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Article

What are the main factors of fuzzy inequality in Chad?

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Abstract: The purpose of this study is to identify the effects of multidimensional (fuzzy) inequalities and marginal changes on the Gini coefficients of various factors. This allows a range of social policies to be specifically targeted to reduce broader inequalities, but these policies are focused primarily on health, education, housing, sanitation, energy and drinking water. It is necessary to target policy areas that are unequally distributed, such as those with access to unevenly distributed drinking water policies. The data are from the Household and Consumption Survey of 6695 households in 2003 and 9259 households in 2011. This paper uses Lerman and Yitzhaki's method. The results revealed that the main contributors to inequalities over the two periods were health and education. These sources have a potentially significant effect on total inequality. Health increases overall inequalities, but sources such as housing, sanitation and energy reduce them. This article provides resources to disadvantaged and vulnerable target groups. Multiple inequalities are analyzed for different subgroups of households, such as place of residence and the gender of the head of household. Analyzing fuzzy poverty inequalities makes it possible to develop targeted measures to combat poverty and inequality. This study is the first to investigate the sources of Gini's fuzzy inequality in Chad via data analysis techniques, and in general, it is one of the few studies in Saharan Africa to be interested in this subject. Some development policies in sub-Saharan Africa should therefore focus on different sources (negative effect), sources (positive effect) and the equalization effect.

Keywords: decomposition by source; fuzzy poverty; fuzzy inequality; marginal effect; Gini coefficient

JEL code: C02; D12; I32

1. Introduction

Rising inequality in Africa has been accompanied by increasing poverty over time. The World Bank also admits that inequality can be a major contributor to poverty (Beegle et al., 2016). Like many other African countries, Chad has experienced increasing inequalities over the years. Within the framework of policies to combat poverty and inequality, social interventions in health have improved health indicators. Life expectancy was 48.06 years in 2003 and 50.01 years in 2011 (Demsou, 2023; World Bank, 2021). Chad's policy aims to ensure food self-sufficiency, improve nutrition, increase incomes and organize markets. Social work has been carried out in the areas of energy, water and sanitation (Demsou, 2023). In the area of education, the goal is to eliminate inequality (girls/boys), training and employment.

The Gini 2023 indices in the CEMAC (Central African Economic and Monetary Community) are as follows: Cameroon, 46.2%; Central African Republic, 43.0%; Congo, 48.9%; Gabon, 38.0%; and Chad, 37.4% (World Bank, 2024).

Gender inequalities in Chad are persistent everywhere: in 2021, 14.1% of girls and 24.2% of boys completed lower secondary schools in Chad. Adult literacy is lower

among women (18.9%) than among men (35.8%) in 2022, and 25.9% of seats in the national parliament were held by women in 2022 in Chad. In 2022, 22.6% of women and 24.9% of men in Chad accounted for, the female participation rate was 48.6%, and the male participation rate was 72.2% in 2023 (World Bank, n.d.). Income inequality increased from 2003–2011 but then decreased. From 2003–2011, while poverty rates declined, the inequality of consumption distribution rose from 39.4% to 42.1%. However, inequality decreased to 35% in 2014 and 33.6% in 2018, with declines particularly pronounced in urban areas. The urban Gini coefficient rose from 37.4% in 2014 to 33.7% in 2018 (World Bank, 2021).

Specific steps have been taken to reduce inequality and inequity between men and women by giving preferential treatment to disadvantaged groups. However, social policies aimed at reducing poverty and inequality appear to have led to a reduction in monetary poverty. In 2003, income poverty was 54.8%, and in 2011, it was 46.7% (Demsou, 2023; World Bank, 2021); however, these policies often did not significantly change the structure of the income distribution (Gini index: 43.32 in 2011, compared with 39.82 in 2003) (Demsou, 2022; World Bank, 2021).

This paper identifies at least two main research questions: i) What factors contribute most to total fuzzy inequality? ii) What are the effects of these factors?

This article provides resources to disadvantaged and vulnerable target groups. Multiple inequalities are analyzed for different subgroups of households, such as residence or the gender of the head of household. This study is the first to investigate the sources of Gini's fuzzy inequality in Chad via data analysis techniques, and in general, it is one of the few studies in Saharan Africa to be interested in this subject.

Section 2 focuses on the methodology, and Section 3 provides the results and discussion. Section 4 presents the conclusions.

2. Methodology

2.1. Data

These analyses were conducted by the National Institute for Statistics (INSEED). Sample of surveyed households: 9259 households in 2011 and 6695 households in 2003. The sample was nationally representative and stratified by place of residence and region. The sampling frame consisted of complete lists of 6685 and 12,150 census tracts from the first and second population and housing censuses, respectively (RGPH1 in 1993; RGPH2 in 2009). Census tracts are unique, nonempty territorial units that encompass the entire country. They are portions of a country's territory and are structured to accommodate approximately 1000 residents each

The household survey covers nine main themes: identification of persons living in the household, its composition, education of household members, activities of household members, types of dwellings, wealth of household, health status of household members, past expenditure and personal consumption (Demsou, 2022).

2.2. Variable selection and explanation

The indicator of preference for deprivation is of essential importance. The choice of variables is never exhaustive. There is always a margin of error. However, authors

such as (Guio, 2005, 2009) recommended considering an indicator representing lifestyle deprivation if it meets the following four conditions: i) It reflects the lack of a common standard of living for the majority of populations. In other words, it is recognized as a social necessity; ii) it allows for international comparisons; iii) it allows us to follow evolution over time; and iv) it is sensitive to changes in living standards.

The chosen indicator must be correlated with income to differentiate between poor and rich individuals (with reference to income). The analysis must clearly distinguish between influencing variables and poverty causal variables (Cheli and Lemmi, 1995; Cheli et al., 1994). Furthermore, the choice of deprivation indicator is particularly challenging because decisions cannot be made without administering any dose, and the final measurements obtained depend on data availability (Miceli, 2006).

Deprivation thresholds first identify people who are suffering from deprivation for each selected indicator (Dirksen et al., 2022). **Table 1** provides details of the dimensions and attributes used (Deutsch et al., 2018).

Table 1. List of variables.

Variables	Deprivation thresholds
Education	Not all individuals in the household can read, write and count.
	No school-age children participate
	Head of household has no schooling
Housing	The roofs of his houses are not made of sheet metal/tile and concrete
	The walls of the house are not made of cement
	The floor of the house is made of dirt
Health	The household does not have access to the health center
	More or at least one child is sick during the week
Sanitation	Lack of access to adequate sanitation
	No Water-Closet
Drinking water	Lack of access to clean water
	Access to drinking water more than 30 minutes away
Energy	The household's dwelling is not electrified
	The household does not use fuel for cooking

Source: Author.

2.3. Method

2.3.1. Theoretical framework

In 1982, Shorrocks proposed a method to decompose inequalities measured by the squared coefficient of variation (Shorrocks, 1982). This method provides rules for disaggregating measures of income inequality by subgroup or source of income (Demsou, 2022). The first method is limited to decomposing the index structure into within-group and between-group measures. If we divide the population into two groups, the within-group coefficient represents the magnitude of the distribution of income disparities within the groups, whereas the between-group measure represents the inequality that exists between population groups (Demsou, 2022).

In 1985, Lerman and Yitzhaki developed and used a new method in the United States in 1980 to decompose income inequality into its component parts (Elbers and Lanjouw, 2001; Lerman and Yitzhaki, 1985). Yitzhaki (1990) in Egygt (1981–82), Yitzhaki and Thirsk (1990) in Cote d'Ivoire (1985), Yitzhaki (1994) in Israel (1979–80), Keifman and Maurizio (2012) in Argentina, Brazil, Chile, Mexico, and Uruguay (2003–1910), Mookodi (2021) in Botswana (2009–10 and 2015–16), and Stark et al. (1986), using data from two Mexican villages (1982), used Lerman and Yitzhaki's methodology. Inequality in US consumption expenditures in 1987 is examined via the Lerman and Yitzhaki covariance method for decomposing the Gini coefficient (Clert and Wodon, 2001; Garner, 1993). In 1989, Podder used data from Australia to disaggregate the Gini index by factor components (Podder, 1993).

We use the Lerman and Yitzhaki method of 1985 to identify the effects of multidimensional inequalities and marginal changes on the Gini coefficients of various factors (Amarante, 2016; Demsou, 2022). This decomposition approach helps to explore how small changes in the fuzzy component poverty indices affect overall inequality (Lerman and Yitzhaki, 1985). In addition, the elasticity of the Gini coefficient can be calculated on the basis of a specific fuzzy poverty index. Policy discussions about the level of inequality in society greatly benefit from the use of these elasticities. The significance of the issue can be determined by the fact that a significant percentage of the fuzzy poverty ratio is attributed to cash benefits received from the government. Moreover, the government has the power to indirectly affect other sources of the fuzzy poverty index by using appropriate fiscal or monetary instruments (Podder, 1993).

2.3.2. Model specification

The fuzzy poverty index provides a framework for a better understanding of the different dimensions of poverty. In 1990, Cerioli and Zani explained that this approach has clear advantages because it takes into account the relative numbers of poor people and both their absolute and relative disadvantages (Cerioli and Zani, 1990). However, it does not consider many characteristics that may be important for a thorough understanding of poverty (Cerioli and Zani, 1990). The main criticisms are as follows: i) Assessments of individual income are often inaccurate, mainly due to the reluctance of respondents to provide accurate information. As a result, traditional income-based indices can produce misleading results. In addition, income itself is a rather vague concept. ii) Multidimensional poverty is now under control, but measures based on a single variable are not sufficient (Cerioli and Zani, 1990). iii) A comparison between poverty and nonpoverty seems impossible (Cerioli and Zani, 1990).

Suppose that P, a population of n households and the attribute X_j $(j = 1, \dots, m)$.

$$\mu(X_j) = \sum_{i=1}^{n} x_{ij}\, f(a_i) / \sum_{i=1}^{n} f(a_i) \quad (1)$$

with $w_j = \mathrm{Log}\left(\frac{\sum_{i=1}^{n} f(a_i)}{\sum_{i=1}^{n} x_{ij} f(a_i)}\right)$ (Cerioli and Zani, 1990).

w_j is the ponderation assigned to attribute $X_j = (x_{1j}, x_{2j}, \dots, x_{ij}, \dots, x_{nj})$ and

$$f(a_i) = \frac{M}{m}\frac{K_i}{n_i} \quad (2)$$

is the household weighting a_i or the inverse of the probability for any household a_i to belong to the sample in the stratum, where M is the total number of ZDs (counting areas), m is the number of ZDs in the sample, n_i is the number of households a_i sampled and K_i is the updated total number of households from the ZD of household a_i.

In the sample: $x_{ij} = 1$, if a_i does not have the attribute j, else $x_{ij} = 0$. $\frac{f(a_i)}{\sum_{i=1}^{n} f(a_i)}$ is the proportion of a_i in the total population (Demsou, 2023; Deutsch et al., 2018; Mussard and Pi Alperin, 2005;).

The ratio $\mu(X_j)$ is the degree of deprivation of characteristic X_j. The contribution of X_j attributes to multidimensional poverty can be calculated via attribute decomposition (Dagum and Costa, 2004). The fuzzy poverty index is calculated as follows (Demsou, 2023):

$$\mu = \sum_{j=1}^{m} \mu\left(X_j\right) w_j / \sum_{j=1}^{m} w_j \tag{3}$$

The absolute contribution of the X_j attribute to the multidimensional poverty index is obtained as follows:

$$\mu = \sum_{j=1}^{m} \mu_j \tag{4}$$

where $\mu_j = \mu(X_j) w_j / \sum_{j=1}^{m} w_j$.

We assume a household fuzzy poverty index μ, a minimum level a, a maximum level b, and a cumulative distribution of the fuzzy poverty index F. The half Gini mean difference (G) can be written as:

$$G = \int_a^b F(\mu)(1 - F(\mu))d\mu \tag{5}$$

Using integration by parts, with $u = F(\mu)(1-F(\mu))$ and $v = \mu$, we obtain

$$G = \int_a^b \mu(F(\mu) - {}^1/_2) f(\mu) \tag{6}$$

By defining $\mu(F)$ as the inverse function of $F(\mu)$, Equation (6) can be further transformed to

$$G = 2\int_0^1 \mu(F)(F - {}^1/_2)dF \tag{7}$$

Note that F is uniformly distributed between $[0,1]$ so that its mean is $1/2$ (Lerman and Yitzhaki, 1985; Novignon, 2017).

Equation (7) (Novignon, 2017) can be rewritten as follows.

$$G = \frac{2\, cov\,(\mu, F)}{\bar{\mu}} \tag{8}$$

The fuzzy poverty coefficient is decomposed as follows: $\mu = \sum_{j=1}^{m} \mu_j$.

Where F_j is the cumulative distribution of μ_j and where $\bar{\mu}_j$ is the arithmetic mean. Therefore, the Gini index of the jth component is as follows:

$$G_j = \frac{2\, cov\,(\mu_j,\ F_j)}{\bar{\mu}_j} \tag{9}$$

Then, utilizing the cumulative distributions and averages of the fuzzy poverty ratio,

The Gini coefficient of total expenditures is expressed as follows (Demsou, 2023; Mookodi, 2021):

$$G = \sum_{j=1}^{m} 2\frac{cov\ (\mu_j,F)}{\bar{\mu}} \tag{10}$$

By combining Equations (9) (Lerman and Yitzhaki, 1985) and (10), the index of Gini can be written as:

$$G = \sum_{j=1}^{m} \left(\frac{2\ cov\ (\mu_j,F)}{cov(\mu_j,F_j)} \frac{cov(\mu_j,F_j)}{\bar{\mu}_j}\ \frac{\bar{\mu}_j}{\bar{\mu}}\right) \tag{11}$$

with $R_j = \frac{cov\ (\mu_j,F)}{cov(\mu_j,F_j)}$, $G_j = \frac{2cov(\mu_j,F_j)}{\bar{\mu}_j}$ and $S_j = \frac{\bar{\mu}_j}{\bar{\mu}}$.

Thus,

$$G = \sum_{j=1}^{m} R_j\ G_j S_j = \sum_{j=1}^{m} C_j \tag{12}$$

We write $G = \sum_{j=l}^{m} p_j\ G_j$ with $p_j = R_j S_j$: Gini's weight for attribute X_j.

Where R_j is the correlation between the contribution of attribute j and the multidimensional poverty index, G_j is the index of Gini for each attribute j, and S_j is the contribution to the multidimensional poverty index of attribute j (Demsou, 2023; Lerman and Yitzhaki, 1985).

Similarly, concentration coefficients are sometimes used to measure income inequality:

$$Conc_j = G_j \times R_j \tag{13}$$

We have:

The contribution of attribute j of inequality is

$$I_j = \frac{C_j}{G} \tag{14}$$

Relative marginal effects:

$$I_j - S_j = S_j\left(\frac{G_j \times R_j}{G} - 1\right) \tag{15}$$

and fuzzy poverty index elasticity:

$$e_j = \frac{G_j \times R_j}{G} \tag{16}$$

Typical errors and bootstrap confidence intervals are also estimated via this decomposition method. We use the command sgini in Stata. This allows us to decompose the Gini coefficient via ambiguous poverty index sources and calculate the impact of small variations in a particular ambiguous poverty index on inequality (Kumar Mishra et al., 2019).

3. Results and discussion

3.1. Fuzzy poverty index

The choice of indicators of deprivation is particularly difficult because without dosage interventions, the measures obtained depend on the availability of data. The socioeconomic characteristics used to study poverty status were selected on the basis of the multidimensional concept of poverty, data from the Ecosit 3 in 2011 and the Ecosit 2 in 2003 surveys and the Sustainable Development Goals (Miceli, 2006).

Table 2 shows the fuzzy poverty index. Chad's fuzzy poverty index was 48.74% in 2003 and 58.89% in 2011, whereas it was 54.8% in 2003 and 46.7% in 2011. Fuzzy poverty increased by 10.15%, and income poverty decreased by 8.04% between 2003 and 2011.

According to the results, a strong contribution of variables was observed in 2003: health (25.30%), education (22.60%), drinking water (20.90%), and housing (18.10%). The largest contributors in 2011 were education (29.00%), health (24.00%) and drinking water (22. 10%) and housing (14.30%). Education and housing had high fuzzy poverty and relative contributions over the two periods in Chad.

Table 2. Fuzzy poverty coefficient.

Dimensions	2003				2011			
	Weight	Poverty	Absolute contribution	Relative Contribution	Weight	Poverty	Absolute contribution	Relative Contribution
Education	0.173	0.638	0.110	0.226	0.266	0.643	0.171	0.290
Housing	0.108	0.808	0.088	0.181	0.101	0.833	0.084	0.143
Health	0.317	0.389	0.123	0.253	0.319	0.445	0.142	0.241
Sanitation	0.076	0.727	0.055	0.113	0.076	0.742	0.056	0.095
Drinking water	0.316	0.322	0.102	0.209	0.233	0.558	0.130	0.221
Energy	0.010	0.972	0.010	0.021	0.005	0.986	0.006	0.010
Chad	1.000	0.487	0.487	1.000	1.000	0.589	0.589	1.000

Source: Own estimations.

3.2. Gini coefficient decomposition in fuzzy poverty

The analysis was performed by using household consumer expenditure data from the National Sample Survey in 2003 and 2011.

Instead of decomposing income inequality and consumption expenditures, the fuzzy poverty coefficient method can also consider various nonmonetary inequalities, such as education, housing, health, sanitation, drinking water, and energy (Demsou, 2023). These coefficients are also tools to fight poverty and inequality, considering nonmonetary aspects that are missing in current instruments. If the nonmonetary dimensions of inequality are not taken into account, limitations on inequality reduction would be justified (Aaberge and Langorgen, 2006).

Table 3 shows that the total Gini coefficient of the fuzzy poverty coefficient was 0.229 in 2003 and 0.215 in 2011. The coefficients of the Gini component greater than the overall Gini index for the fuzzy poverty coefficient over the two periods are for drinking water, health, sanitation, and education. These sources are unevenly distributed between the two time periods. These results suggest that unequally distributed resources do not necessarily equate to wealth. This means that not only are

the sources highly unequal (high Gini index), but they can also lead to poverty (Lopez-Feldman, 2006; Taylor et al., 2008).

The smallest component of the Gini coefficient during the 2 periods is the energy source. The Gini coefficient component of education increased from 0.294 in 2003 to 0.354 in 2011.

Table 3. Inequality effects of deprivation and component Gini coefficients.

Variable	S_j	G_j	R_j	$G_j \times R_j$	C_j	$I_j = C_j/G$	$I_j - S_j$	$G_j \times R_j/G$
			2003					
Education	0.226	0.294	0.445	0.131	0.030	0.129	−0.097	0.571
Housing	0.180	0.164	0.426	0.070	0.013	0.055	−0.125	0.305
Health	0.253	0.485	0.656	0.318	0.081	0.351	0.098	1.385
Sanitation	0.113	0.262	0.486	0.127	0.014	0.062	−0.050	0.554
Drinking water	0.209	0.551	0.801	0.441	0.092	0.402	0.193	1.924
Energy	0.020	0.028	0.330	0.009	0.000	0.001	−0.019	0.040
Total	1.000	0.229	1.000	0.229	0.229	1.000	0.000	1.000
			2011					
Education	0.290	0.354	0.710	0.251	0.073	0.340	0.050	1.171
Housing	0.143	0.159	0.554	0.088	0.013	0.059	−0.084	0.412
Health	0.240	0.446	0.666	0.297	0.072	0.333	0.093	1.386
Sanitation	0.096	0.250	0.558	0.140	0.013	0.062	−0.033	0.651
Drinking water	0.220	0.382	0.522	0.199	0.044	0.205	−0.016	0.930
Energy	0.010	0.014	0.654	0.009	0.000	0.000	−0.009	0.044
Total	1.000	0.215	1.000	0.215	0.215	1.000	0.000	1.000

Source: Own estimations.
Note: S_j = Fuzzy poverty index share; G_j = Gini source; R_j = Correlation with rank of total fuzzy poverty index; C_j = Absolute contribution of fuzzy inequality; $G_j \times R_j$ = Concentration factors; $I_j = C_j/G$ = Relative contribution of fuzzy inequality; $I_j - S_j$ = Relative marginal effects; $G_j \times R_j/G$ = Fuzzy poverty index elasticity; G = Total fuzzy poverty index inequality

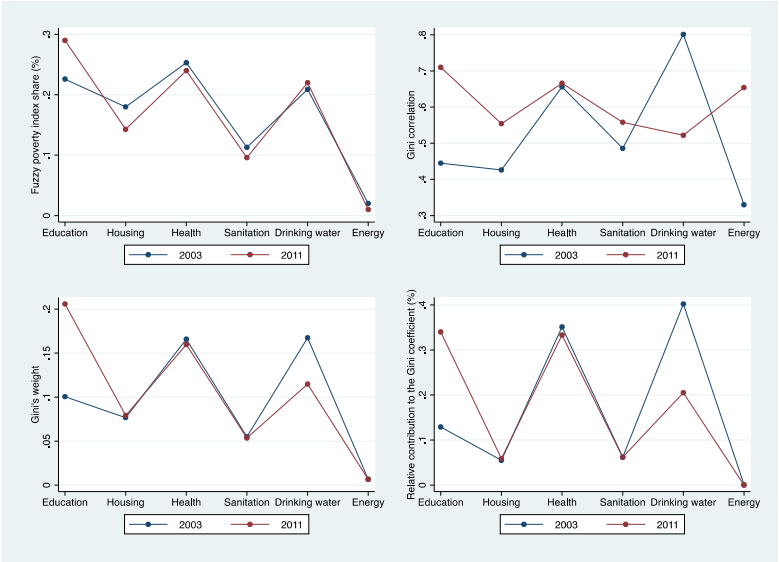

Figure 1. Main sources of contribution to inequalities.

Source: Author.

Figure 1 presents the contribution of each component to overall consumption inequality (Ferrarini and Nelson, 2003). The main sources contributing to inequalities were health and education over two periods. These sources have a potentially significant effect on total inequality.

The relative marginal effects and fuzzy poverty index elasticity results are shown in **Figure 2**. Marginal effects were calculated to better understand the extent to which different causes of fuzzy poverty have an increasing or decreasing impact on overall income inequality (Novignon, 2017). Podder (1993) concludes that when examining whether the influence of a source is increasing or decreasing, marginal effects are more meaningful than proportional contributions to inequality. Paul in 2004 and Kimhi in 2007 reported that the marginal effects of sources are more consistent. Marginal effects also show that a 1% change in a particular source of fuzzy poverty has an impact on overall inequality (Kimhi, 2007; Paul, 2004). A negative (positive) marginal effect is when the share of a particular source increases, overall multidimensional inequality decreases (increases): equalizing (dis-equalizing) effect. A positive marginal effect coefficient and a concentration coefficient with a value higher than the overall Gini coefficient (elasticity coefficient) indicate that inequality increases as the fuzzy poverty rate for that component increases. Overall inequality decreases if the marginal effect coefficient is negative. This is the same for a concentration coefficient with a value below the overall Gini coefficient.

The study revealed that a 1% increase in this source of the fuzzy poverty index, all other things being equal, resulted in an increase in the Gini coefficient of the fuzzy poverty index by 9.80% for health and 19.30% for drinking water in 2003 and, similarly, by 5% for education and 9.30% for health in 2011 (Demsou, 2023).

Over two periods, health had an increasing effect on the Gini coefficient as opposed to housing, sanitation, and energy: a dis-equalizing (equalizing) effect.

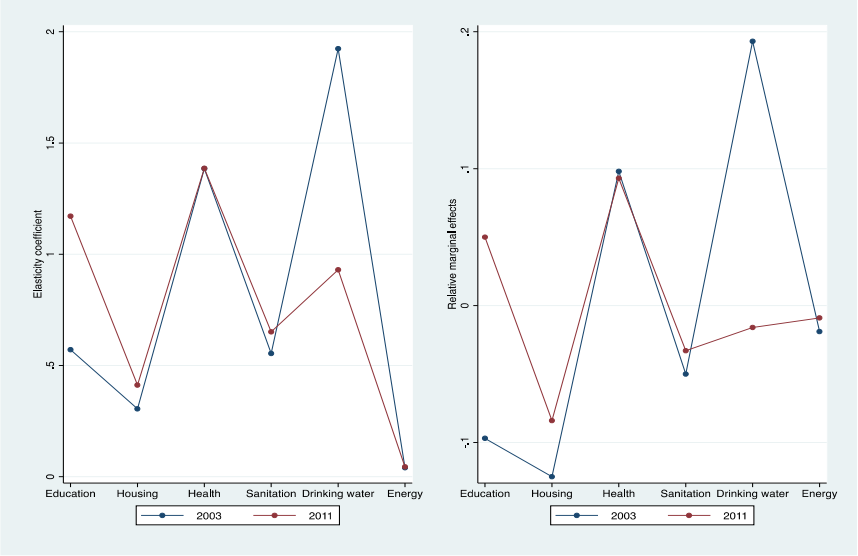

Figure 2. Sources of relative marginal effects.

Source: Author.

3.3. Bootstrap results

The analysis of the decomposition of inequalities has raised important problems with respect to the precision of the parameters. Therefore, bootstrapping is applied as a resampling method that allows the accuracy of the estimator to be estimated via random sampling with replacement from the original dataset (Efron and Tibshirani, 1986). **Table 4** shows the results of the probabilistic sensitivity analysis via the bootstrap approach. Through simple bootstrapping, measures of precision such as bias, variance, and confidence intervals can be assigned to the sample estimates (Mills and Zandvakili, 1997). Column 1 of **Table 4** shows the components of the fuzzy poverty index in each case. Column 5 shows confidence intervals, indicating that they are all significant (García-Sánchez et al., 2014).

Table 4. Bootstrap results in 2003 and 2011.

Bootstrap	**Results**	**Number of obs = 6695**				
		Replications	**=**	**250**		
	Observed	**Bootstrap**			**Normal-based**	
2003	**Coef.**	**Std. Err.**	***z***	***P* > *z***	**[95% Conf. Interval]**	
G	0.229	0.002	108.80	0.000	0.225	0.234
Education	0.294	0.004	70.28	0.000	0.286	0.303
Housing	0.164	0.003	57.08	0.000	0.158	0.170
Health	0.485	0.006	87.22	0.000	0.474	0.496
Sanitation	0.262	0.005	50.36	0.000	0.252	0.272
Drinking water	0.551	0.004	140.70	0.000	0.543	0.559
Energy	0.028	0.002	18.28	0.000	0.025	0.031
Bootstrap	**Results**	**Number of obs = 9259**				
		Replications	**=**	**250**		
	Observed	**Bootstrap**		**Normal-based**		
2011	**Coef.**	**Std. Err.**	***z***	***P* > *z***	**[95% Conf. Interval]**	
G	0.215	0.003	78.32	0.000	0.209	0.220
Education	0.354	0.008	42.39	0.000	0.337	0.370
Housing	0.159	0.004	38.15	0.000	0.151	0.168
Health	0.446	0.006	78.96	0.000	0.435	0.457
Sanitation	0.250	0.006	40.70	0.000	0.238	0.262
Drinking water	0.382	0.006	63.69	0.000	0.371	0.394
Energy	0.014	0.001	17.38	0.000	0.013	0.016

Source: Own estimations.

4. Conclusion

This paper aimed to investigate multidimensional inequalities in Chad. Income inequality was 0.398 in 2003 and 0.433 in 2011 in Chad, whereas inequality in fuzzy poverty was 0.229 in 2003 and 0.215 in 2011. Income inequality is increasing, whereas multidimensional inequality is decreasing.

The results of such a study can serve as an important tool for redirecting policies to reduce poverty and inequality. Comprehensive anti-poverty measures generally aim

to increase incomes, but that goal may not be achieved and is likely to lead to increased inequality that benefits only wealthy individuals (Novignon, 2017). Household incomes may generally increase, but this income distribution may disadvantage the poorest households. Effective poverty reduction policies, including those aimed at reducing inequality, should focus on the poorest households (African Development Bank Group, n.d.). For example, measures to support small and self-employed businesses are essential to achieve progrowth growth. Such measures might include providing access to credit and basic infrastructure to the self-employed (African Development Bank Group, n.d.). The results of this paper show that the main sources contributing to multidimensional inequalities are health and education in both periods. These sources have a potentially significant effect on total inequality.

Marginal effects are the most effective way of establishing whether changes in a fuzzy poverty component increase or decrease overall inequality and equalizing (dis-equalizing) effects (Novignon, 2017). The results show that health has the effect of increasing inequalities. In contrast, housing, sanitation, and energy have a reducing effect on global inequalities in Chad. These findings have important policy implications for Chad. The government should therefore focus on different sources (positive effects), health and sources (negative effects), such as housing, sanitation, and energy. Appropriate actions should be taken to achieve the goals of reducing distributive inequalities and improving the welfare of citizens.

The article suggests that various social policies to reduce multiple inequalities should focus primarily on access to drinking water and education, which are unequally distributed in the two periods. These results suggest that an unequal distribution of resources does not necessarily benefit wealthy people. Finally, further research is needed to address multidimensional inequalities in place of (urban vs. rural) and the gender of household heads in different regions of Chad.

Conflict of interest: The author declares no conflict of interest.

References

Aaberge, R., & Langorgen, A. (2006). Measuring the benefits from public services: the effects of local government spending on the distribution of income in norway. Review of Income and Wealth, 52(1), 61–83. https://doi.org/10.1111/j.1475-4991.2006.00176.x

African Development Bank Group. (n.d.). African Development Bank Group. Available online: https://www.afdb.org/en (accessed on 22 July 2024).

Amarante, V. (2016). Income Inequality in Latin America: A Factor Component Analysis. Review of Income and Wealth, 62(S1). Portico. https://doi.org/10.1111/roiw.12236

Beegle, K., Christiaensen, L., Dabalen, A., et al. (2015). Poverty in a Rising Africa. Washington, DC: World Bank. https://doi.org/10.1596/978-1-4648-0723-7

Cheli, B., & Lemmi, A. (1995). A'totally'fuzzy and relative approach to the multidimensional analysis of poverty https://arpi.unipi.it/handle/11568/24877.

Cheli, B., Ghellini, G., Lemmi, A., & et al. (1994). Measuring Poverty in the countries in transition via TFR method: The case study of Poland in 1990-91. Statistics in Transition, 1(5), 585-636.

Clert, C., & Wodon, Q. (2001). The targeting of government programs in Chile: A quantitative and qualitative assessment. World Bank.

Dagum, C., &Ferrari, G. (2004). Household Behaviour, Equivalence Scales, Welfare and Poverty. In: Contributions to Statistics. Physica-Verlag HD. https://doi.org/10.1007/978-3-7908-2681-4

Dagum, C., & Zenga, M. (1990). Income and Wealth Distribution, Inequality and Poverty. In: Studies in Contemporary Economics. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-84250-4

Demsou, T. (2022). Gini Multi-Decomposition by Subpopulation in Fuzzy Poverty: Evidence of Chad. Theoretical Economics Letters, 12(06), 1566–1576. https://doi.org/10.4236/tel.2022.126086

Demsou, T. (2023). Gini index decomposition by deprivation in multidimensional poverty: evidence from Chad. Gaceta Sanitaria, 37, 102299. https://doi.org/10.1016/j.gaceta.2023.102299

Deutsch, J., Pi Alperin, M. N., & Silber, J. (2017). Using the Shapley Decomposition to Disentangle the Impact of Circumstances and Efforts on Health Inequality. Social Indicators Research, 138(2), 523–543. https://doi.org/10.1007/s11205-017-1690-5

Dirksen, J., Pinilla-Roncancio, M., Wehrmeister, F. C., et al. (2022). Exploring the potential for a new measure of socioeconomic deprivation status to monitor health inequality. International Journal for Equity in Health, 21(1). https://doi.org/10.1186/s12939-022-01661-0

Efron, B., & Tibshirani, R. (1986). Bootstrap Methods for Standard Errors, Confidence Intervals, and Other Measures of Statistical Accuracy. Statistical Science, 1(1). https://doi.org/10.1214/ss/1177013815

Eichhorn, W. (1994). Models and Measurement of Welfare and Inequality. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-79037-9

Elbers, C., & Lanjouw, P. (2001). Intersectoral transfer, growth, and inequality in rural Ecuador. World Development, 29(3), 481-496.

Ferrarini, T., & Nelson, K. (2003). Taxation of social insurance and redistribution: a comparative analysis of ten welfare states. Journal of European Social Policy, 13(1), 21–33. https://doi.org/10.1177/0958928703013001037

García‐Sánchez, I. M., Gallego‐Álvarez, I., Rodríguez‐Domínguez, L., et al. (2014). Rotation of Auditing Firms and Political Costs: Evidence from Spanish Listed Companies. International Journal of Auditing, 18(3), 223–232. Portico. https://doi.org/10.1111/ijau.12027

Garner, T. I. (1993). Consumer Expenditures and Inequality: An Analysis Based on Decomposition of the Gini Coefficient. The Review of Economics and Statistics, 75(1), 134. https://doi.org/10.2307/2109636

Guio, A.-C. (2005). Material deprivation in the EU. Available online: https://www.gesis.org/fileadmin/upload/dienstleistung/daten/amtl_mikrodaten/europ_microdata/Presentations_2015/guio_4th_UC.pdf (accessed on 2 June 2024).

Guio, A.-C. (2009). What can be learned from deprivation indicators in Europe. Indicator Subgroup of the Social Protection Committee, 10.

Keifman, S., & Maurizio, R. (2012). Changes in labour market conditions and policies. ONU-WIDER Working Paper

Kimhi, A. (2007). Regression-based inequality decomposition: A critical review and application to farm-household income data. Available online: https://ageconsearch.umn.edu/record/290001/ (accessed on 2 June 2024).

Kumar Mishra, A., Satapathy, S., Patra, B., et al. (2019). Distributional change, income mobility and pro-poor growth: evidence from India. Journal of the Asia Pacific Economy, 24(2), 252–269. https://doi.org/10.1080/13547860.2019.1576492

Lemmi, A., & Betti, G. (2006). Fuzzy Set Approach to Multidimensional Poverty Measurement. In: Economic Studies in Inequality, Social Exclusion and Well-Being. Springer US. https://doi.org/10.1007/978-0-387-34251-1

Lerman, R. I., & Yitzhaki, S. (1985). Income Inequality Effects by Income Source: A New Approach and Applications to the United States. The Review of Economics and Statistics, 67(1), 151. https://doi.org/10.2307/1928447

López-Feldman, A. (2006). Decomposing Inequality and Obtaining Marginal Effects. The Stata Journal: Promoting Communications on Statistics and Stata, 6(1), 106–111. https://doi.org/10.1177/1536867x0600600107

Mills, J. A., & Zandvakili, S. (1997). Statistical inference via bootstrapping for measures of inequality. Journal of Applied Econometrics, 12(2), 133-150. https://doi.org/10.1002/(SICI)1099-1255(199703)12:23.0.CO;2-H

Mookodi, L. (2021). Decomposition analysis of the Gini coefficient of consumer expenditures in Botswana. Development Southern Africa, 1–21. https://doi.org/10.1080/0376835x.2021.1912587

Novignon, J. (2017). Household income inequality in Ghana: a decomposition analysis. African Journal of Economic and Management Studies, 8(4), 515–526. https://doi.org/10.1108/ajems-03-2017-0045

Paul, S. (2004). Income sources effects on inequality. Journal of Development Economics, 73(1), 435–451. https://doi.org/10.1016/j.jdeveco.2003.02.004

Podder, N. (1993). The disaggregation of the gin1 coefficient by factor components and its applications to australia. Review of Income and Wealth, 39(1), 51–61. Portico. https://doi.org/10.1111/j.1475-4991.1993.tb00437.x

Shorrocks, A. F. (1982). Inequality Decomposition by Factor Components. Econometrica, 50(1), 193. https://doi.org/10.2307/1912537

Stark, O., Taylor, J. E., & Yitzhaki, S. (1986). Remittances and Inequality. The Economic Journal, 96(383), 722. https://doi.org/10.2307/2232987

Taylor, J. E., Mora, J., Adams, R., & Lopez-Feldman, A. (2008). Remittances, inequality and poverty: Evidence from rural Mexico. Migration and Development within and across Borders: Research and Policy Perspectives on Internal and International Migration. Available online: https://www.torrossa.com/gs/resourceProxy?an=5368343&publisher=FZP755#page=103 (accessed on 2 June 2024).

World Bank. (2021). Chad Poverty Assessment: Investing in Rural Income Growth, Human Capital, and Resilience to Support Sustainable Poverty Reduction. World Bank. https://doi.org/10.1596/36443

World Bank. (2024). CEMAC Economic Barometer: Vol. 6 (English). Available online: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099413506112410546/IDU18afcb1f21205d1409f1a2b6155eb4236add5 (accessed on 2 June 2024).

World Bank. (n.d.). World Bank Gender Data Portal. Available online: https://liveprod.worldbank.org/en/economies/chad (accessed on 2 June 2024).

Yitzhaki, S. (1990). On the effect of subsidies to basic food commodities in egypt. Oxford Economic Papers, 42(4), 772–792. https://doi.org/10.1093/oxfordjournals.oep.a041978

Yitzhaki, S., & Thirsk, W. (1990). Welfare dominance and the design of excise taxation in the Côte d'Ivoire. Journal of Development Economics, 33(1), 1-18. https://doi.org/10.1016/0304-3878(90)90002-S