Erasmus School of Economics

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Economics and Business- Health Economics Specialisation

Robust Comparison of Distributions of Child Nutritional status in Ghana and Kenya

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Abstract

This thesis examines the robust comparisons of the trends in child nutritional status based on the hypothesis that summary measures, such as prevalence of stunting only give a partial picture. Using height-for-age z scores of children under the age of five, this thesis computes summary measures based on mean height deficit and proportion of stunting, and (socio-economic related) absolute and relative inequalities for Ghana and Kenya in 2008 and 2014. Robust comparisons using dominance tests are conducted to identify the preferred distributions of nutritional status. The analysis concludes that results of summary measures based on mean and inequality are not always consistent with results based on robust comparisons of distributions of child nutritional status. It shows that summary measures, such as mean height deficit and proportion of stunting are not sufficient indicators to track the improvement in trends of nutritional status.

Key Words: Robust comparisons; Stochastic dominance; Health inequality measurement; Stunting Prevalence; Child nutritional status.

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List of Abbreviations

CDF	Cumulative distributive function
DHS	Demographic and Health Surveys
FOSD	First order stochastic dominance
GL	Generalised Lorenz
HAZ	Height-for-age z score
MDG	Millennium Development Goals
N4G	Nutrition for Growth
NNAP	National Nutrition Action Plan
PHT	Principle of health transfers
SDG	Sustainable Development Goals
SES	Socio-economic status
SOSD	Second order stochastic dominance
UN	United Nations
WAZ	Weight-for-age z score
WHO	World Health Organization
WHZ	Weight-for-height z score

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1 Introduction

In 2015, the international community agreed to “ensure healthy lives and promote well-being for all at all ages” through the adoption of the Sustainable Development Goals (SDGs) (“Sustainable Development Goals”, n.d.-a). Unfortunately, high levels of malnutrition are a significant obstacle to achieving this goal. In 2020, nearly 144 million children under the age of five are stunted (low height for their age), 47 million children are wasted (low weight for their height), and 14.3 million children are severely wasted (“World Health Organization”, 2020). Nearly 45% of the deaths among children under the age of five are related to undernutrition (ibid). Sub-Saharan Africa has reported the least progress in the prevalence of stunting (Smith & Haddad, 2015). Two-thirds of the aforementioned 144 million stunted children belong to Africa (“World Health Statistics”, 2020).

In this thesis, I examine whether the proportion of stunted children and the mean height deficit (relative to a well-nourished child from a reference population) are sufficient indicators to track trends in nutritional status and compare nutritional status between countries. Comparisons solely based on these indicators may give rise to contradictions. It may be that the proportion of stunting is higher in one country (or year) but the mean height deficit is higher in another. In that case, which country (or year) has the least preferred distribution of mean nutritional status?

A further limitation of these two measures is that they do not indicate the level of inequality in child nutritional status. It could be that in 2008 and 2014 both the proportion of stunting and the mean height deficit are higher in one country (or year) but the inequality in nutritional status is higher in the other. Again, which country (or year) has the least preferred distribution of nutritional status? In this thesis, I compute absolute and relative inequalities to address these questions. Moreover, is a decrease in mean height deficit and prevalence of stunting associated with a decrease in inequalities?

In this thesis, I aim to assess the distributions of child nutritional status in Ghana and Kenya in 2008 and 2014. In Ghana, the prevalence of stunting in children under the age of five has decreased from 25% in 2008 to 19% in 2014, and in Kenya, the prevalence of stunting in children under the age of five has decreased from 35% in 2008 to 25% in 2014 (“Ghana: Nutrition

Profile", 2014a, 2018b; "Kenya: Nutrition Profile", 2018). Jonah, Sambu & May (2018) state that in the last 15 years, Ghana and Kenya's economic growth increased rapidly and both countries have seen a rebasing of GDP which led to the shift of these countries from 'low' to 'middle' income country status. Since the United Nations (UN) declared 2016-2025 as the Decade for Action on Nutrition, there is an increased focus to improve nutritional status in developing countries (International Food Policy Research Institute, 2016). International donors try to determine which countries are in most need of support to improve nutritional status. This requires making robust comparisons not relying on one or two indicators, such as mean height deficit and proportion of stunting that give only a partial picture.

There is an increased reliance on stunting as an indicator of child nutritional status for framing and monitoring international goals ("Improving Child Nutrition", 2013). But a decrease in the prevalence of stunting is not sufficient to conclude if there is an improvement in the distribution of nutritional status. The main objective of this thesis is to make robust comparisons of the trends in child nutritional status for Ghana and Kenya for 2008 and 2014 using full distributions of nutritional status. These comparisons are sensitive to both mean nutritional status and inequality of these distributions. I divide the main research objective into the following three research questions:

- *Research Question 1:* Is the distribution of child nutritional status better in Ghana or Kenya, in the years 2008 and 2014 respectively?
- *Research Question 2:* Is the distribution of child nutritional status better in 2014 than 2008, for both Ghana and Kenya?
- *Research Question 3:* What is the level of socio-economic related inequality in 2008 and 2014, for both Ghana and Kenya and in each country separately?

I address these questions by computing full distributions of child nutritional status, its mean, proportion of stunting, and inequalities for both cross-country and within-country analysis. By doing so, I aim to identify the most problematic country (or year) in terms of the level and unequal distribution of undernutrition. I contribute to this thesis by calculating the change in mean height deficit and mean proportion of stunting, and comparing it with the change in inequalities (Bredenkamp, Buisman, & Van de Poel, 2014).

The flow of this thesis is as follows. Chapter 2 provides a policy background on the commitments undertaken by international organisations, governments, donors, businesses, and non-profit organisations to tackle the problem of malnutrition. Chapter 3 develops a theoretical framework of the main concepts used to address the research questions. Chapter 4 describes the sample of children to be studied in both Ghana and Kenya for 2008 and 2014. It also outlines the methods used to empirically test the research questions. Chapter 5 presents and discusses the main findings of this thesis. Lastly, Chapter 6 summarises the thesis and provides an insight into the limitations of the study, and provides some recommendations for future research.

2 Policy Background

In this chapter, I explain what undernutrition is and its importance as an indicator of human welfare. I provide an overview of the actions undertaken by the international community and the governments of Ghana and Kenya to improve nutritional status. Additionally, I describe the determinants of undernutrition.

2.1 International Policies

"World Health Organization" (2020) defines malnutrition as "deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients." Major components of malnutrition are undernutrition, overweight and obesity, micro-nutrient related malnutrition, and diet-related non-communicable diseases. Research on malnutrition helps policymakers understand the detrimental effects of the vicious cycle of poverty, disease and malnutrition and could inform measures to break this cycle ("Global Database on Child Growth", n.d.).

In the year 2000, the historic Millennium Declaration was signed by 191 countries. They committed to achieving a set of eight measurable goals — the Millennium Development Goals (MDGs) — by 2015. Of these eight goals, three focused on child and maternal health and combating diseases such as HIV and malaria. However more than a decade later (in 2013), the progress on poverty, secondary education, child and maternal health has been slow. This slow progress has been mainly due to poor investments in child nutrition. The 2008 Lancet Maternal and Child Health Series (Black et al., 2008) and the 2010 Scaling Up Nutrition (SUN) movement ("The Vision and Principles of SUN", n.d.) drew attention and awareness to the importance of nutrition (Smith & Haddad, 2015). The Lancet 2013 Series on Maternal and Child Health ("The Lancet Series", 2013) introduced a Framework for Action with the following three main components to channel work needed to improve nutrition:

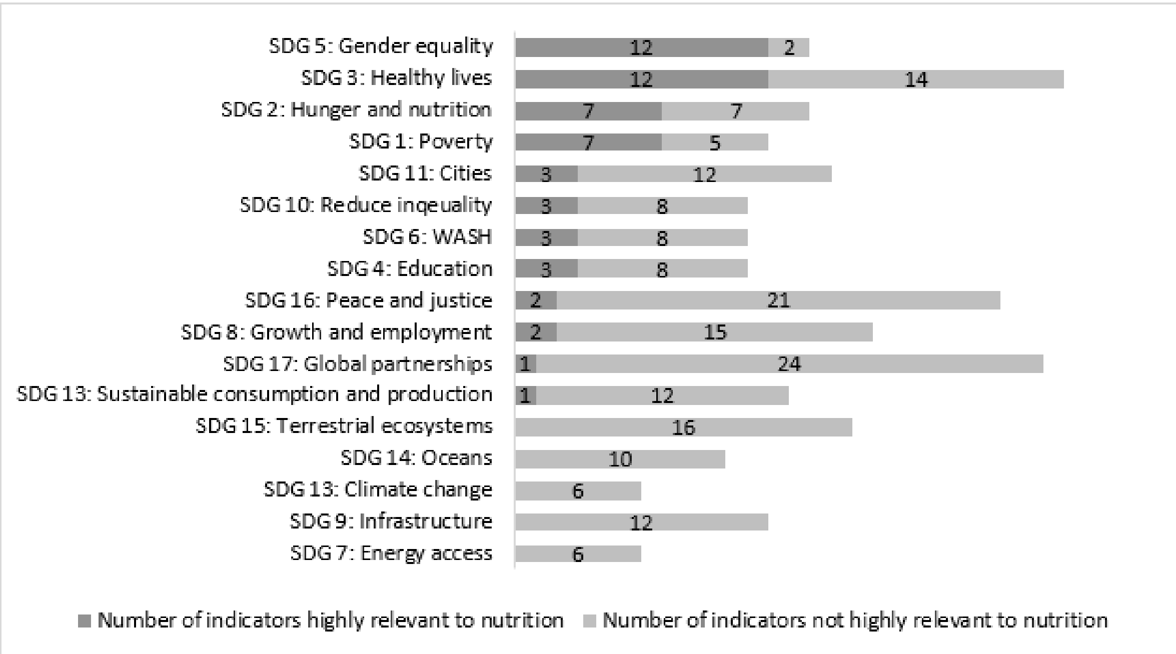
- *Nutrition specific interventions* to address immediate causes of undernutrition-improving dietary intake and poor health status,
- *Nutrition sensitive interventions* to address underlying causes of undernutrition-improving household food security, living environment and quality of care practices for mother and child,

- *Building an enabling environment* to address distal factors- improve economic, political and social context (The Lancet Series, 2013).

Since 2011, there has been a concerted effort to improve nutritional status across the globe. The World Health Assembly in 2012 adopted nutrition targets for the Plan for Maternal, Infant and Young Children (International Food Policy Research Institute, 2016). In 2013, the first Nutrition for Growth (N4G) Summit took place in London and donors pledged over 20 billion dollars for nutrition specific and nutrition sensitive projects (“About N4G”, n.d.).

With the end of the MDG era, significant progress was still to be made in several key areas, such as health, nutrition, and education. In 2015, all UN member countries renewed their efforts and adopted 17 SDGs to act on poverty alleviation, adoption of sustainable practices and to ensure peace and justice by 2030 (“Sustainable Development Goals”, n.d.-a). Of the 17 SDGs, the International Food Policy Research Institute (2016) identified indicators of nutrition in each of the SDGs. Their ranking shows that progress in SDG 3– good health and well-being, and SDG 5– gender equality enables improvements in nutrition (Figure 2.1).

Figure 2.1: Number of SDG Indicators Highly Relevant for Nutrition



Note: Reproduced from the International Food Policy Research Institute (2016)

The Global Nutrition Report of 2016 warns the global society that its current methods are not sufficient to reach the SDG objective of "ending malnutrition in all its forms by 2030". However, malnutrition could be tackled with conscious political action, more investments to fill gaps in country-specific national and sub-national data on nutrition, and evidence-based interventions undertaken. Another important suggestion the Report makes is for every government, business, non-profit organisation, and citizen to be involved and take action against malnutrition (International Food Policy Research Institute, 2016). Stakeholders of nutrition improvement look forward to the 2021 Japan N4G summit, the 2020 UN Climate Change Conference (to be held in 2021) and the 2021 Food Systems Summit with the hope to bridge these gaps, and renew and expand commitments to maximise nutrition benefits ("2020 Global Nutrition Report", 2020). Table 2.1 highlights the commitments taken by the international community towards nutrition in the past two decades.

Table 2.1 Summary of International Commitment to Nutrition

Year	***International Commitment to Nutrition***
2000	UN member nations adopted the MDGs to eradicate poverty and hunger, reduce child mortality and improve maternal health ("Millennium Development Goals, n.d.).
2010	SUN Movement started with a vision to unite and lead governments, civil societies, donors, businesses, researchers, and international organisations such as the UN to end malnutrition in all its forms ("The Vision and Principles of SUN", n.d.).
2012	World Health Assembly adopted targets for Plan on Maternal, Infant and Young Child Nutrition to be achieved by 2025
2013	First N4G Summit committed to improving nutrition.
2014	Second International Conference on Nutrition on 10 commitments in the Rome Declaration on Nutrition
2014	UN reviewed progress on 2011's commitment to prevent and control NCDs
2015	UN member nations adopted 17 SDGs to be achieved by 2030
2016	UN declares 2016-2025 as *Decade of Action on Nutrition,* and translate 2014's International Conference on Nutrition's commitments into action plans
2017	N4G Summit reviews progress and makes further coalitions ("About N4G", n.d.)

2021	Tokyo N4G Summit, 2020 UN Climate Change Conference, and Food Systems Summit to be conducted

Note: Adapted from the (International Food Policy Research Institute, 2016)

2.2 Country-Specific Policies

Sub-Saharan Africa has some of the world's lowest nutritional status. Yet, nutrition has had a low priority in the list of policy agendas. In Ghana, undernutrition was considered to be mainly a food intake issue until the late 1970s. In the late 1980s and 1990s, there was a focus to include the intake of micronutrients and, exclusive breastfeeding practices. However, commitment towards national coordination in policies, effective monitoring and evaluation of policies was still absent.

A National Nutrition Action Plan (NNAP) was developed for Ghana after the 1992 International Conference on Nutrition. There was a paradigm shift in the 2000s where strategies were consolidated to improve nutrition. Community-based growth monitoring and promotion policies were introduced to create awareness and provide necessary information to families (Ghartey, 2010). Additionally, a 'Wealth through Health' policy was introduced which focused on improving overall health with the hypothesis that improvement in health leads to improvement in productivity, economic development and wealth creation (Van de Poel, Hosseinpoor, Jehu-Appiah, Vega, & Speybroeck, 2007). However, problems of government coordination, funding and sustainability persisted (Ghartey, 2010). In 2013, the National Nutrition Policy was developed as a guideline to (a) reposition nutrition as a cross-cutting issue, (b) integrate nutrition in all national policy development, (c) provide a framework for nutrition services and interventions, (d) guide the implementation of high-impact interventions, (e) strengthen each sector for effective delivery of interventions ("National Nutrition Policy for Ghana", 2013).

Kenyan policies on child nutrition can be traced back to 1994 with the introduction of the NNAP which was developed after the 1992 International Conference on Nutrition. This Plan aimed to analyse nutrition situations, incorporate nutrition objectives into policies, create awareness on practices to improve child health, care for vulnerable groups and ensure food security ("Policy - National Plan of Action", n.d.). In 2007, Kenya adopted a policy to improve the nutrition of infants and young children by providing essential interventions ("Policy - National Strategy on Infant", n.d.). "Policy - National Nutrition Action Plan" (n.d.) operationalises the National Food and Nutrition Security Policy of 2012 to achieve overall optimum health for all Kenyans through evidence-based decisions, surveillance, awareness creation, and strengthening and coordination of partnerships among key actors of nutrition.

2.3 Determinants of Child Undernutrition

Buisman, Van de Poel, O'Donnell, & van Doorslaer (2019) identified several proximal and distal determinants that affect the status of child undernutrition in Sub-Saharan Africa. Improvements in education for women, sanitation and promoting gender equality have been identified as key determinants to reduce the level of stunting. More specifically, in Kenya, immunization of children, use of deworming medicines and reduction of the prevalence of diarrhoea were the major determinants associated with a reduction of undernourishment. Whereas in Ghana, consumption of iron supplements by the mother during pregnancy and reduction in diarrhoea were important factors associated with better child nutrition. However, age-appropriate feeding was lacking in both of these countries (Buisman, Van de Poel, O'Donnell, & van Doorslaer, 2019). The above-mentioned determinants indicate that Kenya and Ghana require country-specific policies to tackle the problem of undernutrition.

3 Theoretical Framework

In the first section of this chapter, I describe how to measure undernutrition, and which measure I will use in this thesis. In the second section, I explain how to make robust comparisons of the full distributions of child nutritional status. In the third section, I define summary measures of child nutritional status that depend both on mean and inequality. Lastly, in the fourth section, I extend the above-mentioned inequality concepts to measure SES related inequality.

3.1 Measuring Child Undernutrition

In this thesis, I measure child nutritional status with height-for-age z scores (HAZ). Among other anthropometric growth indicators, HAZ is recognised by the World Health Organisation (WHO) to analyse anthropometric data and identify the prevalence of chronic undernutrition. Leading causes of chronic undernutrition are poor maternal health, poor socio-economic conditions, frequent illness, and poor feeding and diet practices of infants and children in early years of life (“World Health Organization”, 2020). HAZ is calculated as follows:

$$h_i = \frac{height_i - median}{\sigma} \tag{3.1}$$

where $height_i$ is the height of child *i*, $median$ is the median height of a child of the same age and sex as *i* from a well-nourished (reference) population, and σ is the standard deviation of the heights of such children in the previously mentioned well-nourished population (“The Z-score”, n.d.). WHO developed the definition of the reference population, formally called the Child Growth Standard (“Child Growth Standards”, n.d.). A child is considered stunted when the HAZ is 2 standard deviations (or more) below the WHO Child Growth Standards median. A child is considered severely stunted when HAZ is 3 standard deviations (or more) below the WHO Child Growth Standards median (“Cut-off Points”, n.d.).

Other anthropometric growth indicators measuring undernutrition include weight-for-height (WHZ) and weight-for-age (WAZ) z scores. A child with a low WHZ is said to be wasted. A wasted child suffers from acute undernutrition. Such children suffer from a severe loss of weight in a short period because of infectious diseases and/or diet-related non-communicable diseases. On the other hand, a child with a low WAZ is said to be underweight. An underweight child suffers from a mix of chronic and acute undernutrition. Such children are wasted, stunted, or both ("World Health Organization", 2020). The composite nature of WAZ makes it difficult to interpret. The preferred measure of undernutrition has shifted from underweight to stunting for framing and monitoring international goals ("Improving Child Nutrition", 2013).

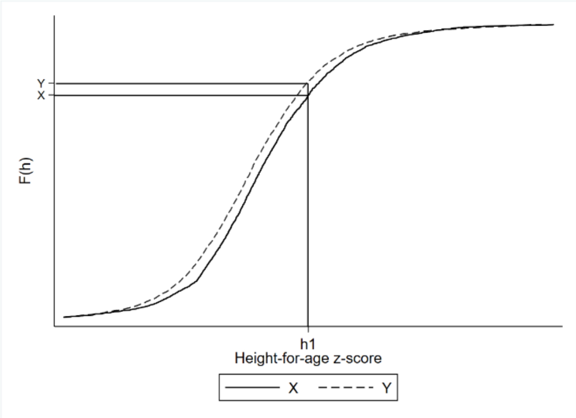
3.2 Theoretical Foundation of Stochastic Dominance

Are children at all heights shorter in Kenya than in Ghana, or is it only at the mean height? Similarly, are children at all heights shorter in 2008 than in 2014, or is it only at the mean height? To answer these questions, I construct full distributions and conduct dominance tests. These dominance tests allow the minimisation of restrictions placed on social preferences compared to the use of summary indices (O'Donnell, van Doorslaer, Wagstaff, & Lindelow, 2008). Stochastic dominance refers to the position and shape of a cumulative distribution function (CDF) relative to another (Davidson, 2006). CDF of height *(h)* in country (or year) *X* is defined as $F_X(h)$. Equation 3.2 defines first order stochastic dominance (FOSD) as follows— $CDF_X >_{FOSD} CDF_Y$ if and only if, for every level of height there is a smaller (or equal) proportion of children shorter than that height in distribution *X* than in distribution *Y*, and there exists at least one height at which the proportion shorter than that height in distribution *X* is strictly less than the proportion shorter than that height in distribution *Y* (Davidson, 2006).

$$F_X(h) >_{FOSD} F_Y(h)$$
$$iff\ \forall h_j = \{h_1, h_2, \dots, h_k\}, F_X(h_j) \leq F_Y(h_j)\ and\ \exists\ h_j, F_X(h_j) < F_Y(h_j) \tag{3.2}$$

In Figure 3.1, at every level of HAZ, there is a smaller (or equal) fraction of short children, such as *h1*, in the distribution of X than that of Y. No matter what HAZ is chosen, there is a smaller fraction of children shorter than that HAZ in the distribution of X. Assuming that on average taller children are healthier, and it is preferred for children to be healthier, then the distribution of X is preferred to that of Y by the Pareto principle. This implies that $CDF_X >_{FOSD} CDF_Y$. If one (or both) of the conditions given in Equation 3.2 are not met, either the distributions are equal at all heights *j* or the distributions intersect, and (strong) FOSD is not found (Davidson, 2006).

Figure 3.1: Hypothetical Example of FOSD



In the scenario where FOSD is not found, I will test for second order stochastic dominance (SOSD). There is a possibility that two distributions can balance out the mean nutritional status if one of them has heights of children close to the estimated mean, while the other distribution has children with very tall and very short heights. In that case, the more equal distribution is preferred based on the assumption of the Pigou-Dalton principle of health transfers (PHT). PHT states that a transfer of health from a healthier person to a less healthy person does not lead to a decrease in social welfare, given that the ranking of the individuals in terms of health does not change post-transfer (Bleichrodt & van Doorslaer, 2006). Applying this principle to height, PHT may be accepted as an assumption because the marginal welfare generated by height is decreasing. PHT holds if social welfare is increasing with height (or health) but at a decreasing rate. If PHT is accepted, then SOSD can be used to rank distributions in terms of welfare they generate (Davidson, 2006).

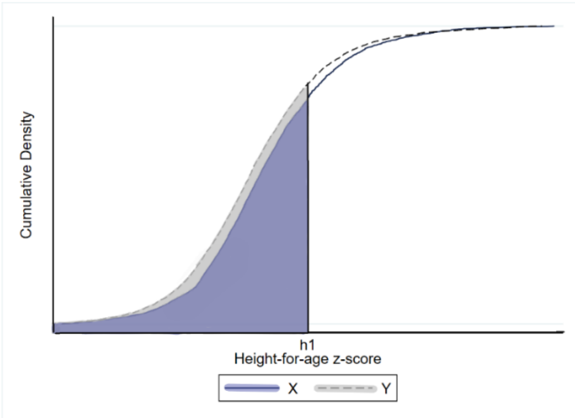
$$F_X(h) >_{SOSD} F_Y(h)$$

$$iff\ \forall h_j = \{h_1, h_2, \dots, h_n\}, \int_{h_{min}}^{h_j} F_X(h)\, dh \le \int_{h_{min}}^{h_j} F_Y(h)\, dh \tag{3.3}$$

$$and\ \exists\ h_j, \int_{h_{min}}^{h_j} F_X(h)\, dh < \int_{h_{min}}^{h_j} F_Y(h)\, dh$$

Equation 3.3 defines SOSD as follows — $CDF_X >_{SOSD} CDF_Y$ if and only if for all heights, the integral of the distribution of X is smaller than or equal to that of Y, and there exists at least one height where the integral of the distribution of X is strictly smaller than that of Y. Figure 3.2 shows that for every level of HAZ, such as *h1*, the area under the distribution of X is smaller than the area under the distribution of Y. At both ends of the curve, the CDFs appear equal. So, $CDF_X >_{SOSD} CDF_Y$ (Davidson, 2006).

Figure 3.2: Hypothetical Example of SOSD



3.3 Theoretical Foundation of Summary Measures

3.3.1 Summary Measures based on Mean

Summary measures of health are often used to allow comparison of health expectancies (and health gaps) of different countries, and countries over time (Mathers, 2002). I explore the relationship between stunting and undernutrition, such as— In 2008 and 2014, does the level of stunting improve in Ghana but the level of mean height deficit improve in Kenya? And in Ghana and Kenya, does the level of stunting improve in 2014 but the level of mean height deficit improve in 2008? To check which country (or year) has a higher prevalence of mean height deficit and stunting, I compute summary measures that depend on mean height deficit (HAZ < 0), and mean level of stunting (HAZ < -2) in Ghana and Kenya separately over time, and within each year. Additionally, I use t-tests to check if mean nutritional status is significantly different when making cross-country and within-country computations.

3.3.2 *Summary Measures based on Inequality*

I compute absolute and relative inequalities to address questions such as— In 2008 and 2014, are the mean height deficit and the mean level of stunting decreasing in Ghana, but the inequality in undernutrition decreasing in Kenya? Similarly, in Ghana and Kenya, are the mean height deficit and mean level of stunting decreasing in 2014, but the inequality is decreasing in 2008? Relative inequality is measured using the Gini index (and Lorenz curves), and absolute inequality is measured with generalised Gini index (and generalised Lorenz (GL) curves). Measurement of inequality with these measures has been widely used since the late 1980s (Le Grand, 1989; Le Grand & Rabin, 1986).

Lorenz curve, a measure of relative inequality, is a graphical representation of a cumulative proportion of health against population ranked by health. A visual inspection of a Lorenz curve in comparison to the line of perfect equality or another Lorenz curve may indicate if there is dominance. However, this visualisation is inadequate to infer if the dominance is statistically significant. So, I compute the Lorenz dominance test to check which CDF has lesser inequality (Jann, 2016; Wagstaff, 2009b). Jann (2016) states that when comparing a pair of Lorenz curves, the dominating Lorenz curve's distribution has lesser inequality. Formally, Lorenz dominance is defined as follows:

$$F_X(h) >_{LD} F_Y(h)$$
$$iff\ \forall p_j = \{p_1, p_2, \dots\}, L_X(p_j; h) \geq L_Y(p_j; h)\ and\ \exists\ p_j\ L_X(p_j; h) > L_Y(p_j; h) \tag{3.4}$$

Bleichrodt & van Doorslaer (2006) define the Gini index twice the area between the Lorenz curve and the line of equality. Computation of the Gini index requires the following conditions to be met:

- Fixed population size
- *Completeness*: For all heights, $h_1, h_2, \dots, h_n$
- *Transitivity*: If $h_3 \geq h_2$ and $h_2 \geq h_1$, then $h_3 \geq h_1$.
- *Monotonicity*: Assuming that taller children are healthier, monotonicity implies that taller children are always preferred (or equal) to shorter children.

- *Anonymity*: Anonymity of all individuals and health profiles to ensure that no other characteristic, such as gender, age, or occupation influences the social value judgements.
- *Equally distributed equivalent level of health for all health profiles*, such that if all individuals receive a constant level of height, all heights are socially indifferent.
- *Additivity*: The principle of additivity states that societies prefer more equally distributed health states such that at least one individual has a reasonable quality of life.
- *PHT*: Introduced in Section 3.2, this principle is criticised because the transfer of health from a healthier, but poor person to a less healthy, but rich person may not be desirable. PHT becomes more relevant when there is a stronger correlation between health and other variables, such as income (Bleichrodt & van Doorslaer, 2006).

GL curve, a measure of absolute inequality, is a graphical representation of a cumulative mean of health against population ranked by health. Similar to the Lorenz curve, a visual inspection of generalised Lorenz curve may indicate dominance but is insufficient to infer if the dominance is significant (Jann, 2016; Wagstaff 2009b). Jann (2016) states that when comparing a pair of Lorenz curves, the dominating Lorenz curve's distribution has lesser inequality. Formally, generalised Lorenz dominance is defined as follows:

$$F_X(h) >_{GLD} F_Y(h)$$
$$iff\ \forall p_j = \{p_1, p_2, \dots\}, GL_X(p_j;h) \geq GL_Y(p_j;h)\ and\ \exists\ p_j\ GL_X(p_j;h) > GL_Y(p_j;h) \tag{3.5}$$

Generalised Gini index is twice the area between the generalised Lorenz curve and the line of equal distribution (Bleichrodt & van Doorslaer, 2006). In addition to the following assumption, generalised Gini index follows the same assumptions as that of the Gini index:

- *Principle of population* (replaces the fixed population assumption): Introduced by Dalton in 1920, this principle states that if there is an *m* fold replication of the population, then health, h, in the m^{th}-fold is the same as that in the original, i.e., $h \sim h^m$. This assumption may not be plausible. If health is replicated *m*-fold, but other characteristics, such as level of consumption and income are not, social welfare in the m^{th}-fold might not be the same as the original (Bleichrodt & van Doorslaer, 2006).

3.4 Theoretical Foundation of SES Related Inequality

Are inequalities higher among the poor in Ghana than in Kenya? Do these inequalities remain consistently high for the poor, when comparing between 2008 and 2014? To address such questions, I extend the inequality measurement to compute SES related inequality using a wealth indicator. This wealth indicator is estimated based on household data on possession of durable items, such as television, car and phone, house building materials, land, sanitation and water supply (Filmer & Pritchett, 2001). Though a consumption measure is preferred to compute socio-economic status, such a variable is not available in DHS (Bredenkamp, Buisman, & Van de Poel, 2014).

SES related relative inequality is measured using the concentration index (and concentration curve), and SES related absolute inequality is measured using generalised concentration index (and generalised concentration curve) (Wagstaff, van Doorslaer, & Paci, 1989). Concentration index can be interpreted as an inequality index for the following reasons:

- It reflects the experiences of the population being studied.
- It reflects the socio-economic status dimension of health inequalities
- It is sensitive to changes in the composition of the underlying socio-economic ranking variables (Wagstaff, Paci, & van Doorslaer, 1991).

The definition of concentration curve is the same as that of the Lorenz curve except that here the population ranked by wealth. Similar to the Lorenz curve, a visual inspection of a concentration curve in comparison to the line of equality or another concentration curve can give an impression of dominance, but is inadequate to infer if the dominance is statistically significant. So, I compute the concentration curve dominance test to check which curve has lesser inequality. When comparing a pair of concentration curves, the dominating concentration curve’s distribution has lesser inequality. The concentration index, like the Gini index, is defined as twice the area between the concentration curve and the line of equality (O'Donnell, van Doorslaer, Wagstaff, & Lindelow, 2008).

Generalised concentration curve and index can be defined analogously (Jann, 2016; O'Donnell, van Doorslaer, Wagstaff, & Lindelow, 2008).

The assumptions made to compute the (generalised) concentration index remain the same as the (generalised) Gini index, except for PHT. PHT is extended to the principle of income-related health transfers which states that a transfer of health from a person who is better off in terms of socio-economic status to a person who is worse off in terms of socio-economic status does not lead to a decrease in social welfare, given the ranking of the individuals in terms of socio-economic status does not change post-transfer. Similar to PHT, this principle may also not be plausible. It is not desirable to transfer health from a poor-health high-standard of living individual to a good health low-standard of living individual. Again, the principle of income-related health transfers is more acceptable when there is a stronger correlation between health and other attributes such as income or wealth (Bleichrodt & van Doorslaer, 2006).

Additionally, I extend the concept of Bredenkamp, Buisman, & Van de Poel (2014) to assess if a decrease (or increase) in the prevalence of undernutrition and stunting are associated with a decrease (or increase) in (SES related) inequalities in Ghana and Kenya. To do so, I first compute the difference between 2014 and 2008 absolute and relative inequalities for both Ghana and Kenya. Next, I compute the difference between 2014 and 2008 mean HAZ < 0 and mean HAZ < -2 for both Ghana and Kenya. Subsequently, I chart these differences on a scatterplot.

4 Research Methods

In this chapter, I explain the process of data collection for analysis, the main characteristics of the data and the exclusion criteria used in this thesis. Next, I describe the complete framework of the thesis and provide a detailed explanation of the statistical models used.

4.1 Data

I conducted the analysis using Stata with data from four Demographic and Health Surveys (DHS), namely, the 2008 and 2014 Ghanaian and Kenyan surveys. These surveys provide nationally representative data on topics such as maternal and child health, nutrition, fertility (Croft et al., 2018). More specifically, the surveys I use consist of information on educational attainment and anthropometric measures of mothers and children under the age of five, such as measured height and weight, and age and sex. Additionally, I use wealth scores that are constructed using the principal component analysis to examine SES related inequality. Along with this information, the DHS dataset calculates and provides HAZ for all observations. There are 2440 and 2736 HAZ observations of children under the age of five for Ghana for the years 2008 and 2014 respectively. For Kenya, there are 5212 and 18825 HAZ observations of children under the age of five for the years 2008 and 2014 respectively.

4.1.1 Summary Statistics of Variable of Interest

I use the variable HAZ of children under the age of five to create full distributions of child nutritional status for the years 2008 and 2014 in both Ghana and Kenya. I check for measurement error by plotting histograms of HAZ separately for each year and country. I observed that there were some breaks, i.e., outliers in the histogram bars at the right extreme. At the left extreme, the density of the bars was low, but there were no breaks. The DHS program also conducts checks for the plausibility of the data, such as flag data points as invalid if HAZ scores lie below -6 and above 6. Moreover, the guidebook provided by DHS explains how they handle missing values. Children whose heights are not recorded at birth, and whose birth month and year are unknown are excluded from the calculation of HAZ (Croft et al., 2018).

Table 4.1: Summary Statistics of HAZ scores, Ghana and Kenya, 2008-2014

Country	*Year*	*N*	*Mean*	*Shortest*	*Tallest*	*10%*	*25%*	*75%*	*90%*
Ghana	2008	2,440	-1.047	-5.99	6.00	-3.03	-2.13	-0.04	1.10
	2014	2,736	-0.967	-5.93	5.97	-2.53	-1.80	-0.15	0.61
Kenya	2008	5,212	-1.305	-6.00	5.71	-3.36	-2.42	-0.32	0.84
	2014	18,825	-1.168	-5.97	5.91	-2.89	-2.10	-0.32	0.61

Comparing Ghana and Kenya, for both 2008 and 2014, Table 4.1 shows that mean HAZ is higher, i.e., children are taller in Ghana than Kenya for both 2008 and 2014. At every percentile, children in Ghana are taller than in Kenya for both years. In 2008 Ghana and Kenya, children are severely stunted at the 10th percentile, stunted in the 25th percentile, undernourished at the 75th percentile, and nourished at the 90th percentile. In 2014 Ghana and Kenya, children follow a similar pattern for undernutrition, except at the 25th percentile where Kenyan children are stunted but Ghanaian children are not.

Comparing 2014 and 2008, for both Ghana and Kenya, Table 4.1 shows that in 2014 overall severe stunting has reduced. But there is a higher number of children who are undernourished in 2014 Ghana. This is observed by the increase in negative HAZ at the 75th percentile and a decrease in the positive HAZ at the 90th percentile. This may be the reason for the 0.08 improvement in Ghanaian mean in 2014. In Kenya, while severe stunting has reduced, stunted children are still observed at the 25th percentile. But the mean HAZ goes up by 0.137.

In Table 4.1, the number of observations in 2014 Kenya has increased drastically. Until 2010, Kenya was divided into eight provinces. In 2010, with the adoption of the new constitution, the total area was re-grouped into 47 counties (Macharia et al., 2019)**.** This change might have induced a change in methodology, increasing the number of observations to achieve national representativeness.

4.2 Computation of Stochastic Dominance

4.2.1 First Order Stochastic Dominance

I begin the analysis by graphically and empirically testing for FOSD in 2008 and 2014 within each country, and across countries for each year. First, I show CDF plots to indicate whether there appears to be FOSD between years and countries. Second, I employ a bi-directional test for stochastic dominance. This two-stage test analyses stochastic dominance between two distributions (X, Y) and distinguishes the four possible inferences, namely, (a) the equality of distributions, (b) $CDF_X >_{FOSD} CDF_Y$, (c) $CDF_Y >_{FOSD} CDF_X$, or (d) CDF_X and CDF_Y cross. The 1st stage tests whether CDF_X and CDF_Y are equal. If this hypothesis is rejected, the 2nd stage tests whether CDF_X is greater than, less than, or equal to CDF_Y (Bennett, 2013). FOSD implies dominance at all higher orders (Davidson, 2006). If FOSD is not found, I proceed to test for SOSD.

4.2.2 Second Order Stochastic Dominance

SOSD is equivalent to GL dominance (Shorrocks, 1981). To explain the computation of GL dominance, I first explain what GL curves denote. Equation 4.1 defines GL curves as follows:

$$GL\ (p;\ h) = \int_{-\infty}^{F^{-1}(p)} hdF\ (h) = E[h \times I\ (h \leq F^{-1}(p))] \tag{4.1}$$

where $F^{-1}(p)$ is the p-quintile value of height, h and I () is the indicator function. I=1 if the statement in () is true and I= 0 otherwise. If a discrete distribution is considered and h_I is arranged in an increasing order, such that the 1st child is the shortest and the nth-child is the tallest ($h_1 \leq h_2 \leq h_3 \leq \ldots \leq h_n$), then the GL curve is defined $GL\ (h;k) = \sum_{i=1}^{k} h_i/n$. Hence, the GL curve reaches the mean at its limit, $GL\ (h;\ n) = \sum_{i=1}^{n} h_i/n = \mu$ (Jann, 2016).

Figure 4.1: Example of GL Curves

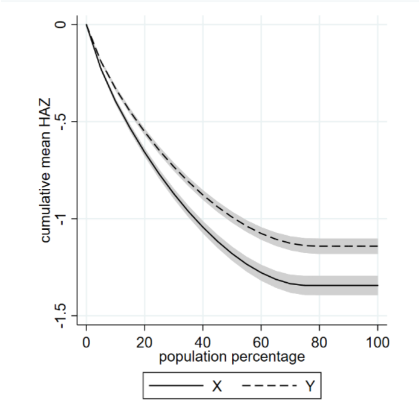
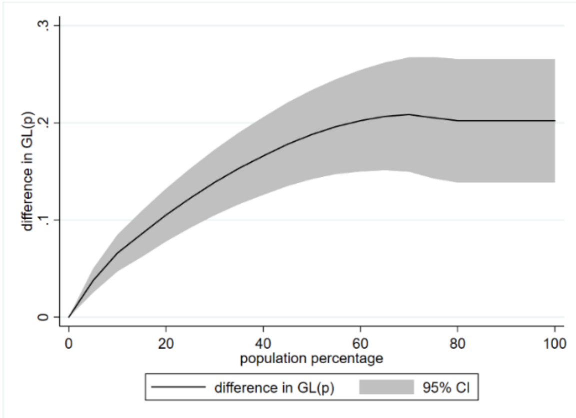


Figure 4.2: Example of Difference in GL Curves



The GL dominance test assesses whether the differences in distributions are significantly different. One way to test for dominance is to compute the difference between a pair of generalized Lorenz curves. If the difference between $GL_X(p) - GL_Y(p)$ is significant for all percentiles, *p*, dominance can be inferred. If there is at least one significant difference between the GL curves in each direction, it can be inferred that the distributions cross. If there are no significant differences between GL curves in either direction, the null of non-dominance cannot be rejected (Jann, 2016; O'Donnell, van Doorslaer, Wagstaff, & Lindelow, 2008).

In Figure 4.2, the difference between $GL_Y(p) - GL_X(p)$ shows that all percentiles the difference is significant. This can be observed by the positive lower bound 95% confidence interval at every percentile. This implies $CDF_Y >_{GLD} CDF_X$. This denotes $CDF_Y >_{SOSD} CDF_X$.

4.3 Computation of Summary Measures

4.3.1 Summary Measures based on Mean

I calculate two summary measures that are based on the mean, namely, the mean nutritional status and prevalence of stunting. I compare the means (of HAZ < 0 and HAZ < -2) of 2014 and 2008, for both Ghana and Kenya, and within each country separately. I check if these means are statistically different from each other using two-sample t-tests with unequal variances.

4.3.2 Summary Measures based on Inequality

Inequality based measures are divided into absolute and relative inequality. Absolute inequality is measured using generalised Gini index (and the associated GL curves). GL curves were defined in Section 4.2.2. Generalised Gini index (defined in Chapter 3) lies between 0 and 1, where 0 represents perfect equality and 1 represents perfect inequality (Cowell, 2011). Additionally, I use t-tests to check if a pair of generalised Gini indices are significantly different from each other.

One measure of relative inequality is the Gini index, which takes positive values between 0 and 1, where 0 represents perfect equality and 1 represents perfect inequality. Lorenz curve is simply the GL curve divided by the mean (Cowell, 2011). Formally, the Lorenz curve is defined as follows:

$$L\ (p;\ h) = \frac{1}{\mu} \int_{-\infty}^{F^{-1}(p)} hdF\ (h) = \frac{1}{\mu} E[h \times I\left(h \leq F^{-1}(p)\right)] \tag{4.2}$$

If a discrete distribution is considered and h_i is arranged in an increasing order, such that $h_1 \leq h_2 \leq h_3 \leq \ldots \leq h_n$, then the Lorenz curve is defined $L\ (h;k) = \sum_{i=1}^{k} \frac{h_i}{n\mu}$ (Jann, 2016).

Lorenz curves plot the cumulative share of height against the cumulative proportion of the population ranked from the shortest to the tallest child. Relative inequality is higher when the Lorenz curve is further away from the line of equality. At the bottom 20% of the population in Figure 4.3, the cumulative HAZ proportion for distributions X and Y is 0.5 and 0.45, respectively. This suggests that there are a greater number of shorter children in the distribution of X than that of Y for the bottom 20%. For the top 20% of the population, the cumulative HAZ proportion is almost 1 for both distributions X and Y (Cowell, 2011).

Figure 4.3: Example of Lorenz Curves

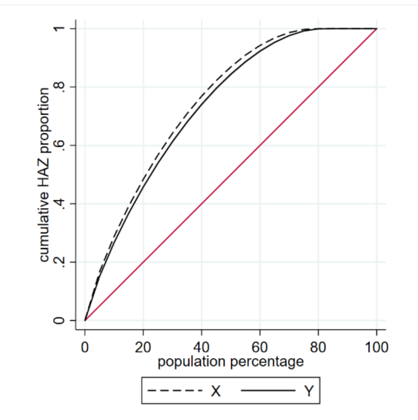
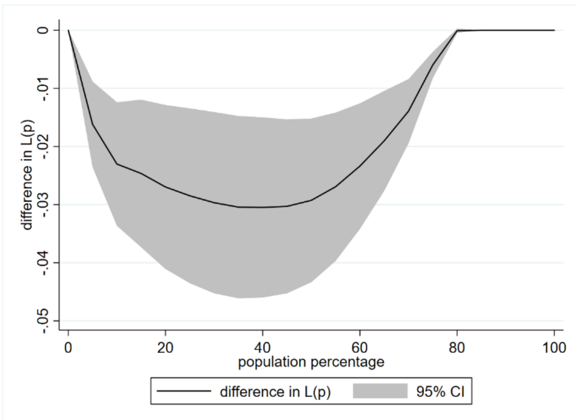


Figure 4.4: Example of Difference in Lorenz Curves



To check for a significant difference between two Lorenz curves, a Lorenz dominance test is conducted. I follow the same procedure as for GL dominance by computing the difference between a pair of Lorenz curves. If the difference between Lorenz curves, such that $L_X(p) - L_Y(p)$ is positive for all *p*, it can be inferred that CDF_X Lorenz dominates CDF_Y (Jann, 2016). If there is at least one significant difference between the Lorenz curves in each direction, it can be inferred that the distributions cross. If there are no significant differences between Lorenz curves in either direction, the null of non-dominance cannot be rejected (Jann, 2016; O'Donnell, van Doorslaer, Wagstaff, & Lindelow, 2008). Additionally, I use t-tests to check if a pair of Gini indices are significantly different from each other.

In Figure 4.4, the difference between $L_Y(p) - L_X(p)$ shows an overall positive lower bound 95% confidence interval in Lorenz curves, and implies $CDF_Y >_{LD} CDF_X$.

4.4 Computation of Summary Measures based on SES Related Inequality

I extend the analysis of absolute and relative inequalities to assess SES related absolute and relative inequality. Absolute inequality is measured using generalised concentration index (and generalised concentration curves). Relative inequality is measured using concentration index (and concentration curves). Measurement of (generalised) concentration index is the same as (generalised) Gini index. Measurement of (generalised) concentration curves is the same as (generalised) Lorenz curves, except that the population is ranked from the poorest to richest, rather than shortest to tallest. Thus, generalised concentration curves plot the cumulative mean HAZ scores against the cumulative fraction of the population from poorest to richest. And the concentration curves plot the proportion of HAZ scores against the cumulative proportion of the population from poorest to richest. (O'Donnell, van Doorslaer, Wagstaff, & Lindelow, 2008).

Dominance tests for (generalised) concentration curves follow the same procedure as for (generalised) Lorenz curves. If the difference between generalised concentration curves, such that $GCC_X(p) - GCC_Y(p)$ or $CC_X(p) - CC_Y(p)$ is positive for all *p*, it can be inferred that the (generalised) concentration curve X dominates that of Y. If there is at least one significant difference between the (generalised) concentration curves in each direction, it can be inferred that the distributions cross. If there are no significant differences between (generalised) concentration curves in either direction, the null of non-dominance cannot be rejected (O'Donnell, van Doorslaer, Wagstaff, & Lindelow, 2008). Similar to the (generalised) Gini indices, I use t-tests to check if a pair of (generalised) concentration indices are significantly different from each other.

5 Results

In this chapter, I present the main findings of the thesis. First, I present findings of the first research question— a comparison of means, full distributions and inequalities between Ghana and Kenya for both 2008 and 2014. Next, I present findings of the second research question— a comparison of means, full distributions and inequalities between 2008 and 2014 for both Ghana and Kenya. Subsequently, I present results of SES related inequalities for both cross-country analysis and within-year analysis. Finally, I plot graphs to show the difference between mean level of undernutrition (and proportion of stunting) against the difference in inequality.

5.1 Comparison of Ghana and Kenya, Separately for both 2008 and 2014

5.1.1 Summary Measures based on Mean Nutritional Status

I begin my analysis with an exploration of the main variable of interest— HAZ. Table 5.1 highlights that the mean of HAZ of Ghana is higher, i.e., undernutrition is lower than Kenya for both 2008 and 2014. A two-sample test for equal means indicates that the differences in these means are significant at 1% for both 2008 and 2014.

5.1.2 Summary Measures based on Stunting

Drawing attention to stunting, Table 5.2 shows that the proportion of stunting in Kenya is higher than Ghana for both 2008 and 2014 at 1% significance. Overall, summary measures based on mean HAZ indicate that Kenya has a higher prevalence of undernutrition and stunting than Ghana, for 2008 and 2014.

5.1.3 Stochastic Dominance

Figure 5.1 shows that at every level of HAZ, the proportion of children who are shorter than that (standardized) height is smaller, in Ghana than in Kenya in both 2008 and 2014. Table 5.3 confirms that the HAZ distribution in Ghana FOSD that in Kenya in both 2008 and 2014. In the 1st stage of the Bennett test, the null hypothesis that both CDF_{Ghana} and CDF_{Kenya} are equal is rejected at 1% significance for both years. In the 2nd stage, the test fails to reject the null hypothesis that CDF_{Ghana} dominates CDF_{Kenya} at 10% significance, for both 2008 and 2014.

Analysis of the full distributions indicates similar results as the mean nutritional status that Ghana has lower undernutrition in both years.

Table 5.1: Two-Sample t-test for Equal Means of HAZ, Ghana-Kenya, 2008 and 2014

Year	*Mean*		*Difference in Mean*	*t-statistic*
	Ghana	*Kenya*		
2008	-1.344	-1.551	0.207	6.61***
2014	-1.142	-1.354	0.213	9.8***

***, $p < 0.001$

Table 5.2: Two-Sample z-test for Equal Proportions of Stunting, Ghana-Kenya, 2008 and 2014

Year	*Proportion stunted*		*Difference*	*z-statistic*
	Kenya	*Ghana*		
2008	0.345	0.280	-0.065	-5.66***
2014	0.273	0.194	-0.079	-8.75***

***, $p < 0.001$

Figure 5.1: Cumulative Distribution Function Plots, Ghana-Kenya, 2008 and 2014

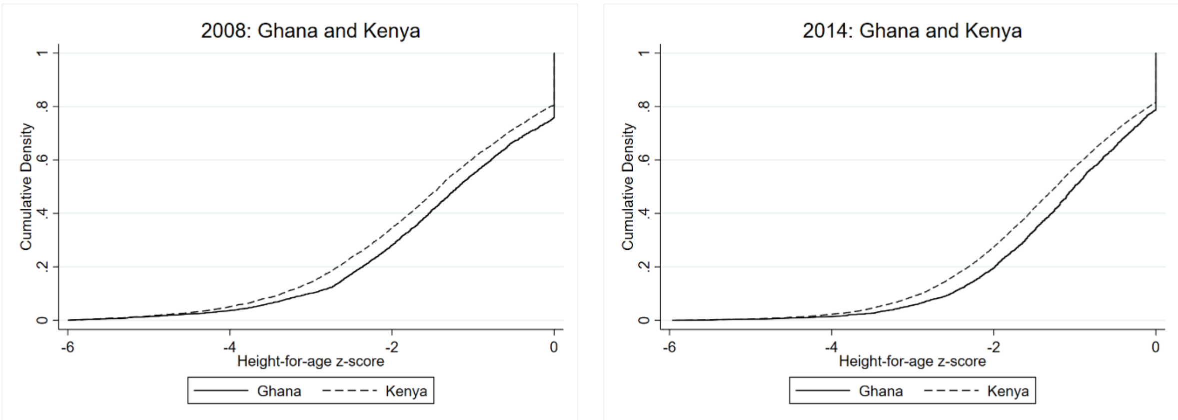


Table 5.3: Bennett Bi-directional Test, Ghana-Kenya, 2008 and 2014

Year	*Group variable**	*Group 1*	*Group 2*	*Significance level*		*Outcome*
				1st stage	*2nd stage*	
2008	Country	Ghana	Kenya	1%	10%	Ghana dominates Kenya
2014	Country	Ghana	Kenya	1%	10%	Ghana dominates Kenya

*Group variable: comparison between type of variable

5.1.4 Summary Measures based on Inequality

5.1.4.1 Absolute Inequality

Table 5.4 highlights that absolute inequality, measured using generalised Gini index is higher in Kenya than Ghana at 1% significance, in both 2008 and 2014.

Figure 5.2 shows the difference between the GL curves of Kenya and Ghana in 2008 and 2014. These differences are negative at every percentile and significant at all percentiles. The lower-bound of the 95% confidence intervals takes negative values for all percentiles, in both 2008 and 2014 (See Appendix for estimates). Given the FOSD result in Section 5.1.3, it is inevitable that the distribution of Ghana GL dominates that of Kenya.

5.1.4.2 Relative Inequality

Table 5.5 observes a negative Gini index that lies between -1 and 0 because I am looking at HAZ < 0 only. The absolute value of the index indicates the degree of inequality. Relative inequality, measured using Gini index is higher in Ghana than Kenya at 1% significance, in both 2008 and 2014.

Figure 5.3 shows that in 2008, the difference between the Kenyan and Ghanaian Lorenz curves takes negative (or null) values at each percentile. This difference is significant at 1% for all percentiles except the 80^{th} percentile. Additionally, the lower bound of the 95% confidence interval takes negative values at each percentile (See Appendix). This suggests that the distribution of Kenya Lorenz dominates that of Ghana.

Similarly, in 2014, Figure 5.3 shows the difference between the Kenyan and Ghanaian Lorenz curves take negative (or null) values for all percentiles and are significant at 1%. The lower bound 95% confidence interval is negative throughout, thus indicating that the distribution of Kenya Lorenz dominates that of Ghana (See Appendix). From these results, I infer that while absolute inequality is higher in Kenya, relative inequality is higher in Ghana.

Table 5.4: Test for Equality of Generalised Gini Indices, Ghana-Kenya, 2008 and 2014

Year	*Generalised Gini Index*		*Difference in Index*	*z-statistic*
	Kenya	*Ghana*		
2008	0.739	0.689	0.050	6.66***
2014	0.637	0.574	0.063	11.12***

***, $p < 0.001$

Figure 5.2: Difference in GL Curves, Ghana-Kenya, 2008 and 2014

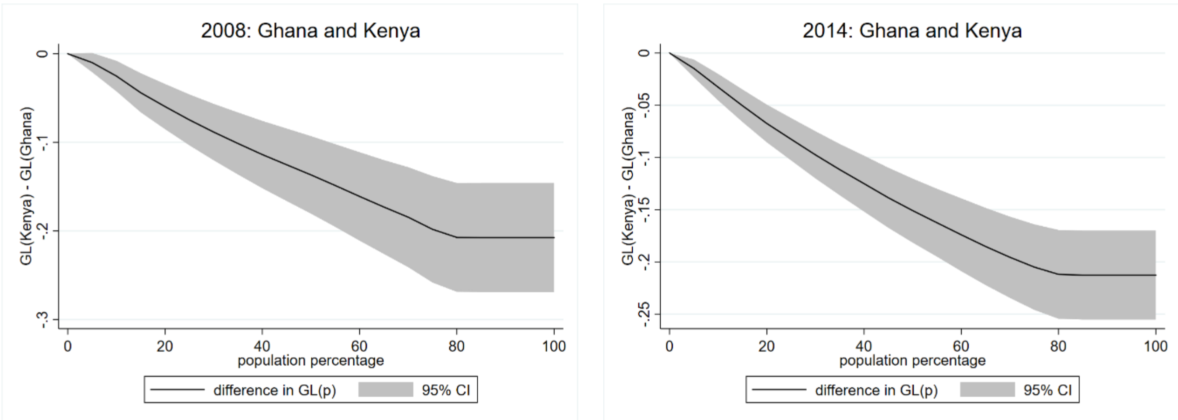
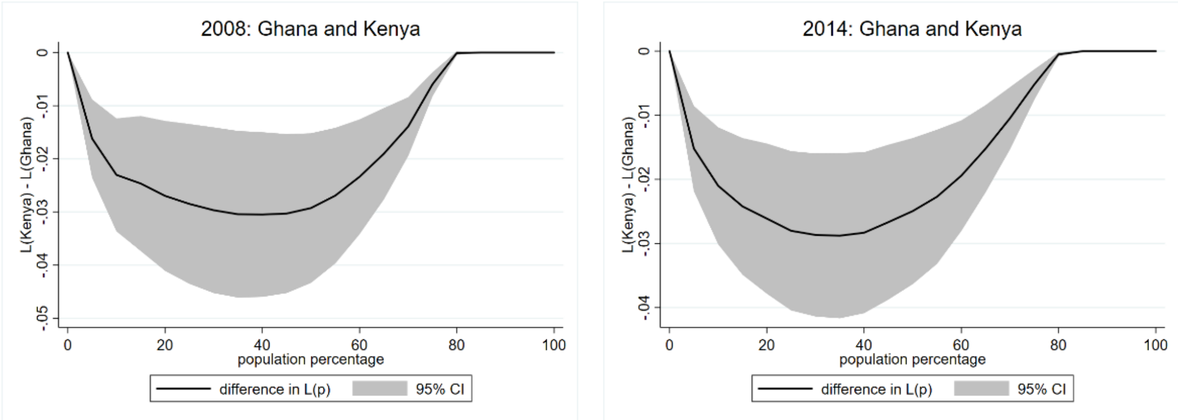


Table 5.5: Test for Equality of Gini Indices, Ghana-Kenya, 2008 and 2014

Year	*Gini Index*		*Difference in Index*	*z-statistic*
	Kenya	*Ghana*		
2008	-0.473	-0.513	0.040	6.65***
2014	-0.470	-0.503	0.033	6.79***

***, $p < 0.001$

Figure 5.3: Difference in Lorenz Curves, Ghana-Kenya, 2008 and 2014



The results in this section contribute to a clearer understanding of the nutritional status when comparing across countries. Contrary to the hypothesized association, mean height deficit and proportion of stunting are higher in the same country— Kenya for both years. A robust comparison using full distributions confirms that undernutrition is indeed higher Kenya for both years. Two-thirds of the total 144 million stunted children are from Africa (World Health Statistics 2020). This includes Ghana and Kenya. While Kenya requires more attention than Ghana to improve child nutritional status, there is a need to make SMART[1] goals to end malnutrition in all its forms by 2030 in both countries ("2020 Global Nutrition Report", 2020).

Nevertheless, the results in this section show that focusing on one indicator, such as mean height deficit or proportion of stunting, is not sufficient. It does not inform the stakeholders of nutrition on how wide the gap is between the shortest and the tallest child. Results in this section highlight that there is higher absolute inequality in Kenya for both years. This contradicts the hypothesis that mean height deficit and proportion of stunting might be higher in one country but inequality might be higher in another. However, in line with this hypothesis, relative inequality is higher in Ghana for both years. These results should be taken into account by the stakeholders when making decisions on which country and which section of the population resources should be targeted towards. While making such decisions, it must be kept in mind how nutritional status differs based on the measure of inequality chosen.

[1] SMART, Specific, Measurable, Achievable, Relevant and Time-bound goals.

5.2 Comparison of 2008 and 2014, Separately for both Ghana and Kenya

5.2.1 Summary Measures based on Mean Nutritional status

Table 5.6 highlights that the mean HAZ of 2014 is higher, i.e., undernutrition is lower than in 2008 for both Ghana and Kenya. A two-sample test for equal means indicates that the differences in 2014 mean and 2008 mean are significant at 1% for both Ghana and Kenya.

5.2.2 Summary Measures based on Stunting

Table 5.7 shows that the proportion of stunting in 2014 is lower than in 2008 for Kenya and Ghana at 1% significance. Overall, summary measures based on mean HAZ indicate that 2014 has a lower prevalence of undernutrition and stunting than 2008, for Ghana and Kenya.

5.2.3 Stochastic Dominance

Figure 5.4 shows that the distribution of 2008 crosses that of 2014 for both Ghana and Kenya. Table 5.8 highlights that in the 1st stage, the Bennett test fails to reject the null hypothesis that both CDF_{2008} and CDF_{2014} are equal. In the 2nd stage, the test rejects the null hypothesis that CDF_{2008} is greater than, less than, or equal to CDF_{2014} for both Ghana and Kenya. From the above analysis, I conclude that FOSD is not found for these distributions.

I proceed with the test for SOSD. Figure 5.5 shows that the difference between the GL curves of 2014 and 2008 is positive at each percentile. The lower-bound of the 95% confidence intervals takes negative values for all percentiles, for both Ghana and Kenya (See Appendix). This implies that $CDF_{2014} >_{SOSD} CDF_{2008}$ and CDF_{2014} is preferable to CDF_{2008} in terms of welfare under weak conditions as defined in Chapter 3 (Lambert, 1992).

While the mean HAZ and prevalence of stunting show an improvement in nutritional status in both Ghana and Kenya, a robust comparison of full distributions of nutritional status indicates that there is no improvement throughout the distribution. SOSD, but not FOSD, is found because the distributions cross at the top for both countries. SOSD puts more weightage at the bottom, i.e., at the shorter members of the society (Davidson, 2006). At the bottom, 2014 distribution has lower undernutrition. As a result, absolute inequality falls over time. When accounting for inequality aversion, which SOSD does, 2014 distribution is preferred in both countries (Wagstaff 2002a). This result demonstrates the value added to the existing literature on nutrition studies.

Table 5.6: Two-Sample t-test for Equal Means of HAZ, Ghana and Kenya, 2008-2014

Country	*Mean*		*Difference in Mean*	*t-statistic*
	2008	*2014*		
Ghana	-1.344	-1.142	-0.202	-6.24***
Kenya	-1.551	-1.354	-0.197	-9.77***

***, p < 0.001

Table 5.7: Two-Sample t-test for Equal Proportions of Stunting, Ghana and Kenya, 2008-2014

Country	*Proportion stunted*		*Difference*	*z-statistic*
	2008	*2014*		
Ghana	0.280	0.194	0.086	7.28***
Kenya	0.345	0.273	0.072	10.16***

***, p < 0.001

Figure 5.4: Cumulative Distribution Function Plots, Ghana and Kenya, 2008-2014

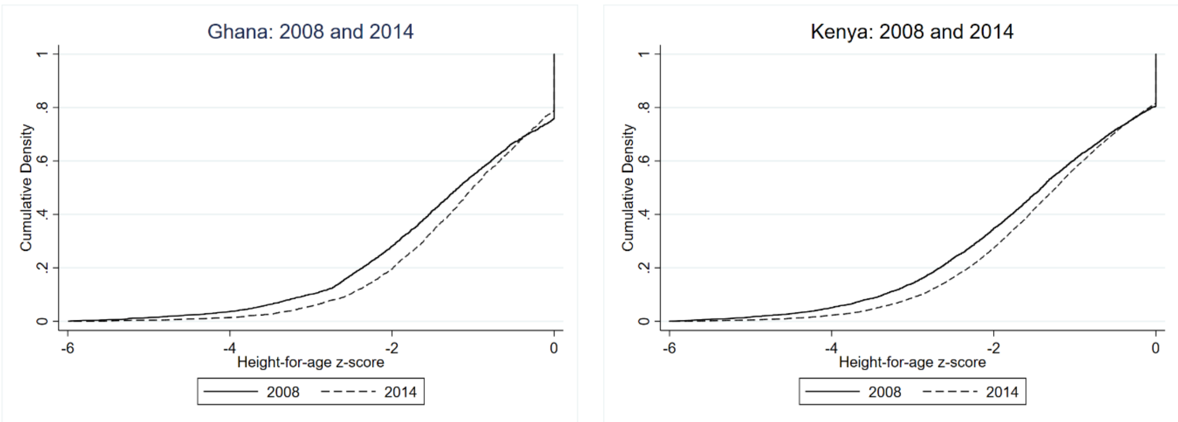
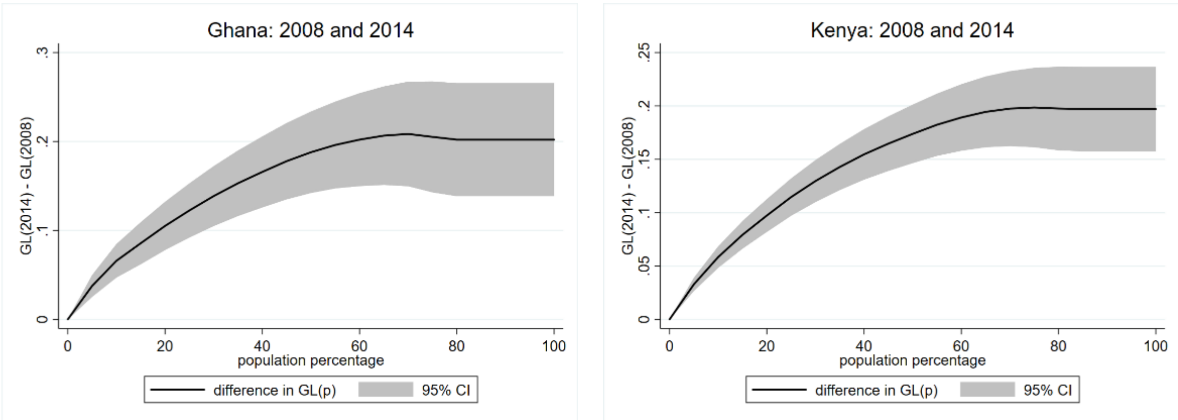


Table 5.8: Bennett Bi-directional Test of FOSD, Ghana and Kenya, 2008-2014

Country	*Group variable**	*Group 1*	*Group 2*	*Significance level*		*Outcome*
				1st stage	*2nd stage*	
Ghana	Year	2008	2014	1%	10%	Distributions cross
Kenya	Year	2008	2014	1%	10%	Distributions cross

*Group variable: comparison between type of variable

Figure 5.5: Difference in GL Curves, Ghana and Kenya, 2008-2014



5.2.4 Summary Measures based on Inequality

5.2.4.1 Absolute Inequality

Table 5.9 highlights that absolute inequality, measured using generalised Gini index is higher in 2008 than 2014 at 1%, for both Ghana and Kenya. As indicated in Section 5.2.3, the difference between GL curves of 2014 and 2008 shows that the distribution of 2014 GL dominates that of 2008 for both Ghana and Kenya.

5.2.4.2 Relative Inequality

Table 5.10 shows that relative inequality, measured using Gini index is higher in 2008 than 2014, for both Ghana and Kenya. However, only the difference in the Gini index for Kenya is significant. As explained earlier in the previous section, the Gini index takes negative values between -1 and 0 because I am looking at HAZ < 0 only. The absolute value of the index indicates the degree of inequality.

Figure 5.6 shows that in Ghana, the difference between the 2014 and 2008 Lorenz curves take negative (or null) values at each percentile. The differences at each percentile are insignificant except the 65^{th} – 75^{th} percentiles. At these significant percentiles, the lower bound of the 95% confidence interval takes negative values (See Appendix). Since the difference between Lorenz curves is not significant at all percentiles, the distribution of 2014 does not Lorenz dominate that of 2008 in Ghana. From these results, I infer that while absolute inequality is higher in 2008 Ghana, the null hypothesis that 2008 Ghana is relatively unequal to 2014 Ghana cannot be rejected.

Similarly, in Kenya, Figure 5.6 shows the difference between the 2014 and 2008 Lorenz curves takes negative (or null) values at each percentile. The differences at each percentile are insignificant for all percentiles except the 80^{th} percentile (See Appendix). Since the difference between Lorenz curves is not significant at all percentiles, CDF_{2014} does not Lorenz dominate CDF_{2008}, in Kenya. From these results, I infer that while absolute inequality is higher in 2008 Kenya, the hypothesis that 2008 Kenya is relatively unequal to 2014 Kenya cannot be rejected.

Note that in the case of Kenya, the difference between Lorenz curves shows that the distribution of 2014 does not Lorenz dominate that of 2008. However, there is a significant difference between 2014 and 2008's Gini index. This can happen for two reasons. First, while the difference in the Gini index is significant, it is not a substantial difference. Second, the difference in Lorenz curves shows that there is no Lorenz dominance. But the Gini index suggests a fall in inequality. Dominance tests are more demanding. If the differences in Lorenz curves at all percentiles are not significant, then dominance cannot be inferred. However, the significant decrease in inequality over time measured by the Gini index will be missed if only the dominance test was considered.

Table 5.9: Test for Equality of Generalised Gini Indices, Ghana-Kenya, 2008 and 2014

Year	*Generalised Gini Index*		*Difference in Index*	*z-statistic*
	2014	*2008*		
Ghana	0.574	0.689	-0.115	-13.74***
Kenya	0.637	0.739	-0.102	-23.86***

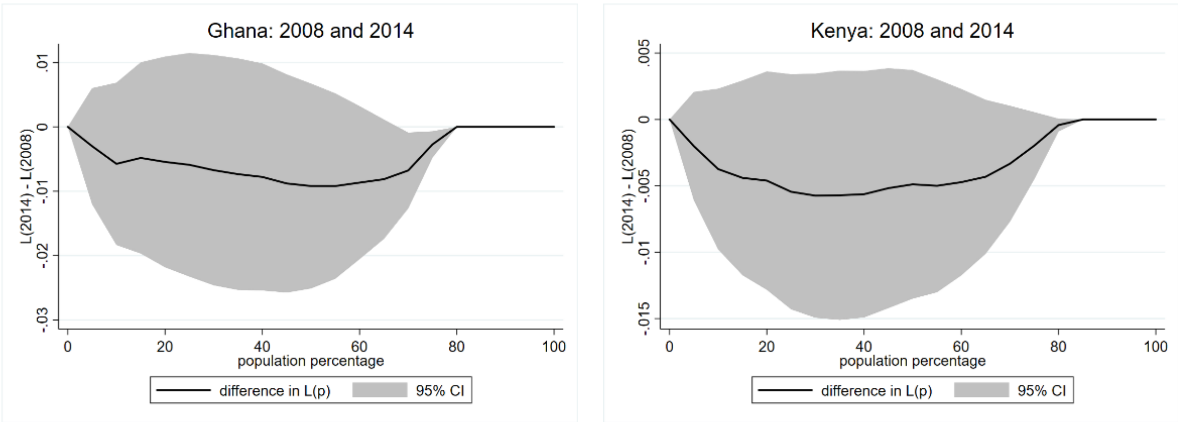
***, $p < 0.001$

Table 5.10: Test for Equality of Gini Indices, Ghana-Kenya, 2008 and 2014

Year	*Gini Index*		*Difference in Index*	*z-statistic*
	2014	*2008*		
Ghana	-0.503	-0.513	0.010	1.48
Kenya	-0.470	-0.473	0.003	2.33**

**, p < 0.05

Figure 5.6: Difference in Lorenz Curves, Ghana and Kenya, 2008-2014



The results in this section contribute to a clearer understanding of the nutritional status when analysing comparisons within countries. Mean height deficit and proportion of stunting are higher in 2008. However, a robust comparison of the full distributions of nutritional status indicates that mean height deficit and the proportion of stunting do not accurately reflect the nutritional status for both countries. Confirming the hypothesis of this thesis, these results provide new insight into the field of nutrition research.

Inequality assessment shows that absolute inequality is lower for 2014 in both countries. Contradictory to the hypothesis that the mean height deficit and the proportion of stunting might be higher in one year but inequality is lower for another year. However, relative inequality is not significantly different over time for Ghana. In Kenya, the Gini index shows that 2014 has significantly lower relative inequality than 2008. But, the difference in Lorenz curves shows that there is no Lorenz dominance.

These results fit with the policies adopted by Ghana and Kenya to create and promote awareness to adopt healthy lifestyles for children and their mothers (Ghartey, 2010; "Policy - National Plan of Action", n.d.). Among other policies, these countries aimed to create awareness and promote exclusive breastfeeding practices, increase micro-nutrient intake, increase and diversify food intake (ibid). The adoption of these policies may have contributed to the decrease in the mean levels of undernutrition over time each of these countries. However, these policies have not succeeded in improving the nutrition levels across all groups of individuals, possibly due to problems of government coordination, funding and sustainability (Ghartey, 2010).

5.3 Comparison of SES Related Inequality

5.3.1 Comparison of Ghana and Kenya, Separately for 2008 and 2014

5.3.1.1 SES Related Absolute Inequality

Table 5.11 observes a positive generalised concentration index. This indicates that the height deficits are disproportionately concentrated on the poor. SES related absolute inequality, measured using generalised concentration index is higher in Kenya than Ghana in 2008, but has the same coefficient as Ghana in 2014. However, differences in these coefficients are insignificant.

Figure 5.7 shows that in 2008 and 2014, the difference between the Kenyan and Ghanaian generalised concentration curves takes negative (or null) values at each percentile. This difference is significant at 1% for all percentiles except the 5^{th} and 10^{th} percentile. Additionally, the lower bound of the 95% confidence interval takes negative values at each percentile (See Appendix). Since all ordinates at all percentiles are not significant, when ranked by wealth, the null hypothesis of non-dominance for absolute inequality cannot be rejected, for 2008 and 2014.

5.3.1.2 SES Related Relative Inequality

Table 5.12 observes a negative concentration index indicates that negative values of HAZ are more concentrated among the poor. SES related relative inequality, measured using concentration index is approximately the same for Ghana and Kenya in 2008, but higher in Ghana 2014. However, these coefficients are insignificant.

Figure 5.8 shows that in 2008, the difference between the Kenyan and Ghanaian concentration curves takes negative (or null) values at each percentile. This difference is insignificant for all percentiles (See Appendix). Since all ordinates at all percentiles are not significant, when ranked by wealth, the null hypothesis of non-dominance of relative inequality cannot be rejected.

Similarly, in 2014, Figure 5.8 shows the difference between the Kenyan and Ghanaian concentration curves takes negative (or null) values at each percentile. This difference is insignificant for all percentiles except the 5th and 10th percentiles (See Appendix). Since all ordinates at all percentiles are not significant, when ranked by wealth, the null hypothesis of non-dominance cannot be rejected. From these results, I infer that when ranked by wealth, the null hypothesis of non-dominance for absolute and relative inequality cannot be rejected in 2008 and 2014.

Table 5.11: Test for Equality of Generalised Concentration Indices, Ghana-Kenya, 2008 and 2014

Year	*Generalised Concentration Index*		*Difference in Index*	*z-statistic*
	Kenya	*Ghana*		
2008	0.116	0.099	0.017	0.89
2014	0.122	0.122	0.000	0.00

Figure 5.7: Difference in Generalised Concentration Curves, Ghana-Kenya, 2008 and 2014

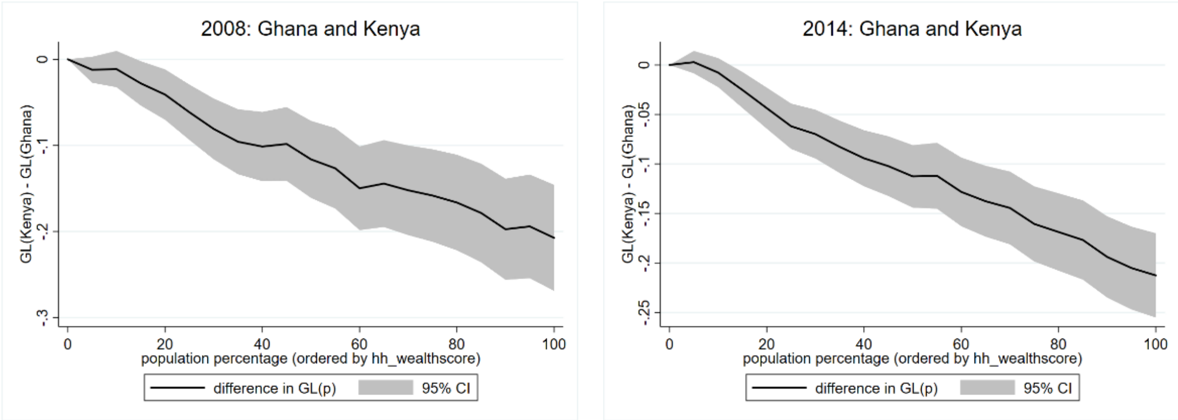
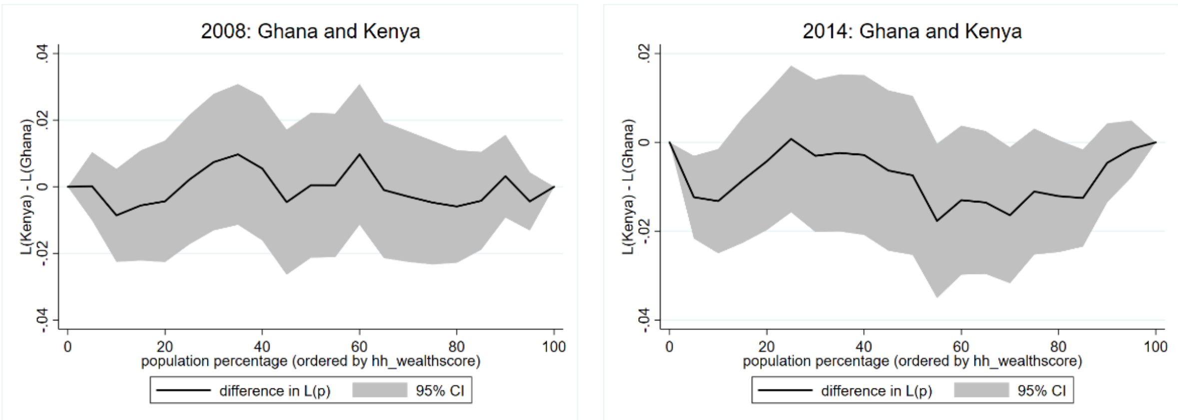


Table 5.12: Test for Equality of Concentration Indices, Ghana-Kenya, 2008 and 2014

Year	*Concentration Index*		*Difference in Index*	*z-statistic*
	Kenya	*Ghana*		
2008	-0.075	-0.074	-0.001	-0.040
2014	-0.090	-0.107	0.017	1.610

Figure 5.8: Difference in Concentration Curves, Ghana-Kenya, 2008 and 2014



The results in this subsection indicate that SES related absolute and relative inequalities in Ghana and Kenya are not significantly different from one another in both years. But the negative sign of the concentration index shows that the burden of undernutrition is higher among the poor. This contradicts the hypothesis that the mean height deficit and the proportion of stunting might be higher in one country but inequality might be higher in another. A practical implication that follows from this result is that funding from donors needs to go to both countries since SES related inequalities in both are not significantly different from one another.

5.3.2 Comparison in 2008 and 2014, Separately for Ghana and Kenya

5.3.2.1 SES Related Absolute Inequality

Table 5.13 observes a positive generalised concentration index. This indicates that the height deficits are disproportionately concentrated on the poor. SES related absolute inequality, measured using concentration index is higher in 2014 than 2008 for both Ghana and Kenya. However, these coefficients are insignificant.

Figure 5.9 shows that in Ghana, the difference between the 2014 and 2008 generalised concentration curves takes positive (or null) values at each percentile. This difference is significant for all percentiles except the 5^{th} percentile (See Appendix). The lower bounds of the 95% confidence intervals are positive except for the 5^{th} percentile. Since all ordinates at all percentiles are not significant, when ranked by wealth, the null hypothesis of non-dominance of absolute inequality cannot be rejected.

Similarly, in Kenya, Figure 5.9 shows that the difference between the 2014 and 2008 generalised concentration curves takes positive (or null) values at each percentile. This difference is significant for all percentiles (See Appendix). The lower bounds of the 95% confidence intervals are positive. Since all ordinates at all percentiles are significant, when ranked by wealth, 2014 dominates 2008 in Kenya. This discrepancy in the results of the generalised concentration index and the difference between the generalised concentration curves maybe because the index is constructed using robust standard errors, but robust standard errors are not used in the difference between the curves.

5.3.2.2 SES Related Relative Inequality

Table 5.14 observes a negative concentration index indicates that values of HAZ are more concentrated among the poor. SES related relative inequality, measured using concentration index is higher in 2014 than 2008, for both Ghana and Kenya. While the difference between 2014 and 2008 concentration indices are significant at 5% in Ghana, this difference is significant at 10% for Kenya.

Figure 5.10 shows that in Ghana, the difference between the 2014 and 2008 concentration curves takes a negative value at the 15th percentile, and positive otherwise. This difference in concentration curves is insignificant up to the 50th percentile and at the 95th percentile. From the 55th to the 90th percentiles, the difference is significant with a positive lower bound 95% confidence interval. (See Appendix). This suggests that when ranked by wealth, the null hypothesis of non-dominance for relative inequality cannot be rejected in Ghana.

Similarly, in Kenya, Figure 5.10 shows that the difference between the 2014 and 2008 concentration curves takes negative (or null) values till the 15th percentile and positive values from the 20th to the 100th percentile. This difference in concentration curves is insignificant up to the 45th percentile. At the 50th percentile, the difference is significant with a negative lower bound 95% confidence interval. From the 55th percentile to the 85th percentiles, the difference is significant with a positive lower bound 95% confidence interval. At the 90th percentile, the difference is significant with a negative lower bound 95% confidence interval. Again, at the 95% percentile, the lower bound of the 95% turns positive. This indicates that the concentration curves cross when ranked by wealth.

The inference drawn from the differences between concentration indices is different from those of the differences between the concentration curves for both Ghana and Kenya. For both countries, the concentration index shows that relative inequality has increased over time. But for both countries, the difference between concentration curves shows that 2014 curve does not dominate the 2008 curve. This is due to the strict rule of the dominance test to have significant differences at all percentiles. But if only the dominance test measure was used, the significant increase in relative inequality based on the concentration index will be missed out.

Table 5.13: Test for Equality of Generalised Concentration Indices, Ghana-Kenya, 2008 and 2014

Year	*Generalised Concentration Index*		*Difference in Index*	*z-statistic*
	2014	*2008*		
Ghana	0.122	0.099	0.023	1.21
Kenya	0.122	0.116	0.006	0.51

Figure 5.9: Difference in Generalised Concentration Curves, Ghana and Kenya, 2008-2014

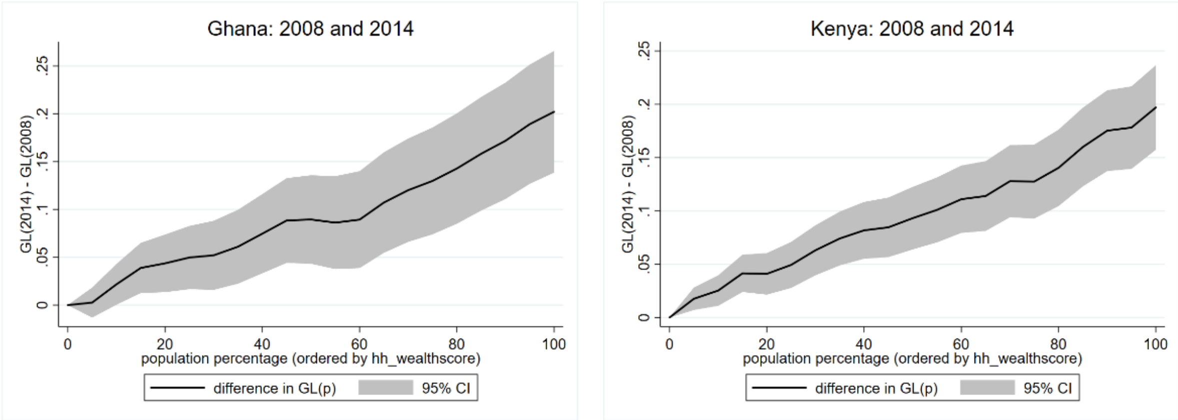
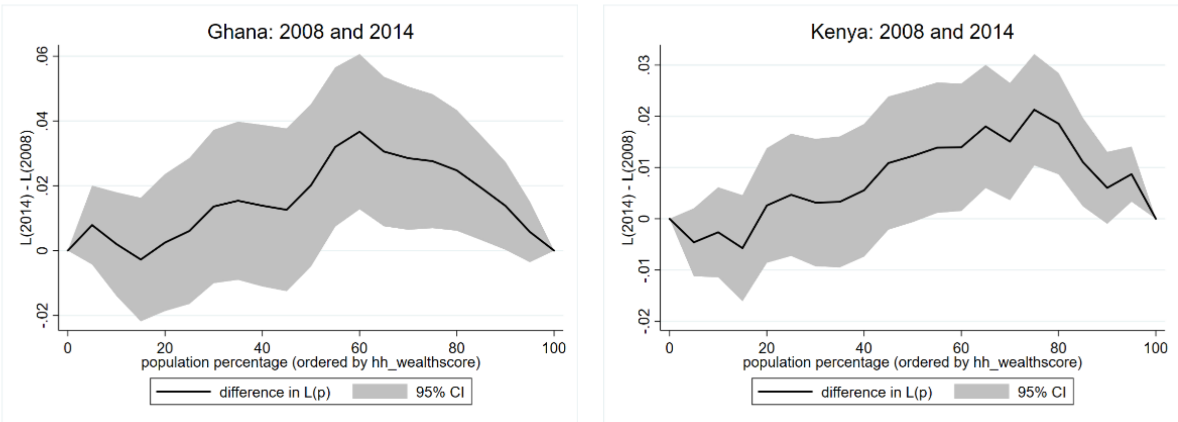


Table 5.14: Test for Equality of Concentration Indices, Ghana-Kenya, 2008 and 2014

Year	*Concentration Index*		*Difference in Index*	*z-statistic*
	2014	*2008*		
Ghana	-0.107	-0.074	-0.033	-2.23**
Kenya	-0.090	-0.075	-0.015	-1.95*

**, p < 0.05; *, p < 0.10

Figure 5.10: Difference in Concentration Curves, Ghana and Kenya, 2008-2014



The results for Kenya in this section confirm the hypothesis that the mean height deficit and the proportion of stunting are higher in 2008, but SES related absolute inequality, measured using the difference between generalised concentration curves, is higher in 2014. But the hypothesis is contradicted when SES related absolute inequality is measured using the difference between the generalised concentration index. The results for Ghana in this section contradict this hypothesis since the results of SES related absolute inequality are inconclusive. Analysis of SES related relative inequality for both Ghana and Kenya show that 2014 has significantly higher SES related relative inequality than 2008. However, dominance tests denote inconclusive evidence.

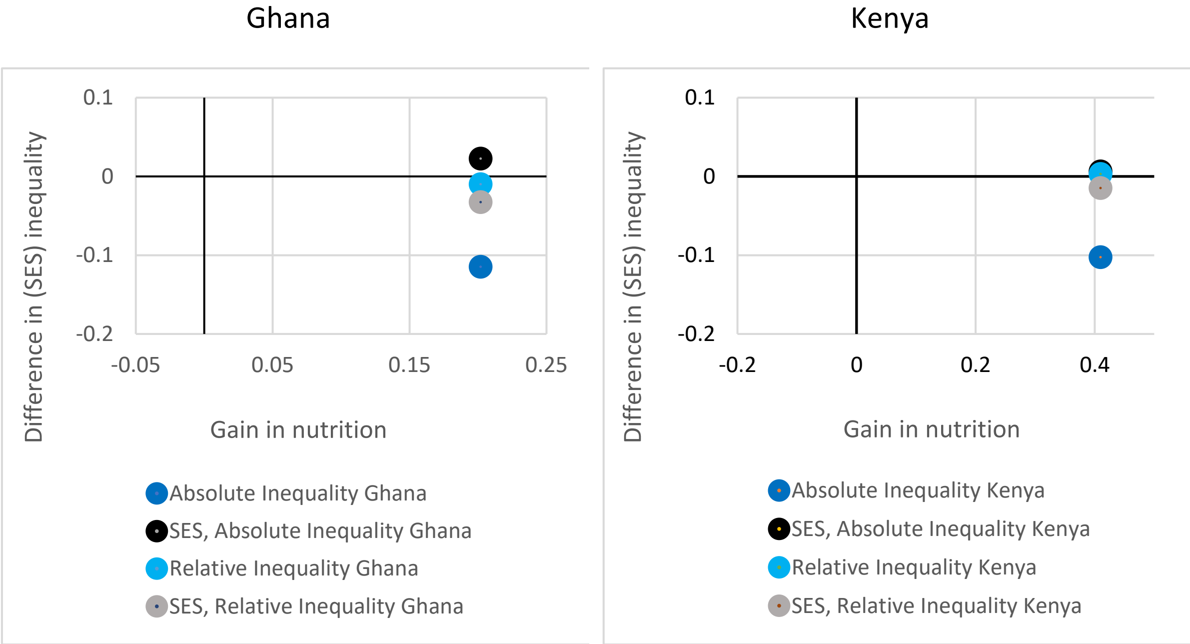
Increasing SES related inequality that is increasing or at the same level with decreasing malnutritional status indicates the need for Ghana and Kenya focus on reducing SES related inequality. Currently their policies for nutrition aim to reduce undernutrition and promote healthy lifestyles (Ghartey, 2010; "Policy - National Plan of Action", n.d.). However, the lack of improvement might suggest that either these policies are not translating into health improvements due to problems of government coordination, funding and sustainability, or there these policies are not targeting the most vulnerable populations (Ghartey, 2010).

5.4 Relationship between Inequality and Mean Nutritional Status

As a final remark on the results, the following scatter plots emphasize the need for robust assessments of distributions of child nutritional status. In Figure 5.11, an increase in mean nutritional level over time is associated with a decrease in inequalities except for SES related absolute inequality in Ghana. For Kenya, increase in mean nutritional level over time is associated with a decrease in absolute inequality and SES related relative inequality, and an increase in relative inequality and SES related absolute inequality.

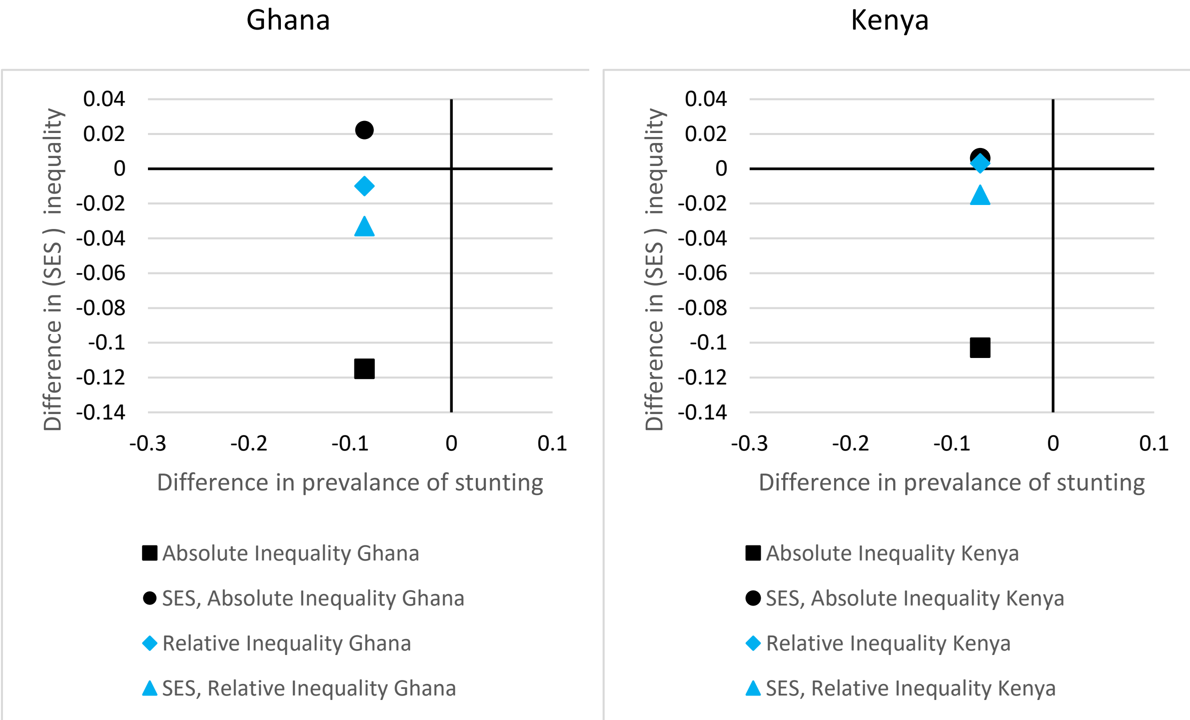
In Figure 5.12, a decrease in proportion of stunting over time is associated with a decrease in inequalities except for SES related absolute inequality in Ghana. For Kenya, a decrease in proportion of stunting over time is associated with a decrease in absolute inequality and SES related relative inequality, and an increase in relative inequality and SES related absolute inequality.

Figure 5.11: Relationship between gain in mean HAZ and change in inequality, Ghana and Kenya



Note: X-axis shows describes a reduction in negative HAZ, i.e., improvement in nutrition; y-axis the difference between inequality indices [(generalised) Gini index and (generalised) concentration index].

Figure 5.12: Relationship between gain in mean HAZ and change in inequality, Ghana and Kenya



Note: X-axis is a 0/1 variable where positive trend describes increase in stunting; y-axis the difference between inequality indices [(generalised) Gini index and (generalised) concentration index].

Figure 5.11 and 5.12 show that there is no obvious relationship between change in mean nutrition and inequality. Depending on the measure of inequality and mean nutritional status selected, the interpretation and decision regarding which country to focus resources on changes. These scatterplots clearly show that it assessing nutritional status solely based on summary measures based on mean and inequality is not ideal, thereby indicating the need for robust comparisons.

6 Conclusion

This thesis was an attempt to contribute to child nutrition research in Ghana and Kenya for both 2008 and 2014. Undernutrition is usually measured using mean height deficit (HAZ) compared to a well-nourished population, or rate of stunting. This thesis builds on the hypothesis that relying on undernutrition measures such as the above may prove contradictory. It may be that rate of stunting is higher in Country X but mean height deficit might be higher in Country Y. Or, the rate of stunting and mean height deficit is higher in Country X but inequality in undernutrition is higher in Country Y. Similar contradictions in nutritional status measures may arise in comparisons in countries over time. This makes it difficult to understand which country (X or Y) is performing better or whether a country is performing better over time.

The objective of this thesis is to make robust comparisons of full distributions of nutritional status between Ghana and Kenya for both 2008 and 2014, and between 2008 and 2014 within Ghana and Kenya. The analysis revolves around three research questions. First, is the child nutritional status better in Ghana or Kenya, in both 2008 and 2014? Second, is the child nutritional status better in 2008 or 2014, for both Ghana and Kenya? Third, what is the level of SES related inequality for both within-country and cross-country analysis?

A robust comparison across countries shows that while mean height deficit and proportion of stunting are higher in Kenya, relative inequality is higher in Ghana in both years. However, absolute inequality is higher in Kenya in both years. Robust assessments of prevalence of undernutrition and inequality confirm the same.

Similarly, a comparison within countries shows that the mean height deficit and proportion of stunting are improving over time. But this improvement is not robust to the full distribution. Whether inequality has increased or decreases depends on the measure of inequality chosen. Absolute inequality in both countries improves over time, but relative inequality for Ghana is inconclusive. Relative inequality in Kenya is improving over time when using Gini index. Differences in distributions of inequalities using dominance tests confirm the same except for relative inequality in Kenya. These conflicting results from the use of full distributions justify the value addition of this thesis. Thus, improvement in nutritional status over time may be contradictory depending on the measures chosen.

Subsequently, the analysis of SES related inequality indicates no significant differences across countries in absolute and relative terms. However, analysis of SES related absolute inequality within countries is higher in 2008 for Kenya only when using dominance tests. SES related absolute inequality is inconclusive over time for Ghana. Both Ghana and Kenya show that 2014 has significantly higher SES related relative inequality than 2008. However, dominance tests denote inconclusive evidence.

The main takeaway is that results based on summary measures of mean and inequality are not always consistent with results based on robust comparisons of distributions of child nutritional status. It shows that summary measures, such as the mean height deficit and the proportion of stunting are not sufficient indicators to track the improvement in trends of nutritional status. This emphasizes the importance of a robust assessment of trends in nutritional status since there is no all-encompassing measure of nutritional status.

This thesis acknowledges some limitations. First, there is a more than a three-fold increase in the number of observations in Kenya due to the re-constitution of the area from 8 provinces to 47 counties in 2010. Second, the dominance test used for making robust assessments reduces the power of detecting dominance when true. Another approach to dominance testing, known as the 'multiple comparison approach', can be taken. But even that method is not without its limitations (O'Donnell, van Doorslaer, Wagstaff, & Lindelow, 2008). As a final point, the calculation of the wealth index is sensitive to the assets included. However, it is widely used when reliable information on income and expenditure are not available (Van de Poel, Hosseinpoor, Jehu-Appiah, Vega, & Speybroeck, 2007).

The Global Nutrition Report emphasises the need to make SMART goals to end malnutrition in all its forms ("2020 Global Nutrition Report", 2020). The analysis of this thesis indicates that action taken to reduce malnutrition has succeeded in reducing the mean undernutrition levels but the inequalities continue to be a problem that requires attention. While Ghana and Kenya have specific policies to improve several determinants that affect nutritional status, such as age-appropriate breastfeeding and education, it appears that these policies are not translating into health improvements. This could be either due to the problems of government coordination and funding or these policies are not targeting the most vulnerable populations or regions.

This leads me to the first recommendation for future research. I recommend the extension of the robust comparisons of trends in inequality in nutritional status from a country-wide analysis to a region-specific analysis to identify the vulnerable regions and populations. Secondly, I recommend the use of Wagstaff (2002a)'s achievement index. This index is a single measure that captures average health and inequality between the poorest and richest with the possibility to have more weightage for the poor. This would be beneficial to identify and tackle societies where malnutrition is concentrated among the poor. Additionally, by conducting nutrition analysis that is specific to the individual or household characteristics, specific sections of the population can be targeted to alleviate the problem of malnutrition.

While Sub-Saharan Africa might not be as affected due to its young demographic structure, Mahler, Lakner, Aguilar & Wu (2020) predict that it will be the most affected in terms of extreme poverty, thus starting a vicious cycle of poverty, disease and malnutrition ("Sub-Saharan Africa's Demographic", 2020; "Global Database on Child Growth", n.d.). In such times, health is paramount.

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Appendix

(Generalised) Lorenz and Concentration Curve Dominance Estimates

Generalised Lorenz Curve Dominance Estimates

Table A1: Generalised Lorenz Curve Dominance Estimates, Ghana, 2008-2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	0.037611	0.006231	6.04	0.000	0.025397	0.049825
10	0.065913	0.009586	6.88	0.000	0.047121	0.084705
15	0.085653	0.012033	7.12	0.000	0.062062	0.109243
20	0.105092	0.013824	7.60	0.000	0.077991	0.132194
25	0.122497	0.015511	7.90	0.000	0.092089	0.152906
30	0.138664	0.017158	8.08	0.000	0.105027	0.172302
35	0.153095	0.018771	8.16	0.000	0.116297	0.189893
40	0.165830	0.020350	8.15	0.000	0.125935	0.205725
45	0.177917	0.021870	8.14	0.000	0.135043	0.220792
50	0.187932	0.023348	8.05	0.000	0.142161	0.233704
55	0.196103	0.024861	7.89	0.000	0.147364	0.244842
60	0.202119	0.026636	7.59	0.000	0.149900	0.254337
65	0.206606	0.028229	7.32	0.000	0.151265	0.261946
70	0.208499	0.029981	6.95	0.000	0.149725	0.267274
75	0.205191	0.031810	6.45	0.000	0.142830	0.267552
80	0.202105	0.032399	6.24	0.000	0.138588	0.265621
85	0.202105	0.032399	6.24	0.000	0.138588	0.265621
90	0.202105	0.032399	6.24	0.000	0.138588	0.265621
95	0.202105	0.032399	6.24	0.000	0.138588	0.265621
100	0.202105	0.032399	6.24	0.000	0.138588	0.265621

Note: HAZ = Ghana 2014 – Ghana 2008

Table A2: Generalised Lorenz Curve Dominance Estimates, Kenya, 2008-2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	(omitted)					
5	0.032856	0.003147	10.44	0.000	0.026688	0.039023
10	0.058385	0.005090	11.47	0.000	0.048408	0.068362
15	0.079232	0.006588	12.03	0.000	0.066319	0.092145
20	0.097309	0.007809	12.46	0.000	0.082002	0.112616
25	0.114619	0.008896	12.88	0.000	0.097183	0.132056
30	0.129616	0.010014	12.94	0.000	0.109989	0.149243
35	0.142804	0.010990	12.99	0.000	0.121263	0.164346
40	0.154622	0.012047	12.83	0.000	0.131009	0.178235
45	0.164696	0.013018	12.65	0.000	0.13918	0.190213
50	0.173826	0.013952	12.46	0.000	0.14648	0.201173

55	0.182395	0.014847	12.28	0.000	0.153294	0.211496
60	0.189187	0.015872	11.92	0.000	0.158078	0.220297
65	0.194459	0.016890	11.51	0.000	0.161353	0.227564
70	0.197488	0.017885	11.04	0.000	0.162433	0.232543
75	0.198503	0.018952	10.47	0.000	0.161357	0.23565
80	0.197580	0.019966	9.90	0.000	0.158447	0.236714
85	0.197027	0.020164	9.77	0.000	0.157504	0.236549
90	0.197027	0.020164	9.77	0.000	0.157504	0.236549
95	0.197027	0.020164	9.77	0.000	0.157504	0.236549
100	0.197027	0.020164	9.77	0.000	0.157504	0.236549

Note: HAZ = Kenya (2014) – Kenya (2008)

Table A3: Generalised Lorenz Curve Dominance Estimates, Ghana and Kenya, 2008

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	-0.009973	0.005503	-1.81	0.070	-0.020760	0.000814
10	-0.025207	0.008744	-2.88	0.004	-0.042348	-0.008067
15	-0.044031	0.011226	-3.92	0.000	-0.066038	-0.022025
20	-0.059648	0.012960	-4.60	0.000	-0.085052	-0.034244
25	-0.074642	0.014618	-5.11	0.000	-0.103297	-0.045988
30	-0.088419	0.016212	-5.45	0.000	-0.120199	-0.056639
35	-0.101321	0.017816	-5.69	0.000	-0.136245	-0.066397
40	-0.113815	0.019341	-5.88	0.000	-0.151730	-0.075901
45	-0.125318	0.020827	-6.02	0.000	-0.166145	-0.084492
50	-0.136733	0.022285	-6.14	0.000	-0.180417	-0.093049
55	-0.148748	0.023776	-6.26	0.000	-0.195354	-0.102141
60	-0.161063	0.025422	-6.34	0.000	-0.210897	-0.111229
65	-0.173030	0.026983	-6.41	0.000	-0.225924	-0.120136
70	-0.184488	0.028756	-6.42	0.000	-0.240857	-0.128119
75	-0.198189	0.030601	-6.48	0.000	-0.258175	-0.138203
80	-0.207339	0.031302	-6.62	0.000	-0.268698	-0.145979
85	-0.207458	0.031394	-6.61	0.000	-0.268999	-0.145917
90	-0.207458	0.031394	-6.61	0.000	-0.268999	-0.145917
95	-0.207458	0.031394	-6.61	0.000	-0.268999	-0.145917
100	-0.207458	0.031394	-6.61	0.000	-0.268999	-0.145917

Note: HAZ = Kenya (2008) – Ghana (2008)

Table A4: Generalised Lorenz Curve Dominance Estimates, Ghana and Kenya, 2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	-0.01473	0.00429	-3.43	0.001	-0.02314	-0.00631
10	-0.03273	0.00643	-5.09	0	-0.04534	-0.02013
15	-0.05045	0.00788	-6.4	0	-0.06591	-0.035
20	-0.06743	0.00917	-7.35	0	-0.08541	-0.04945
25	-0.08252	0.0103	-8.01	0	-0.1027	-0.06234

30	-0.09747	0.01148	-8.49	0	-0.11997	-0.07496
35	-0.11161	0.01248	-8.95	0	-0.13607	-0.08715
40	-0.12502	0.01361	-9.19	0	-0.15169	-0.09835
45	-0.13854	0.01463	-9.47	0	-0.16721	-0.10987
50	-0.15084	0.01559	-9.67	0	-0.1814	-0.12028
55	-0.16246	0.01653	-9.83	0	-0.19485	-0.13006
60	-0.17399	0.01775	-9.8	0	-0.20879	-0.1392
65	-0.18518	0.01882	-9.84	0	-0.22206	-0.1483
70	-0.1955	0.01979	-9.88	0	-0.23429	-0.1567
75	-0.20488	0.02085	-9.83	0	-0.24574	-0.16402
80	-0.21186	0.02164	-9.79	0	-0.25429	-0.16944
85	-0.21254	0.02169	-9.8	0	-0.25506	-0.17001
90	-0.21254	0.02169	-9.8	0	-0.25506	-0.17001
95	-0.21254	0.02169	-9.8	0	-0.25506	-0.17001
100	-0.21254	0.02169	-9.8	0	-0.25506	-0.17001

Note: HAZ = Kenya (2014) – Ghana (2014)

Lorenz Curve Dominance Estimates

Table A5: Lorenz Curve Dominance Estimates, Ghana, 2008-2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	-0.00301	0.00460	-0.65	0.514	-0.01203	0.006016
10	-0.00575	0.00643	-0.89	0.372	-0.01836	0.006864
15	-0.00483	0.00758	-0.64	0.524	-0.01969	0.010032
20	-0.00545	0.00835	-0.65	0.514	-0.02182	0.010919
25	-0.00590	0.00886	-0.67	0.505	-0.02327	0.011468
30	-0.00673	0.00913	-0.74	0.461	-0.02463	0.01116
35	-0.00735	0.00918	-0.8	0.423	-0.02534	0.010637
40	-0.00778	0.00900	-0.86	0.387	-0.02543	0.009861
45	-0.00880	0.00865	-1.02	0.309	-0.02576	0.008164
50	-0.00920	0.00812	-1.13	0.258	-0.02512	0.006725
55	-0.00920	0.00735	-1.25	0.211	-0.02361	0.005204
60	-0.00867	0.00606	-1.43	0.153	-0.02055	0.003216
65	-0.00814	0.00473	-1.72	0.085	-0.01741	0.001136
70	-0.00678	0.00300	-2.26	0.024	-0.01267	-0.00089
75	-0.00272	0.00104	-2.62	0.009	-0.00476	-0.00068
80	0	(omitted)				
85	0	(omitted)				
90	0	(omitted)				
95	0	(omitted)				
100	0	(omitted)				

Note: HAZ = Ghana (2014) - Ghana (2008)

Table A6: Lorenz Curve Dominance Estimates, Kenya, 2008-2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	-0.00201	0.002083	-0.97	0.334	-0.00609	0.002071
10	-0.00374	0.003089	-1.21	0.226	-0.00979	0.002316
15	-0.00440	0.003740	-1.18	0.239	-0.01173	0.002931
20	-0.00461	0.004197	-1.10	0.272	-0.01283	0.003619
25	-0.00545	0.004517	-1.21	0.228	-0.01430	0.003404
30	-0.00574	0.004690	-1.22	0.221	-0.01493	0.003451
35	-0.00571	0.004789	-1.19	0.233	-0.01510	0.003674
40	-0.00563	0.004734	-1.19	0.234	-0.01491	0.003648
45	-0.00518	0.004608	-1.12	0.261	-0.01421	0.003856
50	-0.00489	0.004392	-1.11	0.266	-0.01349	0.003721
55	-0.00500	0.004092	-1.22	0.222	-0.01302	0.003025
60	-0.00472	0.003580	-1.32	0.187	-0.01174	0.002293
65	-0.00432	0.002956	-1.46	0.144	-0.01011	0.001477
70	-0.00333	0.002225	-1.50	0.134	-0.00769	0.001028
75	-0.00197	0.001287	-1.53	0.125	-0.00450	0.000548
80	-0.00042	0.000243	-1.73	0.084	-0.00090	0.000056
85	0	(omitted)				
90	0	(omitted)				
95	0	(omitted)				
100	0	(omitted)				

Note: HAZ = Kenya (2014) - Kenya (2008)

Table A7: Lorenz Curve Dominance Estimates, Ghana and Kenya, 2008

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	-0.01619	0.00375	-4.32	0.000	-0.02354	-0.00884
10	-0.02302	0.005414	-4.25	0.000	-0.03363	-0.01241
15	-0.02464	0.006474	-3.81	0.000	-0.03734	-0.01195
20	-0.02697	0.007191	-3.75	0.000	-0.04106	-0.01287
25	-0.02848	0.007667	-3.71	0.000	-0.04351	-0.01345
30	-0.02967	0.00795	-3.73	0.000	-0.04525	-0.01408
35	-0.03043	0.007997	-3.81	0.000	-0.04611	-0.01475
40	-0.03048	0.007902	-3.86	0.000	-0.04597	-0.01499
45	-0.03030	0.007627	-3.97	0.000	-0.04525	-0.01535
50	-0.02926	0.007178	-4.08	0.000	-0.04333	-0.01519
55	-0.02692	0.006502	-4.14	0.000	-0.03967	-0.01417
60	-0.02337	0.005501	-4.25	0.000	-0.03415	-0.01258
65	-0.01902	0.004373	-4.35	0.000	-0.0276	-0.01045
70	-0.01392	0.002808	-4.96	0.000	-0.01942	-0.00841
75	-0.00596	0.001137	-5.24	0.000	-0.00819	-0.00373

80	-0.00008	0.000177	-0.43	0.665	-0.00042	0.00027
85	0	(omitted)				
90	0	(omitted)				
95	0	(omitted)				
100	0	(omitted)				

Note: HAZ = Kenya (2008) - Ghana (2008)

Table A8: Lorenz Curve Dominance Estimates, Ghana and Kenya, 2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	-0.01519	0.003384	-4.49	0.000	-0.02183	-0.00856
10	-0.02101	0.004650	-4.52	0.000	-0.03012	-0.01189
15	-0.02422	0.005433	-4.46	0.000	-0.03487	-0.01357
20	-0.02612	0.005970	-4.38	0.000	-0.03782	-0.01442
25	-0.02803	0.006334	-4.43	0.000	-0.04044	-0.01561
30	-0.02868	0.006488	-4.42	0.000	-0.04139	-0.01596
35	-0.02879	0.006572	-4.38	0.000	-0.04167	-0.01591
40	-0.02833	0.006400	-4.43	0.000	-0.04087	-0.01578
45	-0.02668	0.006157	-4.33	0.000	-0.03874	-0.01461
50	-0.02495	0.005807	-4.3	0.000	-0.03633	-0.01357
55	-0.02271	0.005334	-4.26	0.000	-0.03317	-0.01226
60	-0.01942	0.004392	-4.42	0.000	-0.02803	-0.01082
65	-0.01521	0.003462	-4.39	0.000	-0.02199	-0.00842
70	-0.01047	0.002468	-4.24	0.000	-0.01531	-0.00563
75	-0.00521	0.001202	-4.33	0.000	-0.00757	-0.00285
80	-0.00050	0.000166	-2.99	0.003	-0.00082	-0.00017
85	0	(omitted)				
90	0	(omitted)				
95	0	(omitted)				
100	0	(omitted)				

Note: HAZ = Kenya (2014) - Ghana (2014)

Generalised Concentration Curve Dominance Estimates

Table A9: Generalised Concentration Curve Dominance Estimates, Ghana, 2008-2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	0.002627	0.007954	0.33	0.741	-0.01297	0.01822
10	0.021699	0.010822	2.01	0.045	0.00048	0.04291
15	0.038836	0.013338	2.91	0.004	0.01269	0.06498
20	0.043650	0.015326	2.85	0.004	0.01361	0.07370
25	0.049743	0.016809	2.96	0.003	0.01679	0.08270
30	0.052045	0.018383	2.83	0.005	0.01601	0.08808

35	0.061053	0.019655	3.11	0.002	0.02252	0.09959
40	0.074668	0.021067	3.54	0.000	0.03337	0.11597
45	0.088438	0.022544	3.92	0.000	0.04424	0.13263
50	0.089501	0.023556	3.80	0.000	0.04332	0.13568
55	0.086200	0.024743	3.48	0.000	0.03769	0.13471
60	0.089345	0.025792	3.46	0.001	0.03878	0.13991
65	0.107221	0.026745	4.01	0.000	0.05479	0.15965
70	0.120137	0.027522	4.37	0.000	0.06618	0.17409
75	0.129827	0.028435	4.57	0.000	0.07408	0.18557
80	0.142761	0.029380	4.86	0.000	0.08516	0.20036
85	0.158196	0.030239	5.23	0.000	0.09891	0.21748
90	0.171752	0.030984	5.54	0.000	0.11101	0.23249
95	0.189154	0.031752	5.96	0.000	0.12691	0.25140
100	0.202105	0.032399	6.24	0.000	0.13859	0.26562

Note: HAZ = Ghana (2014) - Ghana (2008); ordering with respect to hh_wealthscore

Table A10: Generalised Concentration Curve Dominance Estimates, Kenya, 2008-2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	0.017584	0.005309	3.31	0.001	0.007177	0.027991
10	0.025268	0.007244	3.49	0.000	0.011069	0.039467
15	0.041450	0.008880	4.67	0.000	0.024046	0.058854
20	0.040960	0.009893	4.14	0.000	0.021568	0.060352
25	0.049326	0.010972	4.50	0.000	0.027821	0.070831
30	0.063068	0.011922	5.29	0.000	0.039701	0.086436
35	0.074108	0.012826	5.78	0.000	0.048969	0.099247
40	0.081774	0.013549	6.04	0.000	0.055218	0.108331
45	0.084601	0.014223	5.95	0.000	0.056722	0.112479
50	0.093197	0.014916	6.25	0.000	0.063961	0.122433
55	0.100955	0.015500	6.51	0.000	0.070573	0.131336
60	0.110981	0.016069	6.91	0.000	0.079484	0.142479
65	0.113968	0.016654	6.84	0.000	0.081325	0.146612
70	0.127889	0.017208	7.43	0.000	0.094161	0.161617
75	0.127543	0.017666	7.22	0.000	0.092916	0.162169
80	0.140429	0.018235	7.70	0.000	0.104687	0.176171
85	0.159984	0.018776	8.52	0.000	0.123182	0.196786
90	0.175275	0.019285	9.09	0.000	0.137476	0.213075
95	0.178183	0.019696	9.05	0.000	0.139579	0.216788
100	0.197027	0.020164	9.77	0.000	0.157504	0.236549

Note: HAZ = Kenya (2014) - Kenya (2008); ordering with respect to hh_wealthscore

Table A11: Generalised Concentration Curve Dominance Estimates, Ghana and Kenya, 2008

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	-0.01214	0.00765	-1.59	0.113	-0.02713	0.00286

10	-0.01132	0.01069	-1.06	0.290	-0.03227	0.00964
15	-0.02792	0.01310	-2.13	0.033	-0.05361	-0.00224
20	-0.04097	0.01489	-2.75	0.006	-0.07017	-0.01178
25	-0.06150	0.01635	-3.76	0.000	-0.09355	-0.02944
30	-0.08088	0.01797	-4.50	0.000	-0.11610	-0.04566
35	-0.09579	0.01922	-4.98	0.000	-0.13347	-0.05812
40	-0.10138	0.02049	-4.95	0.000	-0.14155	-0.06121
45	-0.09838	0.02180	-4.51	0.000	-0.14112	-0.05564
50	-0.11624	0.02279	-5.10	0.000	-0.16092	-0.07156
55	-0.12668	0.02379	-5.33	0.000	-0.17331	-0.08005
60	-0.14986	0.02474	-6.06	0.000	-0.19835	-0.10136
65	-0.14439	0.02570	-5.62	0.000	-0.19476	-0.09402
70	-0.15219	0.02652	-5.74	0.000	-0.20417	-0.10020
75	-0.15828	0.02735	-5.79	0.000	-0.21189	-0.10467
80	-0.16639	0.02828	-5.88	0.000	-0.22183	-0.11094
85	-0.17856	0.02918	-6.12	0.000	-0.23576	-0.12137
90	-0.19743	0.02992	-6.60	0.000	-0.25608	-0.13878
95	-0.19413	0.03069	-6.32	0.000	-0.25430	-0.13397
100	-0.20746	0.03139	-6.61	0.000	-0.26900	-0.14592

Note: HAZ = Kenya (2008) - Ghana (2008); ordering with respect to hh_wealthscore

Table A12: Generalised Concentration Curve Dominance Estimates, Ghana and Kenya, 2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	0.00282	0.00574	0.49	0.623	-0.00843	0.01407
10	-0.00775	0.00744	-1.04	0.297	-0.02232	0.00683
15	-0.02531	0.00923	-2.74	0.006	-0.04339	-0.00723
20	-0.04366	0.01053	-4.15	0.000	-0.06431	-0.02302
25	-0.06191	0.01164	-5.32	0.000	-0.08473	-0.03910
30	-0.06986	0.01254	-5.57	0.000	-0.09443	-0.04528
35	-0.08274	0.01347	-6.14	0.000	-0.10914	-0.05634
40	-0.09427	0.01440	-6.55	0.000	-0.12250	-0.06604
45	-0.10221	0.01533	-6.67	0.000	-0.13227	-0.07216
50	-0.11255	0.01606	-7.01	0.000	-0.14402	-0.08107
55	-0.11193	0.01693	-6.61	0.000	-0.14511	-0.07874
60	-0.12822	0.01765	-7.27	0.000	-0.16281	-0.09363
65	-0.13764	0.01823	-7.55	0.000	-0.17338	-0.10191
70	-0.14443	0.01871	-7.72	0.000	-0.18111	-0.10775
75	-0.16056	0.01930	-8.32	0.000	-0.19840	-0.12273
80	-0.16872	0.01989	-8.48	0.000	-0.20771	-0.12973
85	-0.17678	0.02038	-8.67	0.000	-0.21673	-0.13682
90	-0.19391	0.02090	-9.28	0.000	-0.23487	-0.15294
95	-0.20511	0.02131	-9.63	0.000	-0.24687	-0.16335
100	-0.21254	0.02169	-9.80	0.000	-0.25506	-0.17001

Note: HAZ = Kenya (2014) - Ghana (2014); ordering with respect to hh_wealthscore

Concentration Curve Dominance Estimates

Table A13: Concentration Curve Dominance Estimates, Ghana, 2008-2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	0.007883	0.006204	1.27	0.204	-0.00428	0.02004
10	0.002019	0.008150	0.25	0.804	-0.01396	0.01800
15	-0.002757	0.009722	-0.28	0.777	-0.02181	0.01630
20	0.002498	0.010779	0.23	0.817	-0.01863	0.02363
25	0.006060	0.011480	0.53	0.598	-0.01644	0.02856
30	0.013614	0.012062	1.13	0.259	-0.01003	0.03726
35	0.015399	0.012445	1.24	0.216	-0.00900	0.03980
40	0.013872	0.012716	1.09	0.275	-0.01106	0.03880
45	0.012597	0.012807	0.98	0.325	-0.01251	0.03770
50	0.020168	0.012769	1.58	0.114	-0.00486	0.04520
55	0.032004	0.012529	2.55	0.011	0.00744	0.05656
60	0.036718	0.012207	3.01	0.003	0.01279	0.06065
65	0.030586	0.011760	2.60	0.009	0.00753	0.05364
70	0.028532	0.011268	2.53	0.011	0.00644	0.05062
75	0.027615	0.010547	2.62	0.009	0.00694	0.04829
80	0.024758	0.009491	2.61	0.009	0.00615	0.04336
85	0.019381	0.008226	2.36	0.019	0.00325	0.03551
90	0.013824	0.006909	2.00	0.045	0.00028	0.02737
95	0.005791	0.004774	1.21	0.225	-0.00357	0.01515
100	0	(omitted)				

Note: HAZ = Ghana (2014) - Ghana (2008); ordering with respect to hh_wealthscore

Table A14: Concentration Curve Dominance Estimates, Kenya, 2008-2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	-0.00459	0.003386	-1.36	0.175	-0.01123	0.00204
10	-0.00263	0.004473	-0.59	0.557	-0.01140	0.00614
15	-0.00573	0.005271	-1.09	0.277	-0.01606	0.00460
20	0.00260	0.005700	0.46	0.649	-0.00858	0.01377
25	0.00468	0.006080	0.77	0.442	-0.00724	0.01660
30	0.00316	0.006339	0.50	0.618	-0.00926	0.01559
35	0.00330	0.006514	0.51	0.613	-0.00947	0.01607
40	0.00556	0.006596	0.84	0.399	-0.00737	0.01849
45	0.01087	0.006621	1.64	0.101	-0.00210	0.02385
50	0.01226	0.006579	1.86	0.062	-0.00064	0.02515
55	0.01388	0.006488	2.14	0.032	0.00116	0.02659
60	0.01396	0.006335	2.20	0.028	0.00155	0.02638

65	0.01803	0.006121	2.94	0.003	0.00603	0.03002
70	0.01507	0.005826	2.59	0.010	0.00365	0.02649
75	0.02128	0.005533	3.85	0.000	0.01044	0.03213
80	0.01856	0.005038	3.68	0.000	0.00869	0.02844
85	0.01106	0.004396	2.52	0.012	0.00244	0.01968
90	0.00604	0.003576	1.69	0.091	-0.00097	0.01305
95	0.00871	0.002736	3.18	0.001	0.00335	0.01407
100	0	(omitted)				

Note: HAZ = Kenya (2014) - Kenya (2008); ordering with respect to hh_wealthscore

Table A15: Concentration Curve Dominance Estimates, Ghana and Kenya, 2008

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	0.00013	0.00524	0.02	0.980	-0.01014	0.01040
10	-0.00859	0.00711	-1.21	0.227	-0.02253	0.00536
15	-0.00561	0.00842	-0.67	0.505	-0.02212	0.01090
20	-0.00436	0.00930	-0.47	0.639	-0.02258	0.01387
25	0.00215	0.00990	0.22	0.828	-0.01725	0.02155
30	0.00741	0.01045	0.71	0.478	-0.01307	0.02789
35	0.00972	0.01077	0.90	0.367	-0.01140	0.03083
40	0.00546	0.01100	0.50	0.620	-0.01610	0.02703
45	-0.00462	0.01110	-0.42	0.677	-0.02638	0.01714
50	0.00047	0.01109	0.04	0.966	-0.02127	0.02221
55	0.00044	0.01098	0.04	0.968	-0.02108	0.02196
60	0.00974	0.01077	0.90	0.366	-0.01137	0.03085
65	-0.00098	0.01042	-0.09	0.925	-0.02140	0.01944
70	-0.00295	0.01000	-0.29	0.768	-0.02255	0.01665
75	-0.00474	0.00946	-0.50	0.617	-0.02329	0.01381
80	-0.00591	0.00861	-0.69	0.492	-0.02279	0.01097
85	-0.00421	0.00748	-0.56	0.573	-0.01888	0.01045
90	0.00318	0.00633	0.50	0.616	-0.00923	0.01558
95	-0.00439	0.00444	-0.99	0.323	-0.01311	0.00432
100	0	(omitted)				

Note: HAZ = Kenya (2008) - Ghana (2008); ordering with respect to hh_wealthscore

Table A16: Concentration Curve Dominance Estimates, Ghana and Kenya, 2014

HAZ	Coef.	Std. Err.	t	P > t	[95% Conf. Interval]	
0	0	(omitted)				
5	-0.01235	0.004746	-2.60	0.009	-0.02165	-0.00305
10	-0.01323	0.005984	-2.21	0.027	-0.02496	-0.0015
15	-0.00859	0.007166	-1.20	0.231	-0.02264	0.005457
20	-0.00426	0.007890	-0.54	0.589	-0.01972	0.011205
25	0.00077	0.008415	0.09	0.927	-0.01573	0.017262
30	-0.00304	0.008746	-0.35	0.728	-0.02018	0.014104
35	-0.00238	0.009014	-0.26	0.791	-0.02005	0.015285

40	-0.00285	0.009175	-0.31	0.756	-0.02083	0.015137
45	-0.00634	0.009200	-0.69	0.490	-0.02438	0.011689
50	-0.00744	0.009129	-0.82	0.415	-0.02533	0.010452
55	-0.01769	0.008860	-2.00	0.046	-0.03505	-0.00032
60	-0.01302	0.008556	-1.52	0.128	-0.02979	0.003753
65	-0.01354	0.008201	-1.65	0.099	-0.02961	0.002536
70	-0.01641	0.007806	-2.10	0.036	-0.03171	-0.00111
75	-0.01107	0.007230	-1.53	0.126	-0.02524	0.003102
80	-0.01211	0.006427	-1.88	0.060	-0.02471	0.000488
85	-0.01253	0.005570	-2.25	0.024	-0.02345	-0.00162
90	-0.00461	0.004527	-1.02	0.308	-0.01348	0.004261
95	-0.00147	0.003243	-0.45	0.650	-0.00783	0.004883
100	0	(omitted)				

Note: HAZ = Kenya (2014) - Ghana (2014); ordering with respect to hh_wealthscore