.351
1980	.332	.340	.345	.307	.309
1981	.311	.318	.323	.286	.289

A = Income and Pensions from public and private sources.

B = A + income from profession, business and agriculture, etc.

C = Total income ie B + investment income, local and foreign.

D = Total income less income taxes.

E = Total income less income taxes less national insurance payments.

NA = indicates "not applicable". The National Insurance Scheme started in 1967.

The major finding is the fact that the income tax system has been less progressive in the 1970's than in the 1950's. The equalisation coefficient which is used to measure the progressivity averaged 13.4 in the 1951-59 period but fell to 12.8 in the 1971-79 period.

We posit that the reduction in the Gini although due largely to the progressive tax system was assisted by the wage policy of larger increases at the bottom of the salary ladder than the increases at the top. The equalising power consists of the combined effects of non-tax variation (wage changes, etc) and changes due to the income tax system (rate adjustments, level of exemptions and deductions). We postulate that the smaller equalisation coefficient (Table 4) in 1970's is due largely to the varying levels of exemptions, such as deductions for mortgages and life insurance which are more applicable to those at the higher end of the income ladder. For example, an increase of BDS\$5,000 in exemptions or reductions cuts away taxable income in the highest bracket, leading to reduction in the equalisation coefficient.

Thus although over the period there has been a distinct reduction in inequality resulting from the progressivity of the tax system, the measures introduced did reduce the impact of income taxes on the redistribution of income.

The present method of computing national insurance contributions makes it regressive in nature as some maximum

Table 4

Gini Coefficients

(Tax Effects)

Year	(C) Before Tax	(D) After Tax	Equalisation Coefficient
1952	.489	.418	14.52
1953	.485	.432	10.93
1954	.484	.417	13.84
1955	.472	.405	14.19
1956	NA	NA	NA
1957	.484	.411	15.08
1958	.458	.398	13.10
1959	.482	.419	13.08
1960	.455	.391	14.07
1971	.424	.372	12.26
1972	.389	.342	12.08
1973	.371	.328	11.59
1976	.358	.307	14.25
1978	.359	.307	14.25
1979	.400	.350	12.50
1980	.345	.307	11.01
1981	.323	.286	11.45

income is the cut off point from which contributions can be made. All increases in the maximum income level for contributions have the effect of moderating the regressivity of this measure.

A comparison of the Gini coefficients before NIS deductions but after tax and the coefficient after both tax and NIS deductions reveals an increase in income inequality. However, the increase in inequality is of negligible proportions. In fact, the inequality has moderated since 1971.

Investment Income Effects

Gini coefficients for total income before and after investment income from local and foreign sources show a distinct downward trend although the Gini coefficients of total income are as expected greater than the coefficient before investment income. During the 1950's the gap between the Ginis are wider than during the 1970's and early 1980's. This suggests that investment income flows have been better distributed and further that investment income has been declining as a proportion of total income.

The coefficients for 1954, 1957 and 1959 are outside the downward trend. During 1954 income before investment was boosted by the large sugar crop which at 182,000 tonnes was nearly 11% greater than the year before. The sugar crop of 1957 at 208,000 tonnes was 55,000 tonnes greater than 1956 and receipts were some \$13.0 million greater due to the increased production and slightly higher export prices. Although crop bonuses and increased wages were paid to agricultural workers, agricultural

income mainly profits for 1954 and 1957 increased by 184% and 64% over 1953 and 1955 respectively.

In 1957, the coefficient increased over the previous years. This is due to increased numbers filing tax returns - a larger number of persons in the higher income brackets, larger incomes from investments, business, agriculture and professions.

The investment income effect coefficient (Table 5) shows that, in the 1950's, investment income had a more substantial impact on income inequality. During the 1970's, virtual equality of the Gini coefficients is observed. The factor responsible for this behaviour has been identified as the large capital inflows which were required to support the development process. Support for this hypothesis may be found in the extremely rapid growth in the outflows of investment income which increased from \$12.2 million in 1973 to \$56.1 million in 1981. The reduction in the level of investment income reported may also be due to the issuing of bonus shares which would not have affected taxable income.

Table 5

Gini Coefficients
(Investment Income Effect)

Year	Before Investment Income (G _{BI})	Total Income (G.I)	Investment Effect ¹ Coefficient (IIEC)
1951	.445	.489	9.89
1952	.436	.485	11.24
1953	.433	.484	11.78
1954	.586	.613	4.61
1955	.417	.472	13.19
1956	n.a.	n.a.	n.a.
1957	.434	.484	11.52
1958	.400	.458	14.50
1959	.429	.482	12.35
1960	.409	.455	11.25
1971	.395	.424	7.34
1972	.363	.389	7.16
1973	.366	.371	1.35
1976	.356	.358	0.56
1978	.342	.359	4.97
1979	.393	.400	1.78
1980	.340	.345	1.47
1981	.318	.323	1.57

$$^1 \text{ Investment Income Effect Coefficient (IIEC)} = \frac{G_I - G_{BI}}{G_{BI}}$$

The greater is IIEC, the more adverse is the effect of investment income on the total income.

Minor Concentration Ratio and Partitioned Gini Coefficient

The minor concentration ratio (MCR) is a measure of the relative position of the "poor" whereas the partitioned Gini analyses the distribution of income within various income ranges. In our case we utilize the partitioned Gini to investigate the distribution of income among recipients of BDS\$1,000 or less in 1951 prices; this is equivalent to BDS\$8,000 or less in 19814. This income level has been selected as an indicator of the low income groups.

It must be emphasised that the two ratios are not comparable as the minor concentration ratio (MCR) covers a wider band of both income and recipients while the partitioned Gini relates to a specific real income group and hence is restricted to both a smaller band of recipients and income levels (Table 6).

The evidence for the 1950's and 1970's show that while on average the distribution of income before tax exhibited much less inequality in the 1970's than during the 1950's - the "poor" did not fare as well in the 1970's as they did in the 1950's. On average the minor concentration ratio (Table 7) for the 1950's (.4036) was smaller than during the 1970's (.4126) - a fall of 2.2% and at the same time the Gini coefficient was reduced by 23.2% (Chart 1).

We must therefore posit the question as to why the "poor" did not share (judged by the MCR) in the considerably better distribution of income.

Table 6

Recipients and Maximum Income Levels
by
Minor Concentration Ratio (MCR) and Partitioned Gini

Year	Recipients		Maximum Income Levels	
	MCR (%)	Partitioned Gini (%)	MCR ¹ (BDS\$)	Partitioned ⁽²⁾ Gini (BDS\$)
1951	66	17	3000	1000
1952	64	57	3000	1154
1953	63	56	5000	1161
1954	68	54	5000	1172
1955	63	55	5000	1176
1956	n.a.	n.a.	n.a.	n.a.
1957	63	47	5000	1208
1958	62	45	5000	1229
1959	63	46	5000	1237
1960	62	42	5000	1265
1961	n.a.	n.a.	n.a.	n.a.
1962	62	37	5000	1301
1963-1970	n.a.	n.a.	n.a.	n.a.
1971	61	25	5000	1939
1972	60	45%	5000	2154
1973	60	38%	5000	2570
1974	n.a.	n.a.	n.a.	n.a.
1975	n.a.	n.a.	n.a.	n.a.
1976	59	55	5000	4427
1977	n.a.	n.a.	n.a.	n.a.
1978	59	56	8000	5258
1979	61	53	8000	5754
1980	59	45	8000	7179
1981	58	38	8000	8226

1. Figures represent maximum of income classes.

2. Figures represent \$1000 (BDS) 1951 prices. The classes used were approximated taking into account the class width.

Table 7

Minor Concentration Ratios

	A	B	C	D	E
1951	.500	.386	.371	.453	
1952	.519	.396	.382	.463	
1953	.520	.432	.402	.470	
1954	.556	.319	.332	.352	
1955	.511	.520	.421	.457	
1956	-	-	-	-	
1957	.544	.439	.418	.433	
1958	.439	.493	.420	.512	
1959	.512	.463	.428	.508	
1960	.487	.471	.458	.455	
1962	.530	.462	.424	.489	
1971	.426	.426	.422	.400	.411
1972	.436	.391	.404	.442	.401
1973	.417	.408	.463	.384	.406
1976	.445	.395	.437	.451	.455
1978	.419	.427	.378	.454	.408
1979	.597	.496	.374	.490	.522
1980	.431	.445	.410	.438	.433
1981	.416	.394	.369	.484	.416

A = Income and Pensions from public and private sources.

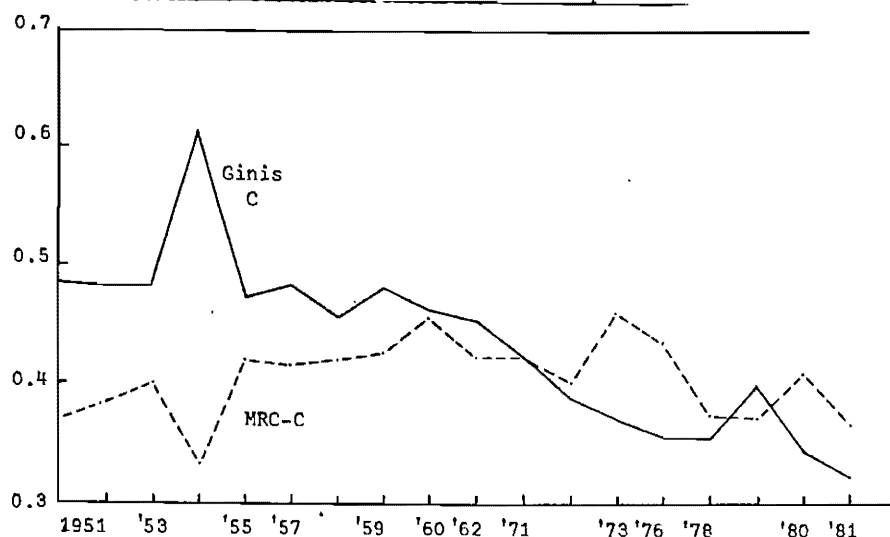
B = A + income from profession, business and agriculture, etc.

C = Total income ie B + investment income, local and foreign.

D = Total income less income taxes.

E = Total income less income taxes less national insurance payments.

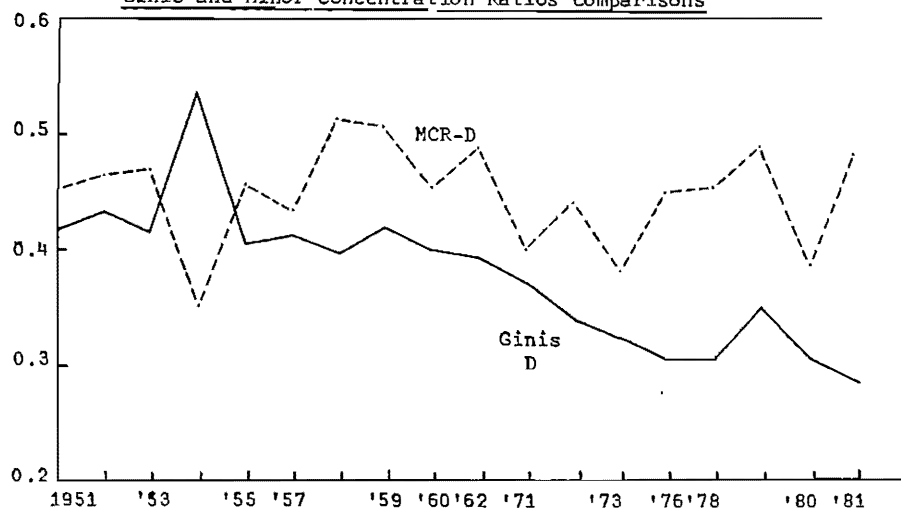
Ginis and Minor Concentration Ratios Comparisons



The following factors can be suggested:

- (a) with the rising unemployment levels during the 1970's, the "poor" bore the brunt;
- (b) the total income among the poor did not increase as fast as the income of the other groups;
- (c) the rapid emergence of a large middle income group;
- (d) the employment opportunities for the poor were principally in the very low wage sectors of the economy, e.g. garment industry; and
- (e) the employment of the poor in the seasonal sectors of the economy (e.g. sugar and tourism).

Ginis and Minor Concentration Ratios Comparisons



The progressive tax system did have the effect of redistributing income but the "poor" did not benefit to any substantial degree. While the Gini coefficient decline on average declined 22.6% for the 1950's and 1970's, the minor concentration Ratio declined by 4.1%. This suggest that the redistributational effects were five times as great for the other groups in society when compared with the "poor".

The partitioned Gini coefficient (Table 8) reveal the very unequal distribution of income among the "poor" especially during the 1950's and early 1970's. It was not until the late 1970's and early 1980's that a less unequal distribution of income was attained. Data on the relative wage levels for selected occupations (Table 9) corroborates the substantial disparity of the earlier period and the smaller variance for 1981.

Table 8

Gini Coefficients and
Partitioned Gini Coefficients*

Year	Gini Coefficients	Partitioned Gini Coefficients
1951	.418	.7432
1952	.432	.6140
1953	.417	.6083
1954	.535	.7002
1955	.405	.6705
1956	n.a.	n.a.
1957	.411	.6319
1958	.398	.6321
1959	.419	.6503
1960	.400	.6511
1961	n.a.	n.a.
1962	.391	.6601
1963-1970	n.a.	n.a.
1971	.372	.7760
1972	.342	.6050
1973	.325	.5519
1974	n.a.	n.a.
1975	n.a.	n.a.
1976	.307	.4956
1977	n.a.	n.a.
1978	.307	.4805
1979	.350	.5803
1980	.307	.4914
1981	.286	.3569

* Based on income after tax.

Table 9

Relative Wage Levels
Selected Occupations

Occupations	1951	1960	1970	1981
Maids	44	45	55	71
Lorry Drivers	89	74	72	96
Clerks	100	100	100	100
Gardener	69	58	63	80
Messenger	79	63	80	93
Agricultural Workers	43	63	47	73
Variance	549	347	361	155

Sources: Barbados Estimates - various issues
Abstract of Statistics - various issues

A comparison between the Gini coefficients and the partitioned Gini coefficients indicates the greater disparity in income distribution among the "poor" as compared with all income earners. The substantial decline in both coefficients occurred during the 1970's and early 1980's and was the result of the incomes policy of granting the lower income groups greater percentage increases than the higher income groups. Exemption from income tax would have assisted (see section on tax effect).

Summary

The inequality in income has declined over the 1950's and 1970's and the progressivity of the income system has been a major factor in the reduction of the overall level of inequality. It is also revealing that the reduction in inequality of income has been sharper during the 1970's than 1950's, when there were substantial increases in exemptions and allowances.

Investment income resulted in a higher level of inequality during the 1950's than the 1970's. However, the lower level of inequality during the 1970's was due to the decline in the proportion of investment income to total income. The country's reliance on foreign investment and the resulting large outflows of investment income was a contributory factor during the 1970's.

The introduction of the National Insurance scheme has had a perverse effect on the distribution of income as it resulted in greater inequality. This is due to the fact that upper limits of insurable earnings have been instituted since the inception of the scheme in 1967.

Although the inequality of income was lessened over the period, the "poor" did not share proportionally in this redistribution. The relative position of the "poor" was much better during the 1950's than the 1970's.

Over time the distribution of income within the lower

income groups ("the poor") although more unequal than the overall, has been better distributed as a result of wage and tax policies.

The data on Barbados does not support the view that income growth is incompatible with a more equal distribution of income. However income growth was accompanied by increased unemployment.

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Footnotes

1. See Cox [1979] for a highlight of the various problems.
2. Watson [1982], in using OLS estimation of the Gini coefficient, indicates that the results from sample data need not be valid for the whole population.

3. The rate of unemployment for selected periods is given below:

<u>Period</u>	<u>Average Unemployment Rate %</u>
1958-1960	8.1
1961-1965	10.0
1966-1970	10.6
1971-1975	16.9
1976-1980	14.0
1981	10.8

Sources: (1) Boamah, Daniel O., "Wage, Formation, Employment
 and Output in Barbados", Unpublished,
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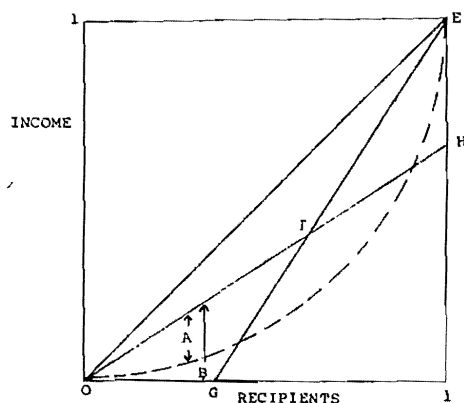
(2) Barbados Statistical Services.

4. The first income class for 1951 covers the income bracket \$0 to \$1000 and was therefore convenient so that the Koo et al method could be applied.

Appendix 1

A description of Hagerbaumer's method of calculating the minor concentration ratio is as follows:

Figure 1



(a) OE is the 45° diagonal and OE (dashed) is the Lorenz Curve.

(b) OGE represents the Lorenz curve corresponding to the income distribution in which the largest number of person receive zero income. This curve is called the minimum curve and for every Gini coefficient there will be a minimum curve. (G has the x-coordinate equal to the Gini coefficient).

(c) OHE represents the extreme distribution in which the income of the poor is maximized. OHE is therefore called the maximum curve. Point H has the y-coordinate (-G).

(d) The intersection (I) of OH and GE has the coordinates $(1/2-G, (1-G)/(2-G))$

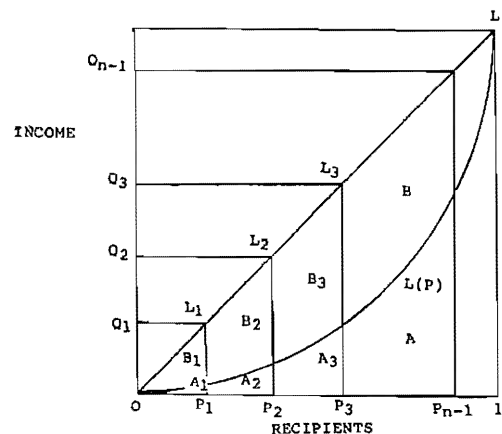
(e) The intersection (I) of OH and GE form the minor Lorenz triangle OIG and its area is equal to $G(I-G)/2(2-G)$.

(f) The dashed Lorenz curve divides the minor triangle OIG in two parts one of which is A, the minor area of concentration.

(g) The ratio of $\frac{A}{B}$ is the minor concentration ratio which is analogous to the Gini ratio.

Appendix 2

The method adopted by Koo et al is as follows:



OL is the 45° diagonal and L(P) is the Lorenz curve. $P_1, P_2, P_3, \dots, P_{n-1}$ and Q_1, Q_2, Q_3, Q_{n-1} represent the cumulative percentage of recipients and income respectively.

Considering the Lorenz diagram OP_1L_1O with a Lorenz coefficient Z_1 .

$$Z_1 = B_1 / (A_1 + B_1) = B_1 / (\frac{1}{2}P_1^2) = 2B_1 / P_1^2$$

If Z_2 is the Lorenz coefficient obtained from $P_1P_2L_2L_1$.

$$Z_2 = B_2 / (A_2 + B_2) = B_2 / (\frac{1}{2}P_2^2 - \frac{1}{2}P_1^2)$$

In like manner = $2B_2 / (P_2^2 - P_1^2)$

$$Z = B_3 / (A_3 + B) = B_3 / (\frac{1}{2}P_3^2 - \frac{1}{2}P_2^2) = 2B_3 / (P_3^2 - P_2^2)$$

In general

$$Z_i = 2B_i / (P_i^2 - P_{i-1}^2)$$

$$\begin{aligned} \text{Now } Z &= (B_1 + B_2 + B_3 + \dots + B_n) / \frac{1}{2}I^2 \\ &= 2(B_1 + B_2 + B_3 + \dots + B_n) \end{aligned}$$

where Z is the Gini coefficients

$$\begin{aligned} \text{Now } 2B_1 &= P_1^2 Z_1 \\ 2B_2 &= (P_2^2 - P_1^2) Z_2 \\ 2B_3 &= (P_3^2 - P_2^2) Z_3 \\ &: \\ &: \\ 2B_n &= P_n^2 - P_{n-1}^2 Z_n \end{aligned}$$

$$\text{Therefore } Z = W_1 Z_1 + W_2 Z_2 + W_3 Z_3 + \dots + W_n Z_n$$

$$\begin{aligned} \text{where } W_1 &= P_1^2 \\ W_2 &= P_2^2 - P_1^2 \\ W_3 &= P_3^2 - P_2^2 \\ &: \\ &: \\ W_n &= P_n^2 - P_{n-1}^2 \end{aligned}$$

$$\text{Therefore } W_i = P_i^2 - P_{i-1}^2 = 1$$