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INEQUALITY IN SUB-SAHARAN AFRICA 1950-80: NEW ESTIMATES AND NEW RESULTS

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Abstract
There is an enormous scarcity of reliable data that measure inequality, especially in LDCs. This study uses anthropometric techniques and extends the inequality database for Sub-Saharan Africa (SSA) to not less than 28 nations over six five-year periods from 1950 to 1980, and to some 200 regions within those countries. We test in depth many potential concerns about height inequality measures, and find no evidence for major inconsistencies. In a second step, we test the determinants of intraregional and interregional inequality. The 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. Among a number of other factors, we find that cash cropping of a single product increase inequality, whereas diversified cash cropping has the opposite effect.

Introduction

Recent economic debates created a large interest in inequality. Inequality is considered on the one hand as an important measure of well-being. Frank (2000) and Deaton (2001) suggested that inequality should be considered as an important component of the standard of living. Being at the bottom of the income distribution is much harder to bear if the distance to the wealthier part of the economy is large. On the other hand, inequality is also a crucial explanatory variable for economic phenomena such as growth, human capital formation, economic processes that lead to violent conflicts and similar issues. For example, many growth studies in the 1990s found a strong negative impact of inequality on growth (Galor and Zeira, 1993; Alesina and Perotti, 1994; Alesina and Rodrik, 1994; Persson and Tabellini, 1994; Birdsall et al., 1995; Clarke, 1995; Benabou, 1996; Deininger and Squire, 1998). Recently, two studies have questioned the generality of this finding. Barro (2000) argued that inequality is preventing growth only in very poor countries, while medium income countries actually grew faster with more inequality. Forbes (2000) found that most of the inequality retardation effect is picked up by time invariant fixed effects, and in the short run inequality is correlated positively with growth. Hence, this is an example for an on-going debate that is certainly indicating the importance of inequality studies by economists - and there are more debates on inequality.

The central question of this paper is whether we can measure inequality in SSA during the 1950s to 1970s with anthropometric variability indicators, such as the coefficient of height variation ('height CV' for short. We will explain below how this measure is constructed). This measure has the potential to increase our knowledge on inequality significantly. The time period of 1950-80 and the countries in Africa have many white spots on the inequality data map. Moreover, if the height CV is a proper inequality indicator in such a multi-ethnic continent as Africa, it would probably be also applicable to other Less Developed Countries

(LDCs). The paper is structured as follows. After discussing the general problems and advantages of anthropometric inequality measures in section 1, we test in depth the validity of some special concerns in section 2, and focus on the female-male relationship of height inequality. We also specify formulas to convert height CVs into approximately equivalent Gini coefficients of income. This can be useful if, for example, further applications want to pool height CVs and other inequality data. In section 3 we present a map, which shows height inequality in (and between) some 200 administrative regions in SSA. And finally in section 4 we provide answers to the crucial question: What determines height inequality in SSA? We will check a number of factors that might not be directly related to economic processes, such as ethnic fractionalization and some interesting economic determinants of inequality such as natural resource abundance and cash cropping. The article closes with a summary.

1. Anthropometric inequality measures for LDCs: problems and advantages

There are numerous ways to measure and conceptualize inequality. Firstly, due to the traditional structure of economic data that tends to be mainly aggregated by national entities, we have to distinguish between-country and within-country inequality. In this study, we will consider only inequality within countries, and within regions of those countries.

The development of inequality within LDCs is particularly unclear because available data are problematic. The well-known Deininger and Squire data set (1996), for example, provides only eight Gini coefficients of income for the period before 1980, labeled as "acceptable" in terms of high quality. Atkinson and Brandolini (2001) convincingly pointed to serious flaws arising from insufficient consistency across countries and time in the income inequality data collected by Deininger and Squire. In contrast, we would argue that significant inconsistencies do not exist in the height data that we will introduce in the following. Moreover, the samples of households are nationally representative[1] for the point of time the surveys were carried out. Thus the analysis of stature can be based on a large population coverage.

Which measures of inequality have been used for LDCs until now? Those studies that go back in time with consistent data have concentrated on wage inequality between industries, or they used indicators such as real wage divided by real GDP/c that do not include whole distributions of income, but just two means. Wage inequality is clearly problematic, as so many inhabitants of LDCs do not receive wages: there are many self-employed people - for example, the numerous peasants of SSA. In addition, many people receive their income in the shadow economy, and many potential wage recipients are unemployed. The amount of transfer between the wage recipient and the rest of her household is also far from constant. In addition, when using wage data we often have to limit our analysis mainly to the large cities, whereas regional inequality is one of the major contributors to overall inequality.

Inequality of heights might be a good complement to conventional indicators, and perhaps an even better indicator in some respect.[2] For Kenya, for example, Klugman et. al. (1999) applied a measure of regional anthropometric inequality. They used the percentage of stunted children under five years by regions. 'Stunted' refers to children, who are more than two standard deviations shorter than the median of a healthy and well-nourished reference population of equal sex and age (WHO Working Group, 1986).[3] Mean adult height can be regarded as an equivalent measure to stunting, which, however, allows us to obtain information on the past: environmental conditions prevailing during the first three years of life have the strongest influence on adult height, because growth velocity in human stature is highest during this age (Eveleth and Tanner, 1990; Baten, 2000a).[4] This is due to the fact that stunted children often end up as shorter adults, which is especially likely in developing countries, where deprivation is very persistent and catch-up growth at later ages negligible. Hence, stature measurements of adults that were recorded decades later can be used to shed light on the period of the first years after birth (such as the Demographic and Health Surveys (DHS), from which we draw the height data). There is a comprehensive anthropometric theory documented in the literature, therefore we can remain brief on this point (Komlos, 1985; Steckel, 1995; Baten, 2000b; and on height inequality especially Baten, 2000a).

The anthropometric parts of the DHS surveys offer an excellent database that reports heights of more than 140000 women from 28 African countries, who were between 15 and 49 years old.[5] Those surveys address child health and health-related behaviour, but they also recorded the heights of mothers, because this is a crucial variable for child health as well. We use this information to answer other important questions.

Since the age of 50 years is considered the edge when individuals start to loose stature, we only excluded women older than this threshold, plus those younger than 20 years because many of them had not yet reached their final height as well as outliers defined as more than three standard deviations afar from the birth cohort mean.

Other advantages of height inequalities are more general. Deaton (2001) and Pradhan, Sahn and Younger (2003) argued convincingly that measures of health inequality are important by themselves, not only in relation to income. While the stature variable has its specific problems, heights do measure important biological aspects of the standard of living.[6] In addition, using this indicator, we are able to include the unemployed, the self-employed, the participants of hidden economies, housewives, children, as well as the previously mentioned wage recipients. We do not claim that height inequality should be the only measure. We would rather argue that in order to answer important questions we have to resort to a multitude of different measures and see the extent to which they correlate with one another.

In principle, we would expect that a certain level of food and medical resources lead to a corresponding height level. If the distribution of these inputs becomes more unequal, the resulting heights should also become more unequal. However, important health inputs are not traded on markets, but are provided as public goods. The height variable has the advantage to be an outcome indicator, whereas real income is an input to human utility. Thus, if inequality of any input oriented kind has a real and severe effect on the net nutritional intake of different groups, then one should find a response in the population's height distribution. Moreover, public goods in the health and educational sphere, for example, with their strong egalitarian impact, are not measured by income inequality, but they are reflected in the inequality of heights.

Height inequality could be measured in principle by standard deviations, coefficients of variation, or centimeter distances between main occupational and income groups. We employ this concept later-on to measure (inter-)regional inequality. The height difference has already often been used by economic historians. In addition, we will use the coefficient of height variation for *intra*regional and overall inequality of a country. The advantage of height CVs is that we do not have to rely on (always somewhat arbitrary) social and occupational classifications. A more detailed study analyzed the different measures of equality for early 19th century Bavaria, as the ideal data set was available for this region and time period (Baten, 1999, 2000a): nearly the whole male population was measured at a homogeneous age and the economic status of all parents was recorded. This allowed for a comparison of the different measures that turned out to be highly correlated. The standard deviation was not a good measure, as anthropologists argued that it increases with average height. The coefficient of variation (CV), in contrast, is a robust estimator of inequality, if certain conditions of homogeneity are fulfilled (especially: no mixture of still growing and adult individuals). Nevertheless, the very high correlation between CV and the standard deviation (if average height is not too unsimilar) makes a comparison with the more intuitive standard deviation possible. Recently, development economists have suggested the Theil entropy measure of height as an inequality indicator (Pradhan, Sahn and Younger, 2003). If the CV of height is calculated for their data, both measures are highly correlated (a regression R-square of 0.99), so the CV can easily be converted into the Theil measure.[7]

Next we need to address the potential problem of measurement error that should be closely scrutinized, especially for data from developing countries. Measurement error leaves mean height estimates unbiased, because errors high and low cancel each other out. Unfortunately, the same is not the case with coefficients of variation, because measurement errors get added into the sum of squares and look to the analyst just like greater inequality. Therefore, variation in CV could be due to variation in measurement error theoretically.

Where would we expect measurement error in our sample? Almost all of the women in a specific country were measured in the same year (some repeated surveys were taken only a few years apart), by similarly educated personnel, so that the sources of measurement error are limited. The only exception is the Nigerian DHS survey. The quality of Nigerian height measurements will be treated separately below. Age misreporting (such as rounding to numbers ending with 0 or 5) cannot be a major problem, because we aggregate all measurements into five year or decadal birth cohorts. One could perhaps imagine that measurement error in general increases over time, because some of the older women start to shrink earlier than others. In that case, we should in general find a larger CV for the age group 45-49. However, if their CV is compared with the one of the age group 40-44 based on another DHS survey carried out about five years prior (thus both age groups are born in the same time period), we find a mean difference in the CV of only 0.004.[8] We also tested whether observations, which depend on less than 300 cases, had higher standard deviations, because a lower number of cases might make an individual measurement error more influential. But again, there is no significant influence when CVs are regressed on a dummy variable for those cases with 300 or less observations (p-value: 0.57). To sum up, while measurement errors should always be seriously scrutinized when using coefficients of height variation, in this case we can reject a potential bias arising from this factor.

2a. Potential problems? "Only" mothers data sets, the age group 20-24, and male vs. female inequality

Two consistency checks and one gender-related question are important to facilitate the interpretation of height inequality derived by the DHS height data.

(1) In some DHS surveys the anthropometric part is limited to women, which have at least given one birth in the last three respectively five years (later called mothers). Thus, only a subgroup of women is included, albeit a large subgroup. Does this selection affect height inequality?

(2) Do still growing individuals introduce an upward bias of the estimated CV in the age group of 20-24 years?

(3) How does the correlation between male and female height inequality look like? Are conclusions about gender redistribution phenomena feasible? Is female height inequality a more sensitive measure than overall height inequality?

(1) In order to analyze the possibility of a biased measure if the CV is based on mothers instead of a totally representative sample of the female population we compute both CVs for those ten countries, for which DHS height data are available for all women. Next, we compare the difference between the CV of mothers (CV_m) with the one of all women (CV_all). Ex-ante, one would expect a lower CV for mothers since this group should be more homogenous: Taller women coming from a rich household have usually less children and are therefore less likely to be selected so the group would consist of the more homogeneous rest.

In general, the development of CV_m and CV_all indicates a very close and positive relationship (Figure 1). Ups and downs often correspond. The age group 45-49 shows the largest deviations, which is not surprising given that mothers in this age group are a relatively small minority and the absolute numbers of observations also are rather small (on average about 150 mothers or 600 women). The line of CV_m is more often below than above the one of CV_all, but intersections occur frequently. Nevertheless, on average, CV_all is larger in all age groups (about 0.05) than CV_m. In the age group 45-49, it differs most, by 0.13 (Table 1). Although the difference of the levels is statistically significant at the 5% level, the extent of this bias represents only 5% of the range of CV_all. Consequently, there would be no fundamental different assessment of inequality, if one uses CV_m instead of CV_all, except perhaps for women in their late forties. As expected the difference between the two CVs vanishes increasingly if the share of the mothers is higher. Given the high fertility rates in Sub-Saharan Africa, mothers cover a large share of the female population. When "all-women" surveys are available, they deliver more reliable information. If only mothers are available and their share of the female population is low, a feasible strategy would be to assign those observations lower weights in regressions or to include the share as a control variable.

(2) Another potential bias could be imagined in the age group 20-24. If some (but not all) women in undernourished societies are growing until their early twenties, this could artificially increase the height CV. In those case, shorter individuals might still grow, and their final height should move closer to the mean and therefore reduce the CV if measured at a later period. We can test this for some countries by comparing the CV of the age group 20-24 with the one of the age group 25-29 in the subsequent survey, because they refer approximately to the same birth cohort (the mean birth years differ half a year on average). In fact, in the twelve surveys mean stature is increasing by four millimeters on average although both age groups are born nearly in the same time period. As expected the increase tends to be

larger the smaller the mean height level of the countries'. Despite of this, the CV of the height distribution is almost constant. The overestimation amounts to a negligible 0.01. Moreover, the Pearson correlation coefficient between the CVs of those aged 20-24 and those 25-29 (of the same birth cohort) is very high (0.61).

(3) With 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 2). In the case of the Ivory Coast the CV for males is on average 7% higher than the one for females. The development, however, has the same pattern with a peak in inequality in 1945 and a falling trend thereafter. The CV of females in Ghana indicates a slowly but constantly increasing inequality, and the CV of males, in contrast, a decline between 1945 and 1960. The absolute difference, however, is small.

One potential reason that height inequality of the sexes does not perfectly correlate is the intra household allocation of resources, which could also change over time. The distribution of high-quality nutrients and medical resources could shift in favor of one sex. For example, in times of economic crises or structural changes, there might be higher expected returns from allocating to one gender only (Klasen 1999; Baten and Murray 2000). Since elasticities are probably higher for females, their CV could even be a more sensitive and reliable measure for inequality: In crisis periods, the poorer households tend to keep the expenditures for boys constant, while they tend to reduce the care for girls.

To sum up, our internal consistency tests suggests the general reliability of our measure and the underlying data for Africa.

2b. The relationship between Gini coefficients of income and height CVs

We would also expect a positive relationship with income inequality, because a more uneven income distribution let the rich people afford a better nutrition and their children to grow taller, while the children of the poor end up with shorter adult height. Conversely, in a totally equal society the *height distribution* should just reflect genetic factors.[9] We already noted that income and height inequality would not be perfectly correlated, if the poor can benefit from public health goods, unrecorded food aid or transfers or non-market entitlements. Nevertheless, the question remains: How closely is height inequality correlated with income inequality, notably the Gini coefficient for income, both across regions and over time?

We have to use the limited pieces of information, which the Gini coefficients collected by Deininger and Squire (1996) offer.[10] For the time period under study, data on income inequality is available for only 15 African countries and a total of 33 five-year periods, mostly 'inconsistently' measured. 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.[11] In the regression we additionally include country fixed effects (Table 2, column 2 and 5). Controlling for the country's fixed effects means that we are analyzing mainly intertemporal effects, excluding most of the slowly changing interregional inequality.

The CV is significantly and positively correlated with the Gini coefficients. However, an increase in the CV by one unit means a rise in the Gini coefficient by only 5.5 points in the fixed effects specification. The relatively small size of the coefficient is almost exclusively influenced by Nigeria, for which 11 Gini coefficients of income are available, and which therefore has a large weight in the regression. In the second regression we add an interaction term for Nigeria and omit country fixed effects. Consequently, the regression coefficient of the CV is much larger. A rise in the CV of one unit means an increase in the Gini coefficient by 20 points under this specification. The significantly negative interaction term (CV*Nigeria) indicates, that the relationship between CVs and Ginis is still positive when running the regression for Nigeria alone, but due to the larger variation of the Nigerian CVs the coefficient is simply smaller. What is so special about Nigerian data? The Nigerian CVs are extreme outliers (between 5.5 and 7) and vary additionally about four times more compared to the CVs of the other African countries (the cross-sectional CVs of all other countries in this regression ranges between 3.52 and 4.22). A likely reason for these exceptional characteristics of the Nigerian CV is the data quality of the DHS survey. The anthropometric part is substantially worse than in the other surveys, which does not convey much confidence in the estimated standard deviation of the underlying height distribution. In their final report the National Population Commission (2000) of Nigeria admits, that 'height and weight information of 42 percent of the children under three were deemed to be implausible'. The general lack of accuracy is also evident in the reported heights of their mothers: 10% of the heights are implausibly recorded below 100 cm or above 200 cm. Another 10% of the eligible women were not measured. When using the remaining 80% of the sample, the height distribution turns out to have very heavy tails and still a range from 124 cm to 199 cm (Figure 3). One might argue that the enormous population size and the very large number of ethnic groups in Nigeria might affect the range of heights and that the Nigerian Gini coefficients indicate indeed a high inequality. Nevertheless, given the deficiencies in height measurements, we prefer the conservative procedure to exclude Nigeria totally from the analysis. The regression without Nigeria (3) is equivalent to regression (2) and we obtain a correlation coefficient between height and income inequality of 19.5, which comes very close to the estimate of Baten and Fraunholz (2003) doing the comparison for Latin America: they report a significant coefficient of 15.5 based on Gini coefficients with the highest data quality.

In many cases we have more than one Gini coefficient of income for the same period and country, but measured in different ways. Taking into account that they represent estimations of the same income inequality, we weight them accordingly in the last two regressions. Under this specification, country fixed effects and any other single variable are insignificant, which is simply due to overspecification (only six degrees of freedom). After reducing the model we obtain a regression coefficient for the CV of 20.5. Although this 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.

Note, that the relationship is not sensitive to country fixed effects in general. Only the dummy for Gabon[12] (and Nigeria) had a robust and significantly positive coefficient. For Gabon's oil economy the Gini coefficients indicate a very high income inequality level, but a modest anthropometric inequality (the development over time, in contrast, does correspond). Oil booms let typically skyrocket income inequality via the incomes of relatively small groups whose impact on the overall height CV of the population is modest. 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.

An excellent case to compare 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 4). The development of both inequality measures is nearly identical, except for the sudden fall in 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 the smoother and less volatile movement of the height CV seems at least as likely (there might also be some consumption smoothing making the height CV less volatile). But 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 declining inequality after those events is confirmed by both measures.

Summing up, especially the development of the CVs is a very promising measure to cope with the non-existence or unreliability of inequality data on African countries (see

Appendix). For pooling this data with available Gini coefficients of income one should use the relationship presented in model (5), Table 2.

3. Mapping of Height Inequality at a Disaggregated Scale

In this section, we will address questions such as: how much taller or shorter are women in the regions relative to the national mean? How large is height inequality within a region? Based on the information, in which region the individuals live, the height data allows the mapping of height inequality at a very disaggregated scale. We consider two measures. First, the CV of the region, which indicates nutritional inequality *within* the administrative unit (*intra*regional inequality). Secondly, the region's height difference relative to the national mean stature. A mean stature less than average points to nutritional and health conditions worse than in the rest of the country. This second measure reflects inequality *between* regions (*inter*regional inequality).[13] Given that the 1960s are particularly well documented in our sample, we will focus on inequalities of this birth decade in the following.

When we look at the map of interregional inequality first (Figure 5), we find that some countries have similar north-south patterns of height differences. In Chad, Cameroon, Ivory Coast, Mozambique and Zimbabwe nutritional and health conditions improve from north to south. In contrast, in Mali, and Senegal, the nutritional status of females gradually increases from south to north. Taller women can be also found around Lake Tanganyika (this region is shared among Kenya, Uganda and Tanzania). In many cases, those patterns follow the regional distribution of protein production. In Kenya, Uganda and Tanzania, for example, livestock farming is seriously hindered in the other areas, in which Trypanosomiasis is endemic (Ford, 1971 and Jahnke, 1976). This suggests that there are benefits of proximity to production that we will test below. One exception to this rule is certainly Chad, where the highest cattle per capita values and the shortest women are situated in the North. Chad's spatial pattern of *inter*regional inequality is a perfect example of ethnic discrimination.

Already in colonial times the southerners were favored by the French colonial authorities. More subsidies, more highly paid government positions, more public goods and similar benefits were directed to the south of Chad (Azam and Morrison, 1999). After independence Chad's government consisted mainly of southerners and continued to discriminate the northerners in the access to education, health and other infrastructure. Heights reflect these discriminatory policies astonishingly well: we find the average northern woman born around 1960 three centimeters smaller than a southerner. One might object, that the (Muslim) northerners live in an extremely harsh environment and that female discrimination could have further reduced the stature of women, but Chad's northerners are also two centimeters smaller than the population in the north of neighboring Niger, where similar but less discriminatory conditions prevail.

The map of intraregional inequality (Figure 6) indicates that CVs within a country's regions can be relatively heterogeneous. In Ethiopia, the Ivory Coast, Kenya, Mauritania, Uganda and Zimbabwe, regions with CVs at the top end are close to regions with intraregional inequality at the lower end. In contrast, there is not much difference in the regional CVs in Chad, Ghana, Togo, and Tanzania. Additionally, we can identify a cluster of high inequality running across borders in Northwestern Africa (around Guinea and Cameroon). An interesting case for our measure of intraregional inequality is Namibia. Namibia has a large white minority almost exclusively living in the two large southern regions. Whites have a much higher standard of living than blacks in this country. The height CV does indeed indicate a large intraregional inequality in the two southern areas. However, the mean height of the black population in the two northern areas is even somewhat higher than in the south, so that intraregional inequality is apparently not influenced by their presence.

Apparently, in some extreme cases the national CV is mostly determined 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 amounts to seven centimeters. Similarly, females in the north of Tanzania are six centimeters taller than in the South. In contrast, the CV of most of Tanzania's and Mozambique's provinces is relatively small (below 3.6).

4. Cross-sectional Determinants of Height Inequality between/within the Regions

What factors can explain the observed differences in the CV and mean heights of the administrative regions? We will start with agricultural variables and focus on cattle farming and the cash-crop debate in particular. Other sets of potential influences are industrial structure, mineral resources, distance to the country's capital, urbanization, education, population density and ethnic fractionalization. We will explain how we would expect these factors to influence inter- and intraregional inequality and present the results from a regression analysis in the following.

About 85% of the African population depended on agriculture for their livelihood in the 1960s.[14] In addition, live stock farming and cattle herding is the most important source of animal *proteins*, so that the number of cattle is a good indication of the extent of available proteins. Prices of high-quality proteins tend to be lower in the producing regions, because transaction costs are particularly high in SSA. Hence, this region's consumers benefit more from lower relative food prices (compared to consumers in other regions). Another view expressed by Ndagala (1981) relates to average heights: He 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 like crops to markets. They also do less depend on storages. These characteristics makes holding cattle a form of storing wealth in the absence of conventional credit markets in many parts of SSA (Fafchamps et al. 1998; Dercon 1998). Even though these aspects should be reflected in the prices under perfect competition, competition is not always perfect. In our countries in particular, economic policy and traditions limit the efficiency of markets. Therefore we would expect to find taller women in areas, where cattle per capita is high, because of the higher protein supply and the indication of relative wealth. In areas with production of perishable goods, there are also often non-marketable side-products (such as offal or blood in meat production) that may be consumed by the poorer segments of the local society. Thus, we would also expect lower *intra*regional inequality in protein-producing regions.

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 take information on the regional distribution from his maps and multiply the share within a region with the 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 data.

In fact, cattle per capita relative to the country mean is an important explanatory variable in the regressions of the interregional height differences (Table 3): the higher the relative protein production in a region, the higher the average height. Moreover, the results indicate that a region with higher cattle per capita relative to the country mean has also lower intraregional inequality. However, after replacing the country fixed effects in columns (1) and (4), with measures at the national level, we obtain the opposite effect for national cattle per capita (in the bottom part of Table 4).[15] This result is robust, when we weight the regions by their population share in order to give each country the appropriate weight in the regression (last two columns of Table 3 & 4). Thus, countries with a high national cattle per capita like Burkina Faso, Chad, Ethiopia, Mali, Mauritania, Kenya, Namibia, Niger, Tanzania, Zimbabwe have in general a higher height inequality, but the regions, where cattle are largely concentrated, enjoy still less inequality.

At the national level, we also focused on calories per capita derived from the FAO Food Balance Sheets and found a non-linear relationship.[16] The square root of calories has a significant positive influence in intra-regional inequality, whereas the linear term is significantly negative. Hence at low levels of calories inequality rises with calorie supply, and at higher levels this effect diminishes. This relationship is not unplausible. Moradi (2004) argued, that for SSA food supply is a better indicator of poverty than GDP per capita. While a low calorie supply indicates, that the country is so poor, that it cannot secure the basic nutritional needs, a high calorie supply implies a rather sufficient access to food for probably most of the people. Taking calories as an indicator of deprivation, height inequality between these two extremes should be indeed higher.

Food crops are generally considered to enhance the nutritional situation, but there is a controversial debate on the effect of *cash cropping*. Cash cropping is an important source for income and especially export revenues in Sub-Saharan Africa, but it has been accused of increasing inequality. The importance can be easily illustrated with the fact that in 1965, agricultural cash-crop products generated 74% of the export revenues. Agricultural exports are also substantial in relation to GDP: the ratio of agricultural exports to GDP is as large as 10%.[17] Many African countries have comparative advantages in agriculture like Senegal in the production of groundnuts (Goetz 1992). From the substantial export revenues from groundnuts, food crops can be sufficiently imported. Whether African people could in general gain by specialization and participation in the process of globalization is a fundamental question. Largely positive effects could be an argument to shift policy and opening the economy, but if inequality is associated with cash cropping, the costs in terms of social conflict could be too high.

Which influence of cash cropping would we expect on inequality between regions? On the one hand, cash crops offer a source of income, which could be used to buy food and other goods the household cannot cheaply produce and therefore realizes gains through specialization. This should put a cash crop region ahead compared to regions, where subsistence farming is widespread. However, there are some concerns. Firstly, it is not entirely clear, how large the benefits are. Since the early 1950s real prices for cash crops started to decline, at least until the early 1970s (Deaton and Miller, 1995). Thus, the cash-cropper's real income decreased during the 1960s. Moreover, for generating additional state revenues under the import substitution policy, state owned marketing boards exploited their monopsony position and paid the rural producers less than the world market prices (Ellis, 1982). Therefore, a part of the surplus might have been redirected to other regions. Secondly, cash cropping increases also the dependence on food prices. Given the deficiency in African credit markets savings may not compensate the lower income in years of bad harvests, so that at least in some years subsistence farmers might be better off. Thirdly, it has been argued in gender-related studies that the intra-household allocation in cash-cropping regions disadvantages women. Women loose their income from small sales of agricultural side-products that are typical for subsistence farmers. This might lead to lower expenditures for education, nutrition and health care of children and hence a lower adult height later.

From theoretical reasoning the effect of cash cropping on interregional inequality could be positive, zero or negative. What has the empirical literature found on the interregional effect of cash cropping? Previous studies were mostly based on small numbers of villages. Hence it was difficult to arrive at 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 the opposite effect was observed.

And what about inequality within regions? The literature mostly agrees that cash cropping tended to increase inequality within regions. Those peasants that adopted early had typically a considerable advantage. They benefited from commercial relations. And they 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, which most of the African countries pursued in this period, often favored large cash crop estates by providing subsidies such as cheap input supply of fertilizers, seed or even specialized training programs. Pressure on the collective land tenure system deprived the poor from free access to land. Consequently, a small group of owners of commercial plantations benefited. Furthermore, in the case that marketing is not state owned, cash cropping gave rise to new and better paid occupations like traders, who may also disproportionately benefit compared to the peasants. Therefore, we would expect our *inter*regional measure lower in cash cropping regions.

Given the limited database of earlier studies it is very important to study the effect of cash cropping on both, inter- and intraregional inequality. How could we measure cash cropping in our 200 regions during the 1960s? There are different definitions of cash cropping. Applying the most general definition that a cash crop is a crop sold for cash, a good approximation for cash crop areas is the existence of industries, which process agricultural raw output like sugar cane, tobacco, cotton or grain. Conversely, subsistence farming might be a likely and major activity in the regions, where none of these industries exist. The Oxford Regional Economic Atlas prepared by Ady (1965), describes the locations of agricultural industries, and their underlying resources additionally providing the number of up to eight different cash crop industries.[18] A great variety of agricultural industries points to diversification, so that cash-crop regions would have a more secure income. A concentration on a single cash crop, in contrast, means that the dependency on this segment of market demand is very high. According to this measure monocultural regions are Southeastern Guinea, Northeastern Tanzania, Southern Senegal or the Southern Kenyan coast, for example. A strategy of diversification exists in the Kenyan Rift Valley (the 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 the region’s average height by almost one centimeter (Table 3) and increases intraregional inequality (Table 4). Very interestingly, a diversified cash-cropping strategy has the opposite effects. Heights increase nearly three millimeter for each additional cash-crop industry, and inequality is consistently lower. The coefficients are not only statistically, but also economically significant, because one additional industry lowers inequality by about 0.10, which is about one quarter of the difference between extreme low-inequality countries (Ghana, Togo) and high inequality countries (Namibia, CAR). This finding has important policy implications. Specialization in cash cropping and participation in the process of globalization could have overwhelmingly positive effects on a region’s development with even decreasing inequality as long as a strategy of diversification is pursued.

In some African regions, *industrial production* represented already in the 1960s an important part of economic activity. The development between light and heavy industries was quite different: The latter (steel processing, heavy machinery etc.) was particularly subsidized by governments, because the economic ideologies of the 1960s suggested a key role for those industries. Often, heavy industrial firms were even taken over (or more frequently founded) by the state. Those subsidies or nationalizations typically caused the formation of a small group of high-income earners (managers and their families, and workers in large subsidized or nationalized firms), whereas the rest of the regional economy remained poorer. On average, however, the living standard of those regions might have been slightly higher than the national mean. In contrast, light industries (textiles, footwear, printing) developed under competitive market conditions. Their workers were rather paid the normal, low wages of African economies, because those firms had to compete on goods and labor markets. Nevertheless, their wages might have been still higher than in the rural sector, especially for skilled labor. We therefore would expect higher average regional height, and perhaps lower inequality in light industry regions.

The regression largely confirms our expectations. Heavy and light industries have very different effects on inequality. The existence of light industries is associated with a seven-millimeter higher mean height of the region, which, however, is decreasing with the number of light industries. Unexpectedly, heavy industries display a negative effect on mean height, which is significant when we weight the regions by their population share (Table 3, column (4) & (5)). One reason for this result might be, that heavy industrial regions did not perform well during the 1960s, because of the x-inefficiencies of nationalized or subsidized industries. The same line of reasoning could also explain the better performance of light industry regions. In terms of intraregional effects, heavy industry regions have a much higher inequality (Table 4). In contrast, the number of light industries reduces inequality (significant in the weighted regression).

Mineral resources often generate substantial revenues. If mines apply capital-intensive technologies (mining equipment like diggers) the few that possess the mines or work as high-skilled personnel there (and their relatives) should achieve a high income, the rest of the regional population would be expected to be poorer (Leamer et al., 1999). Moreover, it is often assumed, that the exploitation of mineral resources has no externalities in production like “forward and backward linkages”, so that benefits might no be distributed among other sectors of the economy (Sachs and Warner, 1995). Therefore, mineral resources should have an inequality-enhancing effect. The regression results give mild support for this hypothesis: mineral resources increase intraregional inequality, but only gold, silver, and diamonds do significantly so.

Next, 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 the economically most prospering region. Secondly, the extent of market integration may decrease with the distance to the political center. Thirdly, one could imagine a second set of factors behind distance: the political economy aspects. High inequality in regions near the capital could lead to political dissatisfaction and ultimately successful rebellions. The government might therefore redirect resources so that in regions near the capital, the poorest strata can enjoy more public goods. This is also the case, when weak governments have only a limited control over distant territories. We would therefore expect a higher mean height and less intraregional inequality in regions near the capital. We approximate "periphery" with the great circle distance between the administrative capital and the national capital.[19] We include the absolute distance as well as a relative measure, which is the distance to the capital relative to the farthest administrative region.

The results are ambiguous. Only in the weighted regression regional mean height is significantly reducing with the distance to the capital. The simple distance to the capital has a robust negative impact on the regional CV, suggesting that inequality is lower in distant regions with presumably less market integration. On the other hand, when we take into account that some African countries are small and some are large, a different picture emerges: Relative to the distance of the most remote region distance has a positive effect on inequality. This suggests, that remote regions of large countries have a smaller inequality, but distant regions of small countries have a higher inequality.

We also include dummy variables 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 the economic and cultural characteristics of large cities attract the very rich strata of society - and the very poor as well, because the agglomerated economic activities provide ample employment opportunities. Somewhat related to urbanization could be population density effects. Holding urbanization constant in our regressions, similar considerations could increase inequalities in more densely populated agricultural districts.[20] The urban dummy had in fact the expected positive coefficient in the intraregional inequality regression, whereas population density had no apparent effect.

Finally, we would expect that *education* should have positive effects on average heights of regions, and it might also have an egalitarian effect, because education improves the health and nutritional behavior of the poorer segments more than proportionally. In addition, education could serve as a proxy for the provision of other public goods (such as water-works, health facilities etc). We constructed this variable by calculating the mean number of school years that all the women in the DHS survey enjoyed in a given region. Education is generally higher in southern Namibia and Zimbabwe, along the coast between Nigeria and Gabon, and to a lesser extent in central Kenya. The northern regions of the Sahel states are at the bottom of this ranking, the rest in between. In fact, education reduces inequality within regions and provides a higher standard of living relative to the country mean.

We also included some *control variables*. Firstly, the CV relative to the national CV as a predictor of interregional height inequality, because where inequality is higher, average height is typically lower, given the diminishing marginal return of additional nutritional and health inputs to height at higher levels and the large effect at low levels of height. We find no remaining influence when our set of explanatory variables is included. Secondly, the coverage of female population, since the subgroup "mothers" could be possibly more homogenous. Again, we find no significant influence on intraregional inequality. Thirdly, the size of the region: since large regions have probably less in common than smaller ones, a higher intraregional inequality would be plausible. This variable turned out to be indeed significantly positive.

Recently, Milanovic (2003) has argued, that inequality in SSA is a political phenomenon arising to a considerable extent from *ethnic fractionalization*. In African societies, it is argued, political power is used to acquire economic gains at the costs of society at large. Since political support is organized along ethnic lines politicians favor infrastructure, education, health, or employment in the public sector of members of the own ethnic group, and taxing economic activities, which hurts mostly other ethnic groups. An inflationary number of measures have been suggested to try to approximate ethnicity. Mauro (1995) as well as Easterly and Levine (1997) used the Index of Ethno-linguistic Fractionalization (ELF60), which measures the probability that two randomly selected people from a 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) reports the percentage of population in the largest ethnic group, which provides additional information on the capability of the majority to exercise power over minorities.[21] In fact, those three indices are highly correlated. An important difference (obviously in the definition of ethnic groups) only exists for Madagascar, where ELF60 shows a probability of 0.06, but where the largest ethnic group accounts for 40% of the population. We experimented with the three indices and used both the numbers of ethnic groups and the share of the largest group as explanatory variables (Table 4). In our intraregional regression, an increasing share of the largest group tends to be associated with declining inequality (because the square root of this variable is significant). At higher levels, the variable begins to increase inequality within regions. Apparently, clear majorities based along ethnic lines reduce the need for a balanced policy.

Traditionally, empirical studies on inequality have focused on the *Kuznets* hypothesis, that inequality first rises and at some point declines with economic development. We therefore add real GDP per capita in 1960 from the Penn World Tables 5.6 in linear and quadratic form and expect a positive coefficient of the former and a negative effect for the latter. However, we fail to obtain a Kuznets-type inverted U relationship in terms of GDP per capita.

5. Summary

Inequality is a central issue in economics today, for which data is in particularly scarce supply, especially for LDCs prior to the 1980s. We argued, that the anthropometric inequality measures like the coefficient of variation of the height distribution, has the potential to increase our knowledge on inequality significantly. The comparison between this measure and the income-based Gini coefficients indicates a close correspondence for Sub-Saharan Africa. We tested also several issues that might have casted doubts on height CVs as inequality measure, and found no evidence for major inconsistencies. We extended the inequality database to not less than 28 countries over six five-year periods from 1950 to 1980, and to some 200 regions within those countries. In a second step, we tested the determinants of inequality in the administrative regions and found that the proximity to protein production caused significantly taller heights, and to less inequality. We also contributed to the cash cropping debate that depends crucially on the welfare and inequality effects of this economic strategy. Those of the 200 African regions that concentrated on a single product in a monocultural way experienced substantial increases in inequality, whereas those that developed a diversified cash-cropping landscape reaped the opposite effect, plus higher average heights (relative to the country means). 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 of inequality being ethno-politically determined in SSA. Ethnic diversity has a U-shaped effect on inequality: An increasing share of the largest ethnic group first reduces inequality - but where this largest group gets too large, inequality increases again.

Table 1: Comparison of 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: Countries included in the regressions are 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)

	Robust t-values			weighted regression	
	(1)	(2)	(3)	(4)	(5)
Constant	54.667 (5.09)	-7.306 (-0.24)	-48.586 (-1.86)	19.235 (0.23)	-33.557 (-0.70)
CV	5.489 (3.41)	19.997 (3.05)	19.595 (3.07)	8.988 (0.42)	20.547 (1.67)
Coverage of female population (in %)	0.012 (0.27)	-0.020 (-0.37)	-0.014 (-0.25)	0.024 (0.13)	
CV*Nigeria		-17.670 (-2.43)			
Nigeria		64.036 (2.06)		Totally excluded	
Gabon		20.302 (4.94)	20.483 (4.86)		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	0.001	0.810	0.026
Fixed effects for primary source (p-value)	0.000	0.000	0.077	-	-
R^2-adj.	0.853	0.429	0.557	0.324	0.436
N	89	89	78	29	29
Degrees of freedom	52	64	58	6	19

Note: Only Gini coefficients based on a national coverage were included; t-values in parentheses. 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, economic active population, income recipients, and taxpayers, the income definitions respectively refers to expenditure, net income and income not nearer specified. In cases, in which two DHS surveys offer information on the same birth cohort, we took the average weighted by the female population they cover. The Gini coefficients are based on twelve primary sources. Number of countries: 15.

Table 3: Determinants of *inter*regional height inequality, birth decade 1960s (Height difference to the country's mean stature in mm)

	(1)	(2)	(3)	(4)	(5)
Protein supply					
Cattle per capita relative to country mean	3.376 (2.95)	3.526 (3.19)	3.254 (3.95)	2.941 (2.67)	3.044 (2.98)
Cash cropping					
Cash crop industries (1=yes, 0=no)[2]	-8.907 (-2.30)	-9.501 (-2.37)	-8.860 (-2.27)	-9.249 (-2.52)	-9.507 (-2.83)
No. of minor agr. industries	2.566 (2.78)	2.780 (2.79)	2.598 (2.42)	2.526 (2.85)	2.618 (3.21)
Light and heavy industries					
Light industries (1=yes, 0=no)[3]	9.635 (3.96)	9.367 (3.84)	8.766 (2.34)	9.326 (3.88)	9.107 (3.84)
No. of light industries	-2.054 (-2.53)	-1.924 (-2.30)	-1.770 (-1.59)	-1.684 (-2.54)	-1.524 (-2.37)
Heavy Industries (1=yes, 0=no)[4]	-5.351 (-1.18)	-6.060 (-1.29)		-7.441 (-1.74)	-8.134 (-1.96)
No. of heavy industries	1.500 (0.80)	1.589 (0.84)		1.758 (0.96)	1.863 (1.12)
Mineral resources					
Gold, silver, diamonds (1=yes, 0=no)	1.499 (0.35)	1.090 (0.24)		0.844 (0.21)	
Mineral deposits (1=yes, 0=no)[1]	-2.790 (-1.18)	-2.780 (-1.17)	-2.668 (-1.13)	-0.529 (-0.27)	
Distance, urbanization, density					
SQRT(Distance)	0.030 (0.08)	-0.036 (-0.09)		0.007 (0.02)	
Distance to capital in 1000 km	-1.011 (-0.11)	2.014 (0.20)		-2.638 (-0.27)	
Relative distance (relative to the farthest region)	-2.176 (-0.38)	-2.384 (-0.43)		-5.832 (-1.10)	-6.565 (-2.14)
Urban district (1=yes, 0=no)	1.576 (0.23)	0.453 (0.06)		1.859 (0.28)	
Relative population density	-0.026 (-0.91)	-0032 (-1.10)		-0.006 (-0.47)	
Education					
Mean education(region)/ national mean education	4.900 (2.65)	5.136 (2.73)	5.120 (3.16)	2.623 (1.28)	3.132 (2.23)
Control variables					
Percentage of land cover (in %)	-0.031 (-0.36)	-0.045 (-0.51)		-0.011 (-0.14)	
CV relative to national CV		15.530 (0.76)		-10.611 (-0.86)	
weighted	-	-	-	by share of population	
R^2-adj.	0.089	0.098	0.123	0.134	0.166
No. provinces (countries)	202	202	202	202	202

Note: Nigeria included; By definition between inequality is on average zero in a country. Therefore, we adjusted the explanatory variables that they represent deviations from the national mean. t-values larger than 1.645 are shaded (10%-level of significance).

Table 4: Determinants of *intra*regional height inequality, birth decade 1960s (height CV)

	Mean	(1)	(2)	(3)	(4)	(5)
Protein supply						
Cattle per capita	0.751	0.022	0.019		0.017	
		(0.75)	(0.66)		(0.69)	
Cattle per capita relative to country mean	1.159	-0.055	-0.054	-0.049	-0.0518	-0.044
		(-1.89)	(-2.05)	(-2.46)	(-2.04)	(-2.39)
Cash cropping						
Cash crop processing industries (1=yes, 0=no)[2]	0.255	0.169	0.185	0.222	0.215	0.199
		(1.53)	(1.98)	(2.48)	(2.30)	(2.20)
No. of cash crop industries	0.811	-0.091	-0.091	-0.107	-0.079	-0.074
		(-3.31)	(-3.78)	(-4.36)	(-3.11)	(-3.34)
Heavy and light industries						
Light industries (1=yes, 0=no)[3]	0.199	0.037	0.054		0.064	0.077
		(0.50)	(0.75)		(0.98)	(1.27)
No. of light industries	0.526	-0.018	-0.024		-0.019	-0.037
		(-0.62)	(-1.07)		(-0.75)	(-2.01)
Heavy Industries (1=yes, 0=no)[4]	0.138	0.292	0.280	0.264	0.206	0.223
		(2.83)	(3.04)	(3.51)	(2.57)	(3.76)
No. of heavy industries	0.347	-0.009	-0.007		-0.008	
		(-0.28)	(-0.26)		(-0.27)	
Mineral resources						
Gold, silver, diamonds (1=yes, 0=no)	0.112	0.193	0.184	0.201	0.117	0.168
		(1.90)	(2.01)	(2.41)	(1.46)	(2.47)
Other mineral deposits (1=yes, 0=no)[1]	0.276	0.055	0.047		0.048	
		(1.06)	(1.01)		(1.07)	
Distance, urbanization, density						
SQRT(Distance to capital in km)	15.893	0.007	0.005		0.003	
		(0.84)	(0.71)		(0.40)	
Distance to capital in 1000km	0.337	-0.680	-0.678	-0.616	-0.619	-0.479
		(-3.23)	(-3.65)	(-5.14)	(3.16)	(-4.84)
Relative distance (relative to the farthest region)	0.506	0.145	0.210	0.278	0.186	0.189
		(1.00)	(1.81)	(3.18)	(1.57)	(2.80)
Urban district (1=yes, 0=no)	0.036	0.348	0.314	0.216	0.159	0.164
		(2.34)	(2.74)	(2.47)	(0.75)	(2.20)
SQRT(Population per km²)	4.880	-0.008	-0.005		0.004	
		(-1.05)	(-0.93)		(0.48)	
Education						
SQRT(Mean education in single yearsbased on all women same birth cohort)	1.661	-0.107	-0.097	-0.096	-0.206	-0.095
		(-1.32)	(-2.19)	(-2.66)	(-2.84)	(-2.79)
Control variables						
Coverage of female population (in %)	81.380	0.001	0.000		-0.002	
		(0.28)	(0.15)		(-0.43)	
SQRT(region's size in km²)	226.864	0.00023	0.000245	0.000387	0.000346	0.000386
		(0.98)	(1.19)	(2.28)	(1.46)	(2.49)
National variables: food production, Kuznets, ethnic fractionalization						
Cattle per capita [no variation at the regional level]	0.671		0.062	0.097		0.067
			(1.43)	(2.41)		(2.59)
SQRT(Calories per capita) [no variation at the regional level]	44.709		0.998	1.123		0.570
			(2.43)	(2.85)		(1.94)
Calories per capita [no variation at the regional level]	2004.786		-0.011	-0.013		-0.006
			(-2.39)	(-2.81)		(-1.89)
Ln(GDP 1960) [no variation at the regional level]	6.462		-0.124			
			(-0.53)			
GDP 1960 [no variation at the regional level]	728.092		0.000170			
			(0.61)			

SQRT(percent of largest ethnic group)	6.520		-0.636 (-2.11)	-0.619 (-2.25)		-0.301 (-2.91)
Percent of largest ethnic group	44.517		0.037 (2.29)	0.035 (2.49)		0.021 (3.02)
Number of ethnic groups	4.291		-0.081 (-1.31)	-0.077 (-1.37)		
Fixed-Effects (p-value)		0.016	-	-	0.002	-
weighted	-	-	-	-	by share of population	
R^2-adj.		0.193	0.242	0.264	0.265	0.281
No. provinces (countries)	196	196	188	188	196	188

Notes: Huber/White/sandwich estimator of variance used for t-values (in parentheses). All regressions include a constant. Nigeria not included.

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

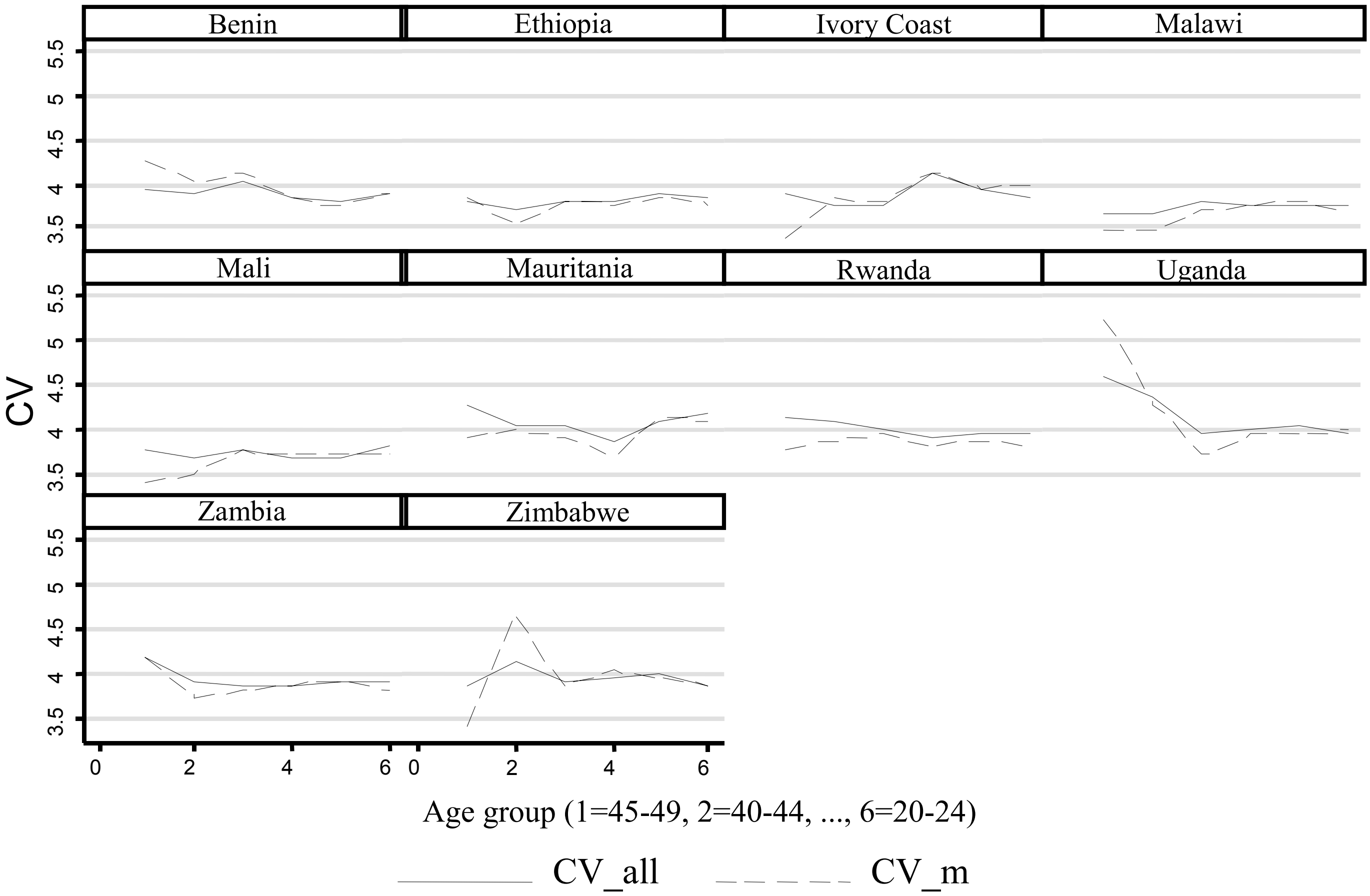
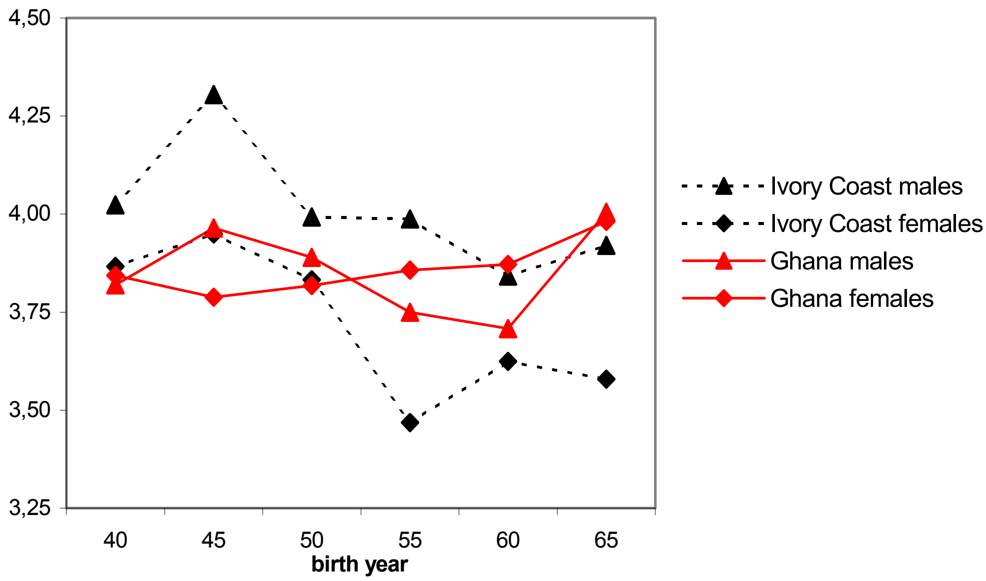
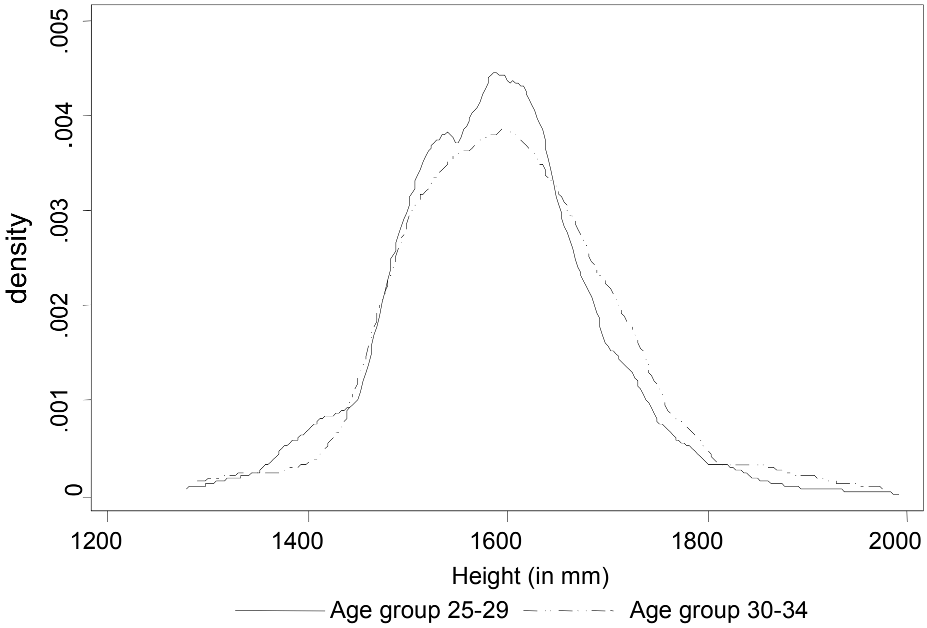


Figure 2: Development of CV by gender in Ghana and Ivory Coast



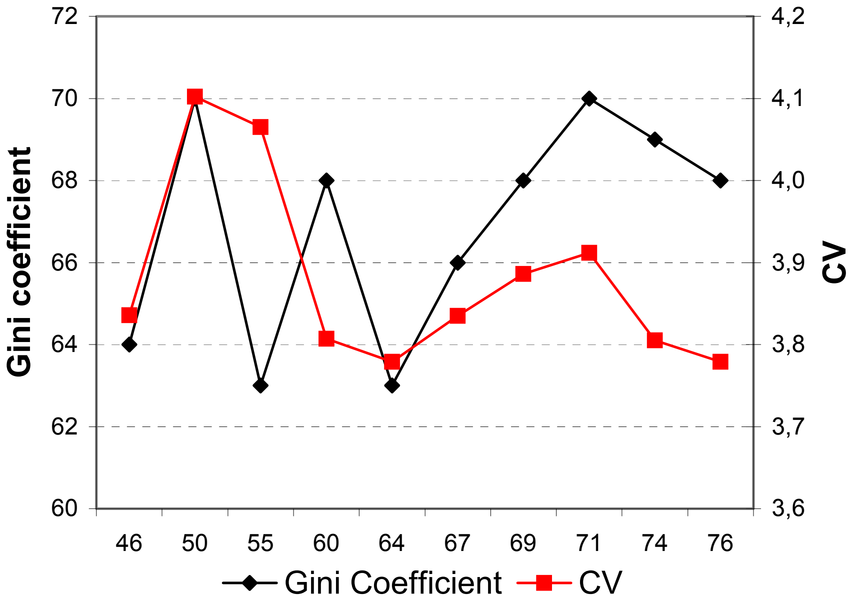
Note: The CV's are based on the anthropometric part of the LSMS surveys GLSS 88/ 89 and CLSS 85/ 86/ 87/ 88. The samples of the different years are not totally independent, since approximately 50% of the households are part of a rotating panel. About 40% of the individuals in the CLSS respectively 60%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

Figure 3: Distribution of Nigerian heights: Age groups 25-34



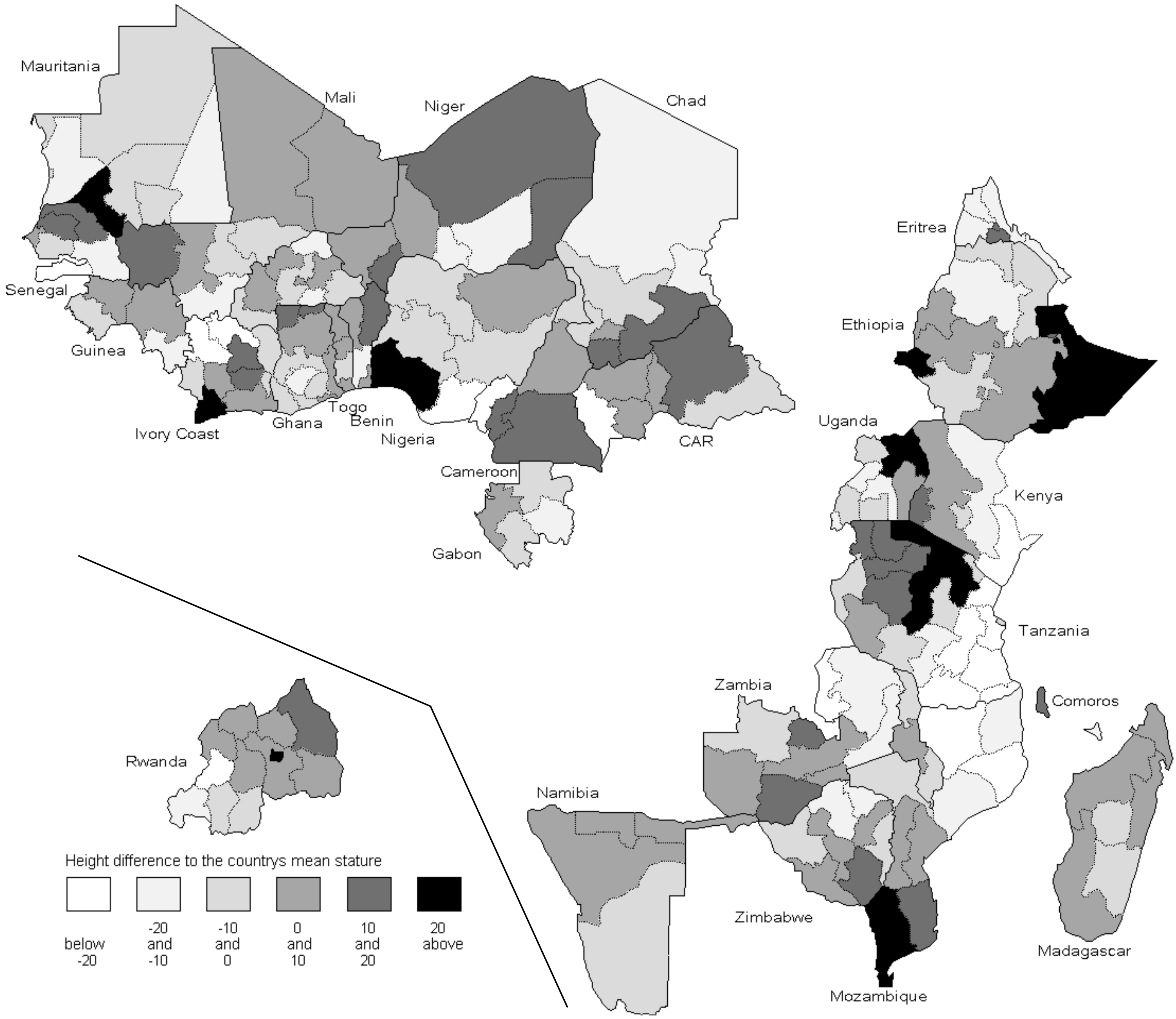
Note: Heights, which were deemed to be implausible by Macro International/Nigerian statistical office, were excluded. The age group 25-29, 30-34 consists of 706 respectively 514 observations.

Figure 4: Temporal development of income and height inequality in Kenya



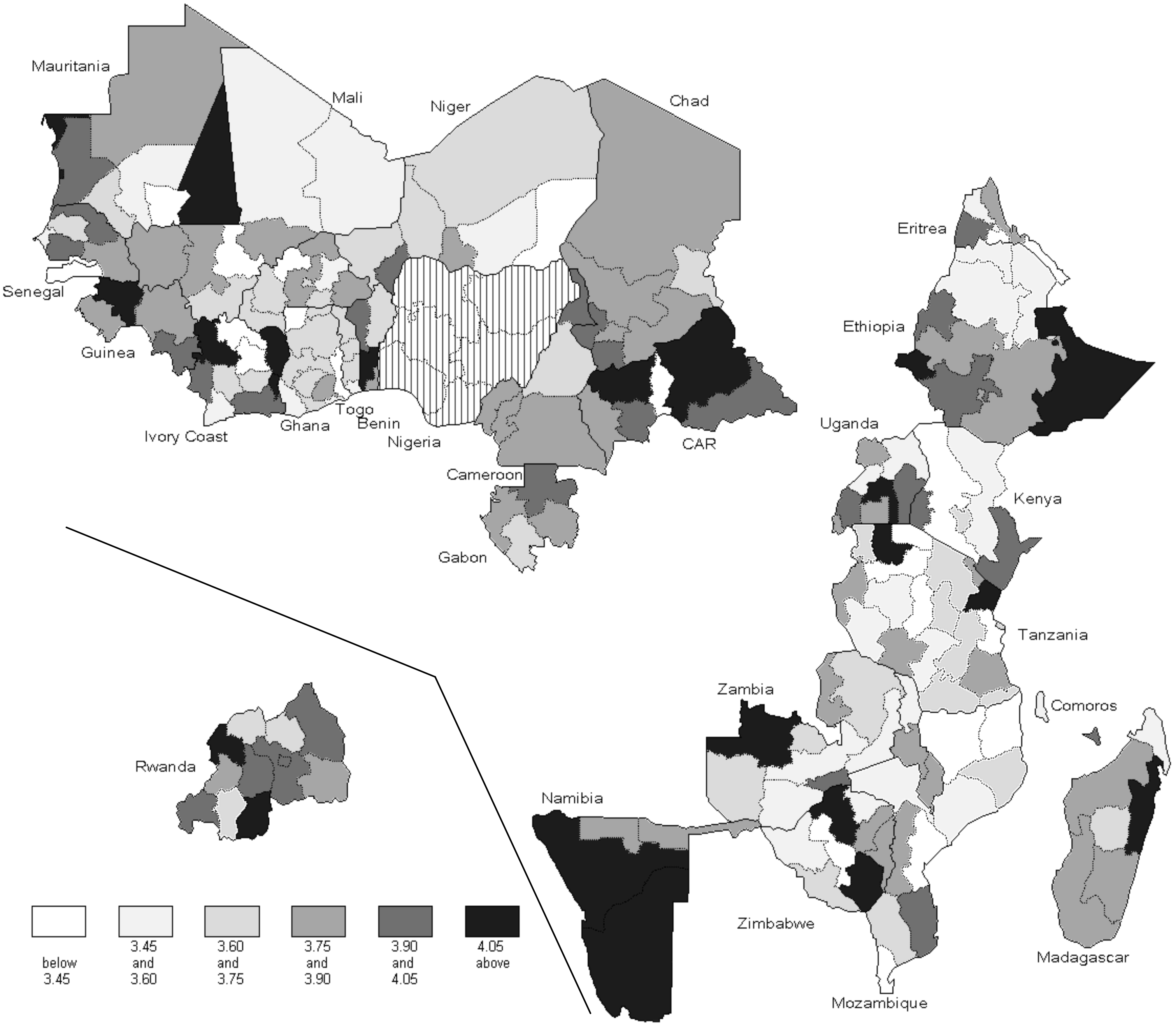
Note: The Gini coefficients are from Bigsten (1985) with a national coverage but based on national accounts of income groups although Deininger and Squire 1996 label them as based on taxpayers. He admits, that given his estimation technique the Gini coefficients should be about 20 percentage points lower. Birth cohorts were averaged from Kenya II and Kenya III weighted by the coverage of female population. Since the Kenyan province North Eastern was not covered by the DHS surveys the development of the CV is not fully representative, although the influence of neglecting about 3% of the population should be rather small.

Figure 5: Height difference 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 administrative regions chosen by the DHS surveys. In some cases, however, we pooled regions if the number of individuals was very small (N<50). Similarly, we sometimes divided very populous administrative regions and chose/pooled districts.

Figure 6: CVs in the regions (10 year age group born in the 1960s)



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Appendix: Height 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. Coverage of the female population in brackets. The figures refer to the beginning of the periods. We averaged the CVs of adjacent age groups (weighted by the coverage of the female population), if the mean birth year does deviate more than two years from the beginning of the period.

[1] Except for Kenya, where the North Eastern province (about 3% of the population) was not surveyed.
[2] Komlos (1985) was arguing on very similar grounds for the usefulness of stature as an indicator of the standard of living.
[3] See Habicht, J. et al. (1974) and Silventoinen, K. (2003) for a discussion of genetics vs. environment. Briefly summarized, height differences are much larger between elites and the poor within a country than between elites and the reference population.
[4] But still, one potential lacuna is theoretically the environmental influence on growth at later ages, especially during the adolescent growth spurt. However, Baten (2000b) finds in a multi-country empirical study that this effect is negligible compared to the impact of the first three years, as long as individuals have reached their final height.
[5] Available at www.measuredhs.com. 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*.
[6] For collections of recent examples, see Komlos and Baten (1998), Steckel and Floud (1997), and Komlos and Cuff (1998). On height inequality research, see Soltow (1992) and Quiroga and Coll (2000).
[7] Using their data in Table 2 and 3, the regression of CV of height on the Theil entropy measure and their square yields:
CV = 4.096 + 1.652 * Theil – 0.110 * Theil-squared. All significant at 1-percent-level of significance. Adjusted R-square is 0.999. N=55. The authors argue that heights of children under age 5 are better suited than adult heights, but do not really prove this hypothesis in our view. Their main argument is that some anthropometric studies have found height distributions of young children to be homogenous between genetic groups. We do not yet have studies that found the opposite for adults, if all environmental factors are controlled for. Clearly, for the time period under study by Pradhan et al. (2003) only heights of children below age 5 are available.
[8] Based on 2x7 surveys with mothers only to exclude the effect of the selection of mothers, which is largest in this age group (see below).
[9] The CV of a totally equal society is not known, because – as we would argue: it does not exist. Even in egalitarian Scandinavia there is probably some remaining height inequality. Pradhan, M. et al. (2003) tried to standardize height inequality by assuming that the height distribution in OECD countries reflects the genetic growth potential of the individuals only. This, however, would mean, that there is no nutritional and health inequality in OECD countries. This seems not to be true. For example, in Germany during the 1990s, height differences between social groups were as large as two centimeters (Boehm 2003, see also Komlos and Kriwy 2003).
[10] The World Income Inequality Database/ WIDER does not provide any additional Gini coefficients for SSA in this period.
[11] For results of this strategy on a global sample, see Gruen, C. and Klasen, S. (2001). Note, however, that this strategy does not result in a total correction of the inconsistencies, e.g. if the definitions absorb time effects.
[12] We excluded the pygmies, since their adolescent growth spurt is substantially shorter (Cavalli-Sforza, 1986).
[13] Note, that migration might affect both measures. When assuming that the poorest (and shortest) people move into prospering regions the height difference between the regions could decrease. The effect on the CV within the regions might be positive in the immigration region and negative in the emigration region. However, the region's CVs as well as height differences are closely correlated between DHS surveys measured in two different point of times (two surveys for a country) indicating, that differences are rather small.
[14] The figure was calculated from the FAOSTAT database and refers to the 28 countries in our analysis.
[15] 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.
[16] Available at http://apps.fao.org/.
[17] 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 of agricultural exports and GDP (in current US$) are derived from FAO records, respectively the World Bank.
[18] Ady (1965) is also the source for the data for other industries and mineral deposits.
[19] The location (latitudes and longitudes) of the administrative capitals was derived from the GEOnet Names Server. The database is the official repository of foreign place-name decisions approved by the U.S. Board on Geographic Names. Data available at http://www.nima.mil/.
[20] The population data is chosen from census figures reported by Law (1999) in such a way that the geographical units match. Since the census years differ between the countries we calculated the population share with which we multiplied 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.
[21] Data available at http://africa.gov.harvard.edu// (African Research Program at Harvard University).