HEIGHTS OF WOMEN IN SUB-SAHARAN AFRICA 1950-1980: AN ECONOMIC PERSPECTIVE

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Abstract
Did the Sub-Sahara African economies catch up to the developed countries in the 1950s to 1980s? Based on heights as an indicator for human well being this article presents evidence that there is still a long way for achieving convergence.
Additionally, we explore the impact of various socio-economic, nutritional and health variables like GDP per capita, infant mortality rates, national food supply on heights.
The most remarkable result is that the heights of the African societies stagnated or followed an inverted U indicating a nutritional or health crisis especially in the years 1965-1975. Therefore, this region appears as an important exception from the worldwide trend of upward-sloping heights.
The panel data set was derived from the Demographic and Health Surveys (DHS) conducted by Macro International. Although designed for other purposes, namely fertility and health issues, heights of approximately 90000 mothers were recorded. In order to determine the magnitude of potential biases we compared the heights of mothers with the heights of women exemplary for the Ivory Coast.

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1. Importance of heights in determining the living standard

Scholars of economic history, development and health economics frequently used mean heights as an indicator for nutritional well-being of a population. Final adult height is a function of conditions in youth, especially of the nutritional quality and quantity as well as the epidemiological environment or workload, which the individuals have faced during their period of growth.

Several advantages of the height indicator have contributed to its popularity. First, it measures the outcome of the above-mentioned inputs. Second, the high comparability across time and often even nations makes it a useful proxy to apply. And last but not least, height records are available for periods, for which other reliable data is missing. The applicability of this measure was impressively demonstrated by the relationships found by many economic historians and development economists of global institutions (WHO, World Bank, UN) have promoted the use of heights for assessing malnutrition and targeting individuals at risk.[1]

However, heights of adults living in the less developed countries were seldom recorded, only covering some countries of Sub-Saharan Africa.[2] The recently published and very comprehensive DHS surveys changed the matter and offer for the first time the opportunity to compare the development of nutritional status measured by height in this region, while other reliable data describing well-being is missing or unreliable especially for the early second half of the 20th century.

Our study starts with discussing the data and assessing potential biases due to the selection of mothers instead of women in general. In the sections thereafter, we focus on how well the Sub-Sahara African societies caught up to the developed countries in terms of nutritional status and which determinants favour such a desired convergence. In doing so, we will first

[1] See for example Fogel, R.W. (1994), Steckel, R (1979, 1994), Komlos, J. (1987), Baten, J. (2002) and WHO (1983a).

[2] See the studies of heights of Straus, J. and Thomas, D. (1998) for Côte d'Ivoire, Higgins, P.A. and Alderman, H. (1997) for Ghana as well as Schultz, T.P. (1999) for Ghana and Côte d'Ivoire, as well as Smith, L. C. et al (2001), which made use of all the DHS surveys in an cross sectional analysis.

focus on the height variation between the states by comparing the levels across the countries and then we will consider the variation within the states over time in a panel analysis.

2. Data and bias due to selection of mothers

Mean heights were derived from the Demographic and Health Surveys (DHS) conducted by Macro International.[3] The samples of households are nationally representative but only the heights of mothers instead of women in general were recorded. From approximately 90000 mothers mean heights were calculated for each birth year and country. If more than one survey was available for a single country, the data was pooled. We excluded all mothers older than 50 years. Beyond this age individuals loose stature rapidly.[4] Furthermore, mothers younger than 21 years were entirely excluded, because many of them had not reached their final height, yet.

Since mothers are only a subset of women there is potentially a scope for a bias, which would undermine the representativity of the results for all women. In order to assess this potential problem, we employed two strategies.

For the Ivory Coast, heights of both mothers and women are available. Therefore, we compared the DHS heights with the ones of women in general recorded in the four Côte d'Ivoire Living Standards Surveys (CLSS) from 1985/86/87 and 1988.[5] Figure 1 shows the 95% confidence intervals of the mean heights of both sources. There are apparently no significant differences in levels: the mothers are as often taller as the 'all women' sample, but always insignificantly so. It is also important to investigate, whether the variation in the mean height of women corresponds with the one of the mothers (table 1). The visual inspection

[3] Available at www.measuredhs.com
[4] See Baten, J. and Murray, J. (2000). The age distribution of the mothers is somewhat skewed to the left with a mean between 27 and 29 years.
[5] available at http://www.worldbank.org/lsms/

reveals, that there is a strong negative autocorrelation in the data.[6] We control for this zigzag pattern by including autoregressive terms in the regression in the third column of table 1. We then observe a significant positive relationship: A 1 cm increase in the mean height of women corresponds with a predicted increase in the mean height of mothers of 1,10 cm. This result is valid for DHS mothers older than 25 years, because for the younger DHS mothers no matching CLSS women are available.

Our second strategy to assess potential biases employs a large number of countries, comparing the education of our sample with the underlying population. Since heights typically increase with education, we compared the percentage of primary educated mothers in the DHS data with the gross primary school enrolment rate[7] for females given by the World Bank (1999).[8] We related the enrolment rate of a specific year to the percentage of at least primary educated mothers, which were in the most probable school age for this year, generally assumed to be born eight years prior to the reporting year of the enrolment rate.[9]

The percentage of primary educated mothers appears on average to be very similar to the school enrolment rates except for the birth cohorts 1968-77. During this period the percentage of primary educated women in the sample is 5-10% lower than in the population (figure 2). Information on each country is given in table 2. In most countries a significant increase in the

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[6] This pattern can be readily seen in figure 1. In the first regression of table 1, the Durbin-Watson test indicates that the residuals are significantly negatively autocorrelated, and thus the OLS assumption of a white noise error is violated. In contrast, the second regression does not reveal any specification errors. The oscillating pattern of mean height is evident in all the selected countries and is therefore likely to be a result of the DHS sampling procedure designed for making inferences on current problems.

[7] The gross primary school enrolment rate is defined as the total enrolment in primary schools, *regardless of age*, expressed as a percentage of the official primary school-age (6-11 years) population in a given school year. The net rate is only available for some countries for 1981 onwards.

[8] Education is most suitable for this procedure since it is the only information, which is related to the growth period of the mother. However, there may be positive as well as negative deviations, which do not indicate any selection bias. One reason is that we do neither know when exactly the mothers have attended the primary school nor the number or age pattern of pupils that were enrolled but were beyond the school age. For example, adults may attend literacy programmes. If they were included in the rate, it occurs in a later reporting year than they were in the official school age. In that case, we would overestimate the share of primary educated mothers in the first school-age period and underestimate it in the later one. Another reason may be high drop out rates before the pupils were counted and the mothers are recorded as primary educated in the DHS sample but not by the World Bank. These biases differ from country to country and may even be subject to temporal variation.

[9] Eight years lie in the centre of the primary school age (6-11 years). The results do not substantially change, if six or eleven years would have been chosen.

difference between gross school enrolment rate and percentage of primary educated mothers can be observed in the birth cohorts from 1968 onwards.

However, this can be a statistical artefact resulting from an increasing divergence between gross and net school enrolment. If the difference between the net and gross rate for the 70s is similar to the 80s, then there is clearly no hint for missing educated women in those birth cohorts: As can be seen in the last column of table 2, the percentage of missing women according the gross enrolment rate amounts generally to the difference between the gross and net rate from 1980-88. Moreover, even if differences would exist, substantial biases in height are unlikely. Based on the observed average height difference of one centimetre between at least primary educated and non-educated females, an under representation of educated females in the size of 10% would mean a downward bias of only one millimetre, which seems rather negligible.

Summing up, there is no evidence for a severe selection bias concerning mothers younger than approximately 25 years. Nevertheless, we will control for the differences in the educational composition of each birth cohort to avoid any remaining selectivity problems.

Other available sources for heights such as records of health facilities suffer from a stronger selectivity, because the access to hospitals is often a privilege of the rich. The poor and probably shorter people might be extremely underrepresented.

Data for the determinants of heights were taken from a couple of sources. From Maddison, A. (2001) we obtained GDP per capita measured in 1990 international Geary-Khamis dollars. Infant mortality rates were derived from UN Population Division (1996). The nutritional variables and population figures, which are only available from 1961 onwards, are from the FAO Statistical Data Base.[10] The amount of trade, governmental and consumption expenditures as a percentage of GDP are from the Penn World Tables.[11] The data on deaths from political violence are from the “World Handbook of political and social indicators III, 1948-1982", originally collected by Taylor, C.L. and were made available by the Inter-University Consortium for Political and Social Research.[12]

3. Variation between countries

3.1 Genetics or environment?

Height differences of African women born between 1960-69 are substantial, see figure 3. Are these differences determined by genetic height maxima?

In fact, genetics is an important determinant for the range, in which the individual's final height lies in the height distribution of an ethnic group. However, concerning the position of the height distribution of whole populations reflected by their mean height environmental conditions have a much greater impact than genetics. This applies also to less developed countries (Habicht, 1974; Eveleth and Tanner, 1976). This issue was approached in many studies by comparing heights of socio-economic elites in different geographic locations with the ones of the US-American NCHS reference population[13] finding much smaller differences than between non-elites in the country and the reference population or by analysing the convergence of heights of immigrants' descendents in industrialized countries.[14]

Since the heights are also far from stable for almost all of the selected countries the differences noticed during this snap-shot could vanish in future when nutritional and health conditions change. Therefore, we adopt the general view, that the growth potential of the ethnic groups selected in this article do not differ very much among each other and from the people in the OECD countries.

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[10] available at http://apps.fao.org/

[11] available at http://datacentre.chass.utoronto.ca/pwt/pwt.html

[12] Neither the collector of the original data nor the consortium bear any responsibility for the analysis or interpretations presented here. The data is available at http://www.icpsr.umich.edu/index.html

[13] The reference population is grown up in a healthy and food secure environment. The international convention is to use the CDC/ NCHS surveys, with the latter representative of the entire US population, see WHO(1983a) and Gorstein J. et al. (1994). The US height distribution is in turn similar to the OECD countries.

3.2. How many years is Africa behind?

In the following, we will consider the state of African development in the 1960s when using height or alternatively GDP/ capita as an indicator. We will find that African women's living standard is more favourable in terms of height.

Even in Madagascar and Comoros, where the shortest women live, the mean height is well above 152 cm, the height that was reached by female Dutch underprivileged like orphans and factory workers born in 1849.[15] Furthermore, the average African woman was taller than Irish women born in 1830 (approximately 155 cm).[16] Heights in the majority of countries exceed the 158 cm reached by Bavarian women born between 1865 and 1879.[17] In Chad and Senegal the women are almost as tall as modern US citizens.[18] Summing up, the nutritional status of women studied in this paper could be assumed to be some 20-100 years behind OECD standards in the 1960s if approximated by height.

Using GDP per capita as a measure of living standard one would come to a more pessimistic view of African living standards. Only in Namibia, Mozambique, Nigeria, Côte d'Ivoire, Ghana and Senegal GDP per capita in 1960-69 exceeds the one of the USA in 1820 and except for Namibia all countries are well below the level which was realized by the USA in 1870.[19] Additionally, the ranking of the countries would substantially differ. Mali and Chad for example belong to the poorest countries in terms of GDP per capita, although their mean heights suggest that the nutritional status may not be as poor. Quite the contrary can be observed in Madagascar and Mozambique: According to GDP the living standard is higher than the average, but the small mean height indicates, that resources were not sufficiently spent for health and nutrition of children.

[14] see for example Graitcer, P. L. and Gentry, E. M. (1981), Marshall, W. A (1981), Roberts, D. F. (1981) and WHO Working Group (2000).
[15] see Van Wieringen, J.C. (1972).
[16] See Oxley, D. (2002).
[17] See Baten, J. and Murray J. (2001).
[18] See WHO (1983a).
[19] See Maddison, A. (2001).

3.3. Determinants of heights: cross sectional results

The lack of correlation between GDP and height is also clearly visible in the regressions presented in table 3, in which the determinants of mean height in the cross section are considered.

The level of GDP per capita has no statistically significant influence on mean heights.[20] In contrast, Brinkmann, H. and Drukker, J.W. (1998) found a significant and robust negative relationship between stunting of children (age 0-5) and GDP per capita in less developed countries in the mid-1980's.[21] Since the prevalence of stunting is usually negatively correlated with mean adult heights, we would have expected a significant positive relationship between GDP per capita and final height, if the influence of the level of per capita GDP is independent of time and the sample of countries. However, Brinkmann, H. and Drukker, J.W. (1998) included 46 countries in their analysis, most of them from other regions than Sub-Saharan Africa. Their and our sample have only 9 countries in common. Moreover, they did not have data on Mali, Chad, Ivory Coast, Namibia and Mozambique, which do obviously deviate from the expected GDP/height relationship.

In contrast, daily protein supply per capita is a significant and substantial positive predictor of final female height, which is in line with the results of other authors.[22] An increase in the daily protein supply of 10gr would result in a increase of the mean height between 1,22 and 1,46 cm. Protein is mostly an element of high quality food like meat, fish, eggs and milk. The latter is often fed to infants. All of them have in common that they have further important nutrients like calcium, iron and phosphorus, which are important inputs for muscle and bone formation and therefore favour growth in particular. The strong relationship is also clearly visible in the scatter plot in figure 4. Interestingly, the NCHS median height of a woman at age 18 would

[20] This result does not change when testing the same regression model for each year.

[21] Stunting is defined as the percentage of children under five years, which are more than two standard deviations below the median height of the CDC/NCHS reference population. Brinkmann, H. and Drukker, J.W. (1998) referred to Maddison, A. (1995) as their source for GDP per capita.

[22] See Baten, J. (1999), Brinkmann, H. and Drukker, J.W. (1998).

not lie far from the regression line. Moreover, Madagascar and Malawi are obviously outliers. Qualitative reports on Malawi, indicate a very unequal distribution of available protein resources between children and adults. Thus, the children may not get their share of proteins suggested by the protein figures, since after weaning their food consists usually of porridge with only few proteins inherent.[23] This might also be the case in Madagascar. An alternative explanation could be that the high proportion of Malagasy people of South Asian origin could be responsible for the low stature,[24] although the absence of any bimodality in the height distribution suggests, that there are not two distinct ethnic groups. The outliers were excluded in the subsequent regressions. Consequently, the fit of the model improves sharply. Furthermore, protein supply alone can then explain 60% of the observed height variation.

There are two more aspects worth to note. First, a sufficient protein supply is not conditional on a high GDP per capita per se. In 1960-69, for example, Chad and Mali were the sample's poorest countries, but are nevertheless among the countries with the highest protein supply. This can be explained by their high degree of specialisation in livestock farming as indicated by the high stocks of cattle and sheep per inhabitant. In contrast, Ghana and Mozambique were among the richest and had the lowest protein supply. However, in the subsequent decade the protein supply tends to increase in the richer countries and to fall in the poorer countries, turning the weak negative to a finally weak positive correlation. Second, proteins are a positive function of calories. The including of a calorie variable does not lead to a significant coefficient. That means, that increasing food supply in quantitative terms alone is insufficient to prevent the population from growth retardation, although it is likely that they gain weight instead.

As a surprising result of the regression, primary education turns out to be significantly negatively correlated with final height with, however, explaining a much smaller share than

[23] As reported by a German paediatrician in 1969, see Lienau, C. (1981). He concluded, that protein energy malnutrition is a severe as well as avoidable evil in Malawi.

protein supply. It is very implausible, that this finding reflects a causal relationship since educated women are about one centimetre taller on average within a population. A closer inspection reveals, that Burkina Faso, Niger, Chad, Senegal and Mali are responsible for this result, since their share of primary educated women are clearly below average and their heights are above the regression line when protein supply is the single exogenous variable.

Obviously, the countries with the shorter women had made more successful efforts or faced the higher pressure to improve the educational system. This will certainly result in benefits changing heights in the long run, if education is influencing the household's net nutrition positively.

The infant mortality rate was included as a proxy for medical care. The regression coefficient is significantly negative in the specification of column 4 indicating that higher infant mortality rates cause lower heights. However, first, the seemingly substantial influence is offset by the negative collinearity with the percentage of primary educated women. Dropping this variable does hardly change the fit of the model. Secondly, the relationship is very sensitive regarding the countries included. For example, when excluding Malawi and Madagascar or alternatively Mali and Chad this variable becomes insignificant.

We conclude, that protein supply and therefore the availability of high quality nutrients during the growth phase is the strongest predictor of the cross-sectional differences in African heights of the 1960s.

[24] South Asians were found to be too small given that their environmental conditions are similar to Sub-Saharan Africa, which led to the puzzle, known as 'Asian Enigma' , see Ramalingaswami, V. et al. (1996).

4. Variation within countries

4.1. Which inferences can be drawn from the development of female Africans' heights?

Height trends provide information on the development of the nutritional status. Any decrease of mean height indicates a severe crisis. Moreover, as Baten, J. (2002) argued, even a stagnation of height in the 20th century could be considered as an indication of economic problems since we would expect that the spread of knowledge on hygiene and medical care results normally in lower energy expenditures and in more energy left for growth. Thus, a stagnation of mean height may only occur, if food consumption of a sufficiently large number of individuals does decrease either quantitatively or qualitatively.

In fact, there is evidence for a considerable transfer of medical knowledge to Sub Saharan Africa in the period 1960-1980. Vaccination programmes, which covered also elderly people, provided increasingly protection against whooping cough, small pox, tuberculosis and other diseases.[25] These efforts had an impact on the output side as indicated by steadily declining infant mortality rates and crude death rates.[26] However, there are also hints that progress does not occur continuously or uniformly for all countries. Large-scale benefits were realized for example in the 1980s when oral rehydration products for treating children with diarrhoea became available and the pace of immunization coverage was accelerating.[27] Similarly, the share of population with access to safe water varies in a spatial and temporal dimension without a clear tendency of improvement for all countries.[28] Furthermore, there is no indication that the prevalence of malaria decreased in the period 1962-1981.[29] Since the figures refer mostly to cases treated in health facilities, the real prevalence can be much higher depending on the access to medical centres in the countries

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[25] See WHO (1983b) and the earlier issues of the World Health Statistics Annual.
[26] See UN Population Division (1996).
[27] See UNICEF (1996; 2002).
[28] Based on World Bank data for the period 1980-98.
[29] See WHO (1983b) and the earlier issues of the World Health Statistics Annual. Due to this measurement problem, malaria was excluded in the analysis.

Therefore, decreasing or stagnating heights may reflect problems in both, health and nutritional well-being.

4.2. Did the nutritional status of female Africans improve?

In many African countries mean heights followed an inverted U (figure 5). The increase stops in those cases mainly in the birth cohorts of 1961-65. In Ghana, Madagascar, Senegal and Zambia, the mean height in the 70s were even moving down to the level of the 1950s indicating no sustained development of health and nutritional conditions.

For another group of countries either a downward or no clear trend can be observed (figure 6). Decreasing heights at about one and a half centimetre can be seen in Chad, Malawi, Namibia, Niger and Togo. A substantial reduction in mean height occurred especially in Mozambique, where the earlier birth cohorts are approximately two centimetres taller than the later ones. In contrast, in Cameroon and Uganda the mean heights are nearly constant throughout the entire period.

The only Sub Sahara African countries, which show a clear upward trend are Mali and Kenya, (figure 7). The Kenyan women born in 1965 became one and half centimetres taller than their counterparts born one decade before. But even here growth came to a halt in the subsequent birth cohorts. In Mali the upward trend is only weak although very continuously. In Zimbabwe and Comoros, mean heights were initially declining, but after 1965 recover somewhat, however, without offsetting the sharply fall during the 1950s.

In summary, the Sub-Saharan region appears as an important exception from the worldwide trend of upward-sloping heights indicating, that the second half of the 20th century cannot be treated as a period, in which progress in essential human needs took place almost naturally. Although some African countries made steps forward in the period 1951-65, in the decade thereafter almost the entire Southwest and Southeast of the African continent went to a nutritional or health crisis. In contrast to the current AIDS pandemic, this crisis was not characterised by a fall in life expectancy but by a decrease or stagnation of mean heights.

Thus, on the way to a convergence to the OECD countries in nutritional terms the gap has widened again.

4.3. Determinants of the height development: panel results of regressing the first differences

For estimating the determinants of temporal height variation, we switch to a panel analysis. The large number of degrees of freedom allows us to test more determinants than in the cross-sectional analysis. We examine first differences, as many variables are first order stationary, so that we avoid misinterpretations due to trend correlation. Moreover, we applied a Generalized Least Square (GLS) regression, because the residual sum of squares differs significantly between the countries. Thus, we had to correct for this heteroscedasticity. Furthermore, since the zigzag pattern of heights applies to all countries, but the coefficients may vary individually, we included a panel specific autocorrelation coefficient to relax the imposition of an autoregressive process equal for all countries.[30] After doing this, the residuals are white noise except for Mozambique and Zambia, for which they are still but only weakly negatively autocorrelated. We had to restrict our analysis to the period 1962-77, because of the unavailability of data on the exogenous variables for the period before.

A declining infant mortality rate does significantly increase African mean heights (table 4). The absolute average annual decrease of 2,37 in the infant mortality rate would amount in an annual increase in mean height of 1,7 mm. Although this variable might not measure health conditions perfectly, we conclude, that the nutritional status of female Africans depends on improvements of health services.[31]

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[30] The GLS procedure helps to avoid loosing the first observations, see Maddala, G. S. (2001).

[31] Another weakness of this variable is, that infant mortality rates are only available for 1960/65/70/75. Linearly interpolating the missing values results in a constant decline of the infant mortality rate for all the quinquennium.

Growth rates in the daily supply of animal proteins per capita does obviously not affect growth in the first year of life. If breastfeeding patterns did not change so much between one generation and we can assume the weaning pattern of the mothers to be very similar to their children, then the great bulk of the mothers were breastfed in the first year of life and given supplements in a considerable amount only thereafter.[32] Therefore, it is not surprising, that given the children's diet, animal proteins have only a significant positive effect in the second and third year of life. A one percent rise in proteins would result in an increase in mean height of 0,1 mm. This looks rather small, but the high standard deviation (~7) suggests, that protein supply is very volatile and can therefore explain a substantial share of mean height variation. Moreover, as growth slows down with age, the potential amount of growth is less than in the first year of life, which makes the impact more substantial. Thus, the importance of protein supply found in the cross-sectional analysis is confirmed.

In contrast to the cross sectional analysis of levels, GDP per capita does influence mean heights positively, so that there is no divergent development of mean heights and economic growth. The relationship also demonstrates, that the average citizen benefits from growth in real income, although an unequal distribution of the additional income may nevertheless exist.

We also tested the variation in the proportion of income spent by the government and consumers. From an ex-ante point of view a positive as well as negative influence of the former would be reasonable. On the one hand governmental expenditures may be spent for provision of public goods, like health services, infrastructure, education and enforcement of property rights. On the other hand, the reality in many African countries suggests, that governments have a preference for expanding bureaucracy and an inefficient state sector, rising transaction costs and disrupting the functioning of markets. Moreover, in some cases

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Thus, the variation of the growth rates are limited and may not reflect actual conditions in each year. Therefore, the significance disappears, when excluding the years 1962/63 as done in the forth column. Nevertheless, running the regression for the period 1966-77 and the infant mortality rate would regain significance. Therefore, we feel safe to ascribe the infant mortality rate the above mentioned influence.

[32] See Smith, L. C. et al. (2001).

the distribution of expenditures are employed to subsidise regime supporters and to punish ethnic groups, which were not considered as loyal.[33] However, a significant positive effect appears in the regression. Therefore, the positive effects may offset the negative ones.

The proportion of consumption expenditures has also a significantly positive effect on mean height. Interestingly, the regression coefficient is half as large as the one for governmental expenditures. Thus, a crowding out of consumption would result in a net gain, which could be explained by the non rivalry character of public goods.

The positive effect of both consumption and governmental expenditures means, that increases in the share of investments has a negative influence. The reason might be, that investments create future consumption possibilities at the cost of current ones. The long term consequences should therefore be positive, especially since investments generate economic growth, which has a positive effect on mean heights.[34]

In order to estimate the influence of trade we included the openness variable, which is defined as the sum of exports and imports as a percentage of GDP.[35] We would have expected a positive influence, since trade theory tells us, that the abundant production factor, which in Africa is clearly labour, should benefit from trade and consequently the majority of the population. However, a significant negative relationship arises, which is not sensitive regarding any alternative model specifications.

What economic factors stand behind this openness variable? Unfortunately, one cannot appropriately distinguish between exports and imports, since they are highly correlated. But as the measure from Sachs and Warner (1995) indicates, none of the selected countries was really committed to free trade during the period under concern except for Kenya, which was

[33] See for example Alexander, W.R.J. and Hansen, P. (1998), Fosu, K.A. (1992) or Mbaku, J. M. (1992).
[34] See Fosu, A. K. (1992).
[35] Note, that smaller countries have usually higher openness values, but first differences are independent of the size of a country.

closed in 1968.[36] Moreover, inflation tends to decline when trade is expanding. Even so, this does not exclude the possibility of a trade induced change in relative prices. Furthermore, the specialization in agricultural commodities intended to export like coffee or cocoa[37] might result in a crowding out of agricultural production which would have been available for local consumption. However, these explanations are not very satisfactory, and we are left with a puzzle. We also have to keep in mind, that we consider first differences, so that an increase in openness can create temporary health and nutrition problems. Nevertheless, the negative effect of an expanding trade on the nutritional status of Africans might explain the strong resistance of African countries to take part in the globalisation process. In further research, we plan to specify a multi equation model that will also capture endogeneity of GDP, openness etc.

As in some African countries like Cameroon and Zimbabwe independence was accompanied by substantial violence, distortion of institutions and the withdrawal of the colonial powers by the imposition of economic sanctions, we included a dummy variable for the five year period around independence. Although one may argue, that this variable did not sufficiently account for country specific experiences, any other coding scheme may be equally arbitrary.

A significant negative effect can be seen in the second column. However, when excluding the years 1962/63, we obtained an insignificant coefficient. This suggests that independence had only a negative effect in those countries, which gained it before 1960.

We took also account of civil war effects as they were obvious in Chad, Mozambique, Nigeria or Uganda. Instead of using a dummy variable we measured the extent by the number of deaths caused by these conflicts, which are likely to be correlated with the number of displaced persons, closed roads and disruption of markets. As expected, there is a significant

[36] They labelled an economy as closed, if either average tariff rates were higher than 40% or it had a state monopoly of major exports or a black market premium of more than 20% or a socialist economic system. The data set is available at http://www.cid.harvard.edu/ciddata/ciddata.html

[37] See Deaton, A. and Miller, R. (1995).

negative effect on mean height. Independent of the conflict's reason, the ordinary people do always suffer.

5. Summary

We started our analysis with examining the extent of a bias due to the selection of mothers instead of women in general. Neither the comparison with the mean height of women in Côte d'Ivoire nor with primary education of the underlying population suggests that mothers older than 20 years cannot be considered as representative for all women.

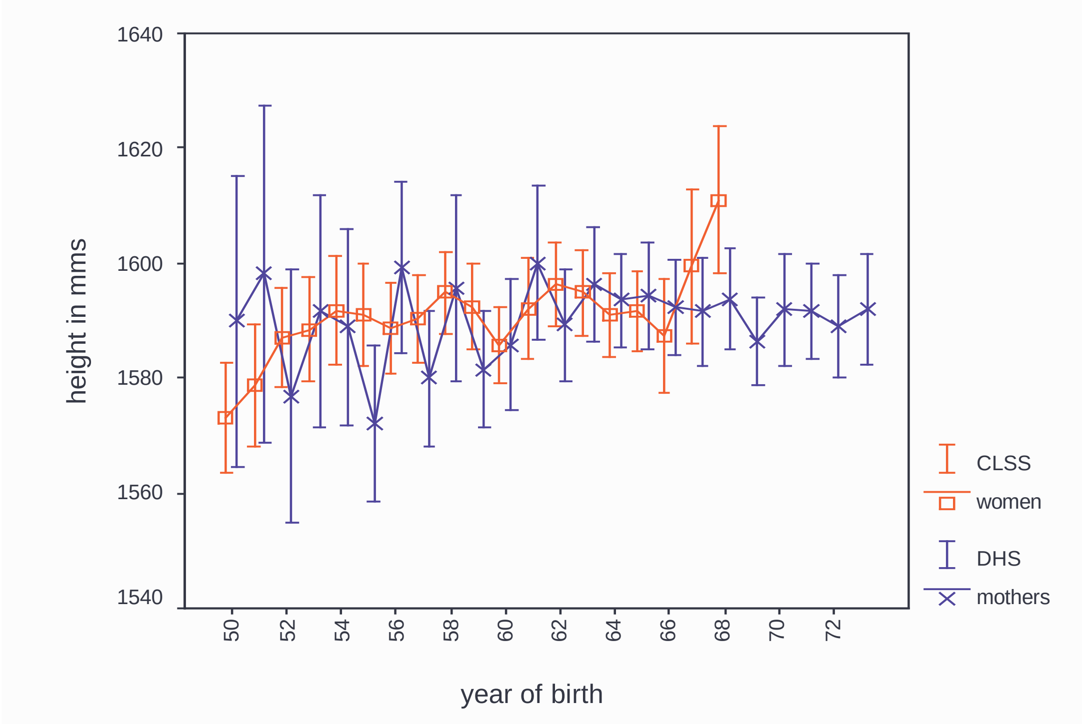
In the cross-sectional analysis we found, that the availability of proteins is the main determinant of the observed height differences across the countries.

When analysing the development of heights over time, we found, that in most of the selected African countries female mean heights stagnate or decrease in the period 1965-77 indicating a nutritional or health crisis. The African continent appears therefore as an important exception from the worldwide trend of upward sloping heights. In a panel regression we presented evidence, that temporal height variations are influenced by health, nutritional, economic and political factors. The puzzling effect of the openness variable offers a promising research field in future. Nevertheless, it shows, that anthropometrics could make an important contribution to the globalisation debate in investigating the impact of free trade on anthropometric measures.[38]

Given the determinants of the temporal height variation and the bad performance of the African states in those determinants in the 1970/80s, we conclude, that there is still a long way for Africa to achieve a convergence in the Biological Standard of Living.

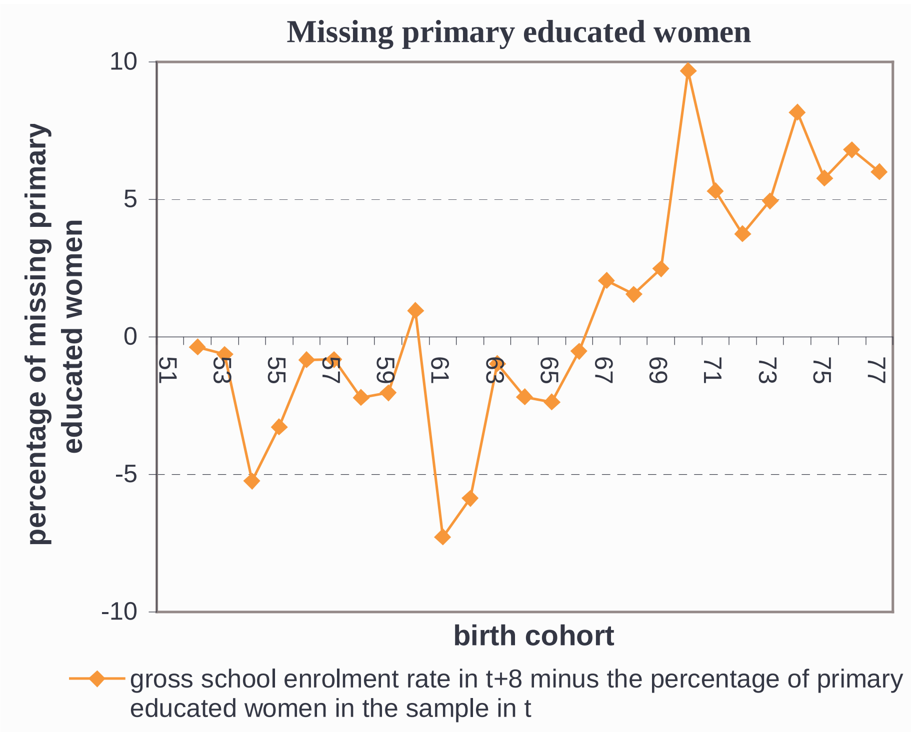
[38] See Baten, J. (2002), who makes use of anthropometric indicators to explain the globalisation backlash in South America.

Figure 1: Mean heights of DHS mothers and CLSS women / Ivory Coast in each birth cohort



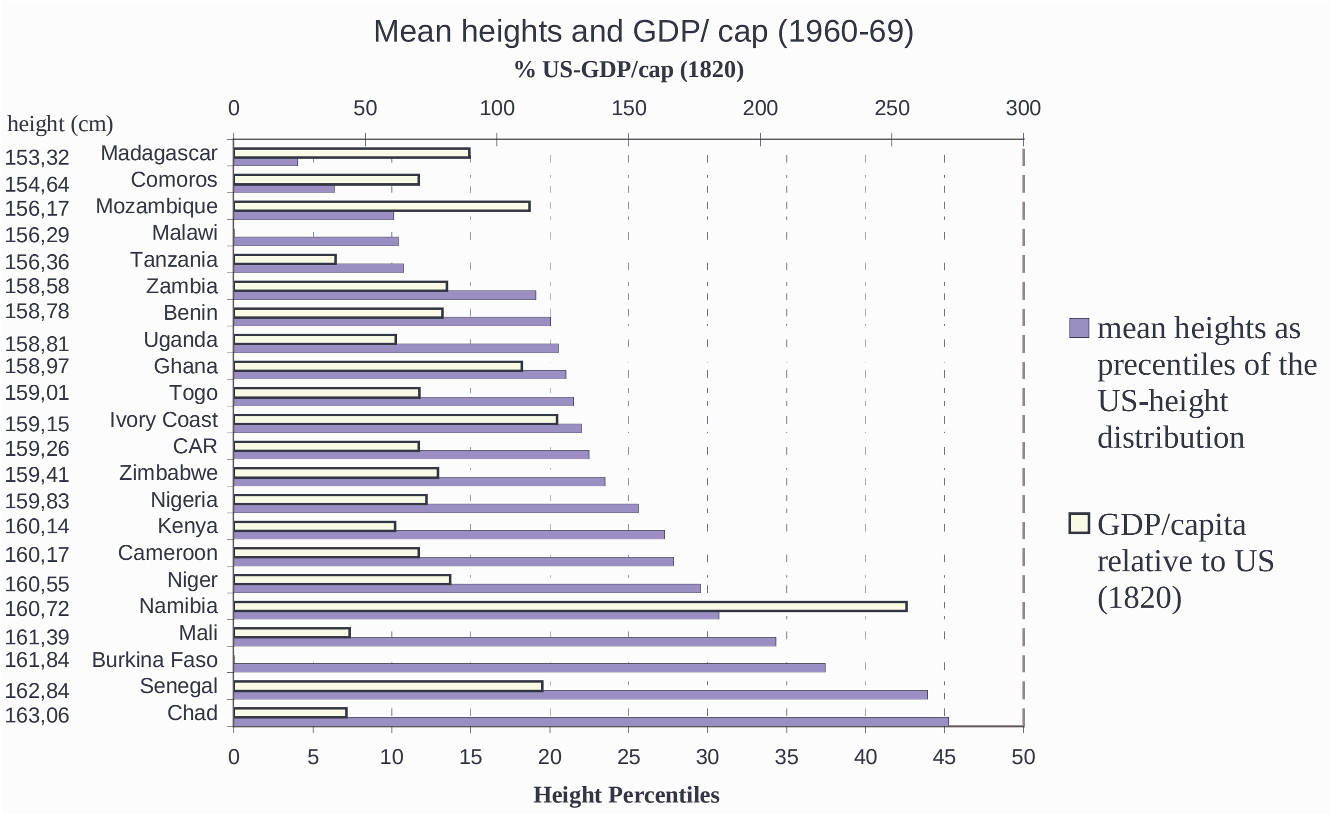
Note: Error bars indicate the 95% confidence interval of the mean height. The four Côte d'Ivoire Living Standard Surveys were pooled. Only women older than 20 years were included. The few heights that were measured twice in the CLSS surveys (~30%) and differ more than two centimetres were excluded. In all other cases the record of the first round was selected.

Figure 2: Average percentage of missing primary educated mothers in the samples



Note: Missing values of the gross school enrolment rate were linearly interpolated. The median difference was taken to account for the influence of countries, where the gross enrolment rate has reached a high level. In those cases the divergence between gross and net enrolment rates would exaggerate the percentage of missing women when taking the mean. No data was available for Namibia.

Figure 3: Interstate variation in GDP per capita and mean heights of mothers (1960-69)



Note: Values on the left show the corresponding mean height, on which the percentiles are based. 50th percentile corresponds with the median height of US women at age 18. US GDP/cap (1820) are from Maddison (2001).

Figure 4: Protein supply and heights 1960-69

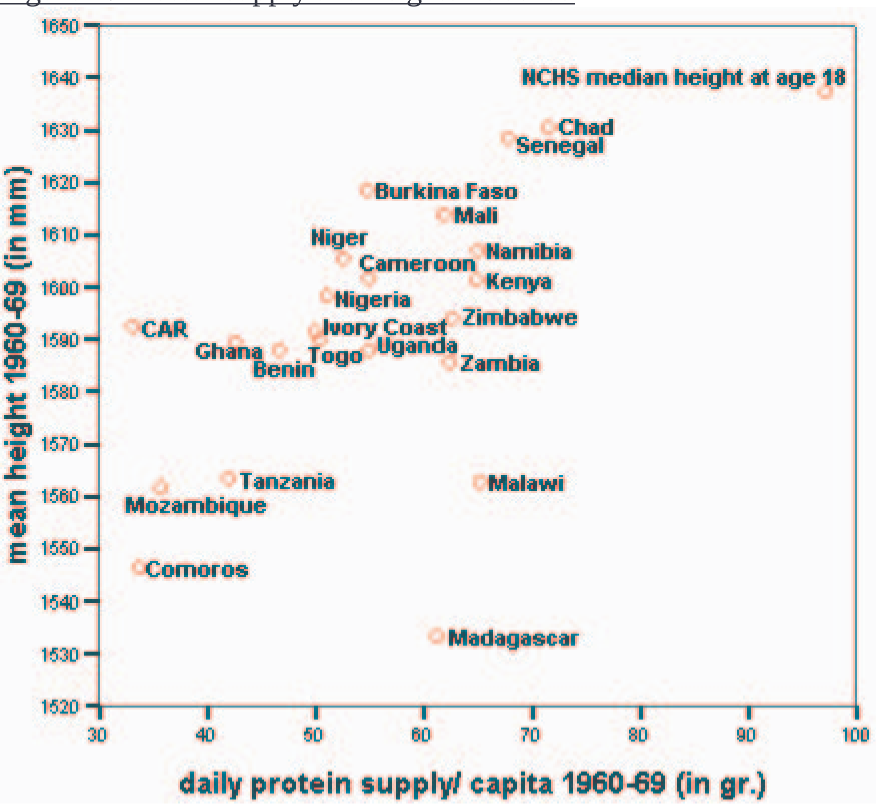
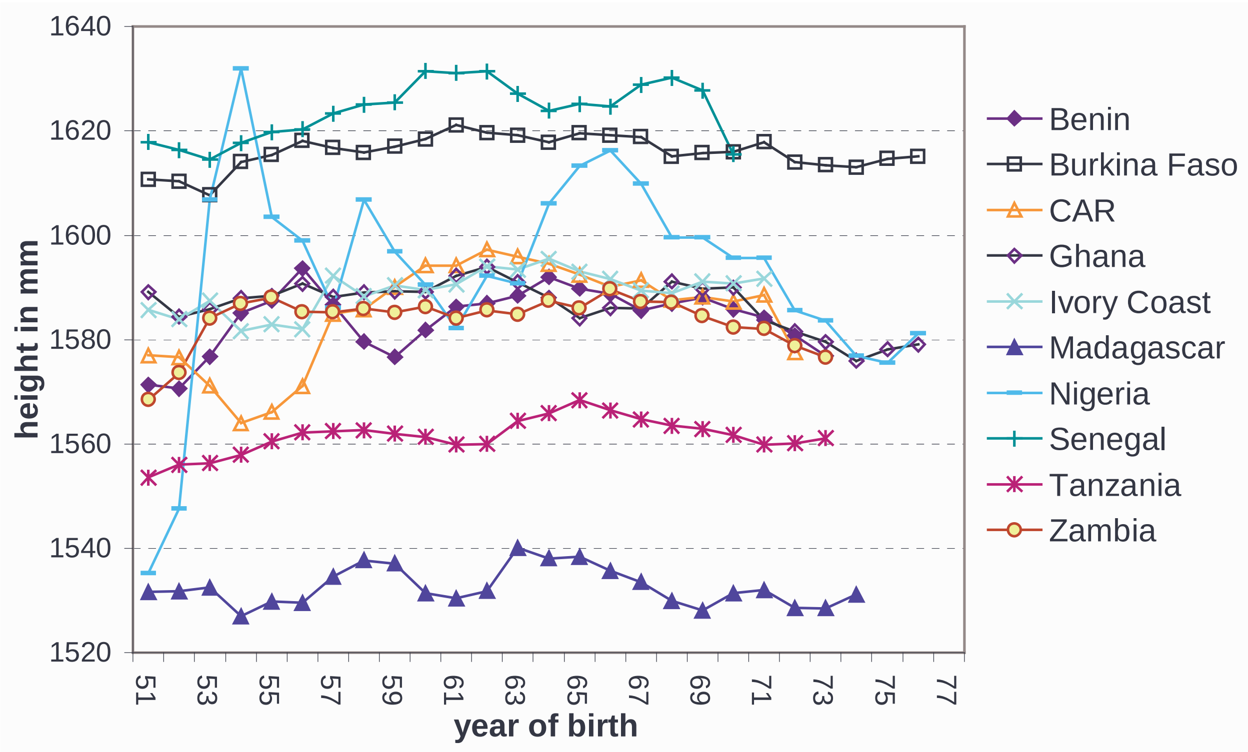
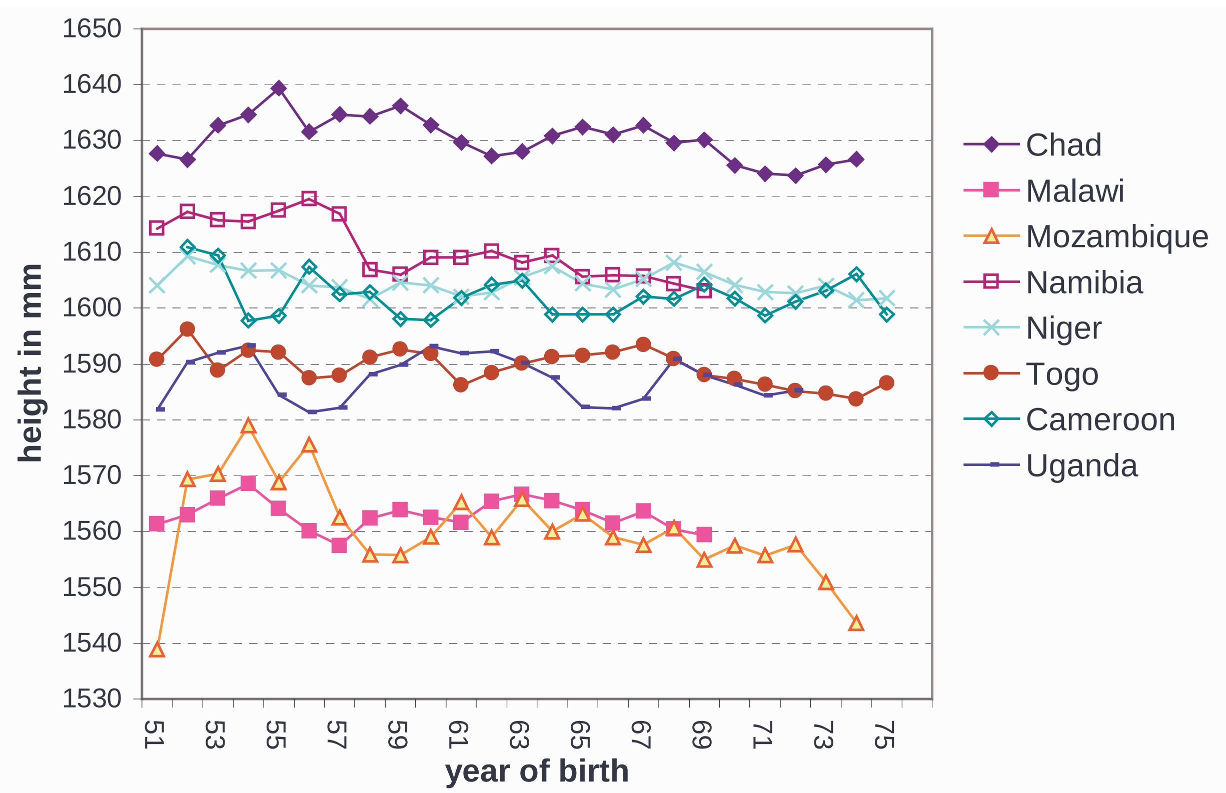


Figure 5: Height trends following an inverted U



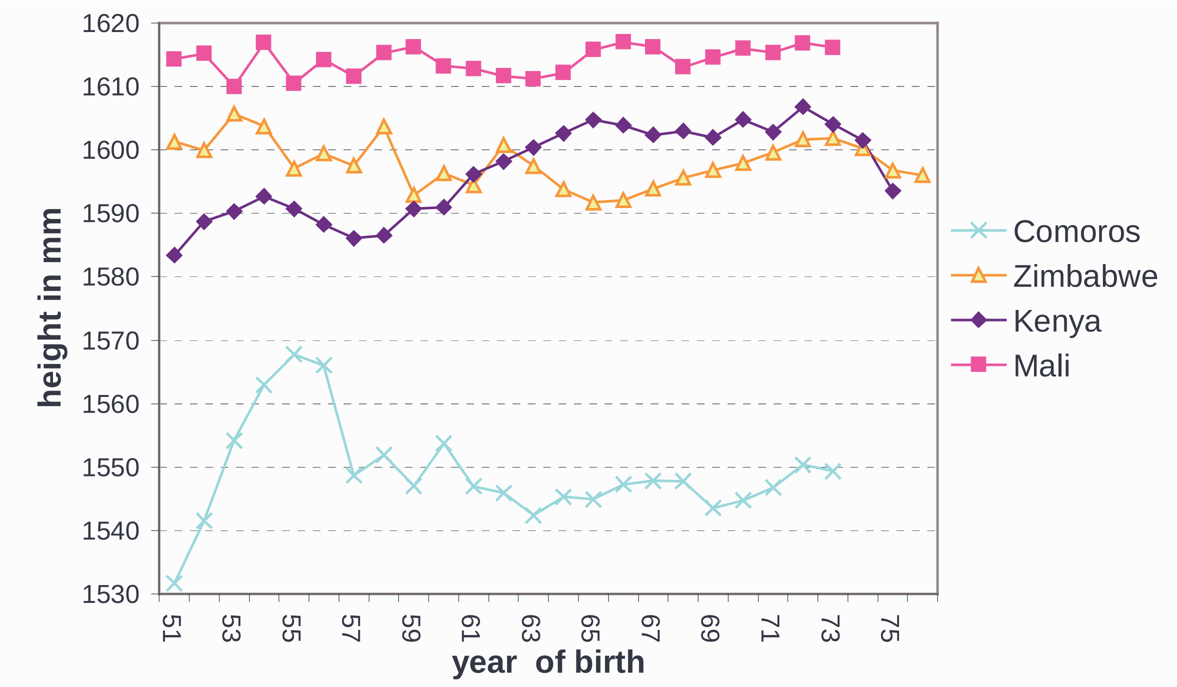
Note: Due to the original oscillating pattern, an MA(3) process was generated from annual mean heights. Only mothers older than 20 years were included.

Figure 6: Downward sloping and stagnating heights



Note: See figure 5.

Figure 7: U shape and Upward trends in height:



Note: See figure 5.

Table 1: Regression of DHS mothers' heights on CLSS women's heights / Ivory Coast

Constant	1,10 (0,29)	0,92 (0,61)
Δheight $(DHS)_{t-1}$		-1,26 (-7,59)
Δheight $(DHS)_{t-2}$		-0,64 (-3,97)
Δheight $(CLSS)_t$	0,33 (0,31)	1,10 (2,58)
DW	3,36	1,70
R^2-adj.	-0,08	0,83
N	14	14

Note: Δ denotes the first difference of the variable.
Dependent variable: Δheight $(DHS)_t$. Time period covered 1952-66. The birth cohorts 67/68 were excluded, since the women's mean heights are then exclusively based on the last CLSS survey conducted in 1988 and a bias due to the increasing weight of this survey in calculating the mean height could not be excluded.

Table 2: 21 Regressions: How much lower is the percentage of primary educated mothers in the DHS samples compared with the underlying population?

country	birth year 1950-67 (constant)	birth year 1968-77 (1=yes)	t-value (birth year 1968-77)	Average difference between gross and net rate 1980-88
Benin	6,91	8,59	5,59	9,58
Burkina Faso	0,17	1,69	1,39	2,99
Cameroon	10,34	11,23	3,22	25,10
CAR	-8,79	3,04	-1,20	7,35
Chad	-3,54	-0,53	-0,22	5,90
Comoros	-3,33	13,52	4,81	16,89
Ghana	-5,05	3,14	0,90	n.a.
Ivory Coast	15,13	8,50	3,07	n.a.
Kenya*	-20,18	26,89	6,91	21,15
Madagascar*	-3,15	36,45	7,27	32,20
Malawi	-5,60	-8,76	-1,28	10,91
Mali	-0,64	3,85	1,96	4,87
Mozambique	-5,01	25,30	5,10	29,39
Niger	1,16	1,53	2,01	1,73
Nigeria*	-14,02	45,88	9,46	n.a.
Senegal	10,14	-0,31	-,10	7,34
Tanzania	-30,06	-33,44	8,00	20,69
Togo	11,61	25,64	7,18	21,74
Uganda	-19,92	-13,63	-3,25	12,47
Zambia	-20,86	18,93	3,12	11,79
Zimbabwe*	-0,95	2,33	0,26	n.a.

Note: The dependent variable is the difference between the gross school enrolment rate for females given by the World Bank (1999) and the frequency of primary educated mothers born eight years prior. Countries marked with an asterisk have enrolment rates higher than 100%. No data was available for Namibia.

Table 3: Determinants of between-country variation of heights in Africa (1960-69)

	Dependent Variable: mean heights in mm				
Excluded countries	Malawi & Burkina Faso	Malawi & Burkina Faso	none	Malawi, Burkina Faso & Madagascar	Malawi & Madagascar
Constant	1598,29 (16,24)	1598,29 (12,19)	1635,10 (34,14)	1439,73 (23,96)	1531,52 (118,59)
Protein supply/cap/day	1,34 (2,99)	1,34 (2,37)	1,22 (2,91)	1,26 (3,28)	1,46 (4,42)
Calorie supply/cap/day	-0,01 (-0,22)	-0,01 (-0,19)		0,03 (1,17)	
IMR	-0,36 (-1,42)	-0,36 (-0,92)	-0,48 (-2,42)	0,14 (0,73)	
LN(GDP/capita)	3,17 (0,29)	3,17 (0,42)		2,62 (0,67)	
Percentage of primary education	-0,65 (-2,58)	-0,65 (-1,66)	-0,48 (-2,42)	-0,15 (-0,76)	-0,29 (-4,56)
Cook-Weisberg test for heteroscedasticity (p-value)	0,02	Robust standard errors			
F-Test (p-value) that all variables excluded in the next regression are jointly 0		0,92		0,24	
N	20	20	22	19	20
R^2-adj.	0,38	0,38	0,50	0,70	0,71

Note: Due to significant heteroscedasticity in the regressions, robust standard errors were estimated; derived t-values in parentheses.
GDP/ cap is not available for Malawi and Burkina Faso. The percentage of primary educated mothers in the sample was included instead of gross primary school enrolment rates for females because they are anyway positively correlated (Beta Coefficient=0,77) and the former is available for all countries. Using gross enrolment rates instead would not change the results.

Table 4: Determinants of temporal Variation in Heights (A panel-analysis of first differences)

Period	(1962-77)	Mean of the variables (1962-77)	(1964-77)	Mean of the variables (1964-77)
Dependent Variable: $Height_t$		-0,64		-0,86
Constant	12,50 (1,80)		3,94 (0,45)	
$Height_{t-1}$	-0,63*** (-11,34)	-0,14	-0,62*** (-10,07)	-0,25
$Height_{t-2}$	-0,30*** (-6,04)	-0,37	-0,33*** (-5,49)	-0,45
Mean education in single years in the birth cohort	2,10*** (3,27)	0,01	1,71*** (2,76)	0,01
IMR	-0,67* (-1,72)	-2,37	-0,38 (-0,87)	-2,36
LN(daily animal protein supply/capita)	0,01 (0,21)	1,56	0,03 (0,54)	0,81
LN(daily animal protein supply/capita)$_{t-1}$			0,10** (2,09)	0,95
LN(daily animal protein supply/capita) $_{t-2}$			0,13*** (2,56)	0,98
LN(GDP/ Capita)	0,19*** (3,08)	0,98	0,14*** (2,50)	0,82
Governmental expenditures as % of GDP	0,86*** (4,50)	0,34	0,68*** (3,43)	0,41
Consumption expenditures as % of GDP	0,37*** (3,68)	-0,46	0,37*** (3,91)	-0,56
LN(Openness)	-0,08*** (-2,59)	0,99	-0,07** (-2,34)	1,57
LN(Population)	-1,60** (-2,29)	2,64	-1,74** (-2,08)	2,68
Independence (5 years=1)	-1,72* (-1,76)	0,15	0,56 (0,49)	0,08
SQRT(Deaths from political violence)	-0,02** (-2,14)	12,40	-0,02* (-1,94)	14,18
Year of birth	-0,18* (-1,87)	68,44	-0,02 (-0,21)	69,46
N	260	260	222	222
Log-Likelihood	-827,33		-697,42	

Note: GLS-Regression with panel heteroscedasticity, panel specific autocorrelation coefficient and fixed effects. All variables in first differences except for deaths from political violence, independence and year of birth. Birth cohorts with less than 30 individuals were excluded.
z-values in parentheses; coefficients significant to the 10%/ 5%/ 1% level are marked with */**/***. Countries included in the regression of the second column (years in brackets): Benin (13), Cameroon (15), CAR (12), Chad (14), Comoros (13), Ghana (16), Ivory Coast (11), Kenya (15), Madagascar (14), Mali (13), Mozambique (14), Niger (15), Nigeria (16), Senegal (10), Tanzania (13), Togo (15), Uganda (12), Zambia (13) and Zimbabwe (16).

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