INEQUALITY IN SUB-SAHARAN AFRICA: NEW DATA AND NEW INSIGHTS FROM ANTHROPOMETRIC ESTIMATES

Alexander Moradi and Joerg Baten

Department of Economics, University of Tuebingen, Germany

Postal adress: Mohlstrasse 36, D-72074 Tuebingen, Germany

Fax +49-7071-29-5119, Tel. +49-7071-29-78167

E-mail: joerg.baten@uni-tuebingen.de

VERSION 280205

Keywords: nutrition, health, anthropometry, income inequality, Sub-Saharan Africa

JEL: I12, I32, N33

This is the last working paper version before this study was submitted and accepted.

Please cite as Moradi, Alexander and Baten, Jörg. "Inequality in Sub-Saharan Africa 1950-80: New Estimates and New Results", *World Development* 33-8 (2005), pp. 1233-1265.

Acknowledgements: We thank Brian A'Hearn, J.W. Drukker, Aravinda Meera Guntupalli, Gerhard Kling, Marco Sunder, participants of the Economics and Human Biology Conference, and of the Groningen Height and Growth Conference for helpful comments on earlier versions. We are also grateful for access to the Demographic and Health Survey database, kindly provided by Macro International, and especially to Stephan Klasen for his idea to use the DHS height data by birth cohorts. Part of this research was doen when Baten was a visiting fellow at Yale University, hence are also thankful to the Leitner Programme at YCIAS and Frances Rosenbluth for the inspiring conversations about anthropometric inequality measures, and financial support.

INEQUALITY IN SUB-SAHARAN AFRICA: NEW DATA AND NEW INSIGHTS FROM ANTHROPOMETRIC ESTIMATES

Abstract

Reliable information on inequality within countries is highly scarce, especially for Less Developed Countries (LDCs). Using anthropometric measures, we extend the inequality database for Sub-Saharan Africa to no less than 28 nations over six five-year periods from 1950 to 1980, and to some 200 regions within those countries. In this process, we also test in depth the validity of objections against the derivation of inequality measures from height data. In a second step, we test the determinants of inequality within and between the 200 regions under study. Our set of explanatory variables includes protein supply, cash cropping, industrial structure, mineral resources, distance to the country's capital, urbanization, education, population density and ethnic fractionalization. We find that monoculture cash cropping increases inequality, whereas diversified cash cropping has the opposite effect.

Introduction

Reliable data on inequality within Sub-Saharan African countries (SSA) for the years 1950-80 is in short supply. As a consequence, the present state of inequality in the region, along with its historic development and the determinants of that process have remained unknown or at least highly speculative until this day. Anthropometric measures have the potential to increase our knowledge thereof significantly. The primary aim of this study is thus to develop new inequality estimates for SSA, both within and between the countries' regions, and to describe the characteristics and limitations of anthropometric techniques.

Average heights can be used as an indicator of net nutritional status. During childhood and adolescence, the quality and quantity of nutrition positively affects bodily growth, while diseases absorb nutrients and therefore stunt growth. Environmental conditions during the first three years of life, in particular, have a very strong influence on final adult stature (Baten, 2000a; 2000b). The velocity of growth is highest during this age - the growth of toddlers responding most sensitively to adverse environmental conditions. Consequently, stunted children often become shorter adults especially in developing countries, where deprivation is persistent and catch-up growth at a later age is negligible (Billewicz and McGregor 1982; Eveleth and Tanner, 1990). Between the early twens and late forties, heights do no longer change much. On the basis of these findings, this study uses height measurements of adult age groups to assess the nutritional and health conditions (and the inequality of their distribution) during the same adults' early years of life. Whether selective mortality patterns introduce a bias to our analysis will be discussed below. Since conditions during early childhood have an overwhelming effect on final adult height, we apply a birth cohort analysis in which the variables used refer to conditions after birth.

A comprehensive anthropometric literature on height determinants exists, but cannot be addressed in detail here (Steckel, 1995; Quiroga and Coll 2000; Steckel and Floud, 1997; Komlos and Baten, 1998). Newcomers to the employment of height techniques for measuring nutritional status are often concerned about genetic differences. Yet while genes are indeed important for individual stature, individuals' high and low genetic potentials cancel each other out when entire populations are considered. Moreover, there is much evidence that poor environmental conditions rather than genetics have prevented Africans from achieving heights similar to those of OECD populations. Habicht et al. (1974), for example, found large height differences between elites and poor people within developing countries (such as Nigeria), more so than between LDC elites and a U.S. reference population. The same conclusion was reached for Ghana (Fiawoo, 1979) and several ethnic groups in Ethiopia (Eksmyr, 1970). Graitcer and Gentry (1981) confirm this result for Egypt, Haiti and Togo. For our analysis, it is noteworthy that the latter's sample of privileged children even corresponds with the percentiles of the U.S. height distribution. Nevertheless, it would be incorrect to ascribe all height differentials of African peoples to environmental conditions. There may be exceptions like bushmen or pygmies, yet these account for only a small share of African populations. Although it is thus reasonably safe to assume that genetics are not an important determinant of inequality when entire populations are considered, we will still test at a later point whether ethnic diversity offers an explanation for inequality, a hypothesis which is somewhat in line with the genetics argument.

Which measures of inequality have been used for LDCs until now? Studies going back in time on the basis of consistent data have usually concentrated on wage inequality between industries, or used indicators composed of several aggregated coefficients such as the real wage divided by real GDP/c, rather than being based on the original income distribution. Wage inequality as an indicator is clearly problematic, however, since many inhabitants of LDCs are self-employed and therefore do not receive wages – like the numerous peasants of SSA. In addition, many people earn their income in the shadow economy or are unemployed, while the amount transferred from the wage recipient to the rest of the household is also far from constant. Lastly, wage data often confines analysis to the large cities, whereas inequality between a countrys' regions (both rural and urban) is in fact one of the major contributors to total inequality within countries.

Heights offer a good complement to conventional inequality indicators and constitute perhaps an even better indicator in some respect. In general, we would expect a certain level of income which enables people to buy food and medical resources to lead to a corresponding height level. Should the distribution of these inputs in an economy become more unequal, heights are therefore expected to also become more unequal. Yet while a correlation with income does exist, this correlation is only partial. Some important inputs are not traded on markets but are provided as public goods, such as public health measures or food supplements for schoolchildren. Public goods lead to modest deviations between purchasing power-based and height-based inequality measures. Moreover, income totally neglects transfers within households. This is a major argument in favour of height-based measures: heights are an outcome indicator, whereas real income represents an input to human utility. Deaton (2001) and Pradhan et al. (2003) have argued convincingly that measures of health inequality are important in their own right, not only in relation to income. Heights do capture important biological aspects of the standard of living (Komlos, 1985; Steckel, 1995), irrespective of the fact that some problems regarding the stature variable may exist.

Anthropometric methods are even more advantageous for studying developing countries. To date, the development of inequality within LDCs could not be sufficiently explored because reliable data were lacking. The well-known Deininger and Squire data set (1996), for example, provides only eight gini coefficients of income for SSA for the period before 1980, labeled as "acceptable".[1] Atkinson and Brandolini (2001) convincingly pointed to serious flaws in the income inequality data collected by Deininger and Squire, arising from insufficient consistency across countries and over time. In contrast, we would argue that height data rarely display significant inconsistencies. The household samples in our study, for example, were demographically representative at the time of the surveys used. Thus, it becomes clear that the analysis of stature can be based on a large population coverage. We do not claim that height is the only accurate measure of inequality, but argue that it generates new insights on inequality while serving as a useful countercheck for other indicators, thereby leading to more meaningful results overall.

Another aim of this study is the empirical application of our method, since only this can reveal the advantages and limitations of the new measure and the new estimates. We will undertake a cross-sectional study of inequality determinants, with the dependent variables being (a) *inter*regional inequality and (b) *intra*regional inequality for 200 SSA regions in the 1960s. The former measure describes how much better or worse a region performed in comparison with the national mean, while the latter indicates the degree of social inequality within a given region. Although it is not within the scope of this article to develop a comprehensive model of determinants, we will test the following set of hypotheses derived from the inequality literature using our own cross-sectional data set:

(1) One frequently discussed determinant of inequality is the choice of farming method (Maxwell and Fernando, 1989). When a region switches from subsistence farming to the market-oriented production of crops like peanuts or coffee, we would expect the average income to rise and nutrition to improve (otherwise, farmers would not switch). However, rising inequality would ensue if the already privileged (like big land owners, men, foreigners or regions with good infrastructure) gained most, with the rest lagging behind. Due to missing data, this hypothesis was never tested comprehensively in the previous literature.

(2) Empirical studies on inequality have hitherto focused on the Kuznets hypothesis (Anand and Kanbur, 1993; Milanovic, 1994; Jha, 1996). Kuznets (1955) imagined inequality to follow an inverse-U relationship during industrial development. Thus, when development takes off, some social groups acquire special skills leading to higher income, whereas other groups (unskilled or agricultural labourers) lag behind. During subsequent periods of development, the low-income groups either converge in skills and income, or their industries become unimportant. Since no

African country can be considered as rich, only the upward-sloping part of the Kuznets Inverse U can be expected as relevant for a sample of Sub Saharan African countries.

(3) Proximity to nutrient production (especially high-quality proteins) leads to increasing average height and lower height inequality (Baten, 1999; 2000a).

(4) Education raises the average height of regions (Loaiza, 1997). Additionally, primary schooling presumably reduces height inequality within a region.

(5) The 'curse of natural resources' reduces average regional welfare due to negative human capital effects and missing forward and backward linkages (rather than problematic impacts on exchange rates, as in the traditional formulation). Additionally, only a small part of the population benefits from natural resources so that rising inequality within regions ensues (Sachs and Warner, 1995).

(6) Similar phenomenona can be observed in regions with government-influenced, heavy industrial activities. Again, only a part of the regional population benefits. Moreover, there are typically x-inefficiencies, reducing incomes and average heights (Steel and Evans 1984). In contrast, regions with more "market-oriented", light industries are expected to have higher average heights and less inequality.

(7) Ethnicity has a strong influence on inequality in Africa, for two possible reasons: (a) ethnic fractionalization has given rise to a political economy of unequal subsidies and discrimination (Easterly and Levine, 1997; Milanovic, 2003), and (b) ethnic groups in Africa have different genetic height potentials.

(8) Peripheral regions within a country are poorer, since governments try to reduce inequality in regions near the capital to avoid political dissatisfaction (Lipton, 1977; Bates, 1981).

The eight hypotheses presented here will be tested below, in addition to some less important side hypotheses.

The structure of this paper is as follows: After describing the data source, we discuss which and how anthropometric measures contain information on inequality. In section 3 and 4, we test in depth the validity of some possible biases and analyse the correlation between income and height inequality. In section 5, we present maps of nutritional inequality. Finally, the hypotheses explained above will be tested in section 6.

1. Data

In the last two decades, a new and comprehensive source of anthropometric data for developing countries has become available: the Demographic and Health Surveys (DHS). Funded by the U.S. Agency for International Development and conducted by Macro International Inc. in association with local statistical offices, the DHS program collects data on population, nutrition and the health of women and children in developing countries. The DHS-surveys are based on comprehensive and representative samples of households and repeated approximately every five years to allow for comparisons over time (Macro Int, 2004).[2] In all surveys standardized household and women's questionnaires were used. The latter covered topics such as women's social background, fertility, contraception, access to medical care, nutrition and health of children, AIDS, etc. For determining the nutritional status, anthropometric data was collected from the beginning of the DHS-program. In the first phase (DHS-I: 1984–1989), however, only the height of children younger than three and five years, respectively, was measured. During the second phase (DHS-II: 1988-1993), DHS started to measure the body height and weight of mothers as well, which became the standard for all surveys of the third phase (DHS-III: 1992–1999). In the current phase, the anthropometric part of the surveys include all women between 15 and 49 years of age. Consequently, the DHS-surveys offer an excellent anthropometric database, reporting the heights of more than 150,000 women in 28 African countries.[3] On average, each survey includes 3900 observations per country, varying typically between 2,000 and 5,000 – a significant extension of the anthropometric data available on ASS (Eveleth and Tanner, 1990). Training and equipment for height measurements followed WHO guidelines (Loaiza, 1997). Conducted by DHS personnel or local experts, training included classroom instructions as well as field practice. A quality-control test was administered thereafter for ensuring proficiency and compliance with international standards. In some countries, a second quality-control test was conducted halfway through the survey. Using measuring boards with a headpiece, heights were recorded to the nearest millimeter. We excluded women below 20 years of age from our analysis because many of them had not yet reached their final height at the time of the survey. Furthermore, we defined outliers as measurements departing from the birth cohort mean by more than three standard deviations.

2. Methodology

Which anthropometric methods are used to measure inequality in nutritional status? Especially in the economic history literature, comparisons have frequently been made between the mean statures of different occupational or income groups (Soltow, 1992; Steckel; 1995; Quiroga und Coll, 2000). The extent to which the mean heights of certain groups differ from each other indicates the degree of inequality in nutritional status and health. However, for applying this method, it is crucial to choose comparable and non-arbitrary classifications of social or occupational status, which is often not feasible for LDCs. In the following, we discuss an anthropometric measure which describes inequality without requiring occupational classification (introduced by Baten 1999a; 2000a; see also Pradhan et al. 2003 on a similar approach). While the height distribution of a given population can be used as a measure of its average nutritional status, it can likewise serve for measuring nutritional inequality within the population. The effects of inequality on heights are best understood by comparing the likely outcomes of a hypothetical experiment, in which a gender-homogenous population is exposed to two alternative allocations of ressources A and B after birth:

(A) All individuals receive the same quantity and quality of resources μ_A (nutritional and health inputs). This case refers to a situation of perfect equality.

(B) Available resources are allocated unequally and independently of the genetic height potential of the individuals.

In the case of A, the height distribution should only reflect genetic factors. Moreover, we would expect the equal endowment with μ_A to lead to a corresponding average height (Figure 1). Despite perfect equality, we observe a *biological variance* of (normally distributed) heights in this case. Yet how does the height distribution respond to an increase in inequality (B)? The unequal allocation of nutritional and medical ressources allows some individuals to gain and grow taller, while others lose and suffer from decreasing nutritional status. In comparison with the situation of perfect equality, the individual heights of the rich (poor) strata shift therefore to the right (left). Thus, from a theoretical point of view, rising inequality should be expressed by the changes in position between A and B, although this effect is weakened by the fact that the genetic height potential of individuals in A is unknown. Another factor which comes into play here, however, is that since the allocation of resources is independent of the genetic height potential, the input-induced variance is to be added to the biological variance. Consequently, the standard deviation of the height distribution in B is higher. A bimodal height distribution would result only if the resource endowment differed extremely between groups. Since the biological variance continues to contribute a large share to the total variance, we would expect the height distribution in (B) to look roughly normally distributed, but with a much higher standard deviation than A.

In order to examine a typical case in point, we compare the height distributions of Uganda and Togo, their mean heights in the age group of 30-34 being almost equal (159.2 cm). Gini coefficients of income suggest a higher inequality in Uganda than in Togo.[4] In fact, there is a striking similarity between the distributions observed and the outcome we would have expected from our previous reasoning (Figure 2). Heights in Uganda are distributed less frequently around the mean of the distribution, but more frequently around the values of 150 cm as well as 168 cm. Extreme heights above 175 cm or below 140 cm are likewise rare in Uganda. Consequently, the standard deviation is remarkably higher for Uganda (6.35) than for Togo (5.77). However, the standard deviation is not a satisfactory measure of inequality, since anthropologists argue that the *biological v*ariance increases with average height (Schmitt and Harrison, 1988). The coefficient of variation (CV) takes this effect into account and is a consistent and robust estimate of inequality. For a country i and a five-year-age group t, the CV is defined as:

$$CV_{it} = \frac{\sigma_{it}}{\mu_{it}} \cdot 100$$

Thus, the standard deviation σ is expressed as a percentage of the mean μ. Baten (1999; 2000a) compared height differences between social groups using the CV for early 19th century Bavaria, since an ideal data set was available for this region and time period, with nearly the entire male population measured at a homogeneous age and the economic status of all parents recorded. The measures turned out to be highly correlated. Therefore, high CVs sufficiently reflect social and occupational differences without relying on (somewhat arbitrary) classifications.[5] The CV of a totally equal society is yet unknown and can only be empirically approximated. For decomposing world health inequality, Pradhan et al. (2003) tried to standardize height inequality by assuming that the height distributions in OECD countries reflect the genetic growth potential of individuals only. However, this would mean that no nutritional and health inequality exists in OECD countries, which seems highly implausible. In Germany during the 1990s, for example, height differences between social groups were as large as two centimeters (Boehm, 2003; Komlos and Kriwy, 2003). Even in egalitarian Scandinavia, some height inequality remains between regions (Sunder, 2003).

In the following two sections, we use the height CV as a measure of inequality within countries. Thereafter, we assume a disaggregated perspective and focus on countries' administrative units. Inequality *between* administrative regions is an important contributor to total *within-inequality* of African countries, but may be influenced by other factors than just inequality between social groups *within* a given region. Hence, we will differentiate intra- and interregional inequality, which we consider as two components of total inequality within countries:

$$I_{total} = F(I_{\text{inter}}, I_{\text{intra}})$$

where interregional inequality I_{inter} indicates the deviation of regional heights from the country mean, and intraregional inequality I_{intra} corresponds with the height CV of a region, thereby indicating differences between social groups within a given region.

3. Pitfalls in deriving inequality from anthropometric measurements

The theoretical reflections outlined in the methodologial section were based on an ideal data set. When working with real height data, attention should be paid to some potential pitfalls. First of all, we need to address measurement errors, which must be closely scrutinized. Mean height estimates remain unaffected by measurement errors, because high and low errors cancel each other out. Unfortunately, the same is not the case with the CV, since measurement errors get added into the sum of squares and thus appear as greater inequality to the analyst. What follows is that variation in CV can be partly due to variation in measurement error, which brings us to the question of where measurement error might be expected in our sample. Age misreporting (such as rounding to numbers ending with 0 or 5) cannot be a major problem, because all measurements were aggregarted into five- or ten-year birth cohorts. All women in a specific country were measured by educated personnel using standard instruments, so that sources of measurement error should be limited. Loaiza (1997) evaluates the measurement accuracy of a number of DHS-surveys by examining the heaping of height measurements on the digits 0 and 5, and concludes that rounding is not a problem in the surveys. A hint regarding the overall quality of the data is provided by the frequency of 'implausible height values', which were defined as recorded heights below 124 cm or above 199 cm. These were later excluded, as the probability of measurement error was particularly high in these cases. In the raw data, the relative frequency of implausible values constitutes 0.30% on average (excluding

Nigeria), indicating a high accuracy of the data. The only exception is the Nigerian DHS-survey, in which a lack of accuracy is generally evident in the reported heights (National Population Commission, 2000), with 12% of the heights deemed implausible. What is more, 9% of eligible women were not measured in Nigeria (2.7% on average for the other surveys).[6] When using the remaining 80% of the sample, the height distribution turns out to be truncated at 124cm and 199 cm, with very heavy tails. Consequently, the Nigerian CVs are extreme outliers (between 6 and 7) and vary in addition about four times more than the CVs of the other African countries. The deficiencies of the height measurements do not allow of much confidence in the estimated standard deviation of the underlying height distribution. Therefore, we eliminated Nigerian CVs from the analysis. We also tested whether observations based on less than 300 cases had higher standard deviations, because a lower number of cases might render an individual measurement error more influential. However, we did not find any significant influence when CVs were regressed on a dummy variable for those cases (p-value: 0.57). To sum up, while measurement errors should always be seriously scrutinized when using coefficients of height variation, we can reject a potential bias arising from this source for most DHS-surveys (apart from Nigeria).

In some DHS-surveys, the anthropometric part is limited to women who had given birth to at least one child in the three or five years, respectively, preceding the survey (later called mothers). Thus, only a subgroup of women, albeit a large one, is included. Does this selection affect our measure of nutritional inequality? In order to estimate the possibility of measurement bias for CVs based solely on mothers instead of a representative sample of the entire female adult population, we computed two CVs for ten countries whose DHS considered not only mothers, but all women. As a next step, we compared the difference between the CV of mothers (CV_m) with that of all women (CV_all). Ex-ante, one would expect the heights of mothers to be more homogenous than those of the entire female population, since taller women often belong to rich households and thus tend to have less children, making the group of mothers consist largely of more average-heighted women.

Hence, a lower CV for mothers is probable. In general, the development of CV_m and CV_all indicates a very close and positive relationship (Figure 3), with ups and downs often corresponding. The age group of 45-49 shows the largest deviation, which is not surprising given that few women give birth in this age group, while the absolute numbers of observations are also rather small (on average about 150 mothers or 600 women). The line of CV_m is more often below than above that of CV_all, but intersections occur frequently. Nevertheless, on average, CV_all is larger than CV_m for all age groups (by about 0.05). In the age group of 45-49, it differs most, by 0.13 (Table 1). Although the difference between the levels is statistically significant at the 5% level, the extent of this bias represents only 5% of the range of CV_all. Consequently, using CV_m instead of CV_all would yield no fundamental differences in the assessment of inequality, except perhaps for women in their late forties. As expected, the difference between the two CVs diminishes increasingly with the share of mothers in a population. Given the high fertility rates in Sub-Saharan Africa, mothers cover a large share of the female population. Still, if available, “all-women” surveys deliver more reliable information. If heights are only available for mothers and their share of the female population is low, a feasible strategy would be to assign lower weight to those observations in regressions, or to include the share as a control variable.

Another potential bias could arise from age effects in the age groups of 20-24 and 45-49. Some (although not all) women in undernourished societies may not have reached full adult height by their early twenties, so that their final height would move closer to the mean when measured at a later period. Initially, however, the height CV of the age group of 20-24 would be artificially high. We can test this by comparing the CV of the age group of 20-24 with that of the age group of 25-29 in the subsequent survey, if available, since both refer approximately to the same birth cohort (the mean birth years differing by half a year on average). What results is that over the twelve surveys under study, mean stature increased on average by four millimeters, although both age groups were born nearly in the same time period. As expected, the increase tends to be larger if a country's mean height level is smaller. In spite of this, however, the overall height CV is almost constant, with overestimation amounting to a negligible 0.01. Moreover, the Pearson correlation coefficient between the CVs of both age groups (of the same birth cohort) is very high (0.61). In the age group of 45-49, some of the older women may start to shrink earlier than others. If that were the case, we should generally find a larger CV for the age group of 45-49. But again, when comparing their CV with that of the age group of 40-44 five years earlier, we find a mean difference of only 0.004.[7] Thus, bias from age effects seems to be negligible in our study.

We use adult stature to project nutritional and health inequality in the first years after birth. Selective mortality patterns might lead to biased results from this backward-projection method, however, since undernourished, short individuals face a higher mortality risk (Waaler, 1984; Pelletier, 1994). Consequently, individuals on the left-hand side of the height distribution would be disproportionately missing. Average height should be overestimated and past inequality might have been larger in high-mortality countries. Indeed, stature can measure only such inequality as faced by survivors. Although this is certainly not a first-best property of an inequality measure, the primary concern lies on the weight of the bias and its influence on the results. Using data from Ahmad et al. (2000) on "under five mortality rates" (U5MR) in the 1960s, we tested whether mortality lowers CVs in a cross-country regression. The bivariate correlation points to a negative association, with the CV decreasing by 0.04 units for each 100 additional deaths under five (robust p-value: 0.169). Admittedly, U5MR is also a broad indicator for social welfare reflecting education, health facilities, income, etc., which makes it unlikely that the estimated relationship reflects the accurate extent of the bias. Yet at least, it can be stated that other important factors seem to determine the variation of African CVs as well. In section 6 below, we will present more evidence for this assumption.

Since our CVs refer to the female population only, questions arise concerning the correlation between male and female height inequality. Is female height inequality a more sensitive measure than male height inequality? Using data from the World Bank Living Standard Surveys, we can compare the development of the CV by gender for two African countries, the Ivory Coast and Ghana (Figure 4). In the case of the Ivory Coast, the CV for males is on average 7% higher than for females. Both CVs' development, however, displays the same pattern, with a peak in inequality in 1945 and a falling trend thereafter. The CV of females in Ghana indicates a slow but constant increase in inequality, whereas the CV of males declines between 1945 and 1960. The overall difference, however, is small. One reason for the imperfect correlation of nutritional inequality between the sexes is the intra-household allocation of resources, which may also change over time if the distribution of high-quality nutrients and medical resources shifts in favor of one sex. For example, in times of economic crises or structural change, higher returns might be expected from allocating resources to one sex only (Klasen 1999; Baten and Murray 2000). Since elasticities are probably higher for females, their CV could serve as a more sensitive and reliable measure for inequality: during crises, poorer households tend to keep the expenditures for boys constant while reducing allocations to girls.

In sum, our internal consistency tests suggest that our measure and the underlying data for Africa are generally reliable. Neither the quality of the data, nor the selection of mothers, nor age effects induce a significant bias. The CVs are delimited in that they reflect only that nutritional and health inequality which was faced by the living population in the past. Since our CVs refer solely to females, future research might focus on the development of male and female height inequality.

4. The relationship between gini coefficients of income and height CVs

We would expect a positive relationship between height inequality and income inequality, because a more uneven income distribution is likely to make the children of rich people taller, and/or those of poor people shorter. In the introduction, we already noted that income and height inequality will not be perfectly correlated if the poor have access to public health services, unrecorded food aid or other non-market entitlements. Nevertheless, the question remains how closely nutritional inequality is correlated with income inequality, notably the gini coefficient for income, both across regions and over time. For lack of other data, we are forced to rely on the limited information offered by Deininger and Squire's (1996) gini coefficients. For the period under study, data on income inequality is available only for 14 African countries and 29 five-year periods (excluding Nigeria). In an attempt to avoid the pitfalls reported by Atkinson and Brandolini (2001), we control for the differences in income definition and population coverage by including dummy variables.[8] In addition, we control for country fixed-effects (Table 2, model 1 and 3) which implies that our analysis focuses mainly on intertemporal effects.

The height CV is significant and positively correlated with the gini coefficients of income. An increase in the CV by one unit corresponds with a rise in the gini coefficient by 13.2 points in the fixed-effects specification. In regression (2), we obtain a coefficient between nutritional and income inequality of 20.9. This comes very close to Baten and Fraunholz's (2004) estimate for Latin America, where they report a significant coefficient of 15.5 based on gini coefficients whose underlying data are of the highest possible quality. In many cases, we had to work with more than one gini coefficient of income for the same period and country, but measured in different ways. Taking into account that they represented estimations of the same income inequality, we weighted them accordingly in the last two regressions. Under this specification, country fixed-effects and all other single variables are insignificant due to overspecification (only six degrees of freedom). After reducing the model, we obtained a regression coefficient for the CV of 20.5. Although this coefficient is not statistically significant at the 10% level (p-value of 0.109), the size of the coefficient is almost the same as under other specifications.

It is noteworthy that the relationship between the CV and the gini coefficient is not sensitive to country fixed-effects in general. Only the dummy for Gabon[9] had a robust and significantly positive coefficient. For Gabon’s oil economy, the gini coefficients indicate a very high income inequality level, but modest anthropometric inequality (over time, however, the development does correspond). Income inequality typically skyrockets during oil booms, when the incomes of relatively small groups, whose impact on the overall height CV of the population is modest, increase drastically (for coverage and age, see the notes of the table).

An excellent case for comparing the development of both inequality measures is Kenya, for which the estimates by Bigsten (1985) offer a consistent source with a sufficient number of data points (Figure 5). The development of both inequality measures is nearly identical, except for the sudden fall of the gini coefficient in 1955, with which the CV does not correspond. We cannot judge here which of the two inequality measures describes the development better, but at least it seems that the CVs movement is somewhat smoother and less volatile (the CV might moreover be less volatile due to some consumption smoothing, as people reduce their savings in harder times to smooth their consumption). However, both the strong rise of inequality in Kenya during the early 1950s and the more gradual rise of the late 1960s are clearly visible in both series. Similarly, the decline in inequality thereafter is confirmed by both measures. Summing up, the development of CVs over time serves as a promising measure of inequality, even more so because other data on inequality in Africa are either non-existent or unreliable (Table 3a).

5. Mapping Nutritional Inequality at a Disaggregated Scale

Based on the regional origin of the individuals surveyed, the height data allows the mapping of nutritional inequality at a very disaggregated scale. The first measure we consider for this purpose is the level of regional heights relative to the national mean stature. A regional mean stature below average points to nutritional conditions worse than in the rest of the country. Thus, this measure reflects inequality *between* regions (*inter*regional inequality I_{inter}). Our second measure is the CV of a region, which is indicative of nutritional inequality *within* the administrative unit (*intra*regional inequality I_{intra}).[10] Because the 1960s are particularly well documented in our sample, we will focus on inequality in this birth decade (Appendix Table A1).

The map of interregional inequality displays similar north-south patterns of height differences for a number of countries (Figure 6). In Chad, Cameroon, the Ivory Coast, Mozambique and

Zimbabwe, nutritional and health conditions improve from north to south. In Mali and Senegal, in contrast, the nutritional status of females gradually increases from south to north. Taller women can be also found around Lake Tanganyika (an area shared by Kenya, Uganda and Tanzania). In many cases, those patterns follow the same regional distribution as protein production. In Kenya, Uganda and Tanzania, for example, livestock farming is seriously hindered in areas where Trypanosomiasis is endemic (Ford, 1971). This suggests that benefits arise from proximity to production, a hypothesis which will be tested below.

The map of intraregional inequality (Figure 7) shows that CVs within a country's regions can be relatively heterogeneous. In Ethiopia, the Ivory Coast, Kenya, Mauritania, Uganda and Zimbabwe, for instance, regions with top-end CVs are close to regions with lower-end intraregional inequality. Additionally, we can identify a cluster of high inequality, stretching across the borders of Northwestern Africa (roughly between Guinea and Cameroon).

In some extreme cases, the national CV is apparently determined to a large extent by high *inter*regional inequality. For example, the high national height CVs of Tanzania (3.94) or Mozambique (3.80) are driven by high interregional inequality, the height difference between the north and south of Mozambique amounting to as much as seven centimeters. Similarly, females in the North of Tanzania are six centimeters taller than in the South. In contrast, the CVs of most of Tanzania's and Mozambique's provinces are relatively low (below 3.6). Thus, the importance of treating intra- und interregional height inequality as different analytical categories becomes obvious.

6. Cross-sectional Determinants of Nutritional Inequality between/within Regions

What factors can explain I_{inter} and I_{intra}? We will start with agricultural variables and focus on cattle farming and the cash-crop debate in particular. Other sets of potential influences include industrial structure, mineral resources, distance to the country's capital, urbanization, education, population density and ethnic fractionalization. In what follows, we will explain how we would expect these factors to influence I_{inter} and I_{intra}, and present the results of our regression analysis. Prior to that, however, three aspects deserve particular notice. First of all, we chose to perform a birth cohort analysis because conditions in the first years after birth are crucial determinants of adult stature. Thus, all explanatory variables refer to the 1960s. Secondly, I_{inter} expresses the variation of regional heights vis-á-vis the national mean. Therefore, we have to adjust the explanatory variables in a way that they also represent deviations from the national mean. Instead of applying mean differences, we prefer a country fixed-effects specification with regional heights as the dependent variable, since this facilitates the implementation of weights while yielding identical coefficients.[11] Thirdly, in order to give each country the same weight in the regression, we weight regions by their population share (last two columns of Table 4 & Table 5).

About 85% of the African population depended on agriculture for their livelihood in the 1960s.[12] In addition, live stock farming and cattle herding were the most important sources of **animal proteins**, making the number of cattle a suitable indicator of the proximity to protein production which has been hypothesized to be a major regional height determinant (Baten 1999). Prices of high-quality proteins tend to be lower in the producing regions, since transaction costs are particularly high in SSA. Hence, consumers in this region benefit more from lower relative food prices (compared with consumers in other regions). Moreover, Ndagala (1981) found that Tanzanian herders are in a better position to buy food than cultivators, because cattle is readily saleable and can be walked rather than carried to markets like crops. In addition, herders depend less on storages. These characteristics render cattle-holding a form of storing wealth in the absence of conventional credit markets in many parts of SSA (Fafchamps et al. 1998; Dercon 1998). Although these aspects should be reflected by prices in a context of perfect competition, competition is hardly ever perfect. In our countries in particular, economic policy and traditions delimit the efficiency of markets. Therefore, we would expect to find taller women in areas where the per capita ratio of cattle is high, owing to the proximity to protein supply, cheaper relative protein prices and the indication of relative wealth.

We would furthermore expect lower *intra*inequality in protein-producing regions. In areas where perishable goods are produced, non-marketable side-products (such as offal or blood in meat production) occur frequently and can be consumed by poorer segments of society. In addition, with lower relative protein prices, even the poor might be able to afford a protein-rich diet, which in other regions is primarily confined to the rich.

In fact, cattle per capita is an important explanatory variable for I_{inter} (Table 4): the higher the relative protein production in a region is, the higher is the average height. Moreover, the results indicate that I_{intra} is lower in regions with a higher cattle per capita share relative to the country mean (Table 5). Interestingly, after replacing the country fixed-effects in (3) with measures at the national level, we obtain the opposite effect for national cattle per capita (in the bottom part of Table 5).[13] Thus, countries with a high national cattle per capita ratio like Burkina Faso, Chad, Ethiopia, Mali, Mauritania, Kenya, Namibia, Niger, Tanzania or Zimbabwe display higher inequality in general, but low inequality in regions with a high concentration of cattle.

At the national level, we also focused on food supply, using **calories per capita** from the FAO Food Balance Sheets (FAOSTAT) and finding a non-linear relationship (bottom part of model (4) & (5), Table 5). The square root of calories has a significant positive influence on I_{intra}, whereas the linear term is significantly negative. Hence, at low calory levels, inequality rises with calory supply, while that effect diminishes at higher levels. This relationship is empirically very plausible and suggests that for SSA, food supply might be a better indicator of poverty than GDP/c. While a low calory supply indicates that a country is too poor even to secure the basic nutritional needs, a high calory supply implies rather sufficient access to food for the majority of the population. Taking calories as an indicator of deprivation, height inequality between these two extremes should indeed be higher.

Proximity to food crops is generally considered as benefitial to the nutritional situation, but there is substantial debate on the effect of cash crops. **Cash cropping** is an important source of income and especially of export revenues in Sub-Saharan Africa, yet it has been made responsible for increasing inequality. Nevertheless, the importance of cash crops as a source of income can be easily illustrated by the fact that in 1965, agricultural cash-crop products generated 74% of SSA's export revenues. Agricultural exports on the whole are likewise substantial in relation to GDP: the ratio of agricultural exports to GDP is as large as 10%.[14] Many African countries have comparative advantages in agriculture, as is the case with Senegal's groundnut production (Goetz, 1992). Since substantial export revenues can be used for importing sufficient amounts of food crops, this leads to the fundamental question of whether African people in general would gain from agricultural specialization and participation in the process of globalization. Should largely positive effects ensue, this could be turned into an argument for policy shifts and the opening up of the economy. If cash cropping were really associated with rising inequality, however, the costs in terms of social conflict could be too high.

Which influence might cash cropping have on inequality between regions? On the one hand, cash crops offer a source of income which can be used to buy foods and other goods not readily available to households, who therefore could realize gains from specialization. Were this the case, it should put cash crop regions ahead of regions where subsistence farming is widespread. However, there are some concerns. Firstly, it is not entirely clear how large the benefits from cash cropping really are. In the early 1950s, for instance, real prices for cash crops started to decline, a process which lasted at least until the early 1970s (Deaton and Miller, 1995). Thus, cash-cropper's real income decreased during the 1960s, an effect which was aggravated further by the fact that in order to generate additional state revenues under the import substitution policy, state-owned marketing boards exploited their monopsony position and payed rural producers less than world market prices. Besides, parts of the surplus might have been redirected to other regions. A second aspect in this context is that cash cropping increases the household's dependence on food prices. Given the deficiencies of African credit markets, savings may not be able to compensate for lower incomes in years of bad harvests or low prices, so that at least in some years, subsistence farmers might in fact be better off. Thirdly, it has been argued in gender-related studies that cash-cropping changes the intra-household allocation of resources to the disadvantage of women, who often lose their income from small-scale sales of agricultural side-products which are typical of subsistence farming. This, in consequence, might lead to lower nutrition and health expenditures for children, and hence to lower adult height later. From a theoretical point of view, the net effect of cash cropping on interregional inequality is therefore unclear. As to the empirical literature's findings on the interregional effect of cash cropping, previous studies focused mainly on a small number of villages. Hence, it was difficult to reach a final conclusion. Bryceson (1989), Jakobsen (1987) as well as Maxwell and Fernando (1989) reported that the nutritional situation of small cash crop farmers is worse than those of subsistence farmers in Sudan, Gambia, the Ivory Coast, South Eastern Kenya and the Southern highlands of Tanzania. In Nigeria and other parts of Kenya and Tanzania, however, the opposite was observed.

Concerning inequality within regions, the literature largely agrees that cash cropping tends to increase within-inequality. Peasants who adopted cash cropping early on had usually a considerable advantage, since they benefited from commercial relations and were able to buy additional, well-suited land in order to capture economies of scale when land prices were still low (i.e., during the introduction phase of cash-cropping). The import substitution policy pursued by most African countries during this period often favored large cash crop estates by the provision of subsidies (such as the cheap input supply of fertilizers, seed or specialized training programs). What is more, pressure on the collective land tenure system deprived the poor from free access to land and favored a small group of commercial plantation owners. A last point to be mentioned here is that unless marketing is restricted to the state, cash cropping gives rise to new and better-paid occupations like traders, who also benefit disproportionately from cash cropping in comparison with peasants. Therefore, we would expect I_{intra} to be higher in cash cropping regions.

Given the limited database of earlier studies, it is very important to examine the effect of cash cropping on both inter- and intraregional inequality. How could we measure cash cropping in our 200 regions during the 1960s? Following the most general definition of cash crops - i.e. crops being sold for cash - the existence of industries which process agricultural raw output like sugar cane, tobacco, cotton or grain serves as a useful approximation for cash crop areas. Conversely, subsistence farming is likely to be a major activity in regions where no such industries exist. The Oxford Regional Economic Atlas prepared by Ady (1965) describes the locations of agricultural industries, providing additional figures on up to eight different kinds of cash crop industries.[15] A great variety of agricultural industries points to diversification, thus making the income of cash-crop regions more secure. In contrast, concentration on a single cash crop entails a very high dependence on a particular segment of market demand. According to this measure, monocultural regions are found in southeastern Guinea, northeastern Tanzania, southern Senegal or the southern Kenyan coast, for example. A strategy of diversification exists in the Kenyan Rift Valley (a long-stretched region in western Kenya), western Ethiopia, southern Cameroon, or southwestern Ghana. Subsistence farming is dominant in the countries of the Sahel zone, Rwanda and Madagascar.

Our regression results indicate clearly that the existence of a (single) cash-crop industry reduces a region's average height by almost one centimeter (Table 4) and increases intraregional inequality (Table 5). Interestingly, a diversified cash-crop strategy has the opposite effect. Heights increase nearly by three millimeters and the CV decreases by 0.10 for each additional cash-crop industry, while inequality is consistently lower. These findings have important policy implications. Specialization in cash crops and participation in the process of globalization could have overwhelmingly positive effects on a region's development, decreasing inequality even further if a strategy of diversification is pursued simultaneously.

In some African regions, **industrial production** represented an important part of economic activity in the 1960s already. The development of light and heavy industries differed considerably, however (Steel and Evans, 1984), as the latter (steel processing, heavy machinery etc.) was particularly subsidized by governments on the basis of the economic ideologies of the time, which suggested a key role for those industries. Heavy industrial firms were taken over (and more frequently founded) by the state, a process which typically led to the formation of a small group of high-income earners (managers, workers in large subsidized or nationalized firms) whereas the rest of the regional economies remained relatively poor. On average, however, the living standard of such regions may indeed have been slightly higher than the national mean. In contrast, light industries (textiles, footwear, printing) typically evolved under competitive market conditions. Their workers were paid the normal wages of African economies, albeit presumably at slightly higher rates than in the rural sector, since labor had to be attracted. We therefore would expect higher average regional height where light industries were prevalent.

The regression analysis largely confirms our expectations. The presence of more market-oriented light industries is associated with higher mean heights, although the advantage is decreasing somewhat with the number of industries. Government-influenced heavy industries have a negative effect on heights, perhaps because of x-inefficiencies. The same line of reasoning could also explain the better performance of regions with light industry. In terms of intraregional effects, regions with heavy industry display much higher inequality (Table 5). In contrast, light industries have no effect on I_{intra}.

Mineral resources often generate substantial revenues. If mines apply capital-intensive technologies, which is likely where large mineral deposits exist like in central Namibia, western Ghana, central Zambia or in Zimbabwe, the small number of high-skilled personnel working there (and their relatives) will probably receive a high income, while the rest of the regional population can be expected to be poorer (Leamer et al., 1999). Moreover, the exploitation of mineral wealth hardly exhibits forward and backward linkages (Sachs and Warner, 1995). Mineral resources do not contribute to a broad human capital development from which other sectors of the economy could benefit. Therefore, mineral resources should have a strong inequality-enhancing effect on I_{intra}. The regression results give mild support for this hypothesis: mineral resources increase intrainequality, yet only in the case of gold, silver, and diamonds significantly so.

As a next step, we take into account the **peripheral location** of provinces. There are several reasons why inequality should differ in the periphery. Firstly, the capital region is often also a prosperous center of economic activity. Secondly, the degree of market integration may decrease with the distance to the political center. Thirdly, high inequality in regions near the capital poses a political threat to governments, who therefore tend to redirect resources to regions near the capital by providing public goods or subsidies, particularly to the poorest strata of society (Bates, 1981). This is also the case when weak governments have only limited control over distant territories. We would therefore expect higher mean height and less intraregional inequality in regions near the capital. Both the absolute distance as well as a relative measure are included in our regression analysis. The results are ambiguous. At first sight, periphery does not seem to be a significant determinant of I_{inter}. However, periphery should not be rejected as an important underlying cause of inequality, on the grounds that it correlates highly negatively with education, which adds to the regional height variations I_{inter}. Distance to the capital has a robust negative impact on regions' CV, suggesting that inequality is lower in distant regions. On the other hand, when we take into account the varying size of African countries, a different picture emerges: relative to the distance of the remotest region, distance has a positive effect on inequality. This suggests that remote regions of large countries like Tanzania, Mali or the Ivory Coast display smaller inequality, wheras distant regions of small countries like Rwanda or Uganda have higher inequality.

We also included a dummy variable for **urban regions** (the capitals of Burkina Faso, Ethiopia (as well as Harari), Guinea, Mauritania, Rwanda and Tanzania). Bogin (1991) and Baten (2000a) found higher height inequality within urban environments, because agglomerated economic activities provide ample employment opportunities which attract the very poor strata of society, while proximity to power and high society life attract the rich as well. Hence, both extreme income groups like to live in the capital. Regarding the poor, similar considerations could increase inequality in more densely populated agricultural districts.[16] The urban dummy had the expected positive coefficient in I_{intra}, whereas population density had no apparent effect.

Finally, we would expect **education** to have a positive effect on the average heights of regions as well as an egalitarian effect, since education improves the health and nutritional behavior of the poorer segments more than proportionately. Moreover, education also serves as a proxy for the provision of other public goods (such as water-works, health facilities etc.). Besides, it indicates how much care and investment women received during childhood. In fact, education reduces inequality within regions and provides a higher standard of living relative to the country mean (on the control variables, see notes to table 4 and 5).

Recently, Milanovic (2003) has argued that inequality in SSA is a political phenomenon, stemming to a considerable extent from **ethnic fractionalization**. In African societies, it is argued, the politically powerful are used to acquire economic gains at the cost of society at large. Since political support is organized along ethnic lines, politicians' support of infrastructure, education, health, or employment in the public sector is likewise restricted to members of their own ethnic group, while economic activities are taxed mainly if they are carried out predominantly by other ethnic groups. We used the population share of the largest ethnic group in our regression and found a non-linear relationship with I_{intra} (Table 5).[17] An increasing share of the largest ethnic group is associated with declining inequality (because the square root of this variable is significant). Minimal inequality is reached when the size of the largest ethnic group amounts to 50% of the population, while inequality within regions increases once this threshold is crossed. Notice should be given to the fact that this relationship does not support an interpretation of genetic height differences. If genes resulted in different mean statures of ethnic groups, then clearly, one should find the lowest inequality within ethnically homogenous societies. Similiarly, when assuming only two ethnic groups and a constant height difference, the standard deviation of stature should be at its maximum when the population is equally split into two 50% shares. Although, there is much speculation about the specific mechanism through which ethnicity operates, the observed pattern fits well to the idea that on the one hand, ethnic heterogeneity approximates the polarization of interest groups, thus lowering the provision of public goods and favoring rent-seeking. On the other hand, clear majorities formed along ethnic lines might reduce the need for balanced policies. Hence, higher inequality in ethnically homogenous as well as heterogenous countries would be a plausible consequence. However, it need not necessarily be the case that power lies with the ethnic majority. Zimbabwe is a case in point, as it was ruled by a racist white minority until 1979 in spite of the fact that 68% of the population belong to the largest ethnic group. High inequality here stems rather from the fact that the majority is discriminated against, despite their demographic dominance.

We also tested the **Kuznets** hypothesis, stating that inequality rises initially with economic development but declines after a certain point. Because most African countries are poor, only the upward-sloping part of the Kuznets Inverse U would make sense in the context of Sub Saharan African countries. We therefore added real GDP/c (PPP) from the Penn World Tables 5.6 in linear form to our regression and found indeed a positive, but insignificant coefficient (regression (5), Table 5).

Finally, Delajara (2004) argues that **fertility** reflects parents' choice between the quantity and quality of children (Weir, 1993; Schneider, 1996). Families with less children invest more in quality, and as such in the nutrition and health of their children. Therefore, lower fertility should be associated with larger mean heights. Since relevant data are scarce, this hypothesis cannot be thoroughly tested within the I_{inter} framework. However, high fertility rates might similarly reflect a discriminatory intra-household allocation, favouring children of higher birth order (and therefore increasing I_{intra}) . We included total fertility rates from the UN Population Devision (2003) as an explanatory variable for I_{intra}, but found no significant impact (regression (4), Table 5).

7. Summary

While inequality is a central issue in economics, relevant data is in particularly scarce supply, especially for LDCs prior to the 1980s. In this paper, we have argued that anthropometric inequality measures like the coefficient of height variation have the potential to increase our knowledge on inequality to a significant degree. The comparison between this measure and income-based gini coefficients indicates a close, but not perfect correspondence for SSA. We also tested several issues which might have casted doubts on height CVs as a measure of inequality, but found no evidence for major inconsistencies. We extended the within-inequality database to no less than 28 countries over six five-year periods from 1950 to 1980, and to some 200 administrative regions within those countries. When testing several determinants of inter- and intraregional inequality in a second step, we demonstrated that height inequality is a convenient and useful measure for shedding additional light on important economic themes like the cash crop debate and others, which depend crucially on welfare and inequality effects. Regions concentrating on a single cash-crop experienced substantial increases in inequality, whereas regions with a diversified cash-cropping landscape reaped the opposite effect and also had higher average heights (relative to the country mean). We found that proximity to protein production leads to significantly taller heights and less inequality. Light industries and education had significantly positive effects on regional heights, and a mixed or reducing influence on inequality. We also found mild support for the hypothesis that inequality is determined politically in SSA. Ethnic diversity has a U-shaped effect on inequality: an increasing share of the largest ethnic group reduces inequality at first, but once this group becomes too large, inequality increases again.

Table 1: Comparison between CV (all women) and CV (mothers only)

Age group	Mean (CV_all - CV_m)	sample share of mothers
45-49	0.125	23.4
40-44	0.033	47.0
35-39	0.052	66.0
30-34	0.023	75.9
25-29	0.020	79.0
20-24	0.038	67.0
All (N=60)	0.048 (2.028)	59.7

Note: Based on Benin, Ethiopia, Ivory Coast, Malawi, Mali, Mauritania, Rwanda, Uganda, Zambia and Zimbabwe (N=10); t-values in parentheses.

Table 2: Relationship between income (gini) and height inequality (CV)

Gini-coefficient of income	(1)	(2)	(3)	(4)
Constant	-23.429 (-0.80)	-65.912 (-2.06)	19.235 (0.23)	-33.557 (-0.70)
CV	13.182 (1.72)	20.932 (2.87)	8.988 (0.42)	20.547 (1.67)
Coverage of female population (in %)	0.016 (0.20)		0.024 (0.13)	
Age group 20-24 (1=yes, 0=no)	-2.073 (-0.85)			
Age group 45-49 (1=yes, 0=no)	-2.343 (-0.60)			
Gabon		19.582 (4.22)		21.167 (3.01)
Country fixed-effects [p-value]	[0.000]		[0.387]	
Fixed effects for population coverage and income definition [p-value]	[0.000]	[0.000]	[0.810]	[0.026]
Fixed effects for primary source [p-value]	[0.000]	[0.052]		
Weighted by	share of female population		multiple country-periods	
R^2-adj.	0.812	0.521	0.324	0.436
N	78	78	29	29
Degrees of freedom	42	58	6	19

Note: Exluding Nigeria and gini coefficients which are not based on a national coverage; t-values in circular parentheses. Number of countries: 14. The reference category represents a gini based on gross income, which covers the total population and persons as reference units. When dummies for countries and the source of gini are included, the reference category additionally represents Kenya and Bigsten (1986). The population coverage controlled for refers to households, economically active population, income recipients and taxpayers, with the income definitions referring to expenditure, net income and income not nearer specified. In cases where two DHS-surveys offer information on the same birth cohort, we took the average weighted by the female population they cover. The gini coefficients were derived from twelve primary sources listed in Deininger and Squire (1996). **Coverage/Age:** Additionally, we would have expected a negative coefficient for the percentage of the female population measured, correcting for the somewhat higher CV when based on more women. Obviously, however, the impact is almost zero. Similarly, age effects have the expected negative sign but do not introduce a significant bias.

Table 3: Nutritional Inequality (CVs) in SSA 1950-1980

Country	1950	1955	1960	1965	1970	1975	1980
Benin		3.953 (100.00)	3.866 (100.00)	4.043 (100.00)	3.808 (100.00)	3.780 (100.00)	3.892 (100.00)
Burkina Faso	3.691 (54.43)	3.708 (72.18)	3.752 (84.12)	3.669 (88.78)	3.481 (86.80)	3.675 (76.24)	
Cameroon		3.260 (21.86)	3.835 (37.04)	4.013 (51.99)	3.936 (57.37)	3.777 (53.04)	
CAR	4.353 (16.95)	4.376 (31.97)	4.246 (46.75)	4.017 (55.32)	4.146 (58.34)		
Chad	4.701 (15.65)	3.846 (43.57)	3.737 (70.79)	3.851 (83.47)	3.936 (88.03)	3.849 (82.51)	
Comoros		3.694 (23.47)	3.279 (45.23)	3.565 (54.47)	3.843 (50.94)	3.557 (35.07)	
Ethiopia	3.699 (100.00)	3.807 (100.00)	3.811 (100.00)	3.880 (100.00)	3.849 (100.00)		
Eritrea	3.389 (32.85)	3.599 (49.66)	3.680 (60.07)	3.698 (64.71)	3.684 (61.57)		
Gabon		3.688 (21.14)	3.771 (40.34)	3.737 (51.52)	3.704 (58.72)	3.859 (63.58)	
Ghana	4.160 (25.19)	3.802 (43.97)	3.645 (58.78)	3.646 (62.96)	3.790 (62.96)	4.087 (57.15)	
Guinea		3.760 (37.52)	3.800 (59.96)	3.946 (73.86)	3.976 (79.32)	3.818 (77.15)	
Ivory Coast	3.888 (100.00)	3.764 (100.00)	3.735 (100.00)	4.124 (100.00)	3.925 (100.00)	3.851 (100.00)	
Kenya	4.102 (36.27)	4.065 (50.27)	3.807 (63.81)	3.784 (75.71)	3.912 (71.35)	3.779 (66.20)	
Madagascar	3.178 (10.37)	3.839 (28.73)	3.769 (45.18)	3.881 (57.20)	3.683 (65.93)	3.639 (65.41)	
Malawi	3.442 (51.81)	3.663 (100.00)	3.760 (100.00)	3.783 (100.00)	3.750 (100.00)	3.765 (100.00)	
Mali	3.737 (29.06)	3.737 (100.00)	3.733 (100.00)	3.734 (100.00)	3.675 (100.00)	3.758 (100.00)	
Mauritania		4.173 (100.00)	4.050 (100.00)	3.942 (100.00)	3.958 (100.00)	4.125 (100.00)	
Mozambique	4.054 (10.46)	3.981 (27.10)	3.444 (39.20)	3.897 (50.31)	3.750 (60.69)	4.349 (63.13)	
Namibia	4.125 (47.91)	3.738 (57.98)	3.881 (69.89)	4.183 (67.45)	4.035 (59.84)		
Niger	3.524 (40.81)	3.693 (55.67)	3.686 (71.17)	3.798 (82.00)	3.732 (79.52)	3.673 (73.62)	
Rwanda		4.111 (100.00)	4.026 (100.00)	3.947 (100.00)	3.943 (100.00)	3.945 (100.00)	
Senegal	3.663 (53.06)	3.525 (70.51)	3.863 (79.25)	3.738 (77.50)	3.617 (64.30)		
Tanzania	4.057 (41.99)	3.838 (59.55)	3.949 (71.37)	4.118 (78.60)	4.019 (76.78)	3.957 (73.92)	
Togo	4.384 (11.84)	3.551 (30.53)	3.808 (47.82)	3.546 (62.04)	3.915 (63.33)	3.791 (48.40)	
Uganda		4.458 (100.00)	4.146 (100.00)	3.970 (100.00)	4.014 (100.00)	4.000 (100.00)	
Zambia	3.940 (48.50)	4.184 (100.00)	3.916 (100.00)	3.867 (100.00)	3.843 (100.00)	3.945 (100.00)	3.917 (100.00)
Zimbabwe		4.021 (100.00)	4.032 (100.00)	3.925 (100.00)	3.970 (100.00)	3.934 (100.00)	

Note: Based on five-year age groups. We averaged the CVs of adjacent age groups (weighted by the coverage of the female population), if the mean birth year deviated more than two years from the beginning of the period. The figures refer to the beginnings of the periods. Coverage of the female population in brackets. For pooling this data with available gini coefficients of income, we recommend the relationship presented in model (4), Table 2: Gini=-33.5+20.5*CV.

Table 4: Determinants of *inter*regional height inequality, birth cohort 1960s

Height difference vis-á-vis the country's mean stature (in mm)	(1)	(2)	(3)	(4)
Proximity to protein supply				
Cattle per capita relative to country mean	3.332 (2.69)	3.306 (2.71)	3.086 (2.36)	2.800 (2.43)
Cash cropping				
Cash crop industries (1=yes, 0=no)[2]	-10.996 (-1.79)	-9.437 (-1.71)	-8.816 (-1.61)	-9.167 (-1.93)
N cash crop industries	3.099 (1.59)	2.368 (1.33)	2.827 (1.50)	3.191 (1.92)
Industrial structure				
"Market-oriented", light industries (1=yes)[3]	14.939 (3.82)	13.524 (4.01)	14.070 (4.03)	11.527 (3.81)
N light industries	-4.185 (-2.06)	-2.993 (-1.58)	-3.532 (-1.86)	
"Government-influenced", heavy industries (1=yes)[4]	-11.141 (-1.56)	-9.174 (-1.67)	-12.056 (-1.93)	-5.245 (-1.46)
N heavy industries	6.332 (1.68)	5.145 (1.62)	5.858 (1.75)	
Mineral resources				
Gold, silver, diamonds (1=yes, 0=no)	1.516 (0.28)		-0.691 (-0.15)	
Mineral deposits (1=yes, 0=no)[1]	-3.829 (-1.24)		-0.766 (-0.29)	
Distance, urbanization, density				
SQRT(Distance)	-1.071 (-0.10)		-4.182 (-0.41)	
Distance to capital in 1000 km	0.339 (0.03)		-3.573 (-0.30)	
Urban district (1=yes, 0=no)	-1.940 (-0.39)		-1.242 (-0.18)	
SQRT(Population density)	0.055 (0.13)		0.125 (0.34)	
Education				
SQRT(Mean education of administrative region/ national mean education)	11.604 (2.41)	11.004 (2.84)	5.315 (1.02)	8.060 (2.19)
Control variables				
CV	4.384 (0.73)		-2.764 (-0.52)	
weighted	-	-		by share of population
R^2 (within)	0.182	0.156	0.226	0.164
No. of provinces (countries)	196 (27)	202 (28)	196 (27)	202 (28)

Note: From all variables, the respective country mean was subtracted (see endnote 11); t-values above 1.645 are shaded (10%-level of significance). The **cattle** distribution of a country is drawn from the very disaggregated map of Deshler (1963). His study is based on veterinary surveys conducted mostly at the end of the 1950s. Nevertheless, for standardization, we only took relevant information on the regional distribution from his maps and multiplied the share within a region with FAO data on national cattle for 1960. Additionally, we added figures from Ady (1965) for Gabon, Ethiopia, Eritrea and Burkina Faso, for which Deshler (1963) does not provide any data. Based on data (latitudes and longitudes) from the National Geospatial-Intelligence Agency, we approximated **periphery** with the great circle distance between the administrative and the national capital. **Education**: By calculating the mean number of school years that all DHS-women enjoyed in a given region, we constructed a variable which also indicates how much care and investments the women received during childhood. We also included some **control variables:** the CV relative to the national CV as a predictor of I_{inter}. Heights are subject to a decreasing marginal product and therefore, average height is typically lower where inequality is higher, but we find no significant influence.

Table 5: Determinants of *intra*regional nutritional inequality, birth cohort 1960s

Height CV	Mean	(1)	(2)	(3)	(4)	(5)
Proximity to protein supply						
Cattle per capita relative to country mean	1.159	-0.039 (-1.73)	-0.043 (-1.99)	-0.036 (-1.63)	-0.037 (-1.76)	-0.040 (-1.95)
Cash cropping						
Cash crop processing industries (1=yes, 0=no)[2]	0.255	0.156 (1.46)	0.20433 (1.96)	0.229 (2.61)	0.161 (1.85)	0.200 (2.56)
N cash crop industries	0.684	-0.095 (-2.97)	-0.115 (-3.77)	-0.091 (-3.18)	-0.080 (-3.00)	-0.096 (-3.75)
Industrial structure						
"Market-oriented", light industries (1=yes)[3]	0.199	-0.001 (-0.01)		0.032 (0.50)	0.090 (1.38)	
N light industries	0.434	0.018 (0.47)		0.019 (0.54)	-0.014 (-0.48)	
"Government-influenced", heavy industries (1=yes)[4]	0.138	0.376 (1.94)	0.240 (3.16)	0.255 (1.66)	0.290 (2.22)	0.193 (3.14)
N heavy industries	0.301	-0.084 (-0.86)		-0.067 (-0.81)	-0.057 (-0.84)	
Mineral resources						
Gold, silver, diamonds (1=yes, 0=no)	0.112	0.179 (1.84)	0.184 (2.04)	0.104 (1.31)	0.142 (1.81)	0.143 (1.92)
Other mineral deposits (1=yes, 0=no)[1]	0.276	0.050 (0.99)		0.047 (1.08)	-0.004 (-0.10)	
Distance, urbanization, density						
SQRT(Distance to capital in 1000 km)	0.502	0.278 (1.10)		0.165 (0.78)	0.125 (0.64)	
Distance to capital in 1000km	0.337	-0.673 (-3.10)	-0.617 (-3.81)	-0.627 (-3.16)	-0.518 (-2.91)	-0.488 (-4.79)
Relative distance (relative to the farthest region)	0.506	0.099 (0.65)	0.248 (2.26)	0.142 (1.09)	0.102 (0.87)	0.181 (2.54)
Urban district (1=yes, 0=no)	0.036	0.351 (2.54)	0.258 (1.96)	0.165 (0.84)	0.171 (1.18)	0.207 (2.96)
SQRT(Population per km²)	4.880	-0.008 (-1.12)		0.004 (0.54)	0.002 (0.26)	
Education						
SQRT(Mean education in single years)	1.661	-0.092 (-1.19)	-0.129 (-1.84)	-0.191 (-2.93)	-0.128 (-2.95)	-0.104 (-3.05)
Control variables						
Coverage of female population (in %)	81.380	0.001 (0.21)		-0.002 (-0.50)	-0.000 (-0.23)	
SQRT(region's size in 1000 km²)	7.174	0.006 (0.93)	0.010 (1.78)	0.011 (1.66)	0.011 (2.09)	0.012 (2.67)
National variables: food, Kuznets, ethnic fractionalization, demography (no variation at the regional level)						
Cattle per capita (1961)	0.671				0.046 (1.30)	0.056 (1.97)
SQRT(Calories per capita)	44.709				0.362 (1.12)	0.566 (1.91)
Calories per capita (1961)	2004.786				-0.004 (-1.08)	-0.006 (-1.87)
Ln(GDP 1960)	6.462				0.020 (0.37)	0.057 (1.48)
SQRT(percentage of largest ethnic group)	6.520				-0.343 (-2.80)	-0.383 (-3.82)
Percentage of largest ethnic group	44.517				0.025 (3.04)	0.027 (3.89)
Total fertility rate (1960-70)	6.926				-0.045 (-1.22)	
U5MR (1965-69)	239.811				-0.0005545 (-1.09)	

Fixed-Effects (p-value)		0.027	0.005	0.005	-	-
Weighted	-	-	-	by population share of region		
R^2-adj.		0.170	0.186	0.239	0.235	0.244
No. of provinces (countries)		196 (27)	196 (27)	196 (27)	188 (25)	188 (25)

Notes: Huber/White/sandwich estimator of variance used for t-values (in parentheses). All regressions include a constant. Nigeria not included. Testing the national variables in a purely cross-country-regression hardly changes the results (available from the authors). See also notes to table 4. **Control variables**: We included the coverage of female population, since the subgroup of mothers could possibly be more homogenous. Again, we find no significant influence on intraregional inequality. Secondly, the size of the region. Since large regions have probably less in common than smaller ones, a higher I_{intra} would be plausible. This variable turned indeed out to be significantly positive. In section 3, we noted that CVs refer only to inequality faced by **survivors** and therefore, past inequality might have been larger in high-mortality countries. We therefore included the U5MR in this multivariate setting to control for a bias in the backward projection method. Again, we obtained a negative relationship with the CV, decreasing by 0.06 units for each 100 additional deaths under five. Nevertheless, neither are the results particularly sensitive nor is the level of mortality the most important single determinant of height inequality.

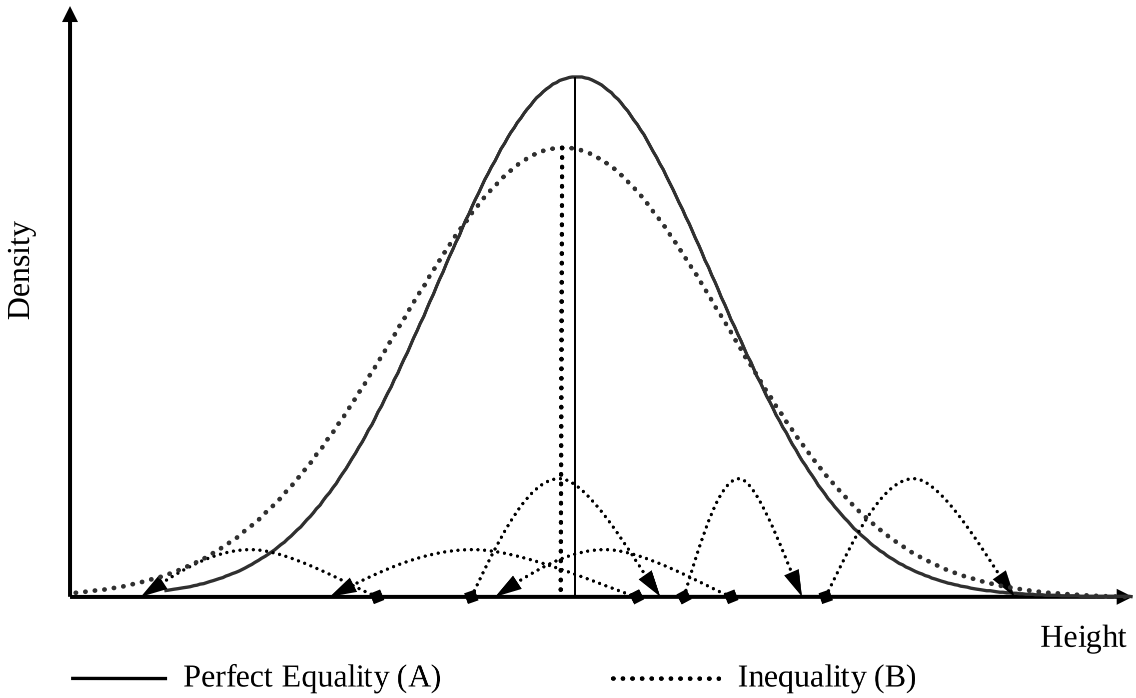
[1] tin, barytes, lead, zinc, copper, arsenic, columbite, antimony, platinum, beryl, lithium, cadmium, ilmenite, asbestos, chromium, phosphates, mica, nickel, pyrites, manganese, tungsten, vanadium, salt, soda ash, bauxite and cobalt.

[2] oil milling, cotton ginning, grain milling, sugar refining, tobacco, wine/ spirits production, timber mills, brewing and mineral waters, canning and tanning.

[3] general chemicals, glass and pottery, paints and varnish, rubber, printing and publishing, footwear, cotton textiles, woolen textiles, making up of textiles and sacking.

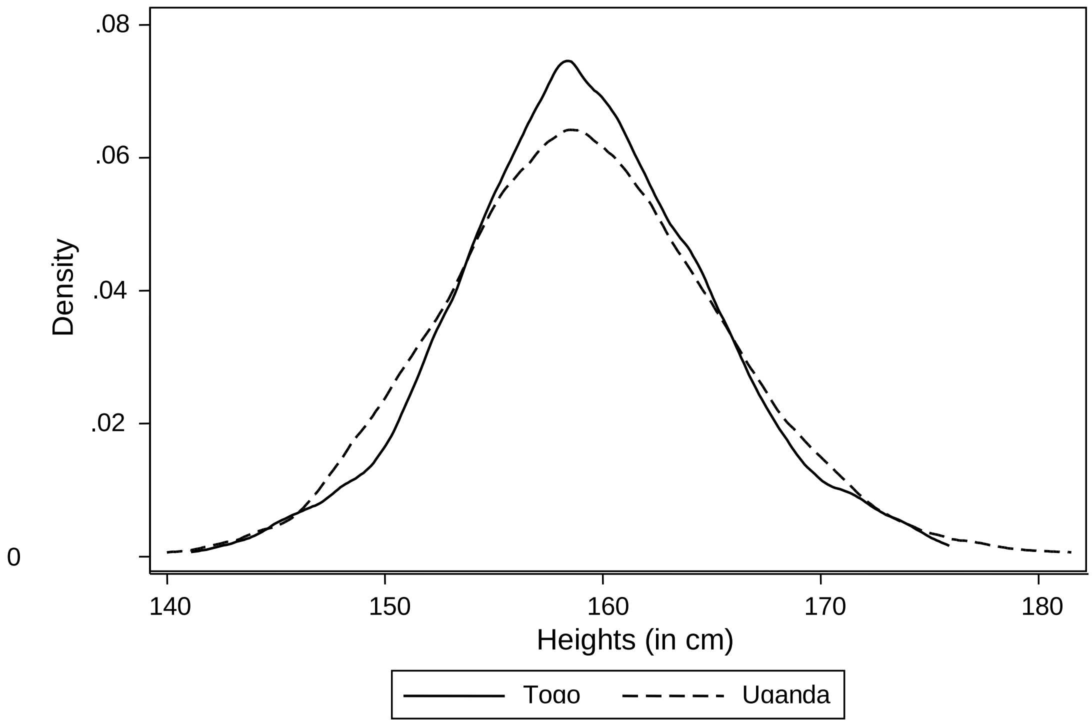
[4] iron and steal, electrical engineering, general engineering, cement production and building materials.

Figure 1 Stylized effects of rising inequality in nutrional resources on the height distribution



Note: The solid distribution line to the right refers to a hypothetical height distribution without inequality. The dotted line to the left indicates increasing inequality. More (less) resources shift the position of individuals to the right (left).

Figure 2 Height distributions in Togo and Uganda, age group 30-34



Note: N(Togo)=831, N(Uganda)=855.

Figure 3: Development of the CV of mothers and the CV of all women by age groups

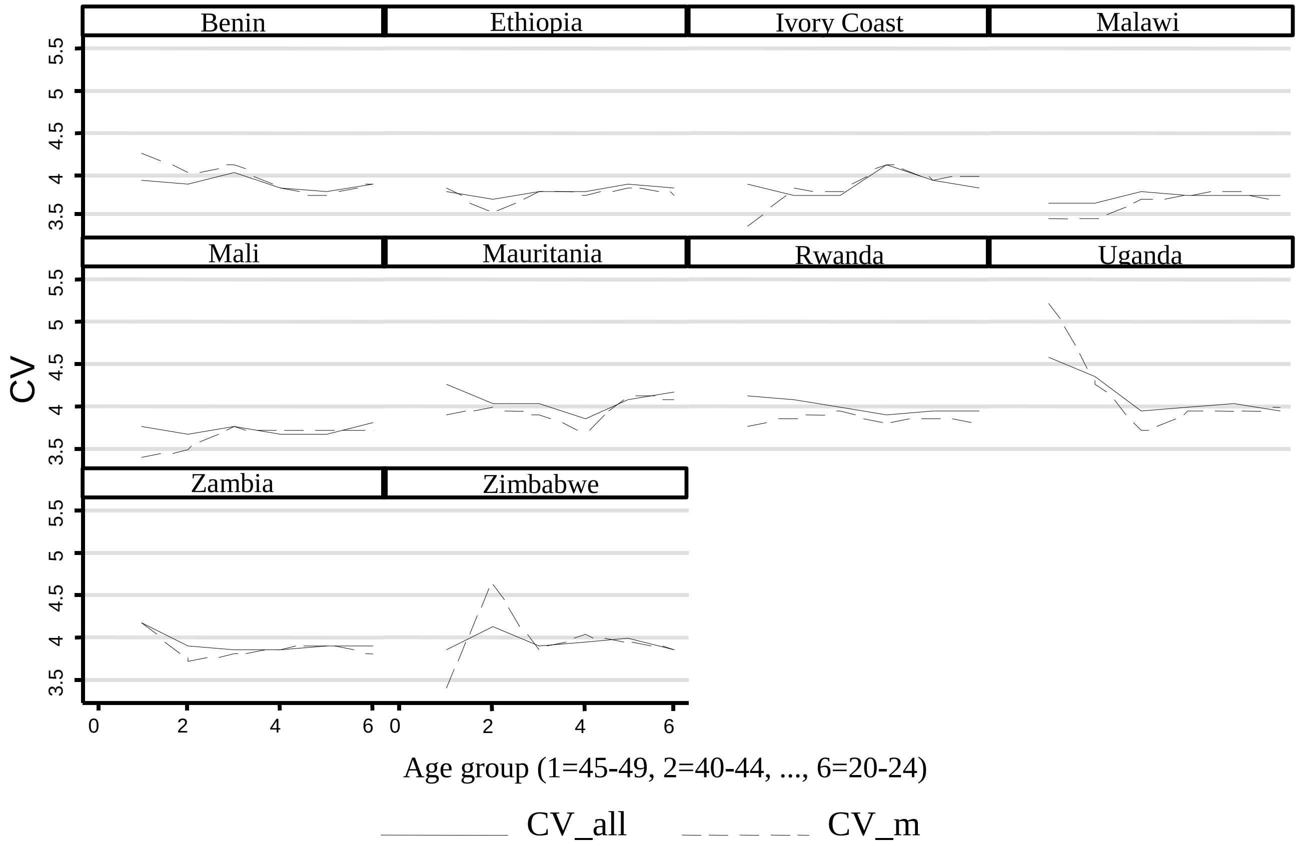
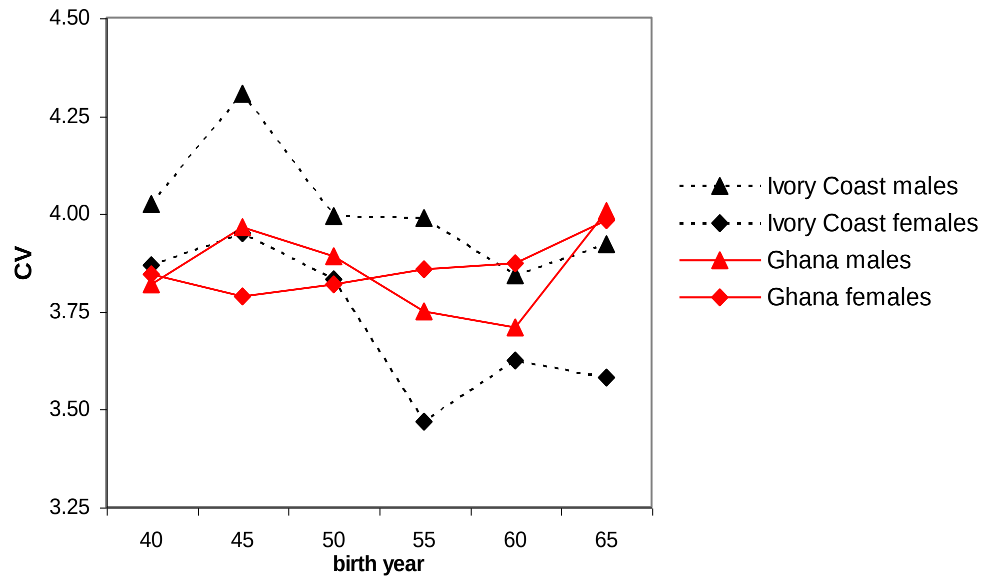
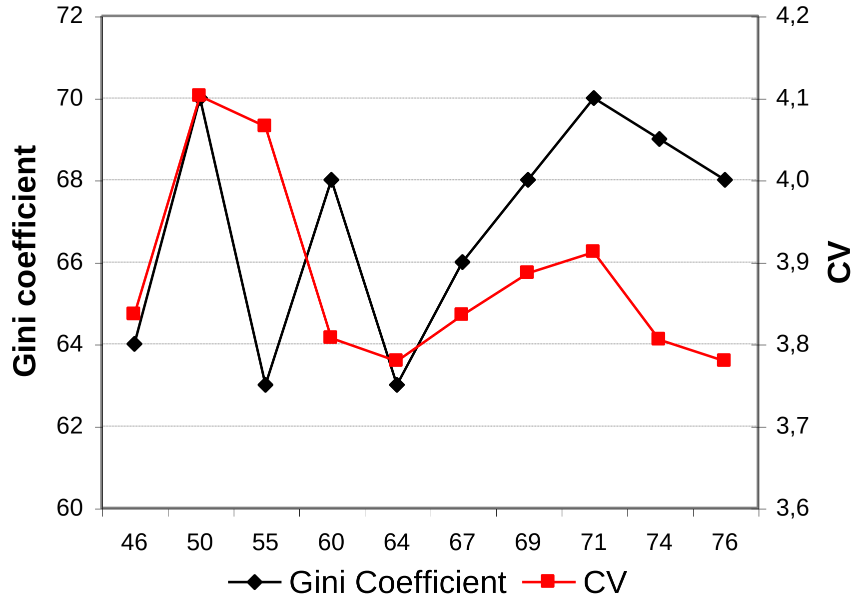


Figure 4: Development of CV by gender in Ghana and Ivory Coast



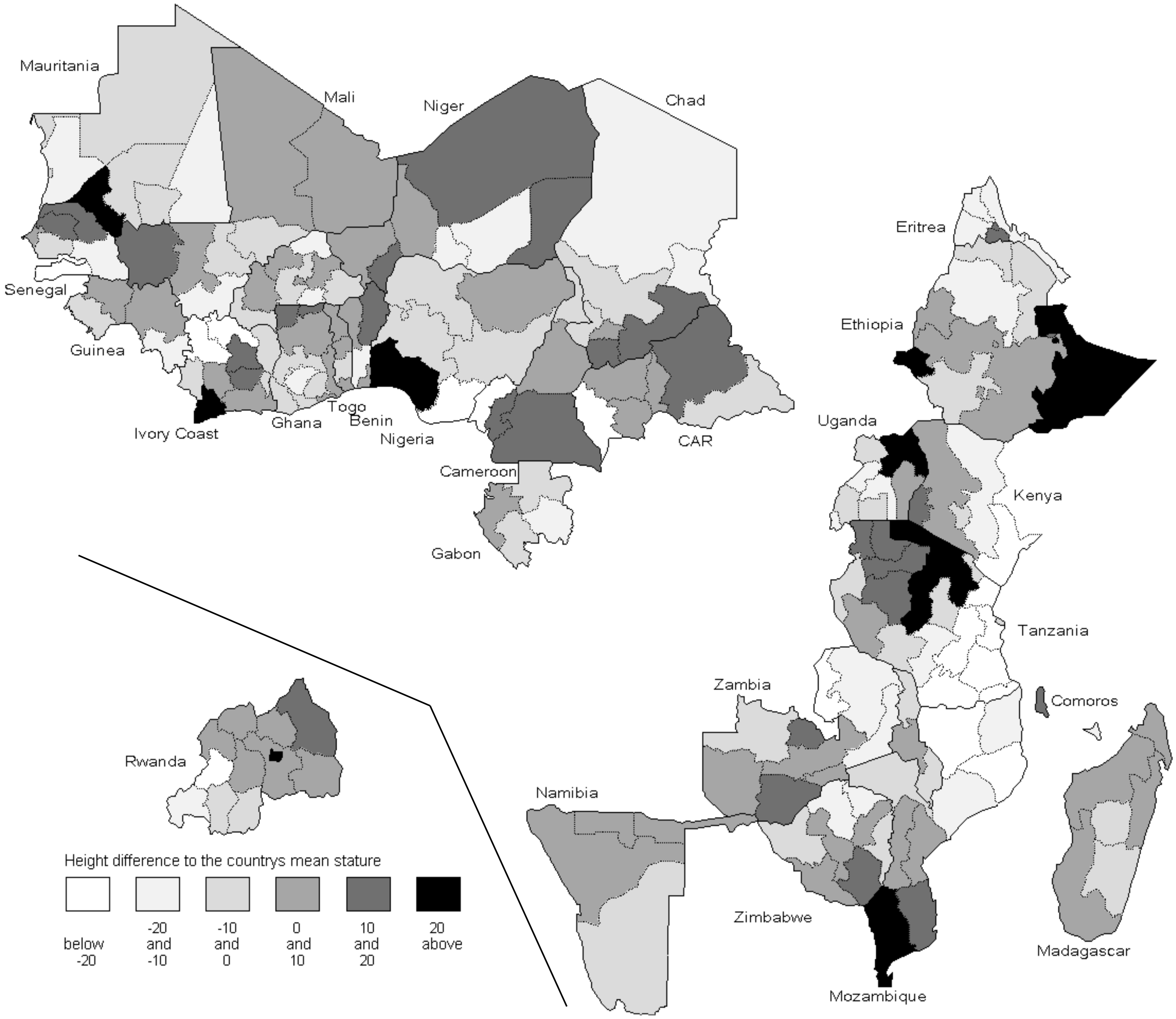
Note: The CVs are based on the anthropometric part of the living standard surveys GLSS 88/ 89 and CLSS 85/ 86/ 87/ 88. The samples of the different years are not totally independent, since approximately 50% of the households are part of a rotating panel. About 40% of the individuals in the CLSS and 60% in the GLSS survey were remeasured in a second round. Inconsistencies between the first and second rounds (sex, age>5 years, height>10cm) as well as extreme outliers were excluded. The remaining minor deviations were averaged. Moreover, we also excluded foreigners, as they were probably not born in the country (especially the many immigrants working in the Ivory Coast). In total, the Ivorian CV is based on 10769 individuals between 20 and 49 years of age, and that for Ghana on 8602 individuals.

Figure 5: Development of income and nutritional inequality in Kenya



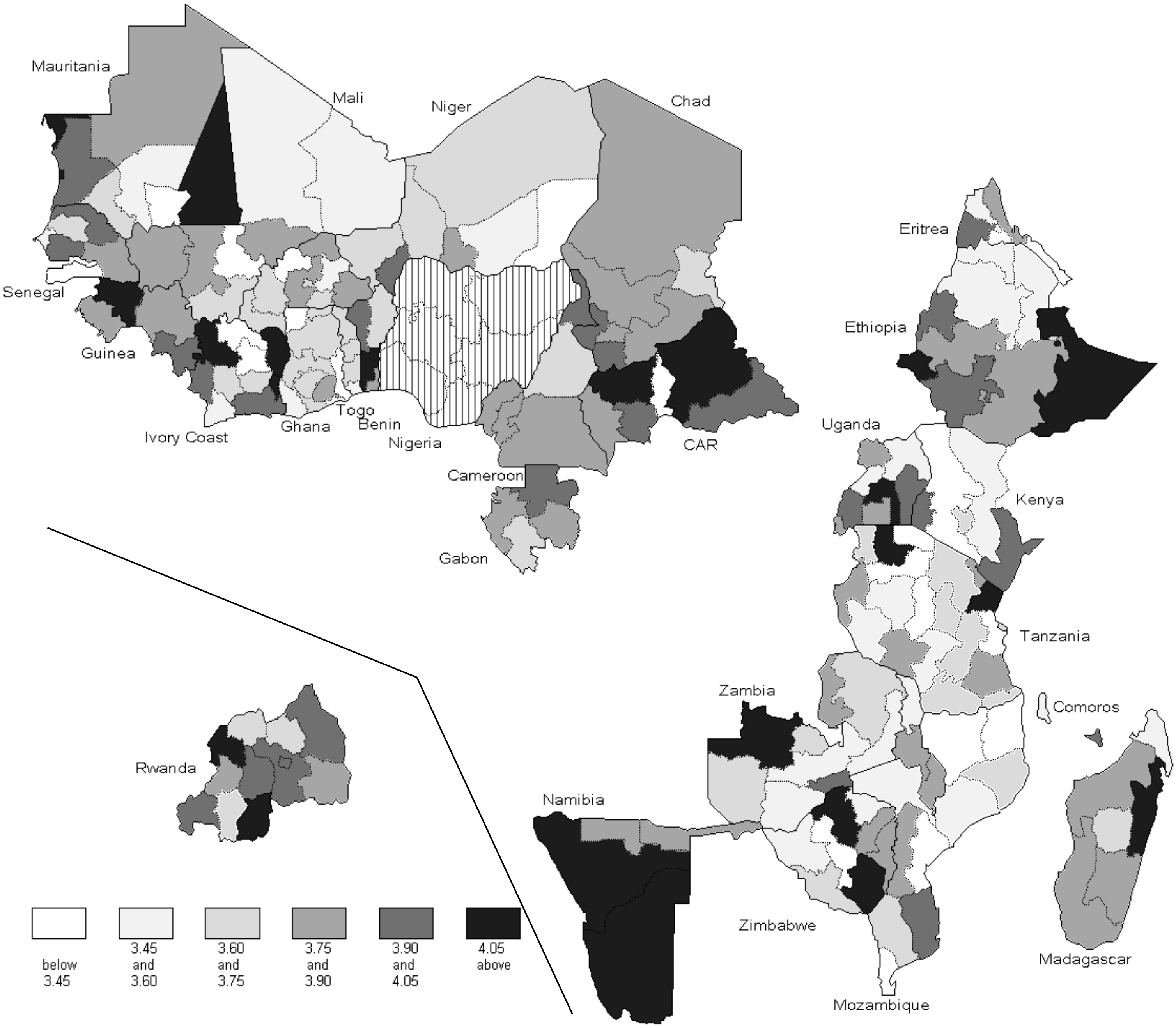
Note: The gini coefficients are from Bigsten (1985) with a national coverage but based on national accounts of income groups, although Deininger and Squire (1996) label them as being based on taxpayers. Bigsten (1985) admits that his estimation technique overestimates the gini coefficients by about 20 percentage points. Birth cohorts were averaged from Kenya II and Kenya III, weighted by the coverage of female population.

Figure 6: Height difference relative to the country's mean stature (10 year age group born in the 1960s)



Note: Number of provinces: 203. Based on 49000 individuals (mostly age group 25-34 or 30-39). In general, we accepted the DHS-surveys' default administrative regions. In some cases, however, we pooled regions if the number of individuals was very small (N<50). Similarly, we sometimes divided very populous regions and pooled districts.

Figure 7: CVs by regions (10 year birth cohort born in the 1960s)



References

Ady, P. (1965). *Oxford Regional Economic Atlas Africa*. Oxford: Clarendon Press.

Ahmad, O. B., Lopez, A. D. & Inoue, M. (2000). The Decline of Child Mortality: A Reappraisal. *Bulletin of the World Health Organization*, 78, 1175-1191.

Anand, S. & Kanbur, S. M. R. (1993). The Kuznets Process and the Inequality-Development Relationship. *Journal of Development Economics*, 40(1), 25-52.

Atkinson, A.B., & Brandolini, A. (2001). Promise and Pitfalls in the Use of 'Secondary' Data Sets: Income Inequality in OECD Countries as a Case Study. *Journal of Economic Literature*, 39(3), 771-799.

Baten, J. (1999). *Ernaehrung und wirtschaftliche Entwicklung in Bayern, 1730–1880.* Stuttgart: Steiner Verlag.

Baten, J. (2000a). Economic Development and the Distribution of Nutritional Resources in Bavaria, 1797-1839. *Journal of Income Distribution*, 9, 89-106.

Baten, J. (2000b). Height and Real Wages: An International Comparison. *Jahrbuch fuer Wirtschaftsgeschichte 2000-1*, 17-32.

Baten, J., & Fraunholz, U. (2004). Did Partial Globalization Increase Inequality? The Case of the Latin American Periphery, 1950-2000. *CESifo Economic Studies*, 50(1), 1-41.

Baten, J., & Murray, J. (2000). Heights of Men and Women in 19th Century Bavaria: Economic, Nutritional, and Disease Influences. *Explorations in Economic History*, 37, 351-369.

Bates, R. H. (1981). *Markets and States in Tropical Africa: The Political Basis of Agricultural Policies.* Los Angeles: University of California Press.

Bigsten, A. (1985). *Income Distribution and Growth in a Dual Economy. PhD thesis, Gothenburg University, Department of Economics.*

Bigsten, A. (1986). Welfare and Economic Growth in Kenya, 1914-76. *World Development*, 14(9), 1151-1160.

Billewicz, W.Z. & McGregor, I.A. (1982). A Birth-to-Maturity Longitudinal Study of Heights and Weights in Two West African (Gambian) Villages. *Annals of Human Biology*, 39, 241-250.

Boehm, T. (2003). Ist der Saekulare Trend zum Stillstand gekommen? Paper presented to the (German) Anthropological Society, Potsdam.

Bogin, B. (1991). Measurement of Growth Variability and Environmental Quality in Guatemalan Children. *Annals of Human Biology,* 18, 285-294.

Bratton, M., & van de Walle, N. (1997). *Democratic Experiments in Africa: Regime Transitions in Comparative Perspective*. Cambridge: Cambridge University Press.

Bryceson, D.F. (1989). Nutrition and the Commoditization of Food in Sub Saharan Africa. *Social Science & Medicine,* 28(5), 425-440.

Cavalli-Sforza, L.L. (1986). *African Pygmies.* New York: Academic Press.

Deaton, A. & Miller, R. (1995). International Commodity Prices, Macroeconomic Performance and Politics in Sub-Saharan Africa. *Princeton Studies in International Finance*, no. 79.

Deaton, A. (2001). Relative Deprivation, Inequality and Mortality. *NBER Working Paper 8099.*

Deininger, K., & Squire, L. (1996). A New Data Set Measuring Income Inequality. *The World Bank Economic Review*, 10(3), 565-591.

Delajara, M. (2004). Economic Development and the Quality of Life of Children. *Revista de Historia Economica*, 22(l), 13-38.

Dercon, S. (1998). Wealth, Risk and Activity Choice: Cattle in Western Tanzania. *Journal of Development Economics*, 55, 1-42.

Deshler, W. (1963). Cattle in Africa: Distribution, Types and Problems. *Geographical Review*, 53(1), 52-58.

Easterly, W., & Levine, R. (1997). Africa's Growth Tragedy: Policies and Ethnic Divisions. *Quarterly Journal of Economics,* 112(4), 1203-1250.

Eksmyr, R. (1970). Anthropometry in Privileged Ethiopian Preschool Children. *Acta Paediatrica Scandinavica,* 59, 157-163.

Eveleth, P.B, & Tanner, J.M. (1990). *Worldwide Variation in Human Growth, 2nd Ed.* Cambridge: Cambridge University Press.

FAOSTAT. Food Balance Sheets. http://apps.fao.org/.

Fafchamps, M., Udry, C., & Czukas, K. (1998). Drought and Saving in West Africa: Are Livestock a Buffer Stock? *Journal of Development Economics,* 55, 273-305.

Fiawoo, D. K. 1979. Physical Growth and the School Environment: A West African Example. In W.A. Stini (Ed.), *Physiological and Morphological Adaptation and Evolution* (pp. 301-314). The Hague: Mouton.

Ford, J. (1971). *The Role of the Trypanosomiases in African Ecology: A Study of the Tsetse Fly Problem*. Oxford: Clarendon Press.

Goetz, S.J. (1992). Economies of Scope and the Cash Crop – Food Crop Debate in Senegal. *World Development*, 20(5), 727-734.

Graitcer, P. L. & Gentry, E. M. (1981). Measuring Children: One Reference for All. *The Lancet* 2: 297-299.

Habicht, J.P., Martorell, R., Yarbrough, C., Malina, R.M., & Klein, R.E. (1974). Height and Weight Standards for Preschool Children: How Relevant are Ethnic Differences? *The Lancet*, 6, 611-615.

Jakobsen, O. (1987). Economic and Geographical Factors Influencing Child Malnutrition in the Southern Highlands, Tanzania. In R. Akhtar (Ed.), *Health and Disease in Tropical Africa: Geographical and Medical Viewpoints* (pp. 203-244). London: Harwood.

Jha, S.K. (1996). The Kuznets Curve: A Reassessment. *World Development*, 24, 773-780.

Klasen, S. (1999). Does Gender Inequality Reduce Growth and Development: Evidence from Cross-Country Regressions. Background Report for the World Bank Policy Research Report on Gender and Development. Presented on the World Bank Conference in Oslo, 22.-24.6. 1999. Washington, DC: The World Bank.

Komlos, J. (1985). Stature and Nutrition in the Habsburg Monarchy: The Standard of Living and Economic Development. *American Historical Review*, 90, 1149-1161.

Komlos, J., & Baten, J. (Eds.). (1998). *The Biological Standard of Living in Comparative Perspective*, Stuttgart: Steiner Verlag.

Komlos, J. & Kriwy, P. (2003). The Biological Standard of Living in the Two Germanies. *German Economic Review*, 4(4), 459-73.

Kuznets, S. (1955). Economic Growth and Income Inequality. *American Economic Review,* 45(1): 1-28.

Leamer, E.E., Maul, H., Rodriguez, S. & Schott, P.K. (1999). Does Natural Resource Abundance Increase Latin American Income Inequality? *Journal of Development Economics*, 59, 3-42.

Loaiza, E. (1997). Maternal nutritional status. *DHS Comparative Studies* No. 24, Calverton, Maryland, USA: Macro International Inc.

Lipton, M. 1977. *Why Poor People Stay Poor*. Cambridge, MA: Harvard University Press.

Macro Int. (2004). Demographic and Health Surveys. www.measuredhs.com. DHS-surveys completed after February 2004 were not included.

Maxwell, S., & Fernando, A. (1989). Cash Crops in Developing Countries: The Issues, the Facts, the Policies. *World Development*, 17(11), 1677-1708.

Milanovic, B. (1994). Determinants of Cross-Country Income Inequality: An Augmented Kuznets Hypothesis. World Bank Policy Research Working Paper 1246**.**

Milanovic, B. (2003). Is Inequality in Africa Really Different? *Working Paper No. 3169*. World Bank, Development Research Group.

Morrison, D.G. & Mitchell, R., & Paden, J. (1989). *Black Africa Handbook, 2nd Ed.* New York: Paragon Press.

National Geospatial-Intelligence Agency. GEOnet Names Server. http://www.nima.mil/.

National Population Commission [Nigeria]. (2000). *Nigeria Demographic and Health Survey 1999.* Calverton, Maryland: National Population Commission and ORC/Macro.

Ndagala, D.K. (1981). Pastoralists and Cultivators in Bagamoyo District. In R. Chambers, R. Longhurst & A. Pacey (Eds.), *Seasonal Dimensions to Rural Poverty* (pp. 186-192). London: Pinter.

Pelletier, D.L. (1994). The Relationship Between Child Anthropometry and Mortality in Developing Countries. *Journal of Nutrition Supplement,* 124, 2047S-2081S.

Pradhan, M., Sahn, D.E., & Younger, S.D. (2003). Decomposing World Health Inequality. *Journal of Health Economics*, 22(2), 271-293.

Quiroga, G., & Coll, S. (2000). Income Distribution in the Mirror of Height Differences: The Case of Spain: 1895–1950. *Journal of Income Distribution,* 9(1), 107–131.

Sachs, J.D., & Warner, A.M. (1995). Natural Resource Abundance and Economic Growth. *NBER Working Paper No. 5398.*

Schmitt, L.H. & Harrison, G.A. (1988). Patterns in the Within-Population Variability of Stature and Weight. *Annals of Human Biology*, 15(5), 353-364.

Schneider, R. (1996). Historical Note on Height and Parental Consumption Decisions, *Economic Letters* 50: 279-283.

Soltow, L. (1992). Inequalities in the Standard of Living in the U.S., 1798–1875. In R.E. Gallman & J.J. Wallis (Eds.), *American Economic Growth and Standards of Living Before the Civil War* (pp. 121–171), Chicago: University of Chicago Press.

Steckel, R. (1995). Stature and the Standard of Living. *Journal of Economic Literature,* 33(4), 1903–1940.

Steckel, R., & Floud, R. (Eds.). (1997). Health and Welfare During Industrialization. Chicago: University of Chicago Press.

Steel, W. F., & Evans, J.W. (1984). Industrialization in Sub-Saharan Africa: Strategies and Performance. *World Bank Technical Paper Nr. 25*. Washington, DC: World Bank.

Sunder, M. (2003). The Making of Giants in a Welfare State: The Norwegian Experience in the 20th Century. *Economics & Human Biology,* 1(2), 267-276.

UN Population Division (2003). *World Population Prospects: The 2002 Revision*. New York: United Nations.

Waaler, H. T. (1984). Height, Weight and Mortality. The Norwegian Experience. *Acta Medica Scandinavica* Supplementum, 679, S1-S56.

Weir, D. (1993). Parental Consumption Decisions and Child Health During the Early French Fertility Decline, *Journal of Economic History,*53(2), 259-274.

World Bank. Living Standard Measurement Study. http://www.worldbank.org/lsms/.

Appendix Table A1: Height CVs, regional height difference (compared to national mean), cattle per capita and education in 200 regions

Country	Region	CV	Regional mean height – national mean height (in mm)#	Population share of region (in %)	Cattle per capita	Mean education in single years
Benin	Atacora	3.896	3.068	14.40	0.251	0.680
	Zou, Mono	4.062	-14.199	31.45	0.026	1.078
	Borgou	3.672	14.880	14.73	0.566	1.286
	Atlantique, Oueme	3.782	4.713	39.42	0.035	3.118
Burkina Faso	Ougadougou, Kadiogo	3.733	6.235	9.41	0.065	3.963
	Kossi, Banwa, Houet, Bougouriba, Ioba	3.634	7.467	18.41	0.378	0.914
	Gnagna, Namentenga, Yagha, Kouritenga, Ganzourgou	3.555	4.904	11.42	0.449	0.237
	Kourweogo, Sissili, Boulkiemde, Oubritenga, Bazega, Sangauie, Ziro	3.815	-3.047	21.24	0.270	0.317
	Bam, Yatenga, Sourou, Nayala, Loroum	3.377	6.245	12.27	0.367	0.443
	Nahouri, Zoundweogo, Boulgo	3.638	-18.990	7.07	0.174	0.413
	Seno, Soum, Oudalan	3.784	-14.759	5.72	1.791	0.107
	Tapoa, Gourma, Koulpelego	3.771	-5.600	7.42	0.332	0.147
	Kenedougou, Comoe, Poni	3.634	-6.324	7.04	0.466	0.407
CAR	Ouham, Ouham-Pende	4.069	0.131	21.60	0.252	0.786
	Haut-Mbomou, Basse-Kotto, Mbomou	3.992	-0.983	13.38	0.000	1.420
	Ombella-Mpoko, Lobaye, Bangui	3.966	5.577	26.00	0.000	4.447
	Vakaga, Ouaka, Bamingui-Bangoran, Hautte-Kotto	4.181	17.581	12.86	0.929	1.928
	Nana-Gribizi, Kemo	3.121	2.625	7.00	0.000	1.943
	Nana-Mambere, Sangha-Mbaere, Mambere-Kadei	3.848	-23.913	19.16	0.440	1.733
Cameroon	Central, South, East	3.797	10.546	24.25	0.009	6.751
	Extrem North	3.971	-5.507	18.20	0.572	0.421
	Southwest, Northwest	3.785	-26.060	20.89	0.286	5.739
	North, Adamaoua	3.691	0.396	10.94	1.302	0.726
	West & Littoral	3.770	15.262	25.72	0.060	7.071
Chad	Mayo-Kebbi	4.039	-0.875	14.94	0.377	0.876
	Tandjile	3.789	7.780	7.01	0.095	0.647
	B.E.T., Kanem, Batha, Biltine	3.870	-16.481	20.59	3.228	0.073
	Logone Occidental, Logone Oriental	3.950	11.249	13.09	0.013	0.645
	Lac, N'Djamena, Guera, Chari-Baguirmi	3.837	-2.366	20.77	1.564	1.082
	Salamat, Moyen Chari	3.844	13.889	14.07	0.353	0.989
	Ouaddai	3.630	-12.587	9.53	2.331	0.123
Comoros	Anjouan	3.899	-14.121	39.66	0.111	2.520
	Grande Comore, Mwali	3.453	10.151	60.34	0.219	4.061
Eritrea	Gash - Barka	3.990	-11.242	19.07	2.146	0.278
	Anseba	3.519	-13.950	14.83	2.760	1.081
	Southern (Debub)	3.266	16.587	25.98	0.000	0.761
	Northern Red Sea (Semenawi-Keih Bahri)	3.887	-16.622	14.52	1.409	0.731
	Central (Maekel)	3.482	12.049	18.58	0.000	5.018
	Southern Red Sea (Debub-Keih Bahri)	3.178	-14.802	7.01	1.459	1.207
Ethiopia	Tigray	3.566	-7.819	5.87	1.101	1.068
	Benshangul-Gumuz	3.954	7.402	0.86	5.623	0.966
	Somali	4.048	61.270	5.90	2.282	0.730
	Addis	3.601	4.430	3.95	0.000	7.737
	Amhara	3.541	-10.988	25.83	1.022	0.920
	SNNP (Southern)	3.963	-4.137	19.46	0.470	1.336
	Harari	4.066	20.386	0.25	0.000	4.585
	Gambela	5.192	49.458	0.34	1.582	1.831
	Afar	3.583	-3.548	2.07	2.601	0.774
	Oromiya	3.884	7.885	35.00	0.969	1.370

	Dire Dawa	3.657	11.468	0.47	0.000	4.896
Gabon	South (Ngounie, Nyanga)	3.597	-7.894	20.72	0.000	5.566
	West (Estuaire, Moyen Ogooue, Oggoue Maritime, Libreville, Port Gentil)	3.783	8.590	38.59	0.000	8.474
	North (Wouleu-Ntem, Ogooue-Ivindo)	3.909	-8.480	21.87	0.000	6.124
	East (Ogooue-Lolo, Haut-Ogooue)	3.836	-14.870	18.82	0.000	6.198
Ghana	Volta	3.375	3.424	9.86	0.093	5.745
	Upper West	3.086	12.596	3.56	0.491	1.624
	Greater Accra	3.523	7.279	11.64	0.029	8.531
	Ashanti	3.727	-10.635	17.00	0.000	6.203
	Western	3.569	-9.783	9.42	0.000	5.649
	Northern	3.605	7.733	9.47	0.220	1.185
	Upper East	3.647	16.831	6.28	0.265	1.428
	Central	3.695	-4.762	9.29	0.000	6.026
	Brong-Ahafo	3.652	-0.261	9.81	0.017	5.814
	Eastern	3.752	-3.307	13.67	0.018	6.889
Guinea	Upper Guinea	3.748	9.922	18.80	0.472	0.436
	Lower Guinea	3.833	-1.666	19.85	0.374	0.829
	Central Guinea	4.110	0.390	27.59	0.648	0.431
	Conakry	3.821	11.811	12.20	0.000	4.830
	Forest Guinea	3.974	-11.655	21.57	0.154	0.940
Ivory Coast	Bouna, Tanda, Bondoukou	4.423	-3.748	4.75	0.256	0.828
	Abengourou, Agnibilekrou	4.084	-8.618	2.78	0.000	1.356
	Katiola, Dabakala, Beoumi, Sakassou, Bouake, Mbahiakro	3.382	10.632	8.46	0.112	1.954
	Abidjan,Grand-Lahou, Tiassale, Aboisso, Adzope, Agboville, Divo, Lakota	3.942	6.226	35.53	0.004	3.728
	Ferkessedougou, Boundiali, Tingrela, Korhogo	2.908	-23.844	6.89	0.530	1.125
	Daloa, Issia, Vavoua, Gagnoa, Oume, Sinfra, Zuenola, Bouafle	3.719	0.963	14.27	0.000	2.511
	Sassandra, Soubre, San Pedro, Tabou	3.519	25.080	5.99	0.000	2.636
	Yamoussoukro, Toumodi, Daoukro, Dimbokro, Bongouanou	3.632	11.592	7.54	0.000	1.573
	Man, Danane, Bangolo, Duekoue, Guiglo, Biankouma	3.990	-2.530	8.95	0.015	2.081
	Odienne, Touba, Seguela, Mankono	4.420	-29.204	4.83	0.224	0.484
Kenya	Central, Nairobi	3.671	-5.982	20.71	0.173	8.051
	Coast	3.989	-26.050	8.76	0.583	4.502
	Nyanza, Western	3.916	15.068	29.21	0.884	6.112
	Rift Valley	3.422	8.652	21.14	1.475	6.006
	Eastern	3.541	-19.931	17.75	0.933	6.294
Madagascar	Antsiranana	3.476	7.080	7.86	1.022	3.695
	Toliary	3.747	8.622	13.60	3.689	2.773
	Toamasina	4.057	0.374	15.51	0.597	4.750
	Mahajanga	3.800	5.206	10.78	1.670	3.589
	Antananarivo	3.627	-5.011	28.51	1.349	5.836
	Fianarantsoa	3.850	-1.917	23.73	0.873	3.247
Malawi	Central	3.788	5.354	38.64	0.130	3.031
	Southern	3.808	-3.847	49.66	0.027	2.937
	Northern	3.515	-3.504	11.70	0.342	5.323
Mali	Gao, Kidal	3.487	4.998	5.04	3.281	2.044
	Kayes	3.785	12.334	13.89	0.632	0.681
	Segou	3.332	-3.564	17.43	0.339	0.536
	Mopti	3.818	-8.357	16.55	0.832	0.661
	Koulikoro, Bamako	3.820	7.494	23.97	0.394	2.341
	Timbuktu	3.496	2.257	5.95	3.176	0.598
	Sikasso	3.727	-11.307	17.18	0.298	0.528
Mauritania	Hodh El Gharbi	3.333	-8.561	8.54	1.686	1.590
	Dakhlet Nouadhibou	4.347	-1.184	3.38	0.000	4.800
	Brakna, Gorgol, Guidimaka	3.643	21.118	26.44	3.420	1.342

	Tagant, Assaba	3.558	-4.346	12.45	2.572	1.358
	Tiris Zemmour, Adrar	3.797	-7.554	5.05	0.158	3.305
	Nouakchott	4.138	-1.709	21.10	0.000	3.769
	Trarza, Inchiri	3.937	-19.373	11.65	2.610	2.791
	Hodh Ech-Chargui	4.052	-13.406	11.38	3.937	1.795
Mozambique	Gaza	3.718	28.655	8.17	0.527	2.919
	Zambezia	3.595	-17.477	20.61	0.039	2.229
	Cabo Delgado	2.835	-14.040	7.75	0.000	1.667
	Niassa	3.166	-20.426	4.24	0.016	1.631
	Tete	3.469	-0.470	6.85	0.309	1.521
	Nampula	3.674	-29.031	19.81	0.003	1.415
	Sofala	3.298	6.428	8.78	0.015	0.978
	Cidade de Maputo, Maputo	3.433	33.466	10.28	0.412	4.561
	Manica	3.862	2.632	5.29	0.025	1.799
	Inhambane	3.939	14.829	8.22	0.089	2.743
Namibia	Northwest (Owambo)	3.797	2.724	43.88	0.316	6.261
	Central (Kaokoland, Damaraland, Karibib, Outjo, Tsumeb, Grootfontein, Okahandja, Hereroland Wes & Oos, Omaruru, Otjiwarongo, Boesmanland)	4.526	3.961	17.12	11.774	5.116
	Northeast (Caprivi, Kavango)	3.760	6.768	14.79	0.208	4.806
	South (Swakopmund, Lüderitz, Karasburg, Bethanien, Keetmanshop, Mariental, Maltahöhe, Namaland, Gobabis, Rehoboth)	4.130	-9.762	24.21	4.768	8.033
Niger	Tillabery, Niamey	3.620	7.587	23.87	0.875	1.252
	Diffa	2.823	15.695	2.61	4.865	0.338
	Agadez	3.650	16.409	2.81	1.204	1.610
	Tahoua	3.680	7.246	18.02	1.175	0.256
	Maradi	3.795	-15.952	19.16	0.884	0.388
	Dosso	3.919	16.550	14.07	0.542	0.387
	Zinder	3.495	-14.059	19.46	1.248	0.288
Nigeria	Nassarawa, Adamawa, Plateau, Taraba, Benue		-1.293	10.92	0.164	1.325
	Abuja, Kogi, Niger, Kwara		-1.526	7.37	0.063	3.114
	Oyo, Osun, Ogun, Lagos, Delta, Ekiti, Edo, Ondo		27.966	25.23	0.008	7.170
	Zamfara, Sokoto, Katsina, Kebbi, Kaduna		-2.403	16.16	0.244	0.982
	Bauchi, Yobe, Borno, Gombe, Kano, Jigawa		0.090	18.94	0.467	5.065
	Abia, Anambra, Imo, Rivers, Cross River, Bayelsa, Akwa Ibom, Enugu, Ebonyi		-29.025	21.38	0.022	7.017
Rwanda	Cyangugu	3.984	-17.462	7.47	0.016	4.309
	Gitarama	3.916	3.267	10.59	0.236	4.041
	Kigali Rurale	3.921	4.517	9.71	0.245	3.674
	Butare	4.201	-4.757	8.85	0.175	3.521
	Byumba	3.678	0.334	8.73	0.218	2.642
	Umutara	3.937	18.484	5.19	0.138	2.842
	Gisenyi	4.047	4.473	10.62	0.090	3.014
	Ruhengeri	3.679	2.308	10.95	0.065	3.125
	Kibuye	3.886	-20.902	5.73	0.208	2.247
	Kibungo	3.879	0.659	8.67	0.124	3.477
	Kigali Ville (PVK)	4.013	27.531	7.45	0.032	6.835
	Gikongoro	3.688	-8.727	6.03	0.256	2.276
Senegal	Diourbel, Fatick, Kaolack	3.954	-1.661	27.70	0.564	0.574
	Tambacounda	3.749	-11.768	5.49	0.621	0.688
	Saint-Louis	3.996	12.955	9.41	0.679	0.966
	Dakar, Thies	3.544	1.569	35.93	0.091	3.468
	Ziguinchor, Kolda	3.184	-34.007	14.20	0.410	2.803
	Louga	3.603	15.067	7.27	1.563	0.779
Tanzania	Kagera	3.734	16.568	5.79	0.181	5.267
	Tabora	3.568	18.043	4.52	1.362	5.883
	Shinyanga	3.428	19.377	7.74	1.745	3.845

	Singida	3.430	20.736	3.46	2.086	5.121
	Kigoma	3.847	-4.100	3.73	0.246	4.523
	Iringa	3.514	-17.285	5.28	0.522	4.896
	Dodoma	3.694	-8.457	5.40	1.286	5.713
	Mara	3.038	36.851	4.24	1.113	5.788
	Kilimanjaro	3.843	-2.901	4.84	0.406	6.788
	Mbeya	3.803	-6.879	6.44	0.549	5.744
	Ruvuma	3.673	-26.463	3.42	0.077	5.903
	Dar Es Salaam	3.734	-0.144	7.58	0.000	6.516
	Arusha	3.695	21.314	5.90	2.310	4.201
	Mtwara	3.630	-43.047	3.88	0.000	4.777
	Tanga	4.242	-26.082	5.60	0.211	5.824
	Morogoro	3.686	-32.440	5.34	0.123	4.915
	Mwanza	4.130	16.523	8.20	1.343	4.095
	Coast	3.409	-29.872	2.78	0.094	5.136
	Rukwa	3.480	6.148	3.03	0.346	4.444
	Lindi	3.815	-36.010	2.82	0.000	5.533
Togo	Savanes, Kara	3.677	0.095	28.88	0.192	1.309
	Centrale	3.699	4.636	10.23	0.169	2.050
	Plateaux	3.744	-2.463	21.36	0.065	2.488
	Maritime, Lome	3.570	0.320	39.53	0.018	3.010
Uganda	Kampala, Mpigi, Masaka, Rakai, Kalangala	3.861	-9.774	17.60	0.226	6.230
	Arua, Moyo, Nebbi, Gulu	3.858	-5.468	8.79	0.308	2.213
	Masindi, Hoima, Kibaale	3.455	-12.167	4.04	0.118	2.871
	Rukungiri, Kabale, Kisoro	3.825	-11.132	5.94	0.187	3.170
	Soroti, Kumi, Pallisa, Kamuli, Mbale, Tororo, Kapchorwa, Jinja, Iganga	3.934	7.536	24.79	0.571	3.869
	Kabarole, Kasese, Bushenyi, Mbarara, Bundibugyo	3.971	-1.752	17.28	0.295	3.280
	Luwero, Mukono, Mubende, Kiboga	4.100	-19.489	11.48	0.513	4.641
	Lira, Apac, Kotido, Moroto	3.488	36.890	10.08	1.799	2.389
Zambia	Copperbelt	3.682	21.311	21.99	0.017	7.596
	Eastern	3.436	-21.262	11.56	0.587	4.124
	Northern	4.033	-14.262	11.94	0.126	4.816
	North-Western	4.071	-1.074	5.31	0.035	4.704
	Southern	3.510	12.248	12.09	1.200	5.966
	Central	3.938	7.877	9.05	0.479	6.113
	Luapula	3.683	-22.055	7.27	0.000	4.379
	Lusaka	3.770	6.829	12.22	0.308	7.089
	Western	3.644	-1.185	8.59	0.965	4.690
Zimbabwe	Mashonaland East, Harare	3.889	5.464	19.82	0.665	8.494
	Masvingo	4.163	19.773	13.67	1.021	5.953
	Manicaland	3.756	-9.306	14.57	0.895	6.559
	Mashonaland West	5.017	-18.996	11.38	0.627	5.304
	Mashonaland Central	3.583	-14.095	7.47	0.603	4.506
	Matabeleland North	3.464	-1.694	11.73	0.780	5.912
	Matabeleland South, Bulawayo	3.600	5.140	6.89	2.996	8.185
	Midlands	3.435	3.036	14.47	0.750	7.217

Because regional population shares differ, the differences do not sum up to 0.

[1] The World Income Inequality Database/ WIDER does not provide any additional gini coefficients for SSA in this period.

[2] Except for Kenya, where the North-Eastern province (about 3% of the population), and Uganda (some northern districts) were not surveyed.

[3] The surveys with an anthropometric section (all-women anthropometric part in italics) are Benin 1996 and *2001*, Burkina Faso 1992/93 and 1998/99, Cameroon 1998, CAR 1994/95, Chad 1996/97, Comoros 1996, Côte d'Ivoire 1994 and *1998/99*, *Ethiopia 2000*, Eritrea 1995, Gabon 2000, Ghana 1993 and 1998, Guinea 1999, Kenya 1993 and 1998, Madagascar 1997, Malawi 1992 and *2000*, Mali 1995/96, *Mauritania 2000*, Mozambique 1997, Namibia 1992, Niger 1992 and 1998, Nigeria 1999, *Rwanda 2000*, Senegal 1992/93, Tanzania 1992 and 1996, Togo 1998, Uganda 1995 and *2000*, Zambia 1992 and 1996, and Zimbabwe 1994 and *1999*.

[4] Lecaillon et al. (1984) quoted a gini-coefficient for Togo of 33.8 in the year 1957, Jain (1975) gives a value of 44.0 for Uganda in 1970. The income definitions of both sources are equal. Although the base year differs slightly, the data provides a rough and general assessment.

[5] Recently, Pradhan et al., 2003 have suggested the Theil entropy measure of height as an inequality indicator. If the CV of height is calculated for their data, both measures are highly correlated (a regression R-square of 0.99), hence the CV can easily be converted into the Theil measure.

[6] This should be interpreted only as a weak indicator of measurement errors, because missing figures mught be due to female employment rather than a refusal to be measured (Loaiza, 1997).

[7] Based on 2x7 surveys with mothers only, to exclude the effect of the selection of mothers which is largest in this age group (see above).

[8] Note that this strategy does not result in a total correction of the inconsistencies, e.g. if income definitions absorb time effects.

[9] We excluded the pygmies, since their adolescent growth spurt is substantially shorter (Cavalli-Sforza, 1986).

[10] Migration might affect both measures. With information from the DHS-surveys, we tested the impact of migration on inequality. After controlling for the determinants in Table 4 & Table 5, however, we found no significant influence of that percentage of inhabitants who had never changed their residence.

[11] Mean differencing of heights y and the explanatory variables x transforms a usual regression equation into:

$$(1.1) \qquad \left(y_{ir} - \overline{y_i}\right) = \sum_{k=1}^{K} \beta_k (x_{k,\,ir} - \overline{x_{k,\,i}}) + u_{ir}$$

for a region r of country i as well as K explanatory variables.

In contrast, a country fixed-effects specification has the following form:

(1.2) $$y_{ir} = a_i + \sum_{k=1}^{K} \beta_k x_{k,\,ir} + u_{ir}$$

where a_i are the country fixed-effects. Taking the mean from (1.2) for each region yields

(1.3) $$\overline{y_i} = a_i + \sum_{k=1}^{K} \beta_k \overline{x_{k,i}} + \overline{u_i} \qquad \text{with } \overline{u_i} = 0$$

Subtracting (1.3) from (1.2), we get (1.1). Consequently, both equations (1.1) and (1.2) give the same estimators β_k.

[12] The figure was calculated from the FAOSTAT database and refers to the 28 countries in our analysis.

[13] The adjusted R^2 is increasing, which suggests that our variables at the national level capture the unobserved country differences of the fixed-effects regression.

[14] Figures refer to the countries in our analysis. Own calculation. Data source for agricultural and total exports (in national currencies) was the Yearbook of International Trade Statistics. The total value of exports, agricultural exports and GDP (in current US$) were derived from FAO records and the World Bank.

[15] Ady (1965) is also the source for the data on other industries and mineral deposits.

[16] The population data is chosen from census figures reported by Law (1999) in such a way that geographical units match. The census years differ between the countries. We therefore calculated the population share and multiplied them by the FAO population estimates for 1960. Since we found a high correlation in the population shares of different censuses, the impact of migration should be negligible.

[17] An inflationary number of measures have been suggested to approximate **ethnicity**. Easterly and Levine (1997) used the Index of Ethnolinguistic Fractionalization (ELF60), which measures the probability that two randomly selected people from any given country in 1960 will not belong to the same ethno-linguistic group. Alternatively, the Ethnicity Index by Bratton and van de Walle (1997) describes the effective number of ethnic groups in a country. Moreover, Morrison et al. (1989) report the largest ethnic group's share of the population, which provides additional information on the majority’s capability to exercise power over minorities. In fact, the three indices are highly correlated.