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COINTEGRATION GROWTH, POVERTY AND INEQUALITY IN SUDAN

Hisham Mohamed Hassan Ali
Faculty of Economic and Social Studies, Department of Econometrics and Social Statistics, University of Khartoum, Sudan
E-mail: hisham@uofk.edu

Abstract

This analytical review explores the links between growth, poverty and inequality in Sudan for the period 1956-2003. This paper build upon different models to investigate empirically the relationship between economic growth - as measured by GDP per capita growth- and inequality as measured by Gini coefficient (the growth, inequality and poverty triangle hypotheses), using data from the national and international sources.

The paper tries to answer the following questions: i) whether growth, inequality and poverty are cointegrated, ii) whether growth Granger causes inequality, iii) and whether inequality Granger causes poverty. Finally, a VAR is constructed and impulse response functions (IRFs) are employed to investigate the effects of macroeconomic shocks.

The results suggest that growth; poverty and inequality are cointegrated when poverty and inequality are the dependent variable, but are not cointegrated when growth is the dependent variable. In the long-run the causality runs from inequality, poverty to growth, and to poverty, while in the short-run causal effects, runs from poverty to growth. Thus, there is unidirectional relationship, running from growth to poverty, both in the long- run and short run.

Keywords: Cointgration, Inequality, Poverty, Economic growth, Sudan

JEL classification: O4, O11, I31, I38

1. Introduction

The relationship between inequality or income distribution and economic development has been an area ongoing study for over five decades. The distribution of income in a country is traditionally assumed to shift from relative equality to inequality and back to greater equality as the country develops. Intuitively, inequality will rise as some people move away from prevailing traditional activities, which yield a low marginal product, into more productive venture. At some point, the marginal product of all economic activities converges and income differences narrow. Based on this reasoning, the so-called Kuznets hypothesis (Kuznets, 1955) postulates a nonlinear relationship between a measure of income distribution and the level of economic development.

Sudan, officially Republic of the Sudan, 967.494 sq mi (2.505.813 sq km), the largest country in Africa, bordered by Egypt (N), the Red Sea (NE), Eritrea and Ethiopia (E), Kenya, Uganda, and the

Democratic Republic of Congo (S), the Central African Republic and Chad (W), and Libya (NW). The principal cities are Khartoum (the capital), Omdurman, and Khartoum North. The most notable geographical feature is the Nile R, rainfall in Sudan diminishes from south to north; thus the southern part of the country characterized by swampland and rain forest, the central region by savannah and grassland, and the north by desert and semi desert.

The first population census gave a total population of 10.3 million in 1955/56 with a density of 10 persons per square mile, with 2.5 rate of growth, 5.7 rate of growth for rural areas; 2.1 for urban areas, and -1.9 for nomadic. While in 1993 census gave a total population of 25.6 million with 2.9 rate of growth, more recent estimate for population in 2003 put the estimate as approximately 33.3 million, , with annual growth rate 2.63 percent. According to CBS, indicators in 2004 put the birth-rate at 50 births per 1,000 and the death rate at 19 per 1,000, for a rate of increase of 31 per 1,000 or 3.1 percent per year. This is a staggering increase; compared with the world average of 1.8 percent per year and the average for developing countries of 2.1 percent per annum, this percentage made Sudan one of the world's fastest growing countries. An average population density of 13 persons per square kilometre, about 33 percent of the population occupying 7 percent of the land concentrated around Khartoum and in central states. Nevertheless, only 34.5 percent of Sudanese lived in towns and cities (Urban); 65.5 percent still lived in rural areas.

In 2003, 44 percent of the population (male 8,730,609; female 8,358,569) was less than 15 years of age; 54 percent (male 10,588,634; female 10,571,199) was between the ages of 15 and 64 years, and those aged 65 years and older accounted for slightly more than 2 percent (male 490,869; female 408,282). In the overall population, there were 1.02 males for every female. The number of births per 1,000 population was 38; the number of deaths, 10. The infant mortality rate per 1,000 live births was estimated at 69. The average number of lifetime births per female was 5.4. Life expectancy at birth was an estimated average of 57 years (56 years for male, 58 years for female).
The National Comprehensive Strategy has decided the economic performance goals in the following: Redoubling of the national income, Guaranteeing of equal income distribution, and guaranteeing of national currency stability. Increasing of the: volume of the foreign commercial exchange; investment volume at rates go in line with targeted national income; funding the governments expenses in a way that coup with the economic growth goals, and Levying *zakat*[1] from financer and expanding sources of insurance and solidarity official funds.

The economy has responded positively to these reforms. Real GDP growth accelerated modestly to an annual average of about 5.7 percent during 1998-2003. Inflation declined from an average of 133 percent in 1996 to 11 percent in 2003. Fiscal revenue buoyancy has increased markedly after year of stagnation at low levels and, coupled with an improvement in budget control, has succeeded in sharply reducing the overall budget deficit. Aided by positive real rates of returns, financial disintermediation has been halted. For the first time in many years, in 2001 the velocity and cash-to-deposits and foreign currency deposits ratios decline and the ratio of quasi-money deposits to current deposits increased. The GDP has also increased from U$ billion 9.5 in 1981 to U$ billion 12.5 in 2001.

[1] A term used in Islamic finance to refer to the obligation that an individual has to donate a certain proportion of wealth each year to charitable causes.

Despite these promising initial steps Sudan still faces formidable obstacles to achieving sustainable and higher economic growth external viability and improve social indicators. The infrastructure has suffered from years of under investment and the South and *Darfour* problems, which is diverting budgetary resources away from productivity use.
Judging by Human Development Index (HDI), human development is extremely low in Sudan. In 2005, Sudan ranked 153 out of the 175 countries for which the index was calculated (UNDP, 2005), and the difference between HDI in 1975 and HDI in 2005 is equal to 0.161 this indicating a little progress in HDI.

According to Ali (1994) and Fergany (1998) the income per adult equivalent is highly unequal distributed in Sudan is clear from the difference between the smaller modal value and the average value of income - the difference being much larger in urban areas. The extent of inequality in income, higher in urban areas, is clearly documented by the Lorenz curves; the divergence between the curves emerges around the fourth income decline and then increases. Thus, the poorest 40% in both rural and urban areas have essentially the same distribution of income, in other words, the rural/urban differential in income distribution is essentially determined by disparities among the relatively rich in both segments of north Sudan.
Spread of poverty in Sudan, has increased during the 1990 decade, despite the overall growth in per capita GDP because of the relatively low growth rates in per capita expenditure and because of the deterioration in the distribution of expenditure. For the period 1990-99 poverty increased by an annual rate of 0.87 percent. For the first half of the 1990s poverty increased marginally at an annual rate of 0.24 percent but for the second half the increase in the headcount ratio was very significant at the rate of 2.4 percent. These estimates are not qualitatively different from the most recent results reported for Sudan, which compare absolute poverty in1990 to that in 1996. According to these results, the incidence of poverty (as measured by the head-count ratio) has increased by an annual rate of 2.62 percent per annum from 77.5% in 1990 to 90.5% in 1996. Moreover, it is reported that the head-count ratio for 1996 was 81.4 percent for the urban areas (using an urban poverty line of £S.292 thousand per person per year) and 94.8 percent for the rural areas (using a poverty line of £S.261 thousand per person per year).

In summary, income inequality in the Sudan is relatively high. This relatively high inequality, however, does not seem to be changing over long periods.
The main aim of this paper is to focus attention, so far lacking, on the behaviour of growth and income distributions in the Sudan over the period 1956-2003, and to explore how inequality and poverty are related to subsequent economic growth in the Sudan.
This paper contributes to this debate by analyzing simple models of growth, inequality and poverty, which allows income distribution, poverty and growth to depend on the latter in the short-to-longer run. In the short-run the model also accounts for the joint effects on growth of shocks, and the society's capacity for managing them.

This paper makes a contribution to the existing literature in the following manner. First, most studies that test the relationship between poverty, inequality and growth hypothesis (PIG) for Sudan do not tend to cover all the period from 1956-2003 and post-liberalization (post-1992) period for more than four or five years at most. This study examines a robust data set for a period of ten years after reform and thus it is better able to capture the effects of liberalization on growth and income distribution in Sudan. It is thus a more up-to-date test of the PIG hypothesis for Sudan. Secondly, this paper employs the recently developed F-bound test cointegration test, which allows us to circumvent the problem of having to impose arbitrary lag lengths (or estimate deterministic trends) in order to assess the cointegration hypothesis (following the Johansen method), which is a problem almost all the studies in the past have faced. To our knowledge, this technique has not been employed previously in empirical tests of the PIG hypothesis, particularly for the case of Sudan.

Finally, the VAR that we construct, along with the estimated impulse response functions allow us to simulate the impact of shocks on a given variable and the impact that has on the other variables. These types of 'conceptual experiments' have also not been previously used for the case of Sudan. Additionally, earlier studies (especially for the case of Sudan) tend to rely almost exclusively on the Johansen method.

2. Literature Review

In recent year's scholars, policy makers have expressed a mounting concern about the problem of income distribution in relation to growth. What triggered interest in this subject is the observation that "more than a decade of rapid growth in underdeveloped countries has been of little or no benefit to perhaps a third of their population? Paradoxically, while growth policies have succeeded beyond the expectations of the first development decade, the very idea of aggregate growth as a social objective has increasingly been called into question" (Atkinson, 1973).
For some decades economists have accept the idea that income inequality was unpleasant precondition for growth (Clarke, 1995). Insofar as income inequality provides incentives for individuals in order to improve their life standards, it could be considered as being growth-enhancing (Rebelo, 1991)

Recent research and development experiences suggest that sufficiently high and sustained growth is a prerequisite for meaningful, and hopefully irreversible, impact on poverty and income distribution. However, careful analysis of historical growth processes across the world reveals that records of sustained and sufficiently deep growth have been the exception rather than the rule. Moreover, even when growth happens, its impact on poverty and income distribution is not automatic. The efficiency of growth in terms of poverty reductions, as well as its sustainability over time depends on the extent of inequality. Indeed, while the received evidence suggests that practically nothing happens without growth, depending on the extent of initial inequality, growth spells may either collapse to a grinding halt, get completely reversed, or instead, they could be the trigger for a virtuous circle from growth-to reduced poverty-to improved equality-to further sustained growth in the future. The importance of inequality for this circle can be argued on two grounds. The basic argument is that growth is responsive to income distribution, and that in the presence of high inequality, growth is not likely to be broad-based and therefore, for both economic and political reasons, it cannot be sustained in the future (Bruno et al, 1998). Second, more recently Rodrik (1998) argues that income and assets inequality, as a cause of "latent" social conflict in a society, can force the choice of growth retarding polices in response to external shocks. The combination of shocks, deep social divisions and weak institutions for conflict management has been shown by Rodrik to be the main factor behind the collapse of growth across developing countries in the 1980s.

No comprehensive study for Sudan has been made in this area. The available literature in this context reveals that Income Distribution in the Sudan with the exception by Nur. T (1992) "Welfare Distribution and Relative Poverty in Sudan" SPS background paper, and Ali. A (1973), "Income Distribution in the Sudan" Sudan Notes and Record, and "Income Distribution and Development: The Implementations of the Dual Economy" Essays on the Economy and Society of the Sudan Vol. 1, 1977. The major finding of this paper is that in the dual economy income inequality tends to increase over time. This result should be contrasted with Kuznet's conjecture that inequality tends to increase during the early stages of development and to decrease thereafter.
Ali (1994), also have contribution to estimates FGT type poverty measures at four time points of critical significance to major economic policy changes in Sudan since the late 1960s.
The main conclusion of Ali's analysis is that structural adjustment programmes implemented in Sudan, whether under the auspices of the IMF and WB during (1978-1985) or under the present government- without formal links with the two institutions- for the period 1989-1992, have resulted in dramatic increases in poverty much larger than predicted by the secular trend in the absence of these programmes.

Nour and CBS "Poverty in Sudan 1992: With and Without Coping Practice" also arrived at estimates of the headcount index of poverty defined on household expenditures of 83% in urban areas and 71% in rural areas of the north of Sudan. Shifting the basis of the poverty measure to income changes the headcount indices to 87% and 86% respectively.
Using the same food basket, though considered problematic, poverty parameters for 1990 and 1996 estimated from the Ministry of Manpower, 1997. The poverty lines for 1990 were estimated at Sudanese pounds 4,152 and 9,624 for rural and urban areas, respectively. The corresponding values for 1996 were 284,757 and 420,716.

Poverty in rural areas estimated to have considerably widened, deepened and increased in severity in the 1990s. On all three measures, however, poverty in urban areas estimated to have ameliorated slightly- a conclusion that does not fit with macroeconomic trends in the 1990s.
According to Nur (1996) findings indicate that the majority of the `middle class' in the public sector (93.8%) are below the poverty line if measured in terms of salaries alone. Also, on the basis of aggregate income, about 61% of them are below the poverty line, i.e., the "new poor" category.
Nur, estimated that for both food and non-food items, anyone who spends/receives less than this estimated poverty line at the February 1996 prices is Ls 27,000 is identified as poor. Then, it remains to determine the level of existence and magnitude of poverty among the middle class. A minimum cost of living, therefore, is a mere subsistence level that should be achieved for survival. For instance, those who are identified as poor, on the basis of the welfare distribution, are those who fall in the categories below the level of Ls. 27,000/month. This means that 60.8% and 41.5% of our middle class are poor on the basis of income (aggregate) and expenditure respectively. These results have been obtained by employing a poverty indicator represented by a poverty line that is fixed over the welfare frequency so as to distinguish the poor from the non-poor.

Fergany, (1997) constructed a relative poverty map for the north of Sudan on the basis of indicators of non-monetary poverty derived from the 1993 population census on the level of Town and Rural Councils.

A composite index of socio-economic standard was constructed as the maximum-normalised, first principal component of 15 variables derived from the Long Form of the census. Fergany concluded to poverty is clearly much more prevalent in rural areas. While essentially no urban areas fall in the ultra poor category, a sizeable minority of urban councils belong to the "rich" category. In rural areas, on the other hand, almost all councils are poor with a large minority being ultra poor. Nevertheless, a tiny number of rural councils cross the border of the rich class. In the north of Sudan, almost three quarters of the population estimated to be poor- more than 30% are ultra-poor- and less than 5% estimated to be rich.
Poverty, particularly extreme poverty, is much more prevalent in rural areas in the north of Sudan, while virtually all the rich (about 90%) are in urban areas.
All poverty in urban areas is of the light variety (essentially none of the urban poor are ultra-poor). In the countryside, however, almost 45% of the populations estimated to be ultra-poor.
Including the ultra-poor, about 42% of urban population estimated to be poor compared to 89% in the countryside

According to Fergany in 1993 numbers, of the 20.4 million population of the North, about 15 million estimated to be poor, of which 6.2 million are ultra-poor. A little less than one million estimated to have been relatively rich.
For a crude assessment of the extent of inequality it is observed that annual household income per adult equivalent varies from considerably less than 100 Sudanese Pounds to more than Sudanese Pounds 10 million in the countryside and from less than Sudanese Pounds 1000 to more than Sudanese Pounds 22 millions in urban areas. Add to this that this observed range of variability occurs in a small sample of about 3000 households only as well as the fact that high incomes are expected to be grossly underreported in such a survey, and it becomes evident that the true extent of inequality in income distribution in north Sudan must be staggering.

Ali (2003) investigates the feasibility of achieving the Millennium Development Goals (MDGs) of reducing poverty by the year 2012 in the context of Sudan. An analytical framework for the changes in poverty over time is presented. The indirect method is used for Sudan. Starting from 2001 as a base year it is showed that Sudan needs attain, and sustain, a GDP growth rate of about 7 percent per annum to achieve the MDG on poverty. Alternatively, it is shown that it will take Sudan, growing at a per capita GDP rate of 2.2 percent per annum equivalent to a GDP growth rate of about 5 percent per annum about 28 years to achieve the MDG on poverty.

3. Methodology

3.1. Conceptual problems and data sources

Studies of the kind undertaken here beset by several methodological and conceptual problems. The methodological problems, particularly, related to the incomparability and inadequacy of the data, as well as shortcomings, which are inherent in the model analysis used.
The other major methodological problem is that of data comparability among government units at a point of time (cross-section data), or over time (time-series data). In time series data, the problem may be aggravated because the incomparability problem changes over time both of terms of its nature and magnitude.

The income data problem is particularly serious in the studies of income distribution in Sudan. This partly accounts of the lack of such studies. However, unless the available data is used no insight into gravity of the problem will be gained. Therefore, our justification for using the inadequate data that exists is that any pioneering work must start somewhere.

The data used in this study come from different sources although I attempted to maintain data consistency. Data on GDP and GDP per capita are from the Ministry of Finance and National Economy- Annual Economic Reviews, Annual Statistical Book CBS, UN statistics, IMF, World Bank, and UNDP reports. Data on income inequality measured in terms on inequality or Gini index. Gini is a measure of inequality, estimated based on different specification and equations of Gini coefficients using indirect methods[2].

The following time series are analyzed for the period 1956-2003:

1. Y: GDP per capita; real GDP Per Capita in constant dollars (international prices, base year 1990)
2. INEQ: Measures the extent to which the distribution of income among individuals or households within an economy deviates from a perfectly equal distribution. A Gini index score of zero implies perfect equality while a score of one hundred implies perfect inequality calculated based on:

$$INEQ_{-1} = 11244.1 - 7.058\, e^{log(Y)} + 0.0025\, e^{log(y)} e^{log(y)} - 4961.3 log(Y) + 583.69 log(Y)^2 \quad (1)$$

3. P: Poverty Head Count Ratio calculated based on:

$$Ln\, P = 4.1732 - 0.00163\, YC + 0.0124\, GINI \quad (2)$$

where YC is Per Capita Consumption Expenditure ($: 1990 PPP).

[2] see : Hassan, Hisham (2007). Growth and Inequality in Sudan: An Econometric Approach. unpublished PhD Uof K.

All econometric estimations in this paper have been carried out using E-views 5. The data employed in this study are graphically displayed in Appendix I. In all the cases except GDP, the probability of the Jarque-Berra test statistic provides evidence in favor of the null hypothesis of a normal distribution (these results are available from the author).

3.2. Unit root tests

In investigating the PIG hypothesis, the traditional approach of first differencing disregards potentially important equilibrium relationships among the levels of the series to which the hypotheses of economic theory usually apply (Engle and Granger, 1987).
We first test for a unit root. Table 1 summarizes the results for unit root tests on assumption of trend on levels and in first differences of the data. Strong evidence emerges that all the time series are I(1). In Table 1, for the ADF[3] tests, the lag length is based on the Schwarz Information Criterion, while for the PP test bandwidth selection is based on Newey-West.

Following a multivariate approach we proceed with considering the cointegration hypothesis between growth, inequality and poverty. These variables have been chosen for analysis for three reasons. First, Bourguignon (2003) have suggested that development in any country depend on the relationship between PIG triangle and they are an important variable while considering causality between growth, inequality and poverty and omission of one could lead to biased results. Secondly, testing the PIG hypothesis is an explicit objective for us and the chosen variables seem appropriate for such an exercise. Finally, given the set of new calculated variables for which time series data is available for Sudan.

A three-stage procedure was followed to test the direction of causality. In the first stage, the order of integration was tested using the ADF and PP unit root tests. Table 1 reports the results of the unit root tests. The ADF and PP statistics for the Y, INEQ and P do not exceed the critical values (in absolute terms). However, when we take the first difference of each of the variables, the ADF and PP statistics are higher than their respective critical values (in absolute terms). Therefore, we conclude that Y, INEQ and P are each integrated of order one or I (1).

[3] ADF is the Augmented Dickey-Fuller test for unit roots; PP is the Phillips-Perron Unit Root Test.

Table 1 - Unit Root Tests (ADF and PP test)

Variable	ADF Statistic	CV	Prob.	PP Statistic [BW]	CV	Prob.
Y	0.8873	-1.947975*	0.9073	0.7622	-1.947975	0.9173
D(Y)	-6.209519	-1.948140	0.0000	-6.033024	-1.948140*	0.0000
INEQ	0.4418	-1.947975	0.6756	0.0425	-1.947975	0.7433
D(INEQ)	-6.928813	-1.948140	0.0000	-7.412846	-1.948140	0.0000
P	0.7965	-1.947975	0.7318	0.0732	-1.947975	0.9553
D(P)	-9.753989	-1.948140	0.0000	-14.37420	-1.948140	0.000

Notes: CV is Critical values at 5% level; and BW is the Bandwidth.

3.3. Cointegration

3.3.1. Bound test approach

The second stage involves testing for the existence of a long-run equilibrium relationship between Y, INEQ and P within a multivariate framework; in order to test for the existence of any long-run relation among the variables we employ the bounds testing approach to cointegration. This involves investigating the existence of a long-run relationship using the following unrestricted error correction model UECM.

For examining the long-term relationship between Y, INEQ and P, we resort to the autoregressive distributed lags ARDL model proposed by Pesaran, et al. (2001). The ARDL procedure has become increasingly popular in recent years for several reasons: First, the technique is more appropriate to be used in testing the long run relationship between variables when the data are of a small sample size (Pesaran, et al., 2001). Second, there is no restriction imposed on the order of integration of each variable under study.

This implies that the test allows testing for the existence of a cointegrating relationship between variables in levels irrespective of whether the underlying regressors are I(0) or I(1). This is different from the general bivariate and multivariate cointegration frameworks, which require that time series in the system should be non-stationary in their levels and that all-time series in the cointegrating equation should have the same order of integration.

$$\Delta lnY_t = a_{0Y} + \sum_{i=1}^{n} b_{iY} \Delta lnY_{t-i} + \sum_{i=1}^{n} c_{iY} \Delta lnINEQ_{t-i} + \sum_{i=1}^{n} d_{iY} \Delta lnP_{t-i} + \sigma_{1Y} lnY_{t-1} + \sigma_{2Y} lnINEQ_{t-1} + \sigma_{3Y} lnP_{t-1} + \varepsilon_{it} \quad (3)$$

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$$\Delta lnINEQ_t = a_{0INEQ} + \sum_{i=1}^{n} b_{iINEQ} \Delta lnINEQ_{t-i} + \sum_{i=1}^{n} c_{INEQ} \Delta lnY_{t-i} + \sum_{i=1}^{n} d_{iINEQ} \Delta lnP_{t-i} + \sigma_{1INEQ} lnINEQ_{t-1} + \sigma_{2INEQ} lnY_{t-1} + \sigma_{3INEQ} lnP_{t-1} + \varepsilon_{it} \quad (4)$$

$$\Delta lnP_t = a_{0P} + \sum_{i=1}^{n} b_{iP} \Delta lnP_{t-i} + \sum_{i=1}^{n} c_{iP} \Delta lnINEQ_{t-i} + \sum_{i=1}^{n} d_{iP} \Delta lnY_{t-i} + \sigma_{1P} lnP_{t-1} + \sigma_{2P} lnINEQ_{t-1} + \sigma_{3P} lnY_{t-1} + \varepsilon_{it} \quad (5)$$

Here Δ is the first difference operator. The *F* test is used to determine whether a long-run relationship exists between the variables through testing the significance of the lagged levels of the variables. When a long-run relationship exists between the variables, the *F* test indicates which variable should be normalised.

In first equation, where Y is the dependent variable, the null hypothesis of no cointegration amongst the variables is $H_0 : \sigma_{1Y} = \sigma_{2Y} = \sigma_{3Y} = 0$ against the alternative hypothesis $H_1 : \sigma_{1Y} \neq \sigma_{2Y} \neq \sigma_{3Y} \neq 0$. This is denoted as $F_Y(Y \backslash INEQ,P)$.

In the second equation, where INEQ is the dependent variable, the null hypothesis for cointegration is $H_0 : \omega_{1INEQ} = \omega_{2INEQ} = \omega_{3INEQ} = 0$ against the alternative $H_1 : \omega_{1INEQ} \neq \omega_{2INEQ} \neq \omega_{3INEQ} \neq 0$. This is denoted as $F_{INEQ}(INEQ \backslash Y, P)$.

In the third equation, where P is the dependent variable, the null hypothesis for cointegration is $H_0 : \theta_{1P} = \theta_{2P} = \theta_{3P} = 0$ against the alternative $H_1 : \theta_{1P} \neq \theta_{2P} \neq \theta_{3P} \neq 0$. This is denoted as $F_P(P \backslash INEQ,Y)$.

We use a relatively new, and as yet little used, estimation technique, which is the bounds testing approach to cointegration, within ARDL framework, developed by (Pesaran, 1997; Pesaran and Shin, 1999; Pesaran *et al.,* 2001).

Kanioura and Turner generate critical values for a test for cointegration based on the joint significance of the levels terms in an error correction equation. They show that the appropriate critical values are higher than those derived from the standard *F-distribution*. They compare the power properties of this test with those of the Engle-Granger test and Kremers et al's t-test based on the t-statistic from an error correction equation. The F-test has higher power than the Engle-Granger test of the error correction test. However, the F-form of the test has the advantage that its distribution is independent of the parameters of the problem being considered, Kanioura and Turner (2005).
Based on Pesaran and Kanioura critical bounds vales if the computed *F* statistics falls outside the critical bounds, a conclusive decision can be made regarding cointegration without knowing the order of integration of the regressors. If the estimated *F* statistic is higher than the upper bound of the critical values then the null hypothesis of no cointegration is rejected. Alternatively, if the

estimated *F* statistic is lower than the lower bound of critical values, the null hypothesis of no cointegration cannot be rejected.

We tested for the presence of long-run relationships. As we use annual data, the maximum number of lags in the ARDL was set equal to 2. The calculated F-statistics are reported in Table 2.
For the F_{INEQ} = 4.545753, F_Y = 0.018322; and for F_P=14.77840. From these results, it is clear that there is a long run relationship amongst the variables when INEQ and P are the dependent variable because its F-statistic are higher than the upper bound critical values 4.260 and 3.90 at the 5 and 10 per cent level of *Pesaran* and *Narayan* respectively. This implies that the null hypothesis of no cointegration among the variables F_{INEQ} and F_p cannot be accepted. However, for F_y the null hypothesis of no cointegration is accepted.

Table 2 - Pesaran and Narayan Bounding Test Critical values

	Pesaran et al. (2001)[a]		Narayan (2005)[b]	
Critical Value	*Lower bound value*	*Upper bound value*	*Lower bound value*	*Upper bound value*
1 per cent	3.74	5.06	4.59	6.37
5 per cent	2.86	4.01	3.28	4.63
10 per cent	2.45	3.52	2.70	3.90

Sources:
[a] Critical values are obtained from Pesaran et al. (2001), Table CI(iii) Case III: Unrestricted intercept and no trend
[b] Critical values are obtained from Narayan (2005), Table case III: unrestricted intercept and no trend.
* indicate significance at 1% level. ** indicate significance at 5% level.

3.3.2. Johansen cointegration test

To confirm our previous result we apply another technique. Two or more variables are cointegrated if they have a long-term, or equilibrium, relationship between them. While the method of Engle and Granger (1987) only applies to the single equation estimation to test cointegration between variables, the estimation techniques by Johansen (1988, 1991) estimate the cointegration vectors, and test for the order of cointegration vectors and linear relationship in a multivariate model. In a vector out-regression, cointegration between variables gives an indication that a shock to any one of the equation will trigger response from the rest of the equations in the system. Table I.1 is a summary of results of cointegration analysis using Johansen maximum likelihood approach, i.e., the co-integration likelihood ratio tests based on maximum eigenvalues and trace of the stochastic matrix. Both tests confirm (as in bounding test) that there are two cointegration vectors in the given set of variables.

The result of significance (exclusion) test provides a p-value of 0.47 for Y (INEQ and P both have p-value=0); therefore, there is some (but marginal) evidence of long-run crowding-out effect.

Once the variables are found to be cointegrated, then the next step is to use the error-correction model to estimate the short-run dynamic causality relationship. Equation (1) can now be constructed into VECM in order to capture both short- and long-run impact of the vector. Defining as the vector of the *t* potentially endogenous variables, we can model as an unrestricted VAR model with lag-length up to 2 and Table 3 shows the VAR Lag Order Selection Criteria.

Table 3 - VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	151.2278	NA	2.03e-07	-6.894315	-6.771441*	-6.849003
1	159.8857	15.70508	2.07e-07	-6.878405	-6.386908	-6.697156
2	175.9923	26.96921*	1.50e-07*	-7.208945*	-6.348824	-6.891759*
3	180.3497	6.688026	1.89e-07	-6.993008	-5.764264	-6.539885
4	187.0301	9.321534	2.18e-07	-6.885121	-5.287754	-6.296062

* indicates lag order selected by the criterion.
LR: sequential modified LR test statistic (each test at 5% level).
FPE: Final prediction error.
AIC: Akaike information criterion.
SC: Schwarz information criterion.
HQ: Hannan-Quinn information criterion.

3.3.3. Granger causality

The third stage involves constructing standard Granger-type causality tests augmented with a lagged error-correction term where the series are cointegrated. The equation INEQ is dependent variables estimated without an error-correction term because we failed to find evidence of cointegration for these equations. However, given that the bounds test suggest that [Y.INEQ, P] are cointegrated when is the dependent variable, we augment the Granger-type causality test when P is the dependent variable with a lagged error-correction term. Thus, the Granger causality test involves specifying a multivariate $\boldsymbol{p}^{th}$ order VECM as presented in Table 4 as follows:

Table 4 - Results of VEC Granger Causality

Null Hypothesis:	F-Statistic	Probability	Decision
P → Y	2.98963	0.06165	Causality
Y → P	2.97465	0.06246	Causality
INEQ → Y	3.15208	0.05355	Causality
Y → INEQ	0.32196	0.72659	No Causality
INEQ → P	1.36252	0.26764	No Causality
P → INEQ	5.36446	0.00863	Causality

Granger (1969) starts from the premise that the future cannot cause the present or the past. Strictly speaking, the term "Granger Causality" means "precedence". For instance, do movements in per capita income precede movements in poverty, or its opposite, or the movement contemporaneous? This is purpose of Granger causality. It is not causality, as it usually understood.

Table 4 above gives results on Granger causality tests. In carrying out the test of causality between P and Y and INEQ, the results indicate directional causality between the P and Y. This causality runs from P to Y and from Y to P. We also see that causality runs from INEQ to Y. We also see no causality from growth to INEQ and from INEQ to P. Table 4 indicates that there is a unidirectional causality between inequality and poverty.

The results show that ECT in all the three equations has the negative and positive sign. However, the ECT in the Y and P equations are found statistically significant at 5 and 1 per cent level, which confirms the results we obtained from the bounds test of cointegration. This implies that in the long run the causality runs from INEQ, P to Y, to poverty and that change in Y are a function of disequilibrium in the cointegrating relationship. The ECT coefficient of 0.64 for Y indicates that adjustment towards the long run equilibrium is about 0.64% per annum, suggesting any deviation from the long run equilibrium is corrected substantially in the following year and 0.111% for poverty. Turning to short-run causal effects, we find that short-run causality runs from P to G and from G to P and, from Y to INEQ, from INEQ to Y, from P to INEQ and, from INEQ to P. Thus, there is unidirectional relationship, running from Y to P, both in the long run and short run.

3.4. Parameter stability

Hansen (1992) cautions that estimated parameters of a time series may vary over time. Parameter tests are important since unstable parameters can result in model misspecification, which have the potential to bias the results. To test for parameter stability we use the Pesaran (1997) test and Hanson (1992) suite of tests. According to Pesaran (1997), the short-run dynamics are essential in testing for the stability of the long-run coefficients. The Pesaran test involves estimating the following ECM for the equation where INEQ and Y are dependent variable for this is the only equation which has a long-run relationship.

Here all variables are as previously defined and the error-correction term is calculated from the long run cointegrating vector. Once the model has been estimated, Pesaran suggest applying the cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ) tests proposed by Brown et al. (1975) to assess the parameter constancy. The models were estimated by OLS and the residuals were subjected to the CUSUSM and CUSUMSQ tests. Fig II.1-5 plots the result. The results indicate the absence of any instability of the coefficients because the plot of the CUSUMSQ and CUSUM statistic are confined within the 5 per cent critical bounds of parameter stability.

3.5. Variance decomposition

Detecting Granger causality it restricted within sample tests, which are useful in describing the plausible Granger exogeneity or endogeneity of the dependent variable in the sample period, but are unable to deduce the degree of exogeneity of the variables beyond the sample period. To examine this issue we consider the decomposition of variance, which measures the percentage of a variable's forecast error variance that occurs as the result of a shock from a variable in the system. Sims (1980) notes that if a variable is truly exogenous with respect to the other variables in the system, own innovations will explain all of the variables forecast error variance.

The variance decomposition results are summarized in Table II.5 over a 12-year period. The variance decomposition analysis indicates that income is the exogenous variable.
A high proportion of its shock is explained by the own innovations compared to the contributions of own shocks to innovations for inequality and poverty. At the end of 12 years, 15 the forecast error variance for income explained by their own innovations is 95.59 percent, while the forecast error variance for poverty and inequality explained by their own innovations are 29.33 and 80.58 per cent respectively.

3.6. Impulse response functions

An alternative method of obtaining information regarding the relationships among the variables included in the variance decomposition analysis is via generalized impulse response functions. Figs present impulse response functions. Fig II.12 plots the response of income to shocks in poverty, and inequality. A shock in income has a positive and decreasing effect on poverty over the 10-year period. A shock to Inequality has a positive effect on poverty and then has a negative effect on income after the six year. The response of Inequality to shocks in real income, and poverty plotted in fig II.13. As in fig II.14, shocks to poverty have positive (decrease) effect on inequality. Consistent with the results of the decomposition of variance results, a large proportion of the variance in inequality is explained by its own innovations.

4. Conclusion

This paper has considered the relationship between growth, poverty and inequality in Sudan using bounds testing, cointegration and causality testing and extended this analysis to examine the degree of exogeneity of the variables beyond the sample period by employing variance decomposition analysis and impulse response functions. The results of the cointegration and causality testing suggest that growth, poverty and inequality are cointegrated when poverty and inequality are the dependent variable, but are not cointegrated when growth is the dependent variable.

The results indicate directional causality between poverty and growth. This causality runs from poverty to growth and from growth to poverty. We also see that causality runs from inequality to growth. We also see no causality from growth to inequality and from inequality to poverty. The result indicates that there is a unidirectional causality between inequality and poverty.

In the long- run the causality runs from inequality, poverty to growth, to poverty. In the short run causal effects, runs from poverty to growth and from growth to poverty and, from growth to inequality, from inequality to growth, from poverty to inequality and, from inequality to poverty. Thus, there is unidirectional relationship, running from growth to poverty, both in the long- run and short run.

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Appendixes

Appendix I

Fig I.1- Sudan: Growth Rate for GDP per capita 1956-2003

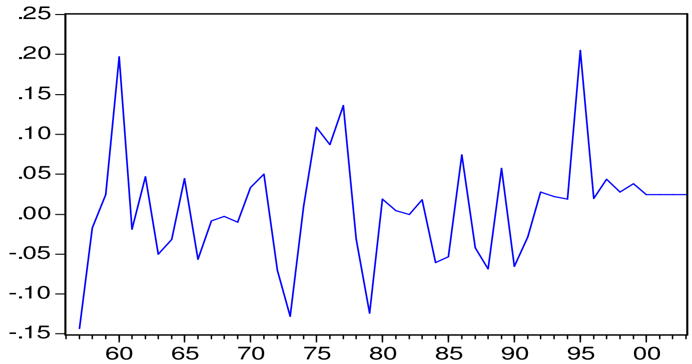

Fig I.2 - Sudan Poverty Head Count Ratio 1956-2003

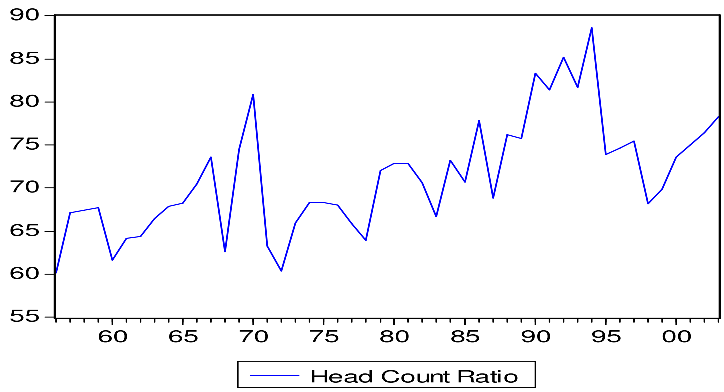

Fig I.3 - Sudan Gini Coefficient 1956-2003

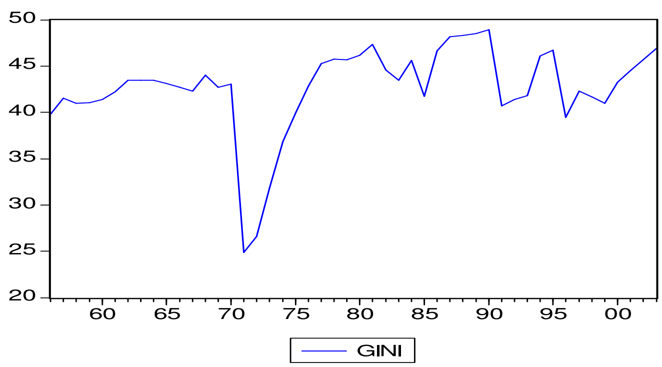

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Table I.1 - Johansen Cointegration Test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.521598	51.51391	29.79707	0.0000
At most 1 *	0.311547	19.07252	15.49471	0.0138
At most 2	0.058385	2.646969	3.841466	0.1037

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.521598	32.44139	21.13162	0.0009
At most 1 *	0.311547	16.42555	14.26460	0.0224
At most 2	0.058385	2.646969	3.841466	0.1037

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p values

Table I.2 - Test of Significant

2(u)	u	p-value		
Test of significance of	Y	2.519260	2	[0.47]
Test of significance of	INEQ	18.82256	2	[0.00]
Test of significance of	P	16.352340	2	[0.00]

Appendix II

Fig II.1- F_p CUSUM Test for Stability

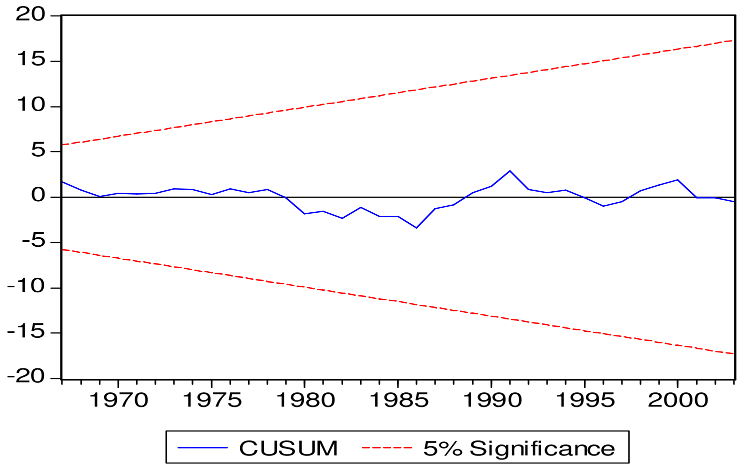

Fig II.2- F_p CUSUM of Squares Test for Stability

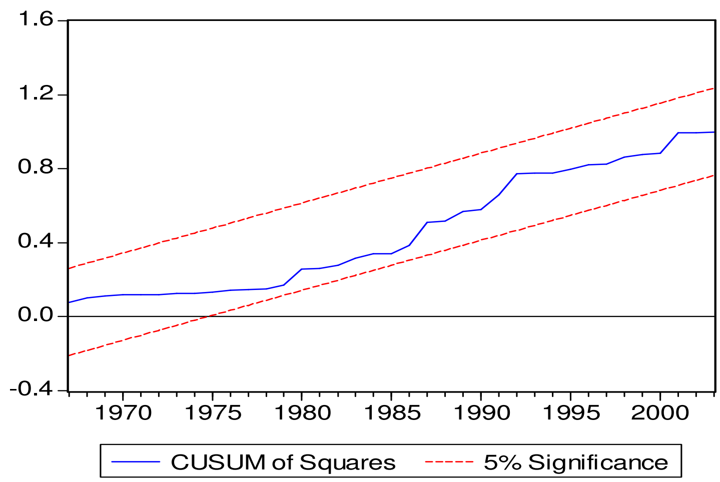

Fig II.3 - F_{INEQ} CUSUM Test for Stability

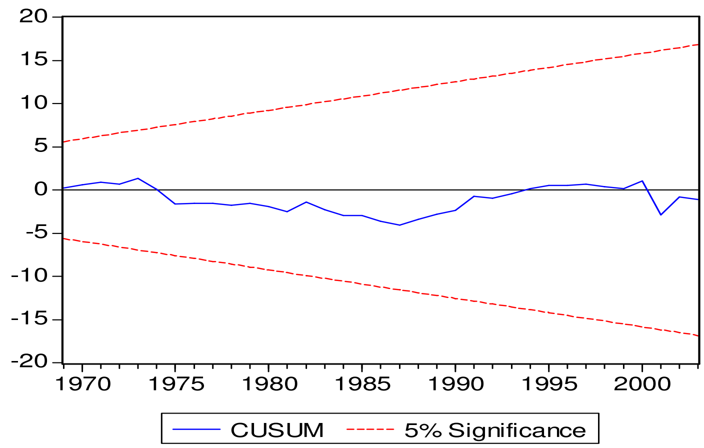

Fig II.4 - F_{INEQ} CUSUM of Squares Test for Stability

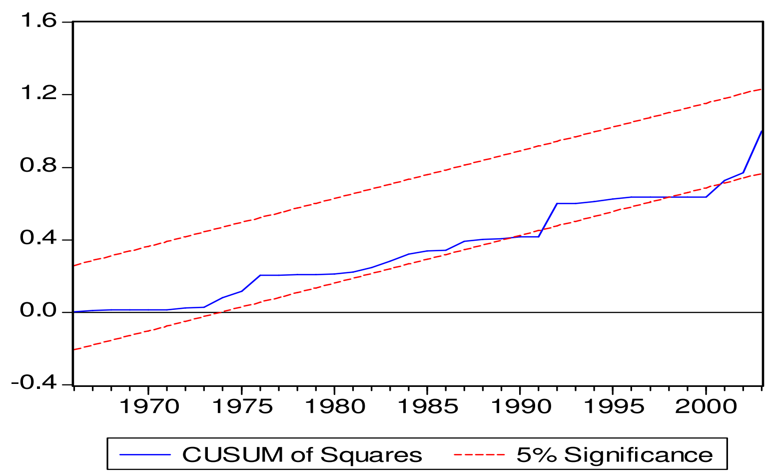

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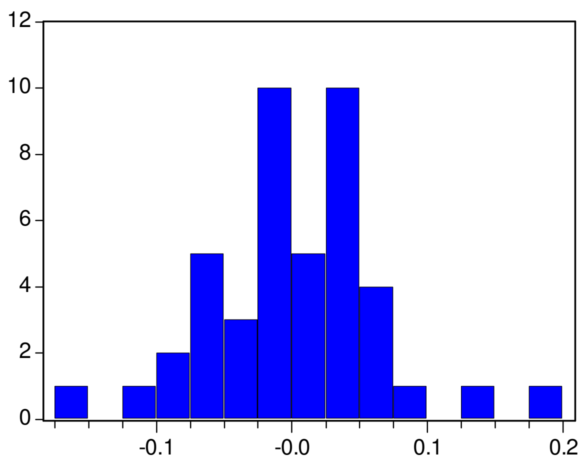
Fig II.5 - F_{INEQ} Correlogram Correlation

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.010	0.010	0.0052	0.943
		2	0.079	0.079	0.3079	0.857
		3	0.169	0.169	1.7197	0.633
		4	-0.152	-0.165	2.8831	0.578
		5	-0.074	-0.104	3.1684	0.674
		6	0.002	0.003	3.1688	0.787
		7	-0.211	-0.152	5.6097	0.586
		8	-0.190	-0.200	7.6372	0.470
		9	0.143	0.170	8.8252	0.454
		10	-0.070	0.022	9.1193	0.521
		11	0.048	0.023	9.2627	0.598
		12	0.187	0.080	11.465	0.490
		13	-0.008	0.019	11.469	0.572
		14	-0.006	-0.085	11.472	0.649
		15	0.149	0.059	13.018	0.601
		16	-0.001	0.079	13.018	0.671
		17	0.077	0.145	13.467	0.704
		18	-0.052	-0.145	13.677	0.750
		19	-0.168	-0.129	15.973	0.659
		20	-0.016	0.041	15.994	0.717

Fig II.6 - F_{INEQ} Normality Test



Series: Residuals
Sample 1960 2003
Observations 44

Mean	-2.62e-17
Median	6.05e-05
Maximum	0.183736
Minimum	-0.151526
Std. Dev.	0.062128
Skewness	0.345570
Kurtosis	4.168917
Jarque-Bera	3.380745
Probability	0.184451

Table II.1- F_{INEQ} Breusch-Godfrey Serial Correlation LM Test

F-statistic	1.800530	Probability	0.181065
Obs*R-squared	4.329017	Probability	0.114806

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Table II.2 F_{INEQ} White Heteroskedasticity Test

F-statistic	0.926691	Probability	0.575523
Obs*R-squared	23.72871	Probability	0.477195

Fig II.7- F_{INEQ} Actual, Fitted and Residual 1956-2003

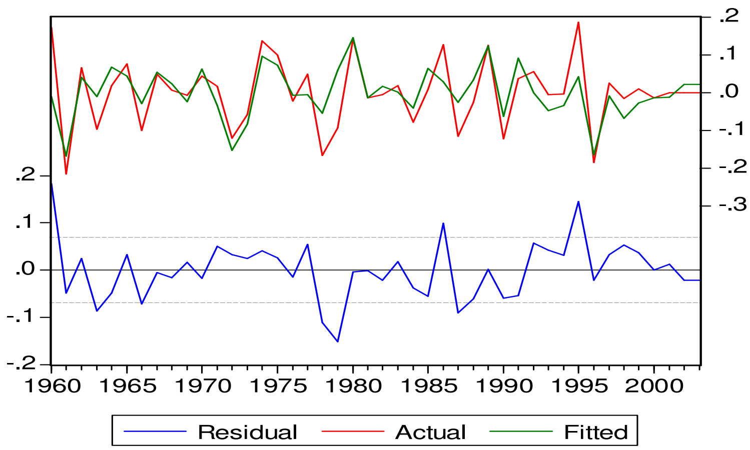

Fig II.8 - F_p Correlogram Correlation

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.012	0.012	0.0067	0.935
		2	-0.038	-0.038	0.0745	0.963
		3	0.109	0.110	0.6621	0.882
		4	-0.002	-0.007	0.6624	0.956
		5	-0.295	-0.290	5.1687	0.396
		6	0.027	0.027	5.2074	0.518
		7	-0.094	-0.119	5.6900	0.576
		8	-0.019	0.053	5.7101	0.680
		9	-0.036	-0.055	5.7852	0.761
		10	-0.147	-0.234	7.0726	0.719
		11	0.102	0.146	7.7079	0.739
		12	0.112	0.041	8.5052	0.745
		13	-0.081	-0.036	8.9350	0.778
		14	0.061	0.018	9.1856	0.819
		15	0.080	-0.072	9.6277	0.842
		16	0.019	0.146	9.6526	0.884
		17	0.033	0.035	9.7347	0.914
		18	0.018	-0.024	9.7596	0.939
		19	-0.055	-0.036	10.006	0.953
		20	-0.038	-0.099	10.130	0.966

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Fig II.9 - F_p Normality Test

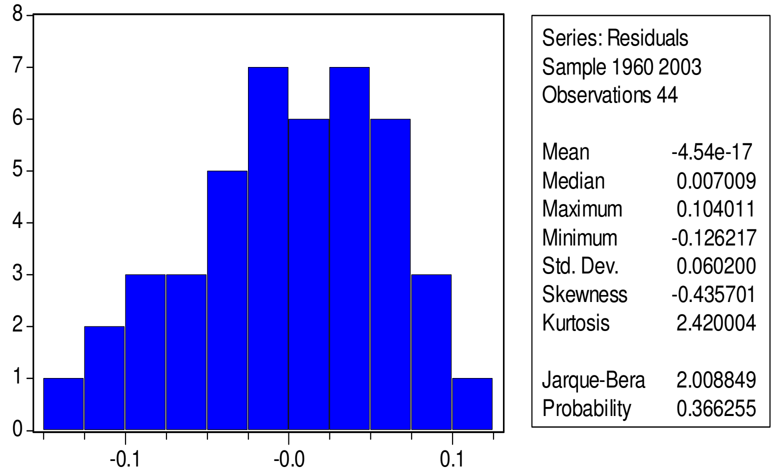

Table II.4 - F_p Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.274816	Probability	0.761171
Obs*R-squared	0.583684	Probability	0.746886

Table II.5 - F_p White Heteroskedasticity Test

F-statistic	1.505162	Probability	0.183168
Obs*R-squared	28.83416	Probability	0.226435

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Fig II.10 - F_p Actual, Fitted and Residual 1956-2003

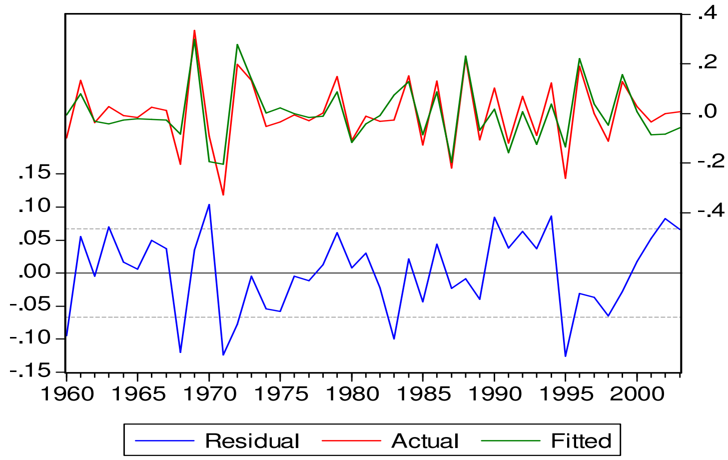

Fig II.11- Inverse Roots of AR Characteristic Polynomial

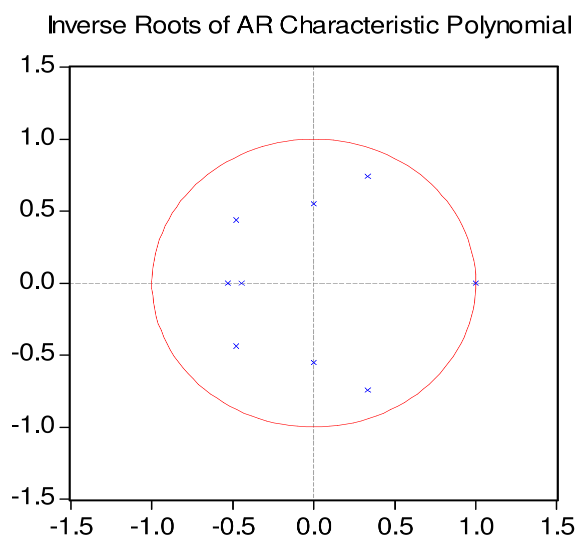

Table II.5 - Variance Decomposition of Y

Period	S.E.	Y	P	INEQ
1	0.081366	100	0	0
2	0.092544	98.52575	0.881498	0.592754
3	0.104336	94.3988	2.06959	3.531614
4	0.118676	93.5119	2.227159	4.260941
5	0.126456	93.84789	1.963567	4.18854
6	0.135117	94.48593	1.823818	3.690252
7	0.143462	94.93532	1.719922	3.344761
8	0.151813	95.0385	1.568867	3.392631
9	0.159303	95.00589	1.518341	3.475766
10	0.166323	95.14968	1.422423	3.4279
11	0.173014	95.39503	1.315848	3.289126
12	0.179497	95.59103	1.238634	3.170332

Table II.6 - Variance Decomposition of P

Period	S.E.	Y	P	INEQ
1	0.074277	34.24111	65.75889	0
2	0.09515	34.25273	58.61788	7.129399
3	0.101878	32.74918	52.70016	14.55066
4	0.111609	40.62354	46.25549	13.12097
5	0.116036	44.34817	43.35649	12.29534
6	0.120242	46.38945	41.23641	12.37414
7	0.125308	48.66154	38.24225	13.09621
8	0.130328	50.51841	35.42834	14.05325
9	0.135001	52.11308	33.62617	14.26075
10	0.139393	53.90142	32.08008	14.0185
11	0.14337	55.29368	30.70298	14.00334
12	0.14738	56.42977	29.33216	14.23807

Table II.7- Variance Decomposition of INEQ

Period	S.E.	Y	P	INEQ
1	0.109594	0.199872	19.52218	80.27795
2	0.127463	0.377702	15.85646	83.76584
3	0.14731	1.53633	12.06272	86.40095
4	0.165035	1.266207	23.96713	74.76666
5	0.17014	2.051635	22.65146	75.2969
6	0.18274	1.780862	21.50186	76.71728
7	0.193756	1.853905	19.67152	78.47457
8	0.203451	1.928998	18.49539	79.57561
9	0.211974	1.908932	18.75651	79.33455
10	0.21905	1.960571	18.59979	79.43964
11	0.226893	1.923569	18.08362	79.99281
12	0.235031	1.899449	17.5231	80.57745
Cholesky Ordering: Y P INEQ				

Fig II.12 - Impulse Responses of Income to One-standard Deviation Shocks in Income, Poverty and Inequality

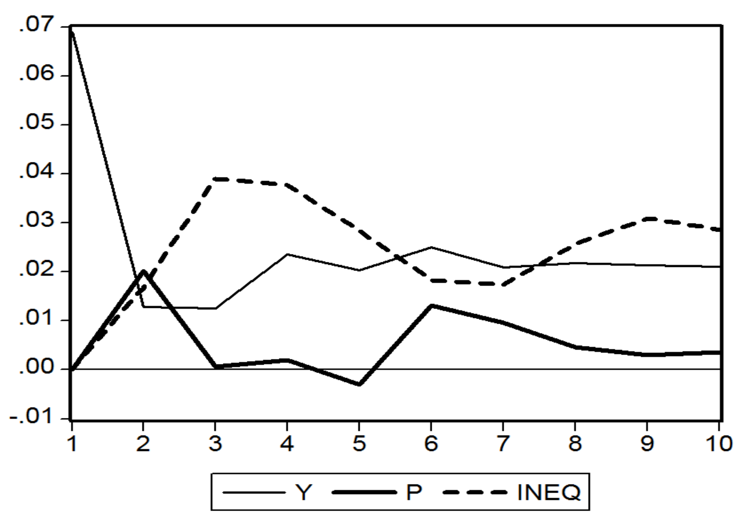

Fig II.13 - Impulse Responses of Inequality to One-standard Deviation Shocks in Income, Poverty and Inequality

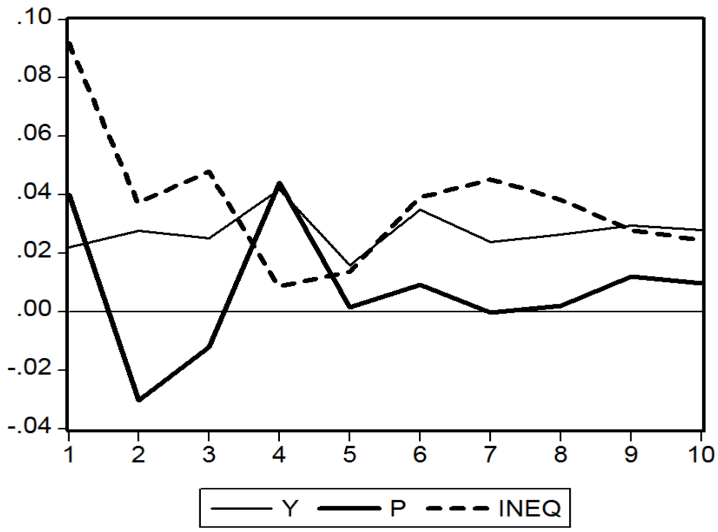

Fig II.14 - Impulse Responses of Poverty to One-standard Deviation Shocks in Income, Poverty and Inequality