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Economic Growth and Child Undernutrition in Africa

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Abstract

Despite recent improvements in economic performance, undernutrition rates in Africa appear to have improved much less and rather inconsistently across the continent. We examine to what extent there is an empirical linkage between income growth and reductions of child undernutrition in Africa. We do this by pooling all DHS surveys for African countries, control for other correlates of undernutrition, and add country-level GDP per capita. We find that increases in GDP per capita are associated with lower individual probabilities of being underweight of about 2.5 percent per one hundred dollars. This association becomes insignificant when time fixed effects are added to the regression. Other explanatory variables such as mother's education, socioeconomic status, and poor mother's nutritional status are quantitatively more important than economic growth suggesting that other intervention to affect these correlates of undernutrition are likely to be more promising than relying on improved economic conditions.

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1 Introduction

Child health affects adulthood health status and socioeconomic status (Case et al. 2005; Duflo et al. 2007; Martorell, 1999). Children are most vulnerable to shocks at the micro and macro level. It is increasingly recognized that investments in child health made during critical periods of economic development results in larger returns and, conversely, that failure to investment can lead to severe long-term economic impact at the household-level, as well as at the macro-economic level. Thus understanding the determinants of child health is critical for long-term well-being of African populations.

Reducing the risk of food insecurity is one of the major challenges in affecting child health in Africa, both in terms of addressing short-term risks such as the recent economic crisis and volatilities in food prices as well as in terms of addressing long-term risks of chronic undernutrition. At the same time, growth in Sub-Saharan Africa has been substantial in recent years, leading to a significant decline in income poverty, from 59% in 1993 to 47% in 2008, using the $1.25 poverty line (Chen and Ravallion, 2012). Theoretical considerations would suggest a close linkage between income, income poverty, and undernutrition. More resources at the household level improve the ability of household members to acquire more calories and of parents to invest more in the nutrition and health of their children. These linkages would likely be larger in aggregated cross-country data as used below than in household-level data, as higher per capita incomes not only mean higher household-level incomes, but also enable higher investments in public services in the areas of health, nutrition, water and sanitation, and social protection for all households, which are other important factors influencing hunger and childhood mortality (UNICEF, 1998).

While it is clear that economic growth can be important for nutritional status of children (e.g. Smith and Haddad, 2002), it is not clear that the poor benefit from economic growth per se. For example, the most deprived population group can be bypassed by an average increase in per capita incomes, particularly if growth is accompanied by rising inequality. In addition, at the national level, increases in GDP per capita must not be translated into a rise in public services in the health sector.

Moreover, at the micro-level, there is growing body of literature that investigates the relationship between family income and the health status of children (see, e.g. Case et al., 2002; Case et al., 2008; Deaton, 2006; Duflo, 2003). Parents in wealthier households may better be able to invest in the health of their children because they are better able to buy health care or services that improve better health outcomes. In addition, income might also be related to other socioeconomic factors such as education, which affects child health positively (Burgess et al. 2004). But it is unclear whether these effects are mostly due to higher incomes or higher socioeconomic status that comes with these higher incomes and may afford several other advantages. Higher socioeconomic status within society might also be the result of selection effects on unobservables that might be beneficial to health outcomes of children. Therefore it might be useful to examine simultaneously the impact of aggregate income levels as well as socioeconomic status to sort out these two effects.

There is only very little literature on the effect of macroeconomic development on the nutritional status of children. We are aware of the following studies: Smith and Haddad (2002) estimate the effect of economic development on undernutrition of children at the macro level for a panel of 63 developing countries with an average of three observations over time. They find a very strong effect and conclude that increases in GDP per capita between 1970 and 1995 have contributed to roughly half of the total reduction in the prevalence of child undernutrition in developing countries.

Haddad et al. (2002) estimate the effect of income on nutritional status of children at the micro level with cross-sectional data for Egypt, Jamaica, Kenya, Kyrgyzstan, Morocco, Mozambique, Nepal, Pakistan, Peru, Romania, South Africa and Vietnam. They also find that income growth reduces child undernutrition, but the magnitude of the effect is not sufficient to reach the Millennium Development Goal of halving the levels of child underweight by 2015 through the effect of economic growth alone (assuming reasonable growth rates).

Klasen (2008) (and a range of similar studies) examines the drivers of undernutrition using cross-country data. He (as well as a range of methodologically related studies) find an impact of (log) incomes on undernutrition, but the effect tends to be rather small.

Subramanyam et al (2011) estimate the association of economic growth at the state level on child undernutrition in India with three household surveys between 1992 and 2006 (repeated cross-section). They find an inverse association between state economic growth and the risk of undernutrition in models that do not account for time fixed effects. In specifications that include time fixed effects, the association between state economic growth and underweight, stunting and wasting becomes insignificant.

A recent study by Friedman and Schady (2009) estimate the additional number of infant deaths in Sub-Sahara Africa as a result of the financial crisis. The authors also pooled DHS data sets for Sub-Saharan African countries and control for fluctuation in national income, i.e. they separately investigate the impact of booms and busts on child mortality rates. They find that there will be 30,000 to 50,000 additional deaths as the results of the reduced growth caused by the global financial crisis in Africa in 2009.

This paper deals with the question of why the number of income poor people is falling but the level of childhood undernutrition is falling only very slowly. While this is true at the global level it is not necessarily the case for sub-Saharan Africa.

The objective of the paper is to investigate the association of increases in GDP per capita and child undernutrition in sub-Saharan Africa. We find that increases in GDP per capita are associated with a reduction of the individual probability of being underweight of 2.5 percent per one hundred dollars (4.1 percent for the probability of being stunted). This association is economically meaningful. But other explanatory variables such as mother's education, socioeconomic status of the household within society, and poor mother's nutritional status are quantitatively more important than economic growth. The association becomes insignificant when time fixed effects are added to the regression.

Focusing on the impact of economic resources on childhood undernutrition, we identify a kind of micro-macro paradox. While resources at the household level have a rather strong influence on reducing undernutrition rates at the individual level, resources at the aggregate level do not seem to have this effect. One possible explanation would be that relative income or selection effects explain the impact of household resources on undernutrition, while aggregate income is much less important. Of course, measurement error in aggregate income levels or growth thereof might also play a role.

The paper is organized as follows. In section 2, we describe our empirical approach and the data. In section 3, we present and discuss the descriptive results and the outcomes of the regressions. Finally, in section 4, we conclude.

2 Empirical Analysis

2.1 Data

To analyze the determinants of child undernutrition across countries and over time, we use the nationally representative Demographic and Health Survey (DHS) data sets. The DHS are undertaken by *Macro International Inc., Calverton, Maryland* (usually in cooperation with local authorities and funded by USAID) and started in 1984. They provide detailed information on child mortality, health, and fertility. In particular, the DHS detailed information on anthropometric outcomes of children of the interviewed women (who are between the age of 15 and 49). In particular, information on child undernutrition is available for children born 5 years prior to the survey. We use these child histories to assess the levels and trends in child undernutrition. Besides the information in the anthropometric outcomes of children, the DHS data contain detailed information on the socioeconomic characteristics of all household members as well as on characteristics of the household. The data are generated by a self-weighted national survey of women aged between 15 and 49. The average sample size is about 5,000 to 6,000 women, and some are surveys are even larger than that.

The DHS include a household member recode and an individual recode for women of reproductive age. The household member recode lists all member of the household. At the household level, the DHS provide information on basic demographics, education and on the possession of household assets. Although the DHS are not completely standardized across time and countries, the design and coding of variables (especially on assets and dwelling characteristics) are generally comparable. The child recode provides detailed information on all children of women aged between 15 and 49 born within the last 5 years prior to the survey, including child health, child mortality and anthropometric indicators

To date, DHS data is available for 28 African countries for several years – resulting in more than 70 large scale household surveys. For our analysis, we pool all existing African DHS data sets between 1991 and 2009.[4] The estimation sample contains around 380,000 children born between 1996 and 2009. The countries and survey years are presented in Table 1. The pooled data includes a complete annual cross section for the time period 1991 and 2009.

We merge our pooled cross section DHS data set with data GDP per capita in constant 2005 prices (chain series) from the Penn World Tables (Version 7.0, 2011) by country and survey year between 1991 and 2009. Besides these advantages of the (pooled) DHS data sets, the data have also some limitations including, for example, the problem of measurement error as a result of the self-reporting of the child morbidity by mothers.[5]

2.2 Measuring undernutrition

The underlying theoretical framework for the choice of the dependent and independent variables closely follows the analytical framework proposed by Mosley and Chen (1984) to study child survival, and a related conceptual framework developed by UNICEF (1998) for childhood undernutrition. The idea of this framework is the assumption that social, economic,

[4] Data before 1991 suffer by many missing values on anthropometric indicators of children.

[5] For a detailed discussion on the limitation of the DHS data, see Bhalotra and Rawlings (2010) and Thomas and Strauss (1998).

demographic, and medical determinants, i.e. the proximate determinants, affect the survival probability of the children through a set of biological mechanism. The proximate determinants are grouped at different hierarchical levels, i.e. the individual, the household level and economic growth measured by GDP per capita at the country and year level. In this analysis, the Mosley and Chen (1984) framework is combined with the conceptual framework to study the causes of child undernutrition proposed by the United Nations Children's Fund (UNICEF, 1998), which is based on assumptions similar to the Mosley and Chen (1984) framework.

The DHS data sets provide information on several anthropometric outcomes of children, in particular the z-scores for weight for age, weight for height, and height for age. We use a dummy variable whether the child is moderately stunted wasted and/or underweight as independent variables, that is, whether the z-score (height for age - stunting, weight for height - underweight, weight for age - wasting) is below -2 standard deviations from the median of the reference population (WHO 2006). The z-score is defined as $z = \frac{AI_i - MAI}{\sigma}$, where AI_i refers to the individual anthropometric indicator (height for age - stunting, weight for height - underweight, weight for age - wasting), *MAI* refers to the median of the reference population, and s refers to the standard deviation of the reference population. For example, the stunting z-scores are the outcomes of the ratio of height over age minus the median of the reference population and the standard deviation of the reference population (see e.g. Klasen, 2003, 2008; Smith and Haddad, 2000). We also consider the case of severe undernutrition where the respective z-score is below -3 standard deviations of the reference. In addition, we also consider the stunting z-scores as the dependent variable to study the determinants of undernutrition.

Two issues might be worth highlighting when considering the z-Score as the key anthropometric indicator which are discussed in detail in deHaen, Klasen, and Qaim (2011). First, due to the worldwide switch to food that is higher in starch, sugar, and fat content (often called the nutrition transition), underweight rates might improve even though the nutritional status of the child has not improved. Stunting rates seem to be less susceptible to this bias. Second, there are debates about the use of a single reference standard to compare undernutrition rates for children across countries (due to differences in the genetic height and weight potential). This is particularly a problem if one compares undernutrition rates across regions and thus might be somewhat less relevant here. Besides GDP per capita at the country and survey year level, we include a set of control variables at the individual and household level. At the household level, we control for the number of children ever born, the geographical area of the household, and the age, sex and education of the household head. As individual child characteristics, we include the age and sex of the child (see Marcoux, 2002; Klasen, 1996). In addition, we control for the fact whether the child has a twin brother and/or sister which might results in difficulties of allocating scarce household resources between the children.

We also control for the nutritional status of the mother to capture possible genetic transmission channels and/or socioeconomic factors that are not captured by the other control variables. In particular, we use the mother's BMI, which might affect childhood undernutrition via a genetic linkage or via a socioeconomic indication to what extent a mother with a low BMI is able to effectively care for her children.[6] We also control for characteristics of the mother that could affect the nutritional status of the child in other ways. In particular, we include whether the mother is currently pregnant and/or breastfeeding to further capture possible constraints on the ability of the mother to care for her children. In addition, we control for the educational attainment of the mother.

As we do not have information on income or expenditure in the DHS, we consider an asset-based approach in defining long-term well-being of the household (Filmer and Pritchett, 2001; Sahn and Stifel, 2001). The so called 'asset index' is often used in the empirical literature on poverty and inequality analysis as a proxy variable for household income or wealth.[7] For construction of the index, we use a principal component analysis on several household assets to derive an index that indicates the material status of a household. We use the following variables to construct the asset index: radio, TV, refrigerator, bike, motorized transport, capturing household durables and type of floor material, type of wall material, type of toilet, and type drinking water capturing the housing quality and we calculate the asset indices separately for each country and period. As we simultaneously control for GDP per capita and construct the asset index separately for each country, the asset index used here is largely an indicator of *relative* socioeconomic status (rather than another absolute income measure). As discussed above, this is exactly what we want as we want to separate the effects of aggregate incomes and relative socioeconomic status in our analysis.

[6] The recommend method to measure the nutritional status of adults is the body mass index (BMI), which is calculated by $BMI = weight(kg)=height2(m2)$. A mother is considered as malnourished if her BMI is less than 18.5.

[7] There is a large body of literature that uses an asset index to explain inequalities in educational outcomes (e.g. Ainsworth and Filmer, 2006; Bicego et al., 2003), health outcomes (e.g. Bollen et al., 2002), child malnutrition (e.g. Sahn and Stifel, 2003; Tarozzi and Mahajan, 2005), or child mortality (e.g. Sastry, 2004) when data on income or expenditure is not available. In addition, asset indices are used to analyze changes and determinants of poverty (Harttgen and Misselhorn, 2007; Sahn and Stifel, 2000; Stifel and Christiaensen, 2007; World Bank, 2006).

2.3 Estimation approach

In two sets of regressions we look at the association of (log) GDP per capita and child undernutrition at the macro level and at the individual level. First, we collapse the individual level survey data to obtain rates of underweight, stunting and wasting for each country and year. In simple linear regressions we study the association of (log) GDP per capita and the rates of underweight, stunting and wasting (moderate and severe). Next, we include country fixed effects to each regression. The regressions with country fixed effects measure the association of within country variation of (log) GDP per capita over time (thus implicitly economic growth) and the three indicators of child undernutrition. The country fixed effects also control for country specific omitted variables (that are constant over time), which potentially bias the result of the simple linear regression without control variables. Such omitted variables could include geographic characteristics, the disease environment but also institutions and infrastructure that did not change much in the observation period (and which are not available in the data sets). All standard errors are clustered at the country level.

Secondly, we study the individual probability of a child of being underweight, stunted or wasted (moderate and severe). To this end we run logistic regressions with an indicator variable that is one if the child is underweight and zero otherwise as dependent variable (same for stunting and wasting). The actual regression coefficients of logistic regressions do not have a meaningful interpretation. Therefore it is common to report marginal effects or odds ratios instead; we choose the latter here. We start with a very simple model that only includes (log) GDP per capita as explanatory variable. Next, we add individual level control variables to the regressions that include characteristics of the household, the mother and the child. The household level control variables include an asset index as a measure of household wealth, an indicator for urban or rural location, the number of children ever born, the sex of the household head as well as the level of education of the household head and of the mother. We further include indicator variables whether the mother is currently pregnant, currently breastfeeding or has a low body mass index. At the child level we control for the sex of the child, the age of the child, whether the child is a twin. Next, we add country fixed effects to the regressions. As in the macro level regressions, the country fixed effects are supposed to account for country specific differences that are constant over time. Finally, we include survey year fixed effects to the regressions. The survey year fixed effects capture general developments that affect all countries. An example could be technological improvements that increase the level of agricultural productivity in all countries. However, the survey year fixed effects also take out the effect of increases in (log) GDP per capita that are common to all countries (e.g. the effects of common trends of rising GDP or the effect of business cycles that are common to all countries such the commodity boom which might affect most African countries or the global financial crisis which might have a similar common effect). We therefore caution to over-interpret the specification with survey year fixed effects as it may underplay the impact of aggregate economic conditions on childhood undernutrition.

3 Results and discussion

3.1 Descriptive statistics

Table 2 shows the mean rates of moderate stunting, wasting, and underweight of children below five years of age as well as GDP per capita in USD PPP (constant 2005 prices) by country and survey year. On average, 24% of children under the age of five are underweight, 41% are stunted, and 10% are wasted in our sample. Average GDP per capita is slightly above 1000 USD. Starting with the levels of undernutrition across indicator, Table 2 shows that in almost all countries stunting rates are considerable higher than wasting rates, followed by rates of underweight. The relatively low rates of underweight might already be an effect of the nutrition transition that lead to heavier but still malnourished children (deHaen, Klasen, and Qaim, 2011).

Table 2 also reveals large differences across countries. Lowest average levels of child undernutrition are found in Senegal, Ghana, and Namibia, the richer countries in our sample. However, even in these countries, levels of child undernutrition are worryingly high. Although wasting and underweight are relatively low, in 2008, still between 20 and 30 percent of the children were stunted – indicating a persistent problem of chronic undernutrition. The highest levels of child undernutrition are found in Madagascar and Niger, where about half of the children are stunted. Levels of GDP per capita also differ between countries. Some countries such as Ethiopia, Malawi, Mozambique, and Niger have a GDP per capita level of about 500 USD. At the same time, other countries showed considerably higher levels of GDP such as Cameroon, Namibia, and Kenya. However, on average levels in GDP per capita are very low and the countries in our sample are among the poorest countries in the world.

The levels of severe undernutrition are shown in Table 3, which by definition are lower across countries. The ranking of the countries in terms of their rates of undernutrition does not differ very much between the various indicators. However, Tables 2 and 3 also reveal first interesting insights into changes in child undernutrition rates over time. First, there is a clear trend observable that Africa increases its level of GDP per capita over time for most countries; there are some exceptions though (see below). Second, it is less clear whether Africa increases or decreases its levels of child undernutrition. This observation is verified by Table 4, which presents the mean annual rates of change of the undernutrition indicators and GDP per capita of the countries for which more than one survey is available. Table 4 reveals three main findings. First, GDP per capita growth is positive in almost all countries, except, Malawi, Togo, Zambia, Cameroon, Madagascar, and Zimbabwe. Second, on average, undernutrition went down. Third, reductions in undernutrition rates are unevenly distributed across countries and across indicators; sometimes the trends in the different indicators even go in the opposite direction in a single country suggesting that the three indicators do indeed measure different aspects of undernutrition. For example, in Benin, underweight and wasting fell considerably but stunting increased. Lastly, and consistent with the arguments related to the nutrition transition, improvements in underweight (and wasting) are more prevalent and larger than improvements in stunting. In fact, in 11 countries stunting rates increased over the time period.

To illustrate the unequal distribution of progress, Figure 1 shows the underweight rates and GDP per capita levels for each country and survey year. The respective results for stunting and wasting are presented in Figure A1 and A2 in the Appendix. We can broadly categorize three groups of countries with respect to their development of GDP per capita over time. First, a group of countries with a positive trend in GDP per capita levels between 1990 and 2009. This group includes Burkina Faso, Chad, Ethiopia, Ghana, Kenya, Lesotho, Mali, Mozambique, Namibia, Nigeria, South Africa, Senegal, Sao Tome and Principe, Tanzania, and Uganda. The second group consists of countries that have experienced a decline in GDP per capita. This group includes Togo, Congo, Dem. Rep., Cote D'Iviore, and Zimbabwe. The third group includes those countries where no clear trend is observable. These countries are Benin, Cameroon, Guinea, Liberia, Madagascar, Malawi, Niger, Sierra Leone, and Zambia. It is more difficult to identify clear trends for undernutrition, because we only have a few observations per country over time. There are countries such as Ghana or Senegal, where increases in GDP per capita are associated with reductions in underweight rates. On the other hand, underweight rates worsened in Burkina Faso despite remarkable increases in GDP per capita. Interestingly in Kenya or Namibia, underweight rates improved in period when GDP per capita was fairly constant and underweight rates were fairly constant when GDP per capita strongly increased. The main result is that there is no clear pattern across countries; but one can note that in general, progress in reducing undernutrition has overall been disappointing, particularly given the generally more positive development in income growth rates.

In Figure 2 we illustrate the association between GDP per capita and child undernutrition. The association between GDP per capita and underweight and stunting respectively is somewhat negative but weak; one should note, however, that the sometimes visible positive relation between income and undernutrition visible among very poor countries is heavily influenced by Zimbabwe, whose per capita income levels collapsed in recent years (making it the poorest country in the sample) while undernutrition rates have not increased nearly as fast; without this observation, the negative gradient would be somewhat clearer, but remains weak. There is no association between GDP per capita and wasting. But of course these weak associations could be due to the failure to control for confounding effects. Thus a multivariate analysis is required to which I now turn.

3.2 Estimation results

We will focus on the regression results with the underweight rate in the aggregate regressions and the individual probability of being underweight in the micro regressions as dependent variable, respectively. We focus on underweight, because it is an indicator for the Millennium Development Goals (MDGs) and therefore has particular political importance. In addition, underweight captures both immediate and chronic effects of undernutrition on child development while wasting and stunting only measure on or the other. However, we report the regression results with stunting and wasting as dependent variables in the appendix (c.f. Tables A1-A4) and briefly discuss the main differences to underweight in the last paragraph of this section.

In Table 5 we report the regression results at the macro level for all indicators of child undernutrition. The regressions confirm the observations from the descriptive analysis, i.e. that there is no statistically significant association between GDP per capita and the various measures of child undernutrition, esp. once we control for country-specific effects (and when therefore the effect of per capita GDP is estimated using within-country variation of GDP over time, i.e. growth or contractions, rather than differences in GDP levels betweel countries). Similar in spirit to Friedman and Schady (2010), we also separate the sample into spells where per capita incomes were growing and those where they were shrinking to see whether the effects differ between periods of expansion and recessions, but could not find a clear pattern here. Also the effects of per capita income remained insignificant. Of course this may be due to the fact that we ignore inter-country heterogeneity in undernutrition and its drivers. Therefore it is useful to report on the individual-level regressions.

In Tables 6 and 7 we report the results of the logistic regressions for the individual probability of being underweight (moderate: Table 6 / severe: Table 7). The reported coefficients are odds ratios (OR) with 95 percent confidence intervals in parentheses. If the odds ratio is greater than one, it can be interpreted as an increased probability of (OR-1)*100 percent of being underweight. If the odds ratio is smaller than one, it can be interpreted as a decreased probability of (1/OR-1)*100 percent of being underweight. In the simple specification without control variables, a hundred dollar increase of GDP per capita is associated with a 1.2 percent smaller probability of being underweight (1.1 percent of being severely underweight). In the specification with control variables the magnitude is slightly smaller (0.5 percent for moderate underweight and 0.3 percent for severe underweight). In the specification with control variables and country fixed effects, a one hundred dollar increase of GDP per capita is associated with a 2.5 percent lower individual probability of being underweight (2.9 percent for severe underweight). It is important to control for heterogeneity across countries, therefore the last specification is the most credible. If we add time fixed effects, the coefficient of GDP per capita turns insignificant both for moderate and severe underweight. This is not surprising, because GDP per capita has a strong positive time trend. The time fixed effects absorb common changes in GDP (either common trends or common business cycles) and the identification is based on variations around these common trends and cycles; thus we would prefer the specification without the time trend as our best estimate. In any case, the effect of GDP per capita on undernutrition there is also rather small.

For the discussion of the control variables we focus on the specification with the individual probability of being underweight as dependent variable with country fixed effects (third column of Table 6).[8] A one-unit increase in the asset index is associated with a 26 percent lower probability of being underweight.[9] Thus it appears that relative socioeconomic status within a society is much more important than average prosperity of the society. Children in urban households are 17 percent less likely to be underweight than children in rural households. Each additional child ever born in a household increases the probability of being underweight by 0.4 percent. Children in a male-headed household are 2.7 percent more likely to be underweight than children in a female-headed household. The age of the

[8] The results in the other specifications are qualitatively similar even though the magnitudes differ to some extent.

[9] We also tried a model specification without GDP per capita to test whether this influences the effect of the asset index. However, leaving out GDP per capita has virtually no impact on the asset index coefficient. In addition, we also test for possible nonlinearities in the effect of the asset index. For this we include the squared asset index, but no nonlinearities could be identified.

household head is associated with a 0.2 percent lower probability of being underweight per year. Children whose household head has primary or higher education are 10 to 18 percent less likely than children whose household head does not have any education. Interestingly, the education of the mother is associated with even lower probabilities of being underweight than the education of the household head (33 to 39 percent).[10] The magnitude of the education variables suggests – similar to the asset variable – that relative socioeconomic status within a society is much more important than the average prosperity of a society. If the mother is currently pregnant, then the child is 24 percent more likely to be underweight. If the mother is currently breastfeeding, then the child is about 21 percent more likely to be underweight. Both of these indicators suggest that mothers who are burdened to care for many children are less able to care for each one. If the mother has BMI below 18.5, then the child is almost twice as likely to be underweight, suggesting a strong genetic and/or socioeconomic transmission from mother to child. Boys are about 21 percent more likely to be underweight than girls, and twins are more than twice as likely to be underweight than non-twins.

It is interesting to note that the inclusion of control variables (except the time fixed effects) does little to change the affect the impact of aggregate economic conditions (proxied by our GDP per capita variable). Sometimes the effect even gets larger once control variables are included. This suggests that the impact of the control variables and aggregate economic conditions are rather separate influences on undernutrition and can therefore be interpreted rather separately. Thus it appears that the influence of GDP per capita does not operate through some of the control variables but properly operates via improvements in the level of household income and improvements in public services that are afforded by these higher average incomes. But it is clear from the size of the effects that the impact of some of the individual-level determinants is just significantly larger than those of aggregate economic conditions.[11]

The outcomes with the individual probability of being stunted as dependent variable are qualitatively similar to the previous results. In the preferred specification with control variables and country fixed effects, a one hundred dollar increase in GDP per capita is associated with a 4.1 percent lower individual probability of being stunted (4.5 percent for

[10] In some cases household head and mother are identical.

[11] Note that this statement comes with the caveat, already discussed above, that per capita GDP might be measured with error and thus lead to a downward bias of the effect. On the other hand, to the extent that per capita GDP increases not only household incomes but also improves public services, the coefficient would be an upwardly biased estimate of the impact of household incomes. It is difficult to assess the relative magnitude of these two biases.

severe stunting). For wasting we cannot find a statistically significant association between GDP per capita and the individual probability of being wasted in our preferred specification. Without country fixed effects, increases in GDP per capita are even associated with an increase in the probability of being wasted. Once time effects are included, increases in GDP per capita are associated with lower probabilities of being wasted. The findings for wasting do not make much sense and are probably due to the fact that the indicator for wasting picks up very recent nutritional problems rather than the nutrition over a period of a few years.

To summarize, our individual-level findings suggest that individual and household covariates are much more important than aggregate economic conditions in explaining undernutrition rates in Africa. Socioeconomic status within a country (as proxied by the asset index) appears to be much more important than average prosperity of a society. This suggests either that being better off within a country is much more important than living in a richer society; this would suggest that lowering inequality in a society could be an important avenue to reduce undernutrition, possibly more important than achieving higher income growth. It might also, however, reflect selection effects in the sense that better off people within a society may have some unmeasured characteristics (e.g. such as health knowledge and behavior) that lead to lower undernutrition.

4 Conclusions

Nutritional status of children is an important indicator for child health and overall well-being. It is by now well known that nutritional status early in life has severe consequences for adult health, cognitive development and adult socio-economic status. Investments in child health and in particular child nutrition have a potentially high pay-off for the long-run development of the individual and of the society. It is important to understand if and to what extent macroeconomic development can contribute to improvements of children's nutritional status. In particular it is unclear whether overall economic growth reaches those who are in need.

Sub-Saharan Africa is particularly interesting case to study, because levels of GDP per capita increased quite strongly in recent years while levels of undernutrition showed very little improvement. And indeed, we cannot establish a link between increases in GDP per capita and rates of undernutrition at the macro level. However, we find that an increase of GDP per capita is associated with a 2.5 percent lower probability of being underweight and a 4.1 percent lower probability of being stunted per one hundred dollars. These associations are economically meaningful (but relatively small) and show the potential effect of economic growth on child undernutrition. The association of GDP with the individual probability of being underweight turns insignificant when time fixed effects are included in the regression. Other explanatory variables, such as mother's education, relative socio-economic status, and the mother's nutritional status are quantitatively even more important – in particular in the short run.

The results suggest that we can only be mildly optimistic that economic growth will help to eliminate undernutrition in sub-Saharan Africa and other developing regions. However, our results also suggest that there are various other factors are much more important in tackling undernutrition; tackling those individual determinants might be more important than economic growth. Among the policies to consider are particularly ways to boost female education, promote fertility decline, and reduce inequality. Policy can thus help to make sure that economic growth reaches those in need and that children in low-income countries can benefit from economic growth rather sooner than later.

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Tables and Figures

Table 1: DHS Data Sample

Country	Year	N (children)	Country	Year	N (children)
Benin	1996	2,589	Mali	1995	5,248
Benin	2001	4,436	Mali	2001	12,727
Benin	2006	53,356	Mozambique	1997	3,498
Burkina Faso	1992	4,524	Mozambique	2003	8,082
Burkina Faso	1998	4,693	Namibia	1992	2,655
Burkina Faso	2003	8,719	Namibia	2000	2,877
Cameroon	1991	3,524	Namibia	2007	3,686
Cameroon	1998	4,164	Niger	1992	5,777
Cameroon	2004	3,309	Niger	1998	3,938
Chad	1996	7,079	Niger	2006	3,842
Chad	2004	4,833	Nigeria	1999	2,795
CongoDR	2007	3,907	Nigeria	2003	4,732
Cote D Ivoire	1994	3,479	Nigeria	2008	23,864
Cote D Ivoire	1998	1,585	Rwanda	1992	4,375
Ethiopia	2000	9,032	Rwanda	2000	6,201
Ethiopia	2005	4,422	Rwanda	2005	3,737
Ghana	1993	1,965	Sao Tome and Principe	2009	1,807
Ghana	1998	2,838	Senegal	1992	4,634
Ghana	2003	3,381	Senegal	2005	2,814
Ghana	2008	2,684	Sierra Leone	2008	2,409
Guinea	1999	4,503	Tanzania	1992	6,533
Guinea	2005	2,710	Tanzania	1996	5,479
Kenya	1993	5,043	Tanzania	2004	7,382
Kenya	1998	3,022	Togo	1998	3,673
Kenya	2003	4,864	Uganda	1995	4,671
Kenya	2009	5,478	Uganda	2000	5,155
Lesotho	2004	1,461	Uganda	2006	2,408
Lesotho	2009	1,731	Zambia	1992	5,029
Liberia	2007	4,626	Zambia	1996	5,575
Madagascar	1992	4,220	Zambia	2001	5,537
Madagascar	1997	3,085	Zimbabwe	1994	2,134
Madagascar	2004	4,722	Zimbabwe	1999	3,040
Madagascar	2009	5,866	Zimbabwe	2006	4,517
Malawi	1992	3,348			
Malawi	2000	9,683			
Malawi	2004	8,658	*Total*		*378,370*

Note: The number of observations refers to the number of children under age of 5.
Source: DHS data; author's calculations.

Table 2: Mean rates of moderate Undernutrition by country and survey year

		Moderate						Moderate			
Country	Year	Underweight	Stunting	Wasting	GDP per capita	Country	Year	Underweight	Stunting	Wasting	GDP per capita
Benin	1996	0.27	0.35	0.18	1087	Mali	1995	0.38	0.36	0.28	706
Benin	2001	0.22	0.39	0.10	1194	Mali	2001	0.31	0.42	0.14	808
Benin	2006	0.20	0.44	0.08	1229	Mozambique	1997	0.29	0.45	0.13	403
Burkina Faso	1992	0.29	0.40	0.16	671	Mozambique	2003	0.22	0.47	0.06	561
Burkina Faso	1998	0.34	0.46	0.16	775	Namibia	1992	0.22	0.35	0.10	3348
Burkina Faso	2003	0.36	0.43	0.22	860	Namibia	2000	0.19	0.28	0.10	3367
Cameroon	1991	0.12	0.25	0.03	1762	Namibia	2007	0.18	0.30	0.08	4780
Cameroon	1998	0.16	0.35	0.05	1633	Niger	1992	0.40	0.48	0.19	492
Cameroon	2004	0.15	0.37	0.06	1799	Niger	1998	0.46	0.47	0.26	519
Chad	1996	0.34	0.45	0.18	720	Niger	2006	0.40	0.55	0.13	535
Chad	2004	0.34	0.44	0.16	1238	Nigeria	1999	0.26	0.53	0.14	1105
CongoDR	2007	0.25	0.45	0.11	227	Nigeria	2003	0.27	0.44	0.11	1776
Cote D Ivoire	1994	0.21	0.32	0.11	1397	Nigeria	2008	0.27	0.41	0.15	1963
Cote D Ivoire	1998	0.18	0.31	0.07	1550	Rwanda	1992	0.24	0.56	0.05	848
Ethiopia	2000	0.42	0.57	0.13	460	Rwanda	2000	0.20	0.48	0.09	662
Ethiopia	2005	0.34	0.50	0.12	510	Rwanda	2005	0.18	0.52	0.05	839
Ghana	1993	0.26	0.33	0.15	817	Sao T. and P.	2009	0.15	0.32	0.11	1681
Ghana	1998	0.21	0.32	0.10	821	Senegal	1992	0.22	0.33	0.09	1077
Ghana	2003	0.19	0.36	0.09	952	Senegal	2005	0.14	0.20	0.08	1465
Ghana	2008	0.14	0.28	0.09	1212	Sierra Leone	2008	0.21	0.38	0.11	855
Guinea	1999	0.21	0.34	0.10	755	Tanzania	1992	0.26	0.50	0.08	683
Guinea	2005	0.23	0.40	0.11	870	Tanzania	1996	0.27	0.49	0.09	675
Kenya	1993	0.20	0.40	0.07	1092	Tanzania	2004	0.17	0.44	0.04	825
Kenya	1998	0.18	0.38	0.09	1125	Togo	1998	0.24	0.31	0.14	865
Kenya	2003	0.16	0.36	0.06	1156	Uganda	1995	0.22	0.45	0.07	691
Kenya	2009	0.16	0.36	0.07	1206	Uganda	2000	0.19	0.45	0.05	821
Lesotho	2004	0.18	0.44	0.06	1251	Uganda	2006	0.17	0.38	0.07	1028
Lesotho	2009	0.14	0.38	0.04	1311	Zambia	1992	0.22	0.46	0.06	1110
Liberia	2007	0.19	0.38	0.08	403	Zambia	1996	0.20	0.49	0.05	892
Madagascar	1992	0.36	0.61	0.06	843	Zambia	2001	0.24	0.53	0.06	810
Madagascar	1997	0.36	0.57	0.10	787	Zimbabwe	1994	0.12	0.29	0.06	348
Madagascar	2004	0.36	0.53	0.16	712	Zimbabwe	1999	0.11	0.32	0.09	390
Madagascar	2009	na	0.49	na	753	Zimbabwe	2006	0.13	0.35	0.07	171
Malawi	1992	0.24	0.55	0.07	540						
Malawi	2000	0.22	0.54	0.07	544						
Malawi	2004	0.18	0.53	0.07	518	**Average**		**0.24**	**0.41**	**0.10**	**1070**

Source: DHS data; author's calculations.

Table 3: Mean rates of severe Undernutrition by country and survey year

		Severe					Severe		
Country	Year	Underweight	Stunting	Wasting	Country	Year	Underweight	Stunting	Wasting
Benin	1996	0.11	0.14	0.07	Mali	1995	0.20	0.19	0.13
Benin	2001	0.07	0.17	0.03	Mali	2001	0.13	0.23	0.05
Benin	2006	0.06	0.24	0.03	Mozambique	1997	0.14	0.25	0.05
Burkina Faso	1992	0.11	0.18	0.06	Mozambique	2003	0.08	0.23	0.02
Burkina Faso	1998	0.15	0.24	0.06	Namibia	1992	0.07	0.13	0.03
Burkina Faso	2003	0.17	0.24	0.10	Namibia	2000	0.06	0.09	0.03
Cameroon	1991	0.05	0.12	0.01	Namibia	2007	0.04	0.11	0.02
Cameroon	1998	0.05	0.16	0.01	Niger	1992	0.19	0.27	0.07
Cameroon	2004	0.05	0.17	0.02	Niger	1998	0.21	0.25	0.09
Chad	1996	0.15	0.24	0.06	Niger	2006	0.16	0.34	0.05
Chad	2004	0.15	0.27	0.07	Nigeria	1999	0.13	0.36	0.08
CongoDR	2007	0.09	0.24	0.05	Nigeria	2003	0.12	0.24	0.05
Cote D Ivoire	1994	0.08	0.14	0.03	Nigeria	2008	0.13	0.24	0.08
Cote D Ivoire	1998	0.05	0.12	0.02	Rwanda	1992	0.07	0.27	0.02
Ethiopia	2000	0.17	0.32	0.04	Rwanda	2000	0.06	0.23	0.04
Ethiopia	2005	0.13	0.28	0.05	Rwanda	2005	0.05	0.25	0.02
Ghana	1993	0.10	0.14	0.05	Sao T. and P.	2009	0.05	0.14	0.05
Ghana	1998	0.06	0.13	0.03	Senegal	1992	0.08	0.16	0.03
Ghana	2003	0.06	0.14	0.03	Senegal	2005	0.04	0.07	0.02
Ghana	2008	0.03	0.10	0.03	Sierra Leone	2008	0.08	0.22	0.05
Guinea	1999	0.07	0.16	0.04	Tanzania	1992	0.09	0.23	0.03
Guinea	2005	0.08	0.19	0.05	Tanzania	1996	0.09	0.23	0.03
Kenya	1993	0.07	0.18	0.03	Tanzania	2004	0.04	0.17	0.01
Kenya	1998	0.06	0.18	0.04	Togo	1998	0.08	0.13	0.04
Kenya	2003	0.05	0.15	0.02	Uganda	1995	0.08	0.20	0.02
Kenya	2009	0.04	0.14	0.02	Uganda	2000	0.06	0.19	0.02
Lesotho	2004	0.05	0.20	0.03	Uganda	2006	0.05	0.15	0.02
Lesotho	2009	0.03	0.14	0.02	Zambia	1992	0.06	0.20	0.02
Liberia	2007	0.07	0.19	0.03	Zambia	1996	0.06	0.23	0.02
Madagascar	1992	0.11	0.32	0.01	Zambia	2001	0.08	0.28	0.02
Madagascar	1997	0.14	0.29	0.03	Zimbabwe	1994	0.03	0.09	0.02
Madagascar	2004	0.13	0.29	0.06	Zimbabwe	1999	0.03	0.13	0.04
Madagascar	2009	na	0.26	na	Zimbabwe	2006	0.04	0.14	0.03
Malawi	1992	0.09	0.29	0.02					
Malawi	2000	0.07	0.30	0.03					
Malawi	2004	0.05	0.27	0.03	**Average**		**0.09**	**0.20**	**0.04**

Source: DHS data; author's calculations.

Table 4: Rates of change in Undernutrition and GDP per capita

Country	Stunting change	Wasting change	Underweight change	GDP per capita growth
Benin	0.872	-3.044	-0.747	2.111
Burkina Faso	0.582	2.763	0.911	1.59
Cameroon	0.901	0.856	0.141	-1.225
Chad	-0.074	0.172	0.039	13.346
Cote D Ivoire	-0.621	-2.095	-1.427	-0.223
Egypt	0.12	0.923	-0.074	4.593
Ethiopia	-1.272	-0.39	-1.339	5.658
Ghana	-0.311	-1.228	-0.739	3.559
Guinea	0.93	0.507	0.292	2.196
Kenya	-0.279	0.328	-0.216	0.866
Lesotho	-1.183	-0.577	-0.818	1.89
Madagascar	-0.833	2.845	-0.098	-0.409
Malawi	0.034	0.223	-0.278	-5.794
Mali	0.962	-7.276	-1.213	3.444
Mozambique	0.032	-2.948	-1.223	6.456
Namibia	-0.362	-0.437	-0.266	2.403
Niger	0.474	-1.865	-0.061	1.459
Nigeria	-1.162	0.427	0.229	2.864
Rwanda	-0.296	-0.089	-0.408	6.588
Senegal	-0.913	-0.139	-0.524	1.109
Tanzania	-0.682	-1.315	-0.743	1.46
Uganda	-0.281	0.055	-0.235	0.789
Zambia	0.704	-0.088	0.164	-3.276
Zimbabwe	0.393	0.061	0.072	0.425
Average	*-0.094*	*-0.514*	*-0.357*	*2.162*

Note: The growth rates refer to annual percentage rates for the countries where at least two DHS data sets are available.
Source: DHS data; author's calculations.

Table 5: Regression results (macro level)

	Moderate Stunting rate	Moderate Stunting rate	Severe Stunting rate	Severe Stunting rate	Moderate Wasting rate	Moderate Wasting rate	Severe Wasting rate	Severe Wasting rate	Moderate Underweight rate	Moderate Underweight rate	Severe Underweight rate	Severe Underweight rate
Loggdp	-0.0576*	-0.0608	-0.0381	-0.0580	-0.00866	-0.0330	-0.00476	-0.0120	-0.0316	-0.0557	-0.0161	-0.0345
	(0.0290)	(0.0410)	(0.0227)	(0.0430)	(0.0118)	(0.0286)	(0.00487)	(0.0155)	(0.0288)	(0.0387)	(0.0144)	(0.0227)
Benin		0.825***		0.593*		0.353*		0.129		0.627**		0.325*
Burkina Faso		0.819***		0.592**		0.395**		0.152		0.690**		0.368**
Cameroon		0.767**		0.575*		0.292		0.104		0.550*		0.302*
Chad		0.844***		0.637**		0.399*		0.149		0.713**		0.381**
CongoDR		0.782***		0.557**		0.285*		0.114		0.550**		0.278**
Cote D Ivoire		0.743**		0.546*		0.330		0.115		0.588**		0.313*
Ethiopia		0.881***		0.632**		0.340*		0.121		0.713***		0.362**
Ghana		0.745**		0.532*		0.335*		0.118		0.588**		0.301*
Guinea		0.777***		0.559*		0.325		0.122		0.592**		0.305*
Kenya		0.795**		0.565*		0.310		0.114		0.570**		0.301*
Lesotho		0.861***		0.589*		0.288		0.110		0.564*		0.289*
Liberia		0.753***		0.541**		0.276		0.104		0.530**		0.278*
Madagascar		0.932***		0.661**		0.322		0.112		0.712**		0.345**
Malawi		0.909***		0.634**		0.269		0.100		0.548**		0.282*
Mali		0.794***		0.588**		0.428**		0.167		0.719***		0.393**
Mozambique		0.829***		0.579**		0.284		0.106		0.577**		0.304**
Namibia		0.809**		0.592		0.366		0.127		0.654**		0.342*
Niger		0.847***		0.615**		0.392**		0.140		0.735***		0.381**
Nigeria		0.907***		0.711**		0.376*		0.156		0.683**		0.380**
Rwanda		0.911***		0.630**		0.281		0.104		0.575**		0.287*
Sao Tome and Principe		0.755**		0.567*		0.378*		0.142		0.566*		0.302*
Senegal		0.709**		0.529*		0.328		0.112		0.583**		0.304*
Sierra Leone		0.779***		0.604**		0.339*		0.129		0.580**		0.307*
Tanzania		0.879***		0.598**		0.290		0.103		0.603**		0.304*
Togo		0.732**		0.528*		0.373*		0.127		0.628**		0.323**
Uganda		0.825***		0.564*		0.285		0.102		0.561**		0.291*
Zambia		0.921***		0.640**		0.286		0.103		0.603**		0.305*
Zimbabwe		0.662***		0.448*		0.260		0.0991		0.440*		0.228*
Constant	0.801***		0.456***		0.161*		0.0706**		0.447**		0.193*	
Observations	69	69	69	69	68	68	68	68	68	68	68	68
R-squared	0.150	0.995	0.124	0.987	0.010	0.956	0.015	0.921	0.056	0.990	0.049	0.975

Source: DHS data; author's calculations.

Table 6: Regression results: Individual probability of being underweight

	Individual probability of being underweight			
GDP per capita/100	0.988***	0.995***	0.976***	0.989
	(0.985 - 0.990)	(0.993 - 0.997)	(0.969 - 0.984)	(0.969 - 1.009)
Asset index		0.838***	0.795***	0.790***
		(0.824 - 0.852)	(0.781 - 0.809)	(0.776 - 0.805)
Urban		0.859***	0.855***	0.860***
		(0.830 - 0.888)	(0.828 - 0.884)	(0.832 - 0.888)
Number of children ever born		1.012***	1.004*	1.003
		(1.007 - 1.016)	(0.999 - 1.008)	(0.999 - 1.008)
Household head is male		1.136***	1.027**	1.024*
		(1.107 - 1.165)	(1.001 - 1.054)	(0.998 - 1.052)
Age of household head		0.997***	0.998***	0.998***
		(0.997 - 0.998)	(0.998 - 0.999)	(0.998 - 0.999)
Household head has primary education		0.708***	0.849***	0.851***
		(0.691 - 0.725)	(0.827 - 0.871)	(0.830 - 0.873)
Household head has secondary or higher education		0.927***	0.909***	0.915***
		(0.900 - 0.956)	(0.882 - 0.938)	(0.887 - 0.944)
Mother is currently pregnant		1.286***	1.235***	1.231***
		(1.237 - 1.337)	(1.187 - 1.284)	(1.184 - 1.280)
Mother is currently breastfeeding		1.227***	1.206***	1.208***
		(1.195 - 1.260)	(1.173 - 1.239)	(1.176 - 1.241)
Mother has BMI below 18.5		2.044***	1.881***	1.878***
		(1.988 - 2.103)	(1.829 - 1.934)	(1.827 - 1.931)
Mother has primary education		0.707***	0.722***	0.721***
		(0.686 - 0.728)	(0.700 - 0.744)	(0.699 - 0.743)
Mother has secondary or higher education		0.803***	0.752***	0.760***
		(0.743 - 0.868)	(0.695 - 0.814)	(0.702 - 0.822)
Child is a boy		1.212***	1.211***	1.212***
		(1.189 - 1.235)	(1.188 - 1.235)	(1.189 - 1.236)
Age of child		1.007***	1.007***	1.008***
		(1.006 - 1.007)	(1.006 - 1.008)	(1.007 - 1.008)
Child is a twin		2.251***	2.361***	2.373***
		(2.094 - 2.421)	(2.193 - 2.542)	(2.205 - 2.555)
Country Fixed Effects			Yes	Yes
Year Fixed Effects				Yes
Observations	326,331	309,187	309,187	309,187

Robust confidence intervals based on clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: DHS data; author's calculations.

Table 7: Regression results: Individual probability of being severely underweight

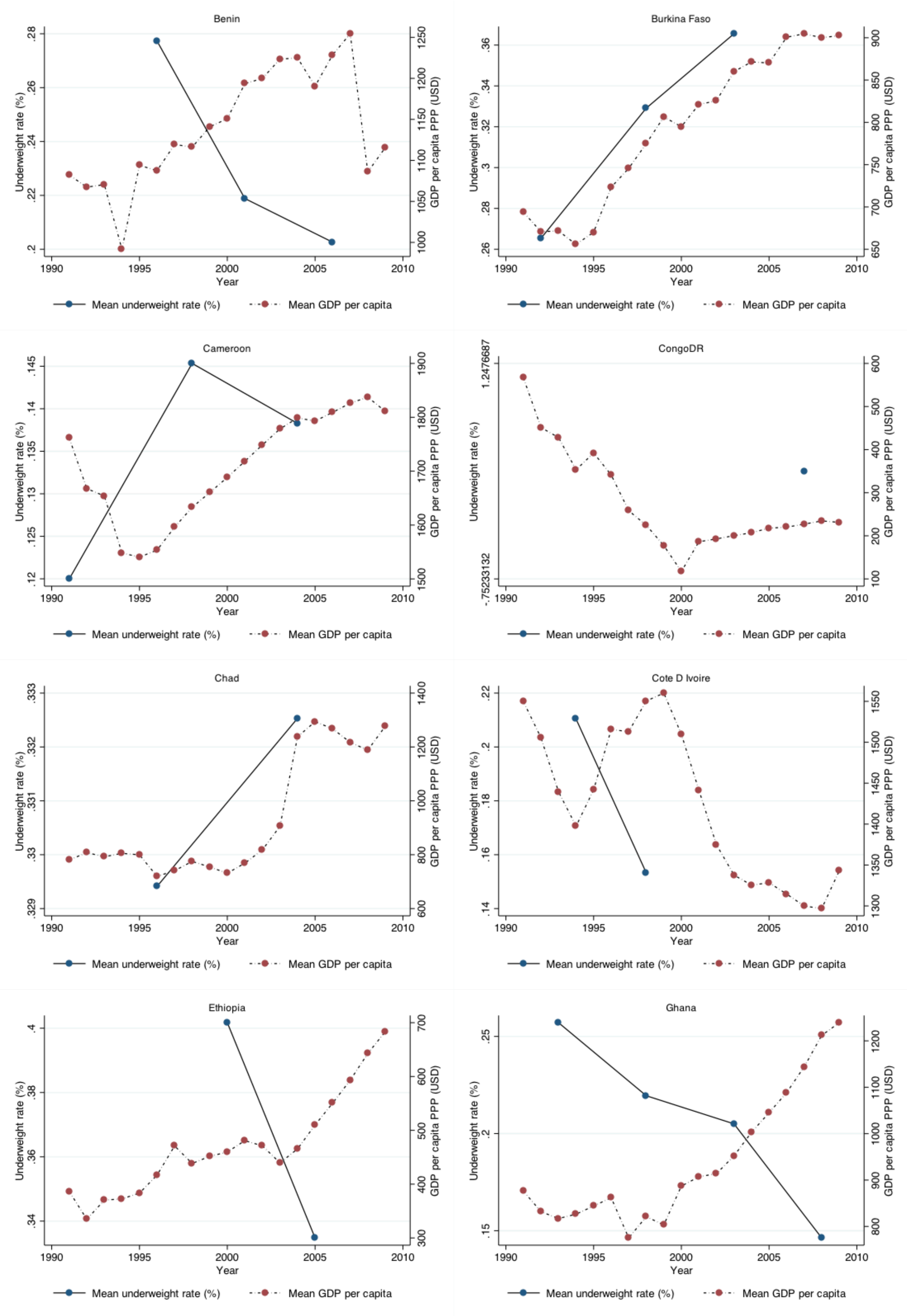
	Individual probability of being severely underweight			
GDP per capita/100	0.989***	0.997*	0.972***	0.989
	(0.986 - 0.992)	(0.994 - 1.000)	(0.961 - 0.983)	(0.960 - 1.019)
Asset index		0.813***	0.759***	0.754***
		(0.791 - 0.835)	(0.738 - 0.781)	(0.732 - 0.776)
Urban		0.841***	0.843***	0.850***
		(0.795 - 0.889)	(0.798 - 0.891)	(0.804 - 0.898)
Number of children ever born		1.022***	1.013***	1.012***
		(1.016 - 1.028)	(1.007 - 1.019)	(1.006 - 1.018)
Household head is male		1.196***	1.039*	1.031
		(1.148 - 1.246)	(0.997 - 1.083)	(0.989 - 1.075)
Age of household head		0.997***	0.998***	0.998***
		(0.996 - 0.998)	(0.997 - 0.999)	(0.997 - 1.000)
Household head has primary education		0.631***	0.810***	0.813***
		(0.609 - 0.654)	(0.778 - 0.843)	(0.781 - 0.846)
Household head has secondary or higher education		0.973	0.926***	0.934***
		(0.927 - 1.021)	(0.882 - 0.972)	(0.889 - 0.980)
Mother is currently pregnant		1.331***	1.276***	1.271***
		(1.258 - 1.408)	(1.206 - 1.350)	(1.202 - 1.345)
Mother is currently breastfeeding		1.263***	1.248***	1.251***
		(1.214 - 1.313)	(1.200 - 1.298)	(1.203 - 1.301)
Mother has BMI below 18.5		2.086***	1.900***	1.894***
		(2.008 - 2.167)	(1.827 - 1.976)	(1.821 - 1.969)
Mother has primary education		0.622***	0.653***	0.653***
		(0.592 - 0.652)	(0.620 - 0.688)	(0.620 - 0.688)
Mother has secondary or higher education		0.854**	0.729***	0.735***
		(0.757 - 0.963)	(0.646 - 0.824)	(0.650 - 0.830)
Child is a boy		1.243***	1.241***	1.242***
		(1.207 - 1.280)	(1.204 - 1.278)	(1.206 - 1.279)
Age of child		1.000	1.001*	1.002***
		(1.000 - 1.001)	(1.000 - 1.002)	(1.001 - 1.002)
Child is a twin		2.362***	2.493***	2.513***
		(2.161 - 2.583)	(2.273 - 2.735)	(2.292 - 2.755)
Country Fixed Effects			Yes	Yes
Year Fixed Effects				Yes
Observations	326,331	309,187	309,187	309,187

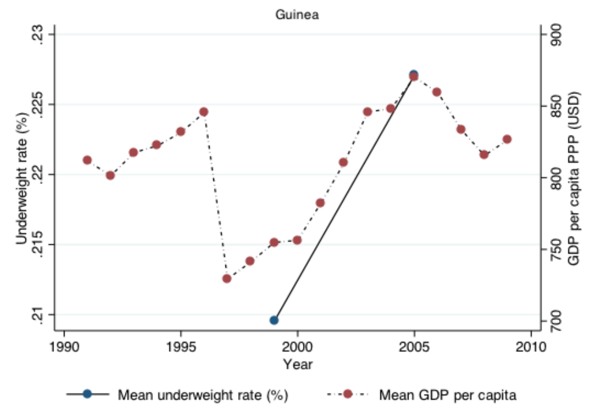
Robust confidence intervals based on clustered standard errors in parentheses

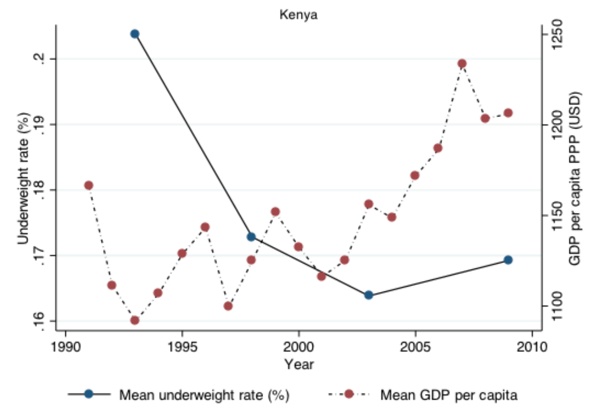
*** p<0.01, ** p<0.05, * p<0.1

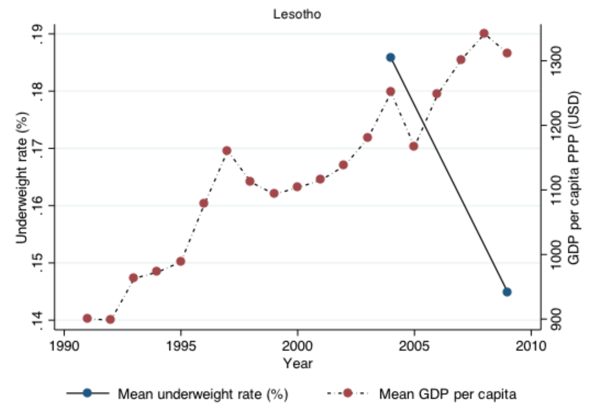
Source: DHS data; author's calculations.

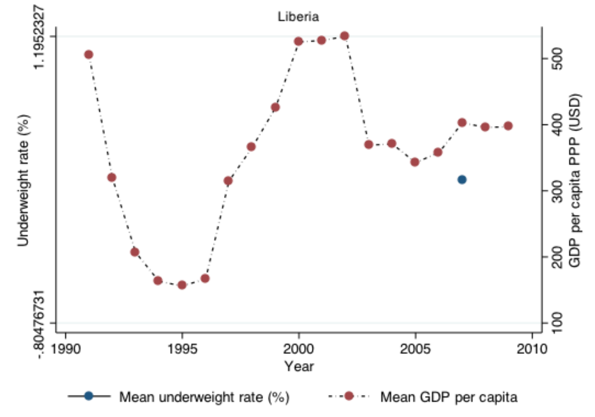
Figure 1: Underweight rate and GDP per capita by country and year

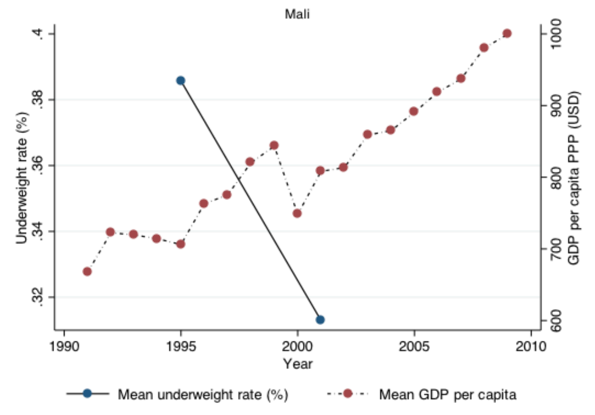


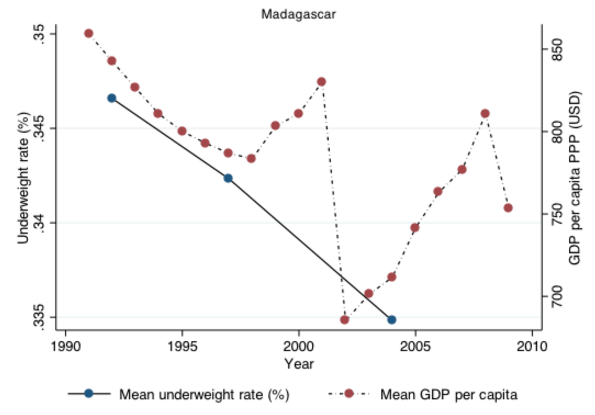

Guinea
Underweight rate (%)
.21
.215
.22
.225
.23
GDP per capita PPP (USD)
700
750
800
850
900
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita

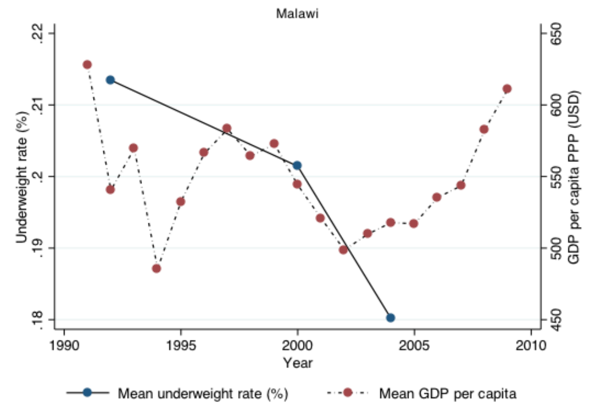

Kenya
Underweight rate (%)
.16
.17
.18
.19
.2
GDP per capita PPP (USD)
1100
1150
1200
1250
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita

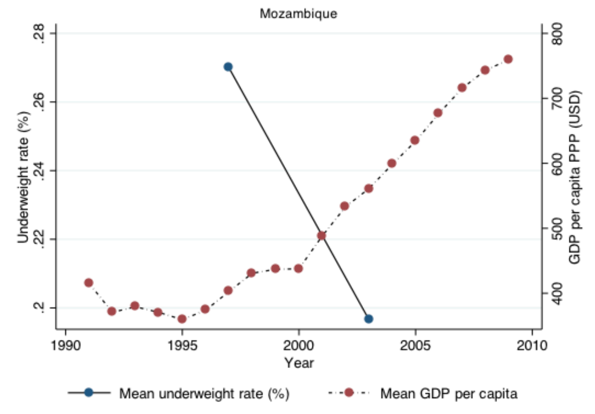

Lesotho
Underweight rate (%)
.14
.15
.16
.17
.18
.19
GDP per capita PPP (USD)
900
1000
1100
1200
1300
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita

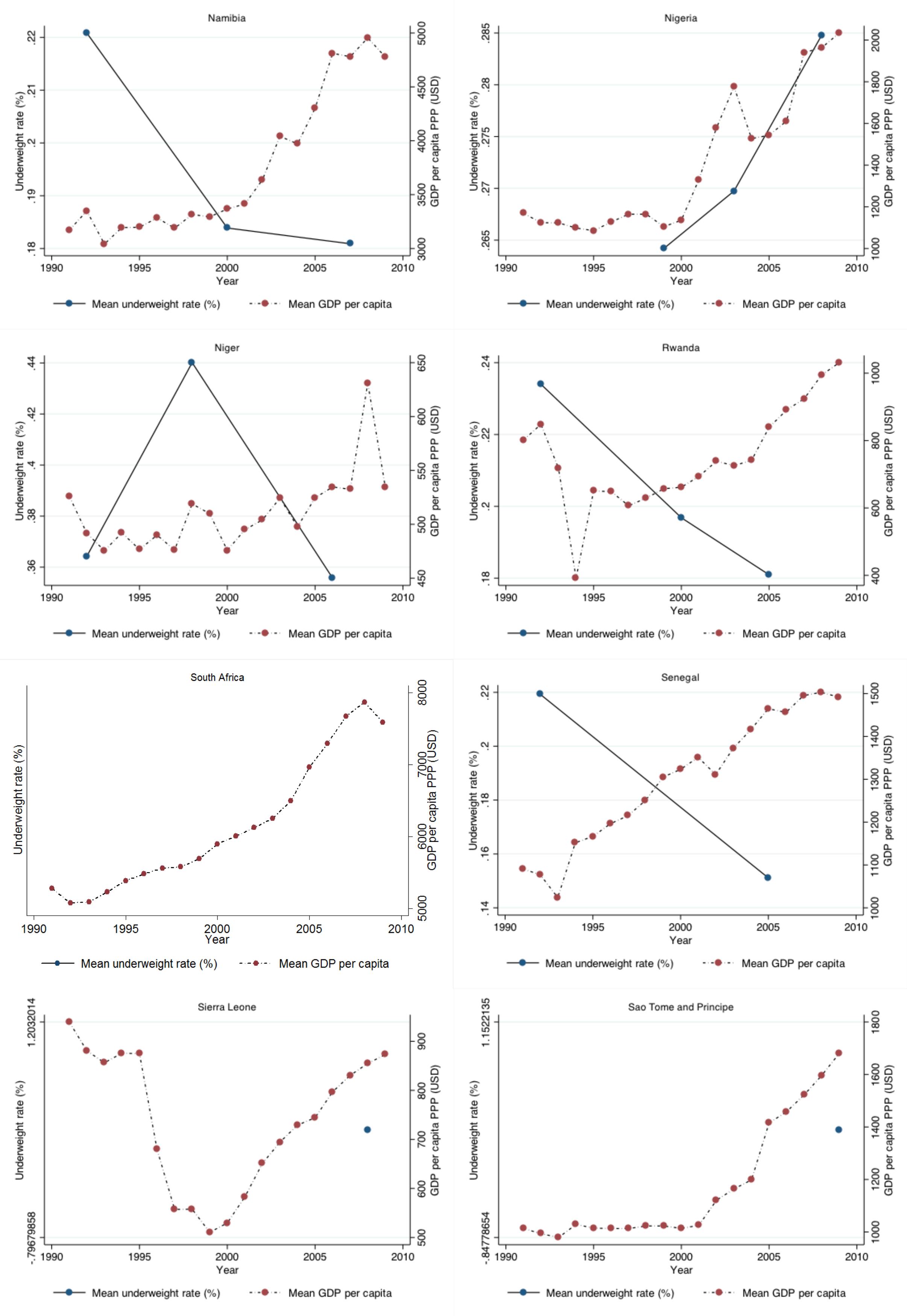

Liberia
Underweight rate (%)
-.80476731
1.1952327
GDP per capita PPP (USD)
100
200
300
400
500
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita

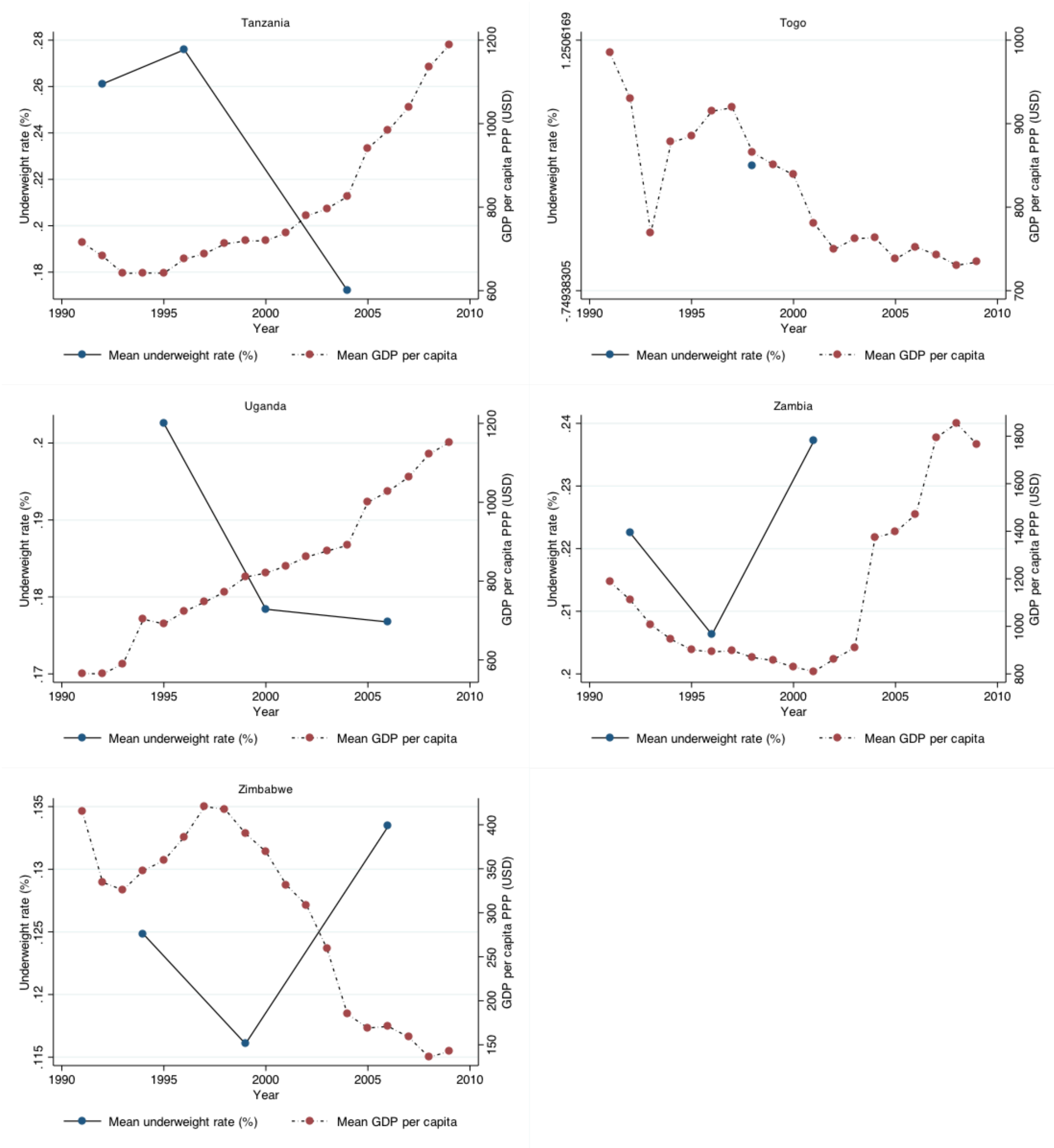

Mali
Underweight rate (%)
.32
.34
.36
.38
.4
GDP per capita PPP (USD)
600
700
800
900
1000
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita


Madagascar
Underweight rate (%)
.335
.34
.345
.35
GDP per capita PPP (USD)
700
750
800
850
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita


Malawi
Underweight rate (%)
.18
.19
.2
.21
.22
GDP per capita PPP (USD)
450
500
550
600
650
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita

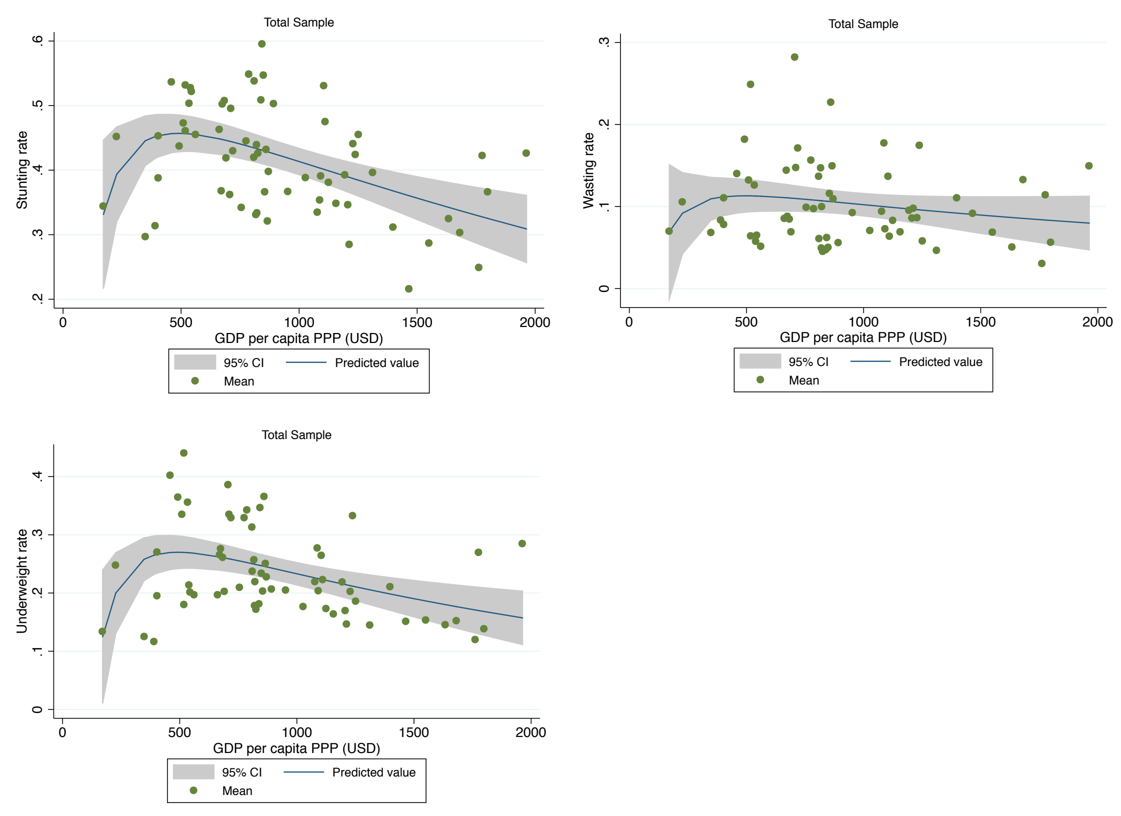

Mozambique
Underweight rate (%)
.2
.22
.24
.26
.28
GDP per capita PPP (USD)
400
500
600
700
800
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita


Namibia
Underweight rate (%)
.18
.19
.2
.21
.22
GDP per capita PPP (USD)
3000
3500
4000
4500
5000
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita
Nigeria
Underweight rate (%)
.265
.27
.275
.28
.285
GDP per capita PPP (USD)
1000
1200
1400
1600
1800
2000
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita
Niger
Underweight rate (%)
.36
.38
.4
.42
.44
GDP per capita PPP (USD)
450
500
550
600
650
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita
Rwanda
Underweight rate (%)
.18
.2
.22
.24
GDP per capita PPP (USD)
400
600
800
1000
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita
South Africa
Underweight rate (%)
GDP per capita PPP (USD)
5000
6000
7000
8000
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita
Senegal
Underweight rate (%)
.14
.16
.18
.2
.22
GDP per capita PPP (USD)
1000
1100
1200
1300
1400
1500
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita
Sierra Leone
Underweight rate (%)
-.79679858
1.2032014
GDP per capita PPP (USD)
500
600
700
800
900
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita
Sao Tome and Principe
Underweight rate (%)
-.84778654
1.1522135
GDP per capita PPP (USD)
1000
1200
1400
1600
1800
1990
1995
2000
2005
2010
Year
Mean underweight rate (%)
Mean GDP per capita



Source: DHS data; author's calculations.

Figure 2: GDP per capita versus Undernutrition (total sample - Africa)



Source: DHS data; author's calculations.

Appendix

Table A1: Regression results: Individual probability of being stunted

	Individual probability of being stunted			
GDP per capita/100	0.979***	0.986***	0.961***	0.948***
	(0.977 - 0.981)	(0.984 - 0.987)	(0.953 - 0.968)	(0.931 - 0.965)
Asset index		0.810***	0.797***	0.795***
		(0.799 - 0.821)	(0.786 - 0.808)	(0.785 - 0.806)
Urban		0.820***	0.844***	0.847***
		(0.797 - 0.844)	(0.821 - 0.868)	(0.824 - 0.870)
Number of children ever born		0.995***	0.990***	0.989***
		(0.991 - 0.999)	(0.986 - 0.993)	(0.986 - 0.993)
Household head is male		1.050***	1.027**	1.029**
		(1.026 - 1.075)	(1.004 - 1.051)	(1.006 - 1.053)
Age of household head		0.996***	0.998***	0.998***
		(0.996 - 0.997)	(0.997 - 0.999)	(0.997 - 0.999)
Household head has primary education		1.051***	0.940***	0.940***
		(1.029 - 1.074)	(0.920 - 0.961)	(0.920 - 0.960)
Household head has secondary or higher education		0.834***	0.897***	0.895***
		(0.813 - 0.855)	(0.874 - 0.920)	(0.873 - 0.918)
Mother is currently pregnant		1.330***	1.293***	1.288***
		(1.289 - 1.372)	(1.254 - 1.334)	(1.249 - 1.329)
Mother is currently breastfeeding		1.055***	1.027**	1.027**
		(1.032 - 1.079)	(1.005 - 1.051)	(1.005 - 1.050)
Mother has BMI below 18.5		1.258***	1.224***	1.227***
		(1.225 - 1.291)	(1.192 - 1.257)	(1.196 - 1.260)
Mother has primary education		0.834***	0.810***	0.808***
		(0.814 - 0.855)	(0.789 - 0.832)	(0.787 - 0.829)
Mother has secondary or higher education		0.709***	0.685***	0.692***
		(0.670 - 0.750)	(0.648 - 0.726)	(0.654 - 0.733)
Child is a boy		1.227***	1.232***	1.232***
		(1.207 - 1.247)	(1.212 - 1.252)	(1.212 - 1.253)
Age of child		1.022***	1.022***	1.022***
		(1.021 - 1.022)	(1.021 - 1.022)	(1.022 - 1.023)
Child is a twin		1.970***	2.023***	2.030***
		(1.830 - 2.120)	(1.876 - 2.180)	(1.884 - 2.188)
Country Fixed Effects			Yes	Yes
Year Fixed Effects				Yes
Observations	321,971	305,038	305,038	305,038

Robust confidence intervals based on clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: DHS data; author's calculations.

Table A2: Regression results: Individual probability of being severely stunted

	Individual probability of being severely stunted			
GDP per capita/100	0.982***	0.989***	0.957***	0.933***
	(0.979 - 0.984)	(0.987 - 0.991)	(0.947 - 0.966)	(0.913 - 0.954)
Asset index		0.789***	0.773***	0.772***
		(0.775 - 0.804)	(0.759 - 0.788)	(0.758 - 0.787)
Urban		0.824***	0.829***	0.832***
		(0.795 - 0.854)	(0.800 - 0.859)	(0.804 - 0.862)
Number of children ever born		1.005**	0.999	0.999
		(1.000 - 1.009)	(0.994 - 1.003)	(0.994 - 1.003)
Household head is male		1.084***	1.033**	1.038***
		(1.056 - 1.114)	(1.005 - 1.062)	(1.010 - 1.067)
Age of household head		0.995***	0.997***	0.997***
		(0.995 - 0.996)	(0.997 - 0.998)	(0.997 - 0.998)
Household head has primary education		0.958***	0.920***	0.917***
		(0.933 - 0.983)	(0.895 - 0.945)	(0.893 - 0.942)
Household head has secondary or higher education		0.847***	0.877***	0.873***
		(0.821 - 0.874)	(0.849 - 0.905)	(0.846 - 0.902)
Mother is currently pregnant		1.356***	1.316***	1.314***
		(1.309 - 1.404)	(1.270 - 1.363)	(1.268 - 1.361)
Mother is currently breastfeeding		1.112***	1.089***	1.089***
		(1.083 - 1.141)	(1.060 - 1.118)	(1.061 - 1.119)
Mother has BMI below 18.5		1.273***	1.221***	1.225***
		(1.236 - 1.312)	(1.185 - 1.257)	(1.190 - 1.261)
Mother has primary education		0.773***	0.780***	0.777***
		(0.750 - 0.797)	(0.756 - 0.804)	(0.754 - 0.802)
Mother has secondary or higher education		0.833***	0.753***	0.759***
		(0.776 - 0.895)	(0.702 - 0.807)	(0.707 - 0.814)
Child is a boy		1.282***	1.286***	1.287***
		(1.256 - 1.308)	(1.261 - 1.312)	(1.261 - 1.313)
Age of child		1.016***	1.016***	1.017***
		(1.016 - 1.017)	(1.016 - 1.017)	(1.016 - 1.017)
Child is a twin		1.990***	2.047***	2.052***
		(1.851 - 2.138)	(1.901 - 2.204)	(1.906 - 2.208)
Country Fixed Effects			Yes	Yes
Year Fixed Effects				Yes
Observations	321,971	305,038	305,038	305,038

Robust confidence intervals based on clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: DHS data; author's calculations.

Table A3: Regression results: Individual probability of being wasted

	Individual probability of being wasted			
GDP per capita/100	0.997**	1.004***	1.000	0.967**
	(0.995 - 1.000)	(1.001 - 1.006)	(0.990 - 1.010)	(0.941 - 0.993)
Asset index		0.961***	0.913***	0.915***
		(0.939 - 0.983)	(0.892 - 0.935)	(0.894 - 0.936)
Urban		1.002	0.991	0.981
		(0.955 - 1.052)	(0.942 - 1.041)	(0.933 - 1.031)
Number of children ever born		1.024***	1.018***	1.018***
		(1.018 - 1.029)	(1.013 - 1.024)	(1.013 - 1.024)
Household head is male		1.172***	1.036*	1.025
		(1.129 - 1.218)	(0.997 - 1.077)	(0.986 - 1.065)
Age of household head		0.998***	0.999*	0.999
		(0.997 - 0.999)	(0.998 - 1.000)	(0.998 - 1.000)
Household head has primary education		0.588***	0.807***	0.810***
		(0.567 - 0.609)	(0.777 - 0.838)	(0.781 - 0.841)
Household head has secondary or higher education		1.105***	1.005	1.010
		(1.060 - 1.153)	(0.962 - 1.049)	(0.968 - 1.054)
Mother is currently pregnant		1.088***	1.065**	1.066**
		(1.027 - 1.153)	(1.004 - 1.130)	(1.005 - 1.131)
Mother is currently breastfeeding		1.134***	1.128***	1.132***
		(1.092 - 1.177)	(1.086 - 1.171)	(1.090 - 1.176)
Mother has BMI below 18.5		1.961***	1.825***	1.813***
		(1.891 - 2.034)	(1.760 - 1.892)	(1.749 - 1.879)
Mother has primary education		0.743***	0.802***	0.798***
		(0.714 - 0.773)	(0.768 - 0.837)	(0.765 - 0.833)
Mother has secondary or higher education		0.998	0.889**	0.878***
		(0.907 - 1.098)	(0.806 - 0.980)	(0.797 - 0.968)
Child is a boy		1.176***	1.174***	1.176***
		(1.144 - 1.208)	(1.142 - 1.206)	(1.144 - 1.208)
Age of child		0.976***	0.975***	0.976***
		(0.975 - 0.977)	(0.974 - 0.976)	(0.975 - 0.977)
Child is a twin		1.526***	1.560***	1.569***
		(1.383 - 1.684)	(1.409 - 1.728)	(1.418 - 1.735)
Country Fixed Effects			Yes	Yes
Year Fixed Effects				Yes
Observations	315,320	298,377	298,377	298,377

Robust confidence intervals based on clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: DHS data; author's calculations.

Table A4: Regression results: Individual probability of being severely wasted

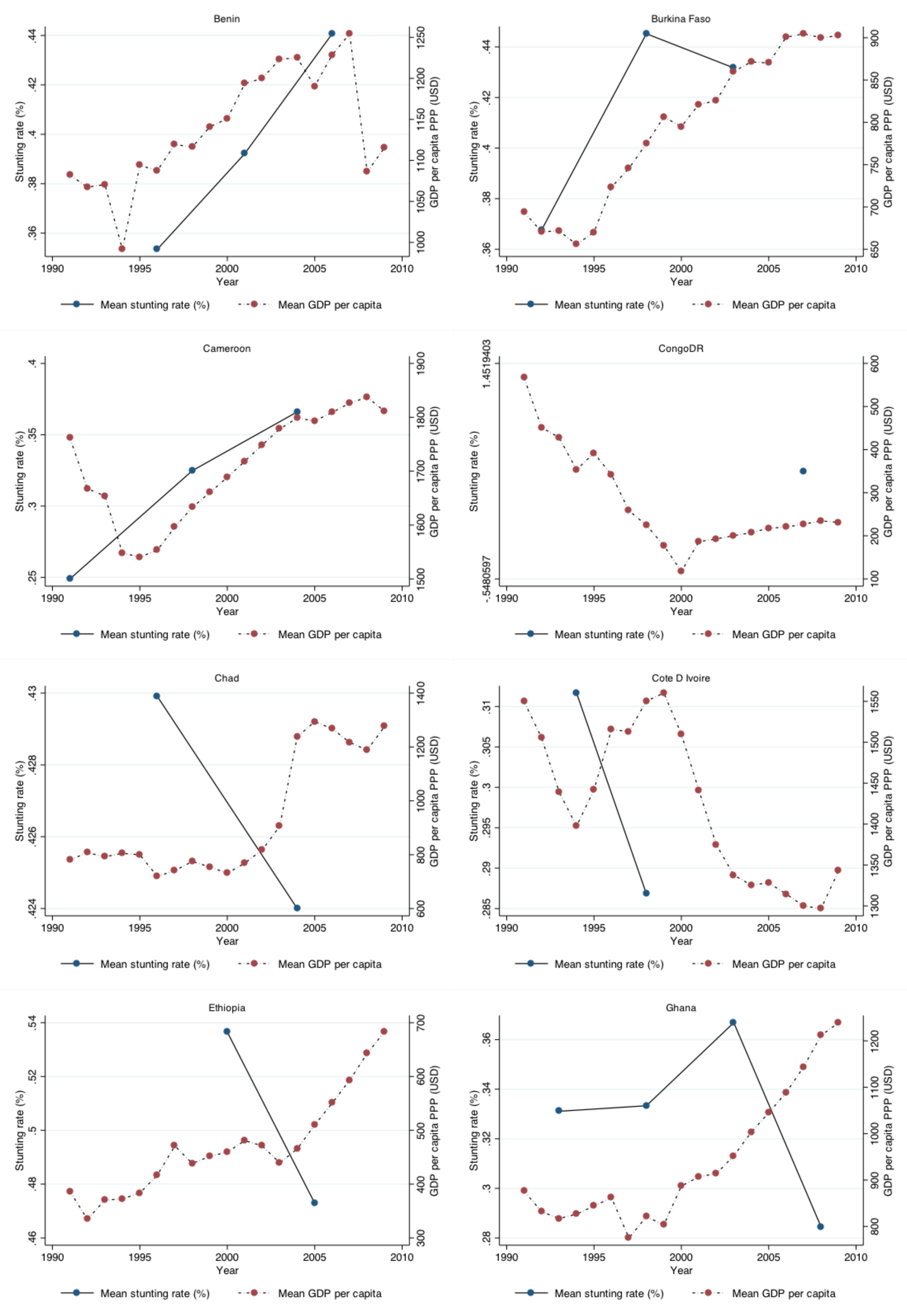
	Individual probability of being severely wasted			
GDP per capita/100	1.002	1.009***	1.010	0.935***
	(0.998 - 1.005)	(1.006 - 1.013)	(0.995 - 1.025)	(0.898 - 0.973)
Asset index		0.930***	0.900***	0.904***
		(0.900 - 0.962)	(0.871 - 0.931)	(0.874 - 0.934)
Urban		0.999	1.000	0.989
		(0.929 - 1.075)	(0.929 - 1.076)	(0.918 - 1.066)
Number of children ever born		1.028***	1.022***	1.021***
		(1.020 - 1.036)	(1.014 - 1.029)	(1.014 - 1.029)
Household head is male		1.270***	1.097***	1.077***
		(1.201 - 1.344)	(1.037 - 1.161)	(1.018 - 1.140)
Age of household head		0.997***	0.999*	0.999
		(0.996 - 0.999)	(0.997 - 1.000)	(0.997 - 1.000)
Household head has primary education		0.596***	0.794***	0.797***
		(0.569 - 0.625)	(0.753 - 0.837)	(0.756 - 0.840)
Household head has secondary or higher education		1.099***	0.987	0.990
		(1.033 - 1.170)	(0.926 - 1.051)	(0.929 - 1.054)
Mother is currently pregnant		1.053	1.039	1.041
		(0.968 - 1.146)	(0.955 - 1.131)	(0.957 - 1.133)
Mother is currently breastfeeding		1.058*	1.057*	1.063**
		(0.997 - 1.121)	(0.997 - 1.120)	(1.003 - 1.126)
Mother has BMI below 18.5		1.821***	1.705***	1.685***
		(1.724 - 1.924)	(1.614 - 1.802)	(1.594 - 1.780)
Mother has primary education		0.743***	0.782***	0.778***
		(0.700 - 0.789)	(0.734 - 0.834)	(0.729 - 0.829)
Mother has secondary or higher education		1.176**	0.935	0.917
		(1.031 - 1.341)	(0.820 - 1.066)	(0.805 - 1.045)
Child is a boy		1.242***	1.242***	1.244***
		(1.193 - 1.293)	(1.193 - 1.293)	(1.195 - 1.295)
Age of child		0.973***	0.973***	0.973***
		(0.972 - 0.975)	(0.971 - 0.974)	(0.972 - 0.975)
Child is a twin		1.522***	1.546***	1.558***
		(1.330 - 1.741)	(1.347 - 1.773)	(1.361 - 1.784)
Country Fixed Effects			Yes	Yes
Year Fixed Effects				Yes
Observations	315,320	298,377	298,377	298,377

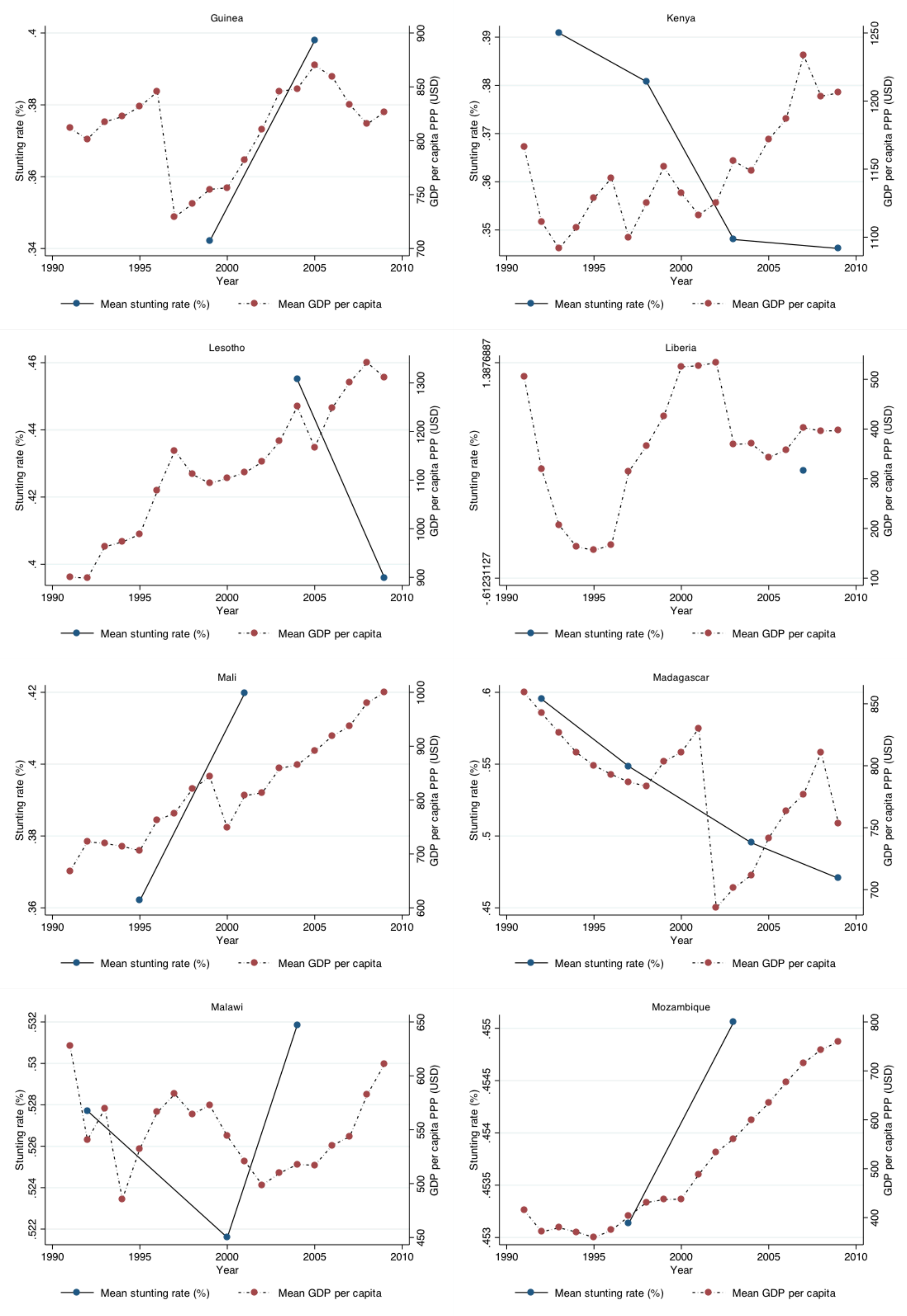
Robust confidence intervals based on clustered standard errors in parentheses

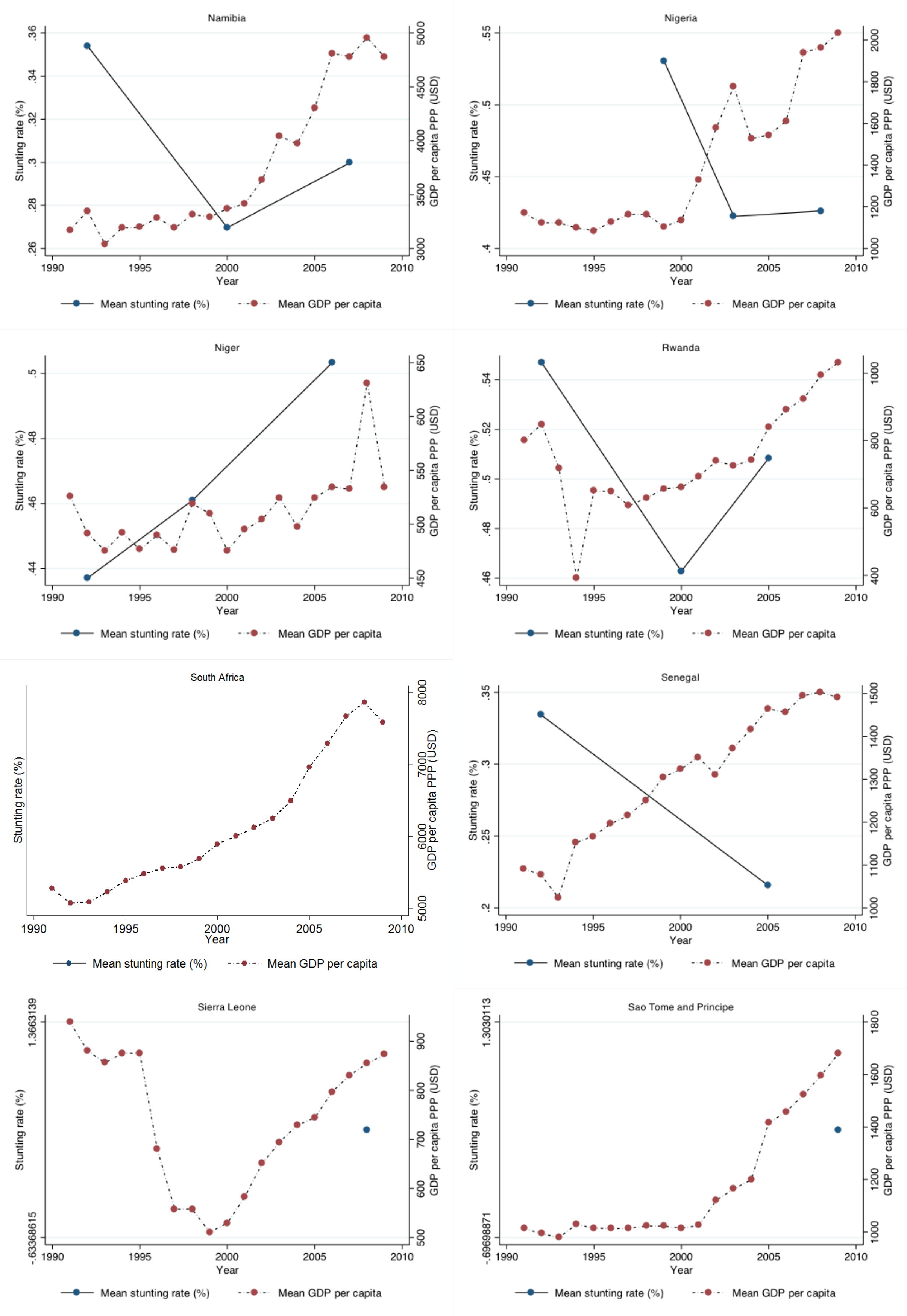
*** p<0.01, ** p<0.05, * p<0.1

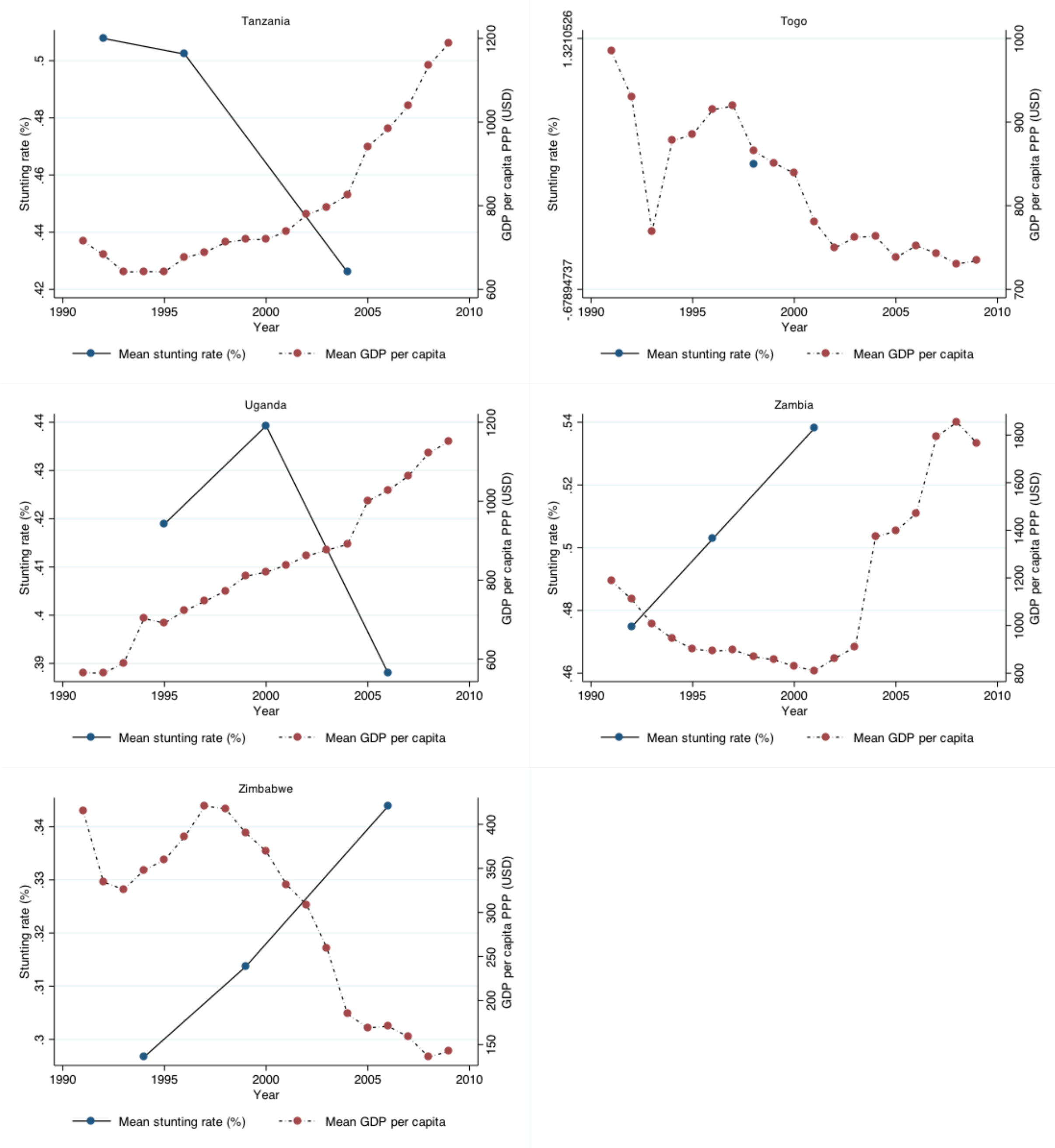
Source: DHS data; author's calculations.

Figure A1: Stunting rate and GDP per capita by country and year



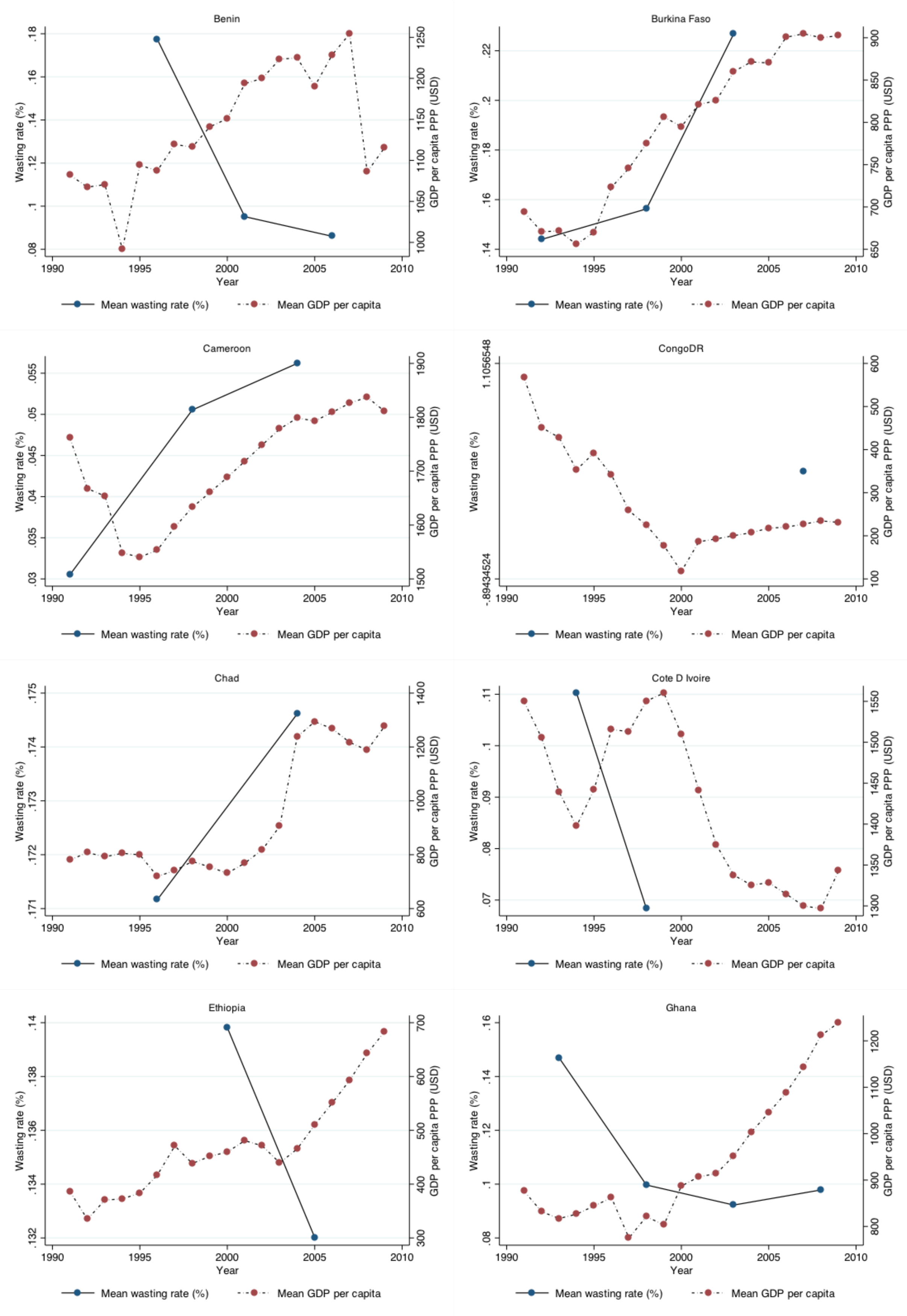

Guinea
Stunting rate (%)
GDP per capita PPP (USD)
Year
Mean stunting rate (%)
Mean GDP per capita
Kenya
Stunting rate (%)
GDP per capita PPP (USD)
Year
Mean stunting rate (%)
Mean GDP per capita
Lesotho
Stunting rate (%)
GDP per capita PPP (USD)
Year
Mean stunting rate (%)
Mean GDP per capita
Liberia
Stunting rate (%)
GDP per capita PPP (USD)
Year
Mean stunting rate (%)
Mean GDP per capita
Mali
Stunting rate (%)
GDP per capita PPP (USD)
Year
Mean stunting rate (%)
Mean GDP per capita
Madagascar
Stunting rate (%)
GDP per capita PPP (USD)
Year
Mean stunting rate (%)
Mean GDP per capita
Malawi
Stunting rate (%)
GDP per capita PPP (USD)
Year
Mean stunting rate (%)
Mean GDP per capita
Mozambique
Stunting rate (%)
GDP per capita PPP (USD)
Year
Mean stunting rate (%)
Mean GDP per capita

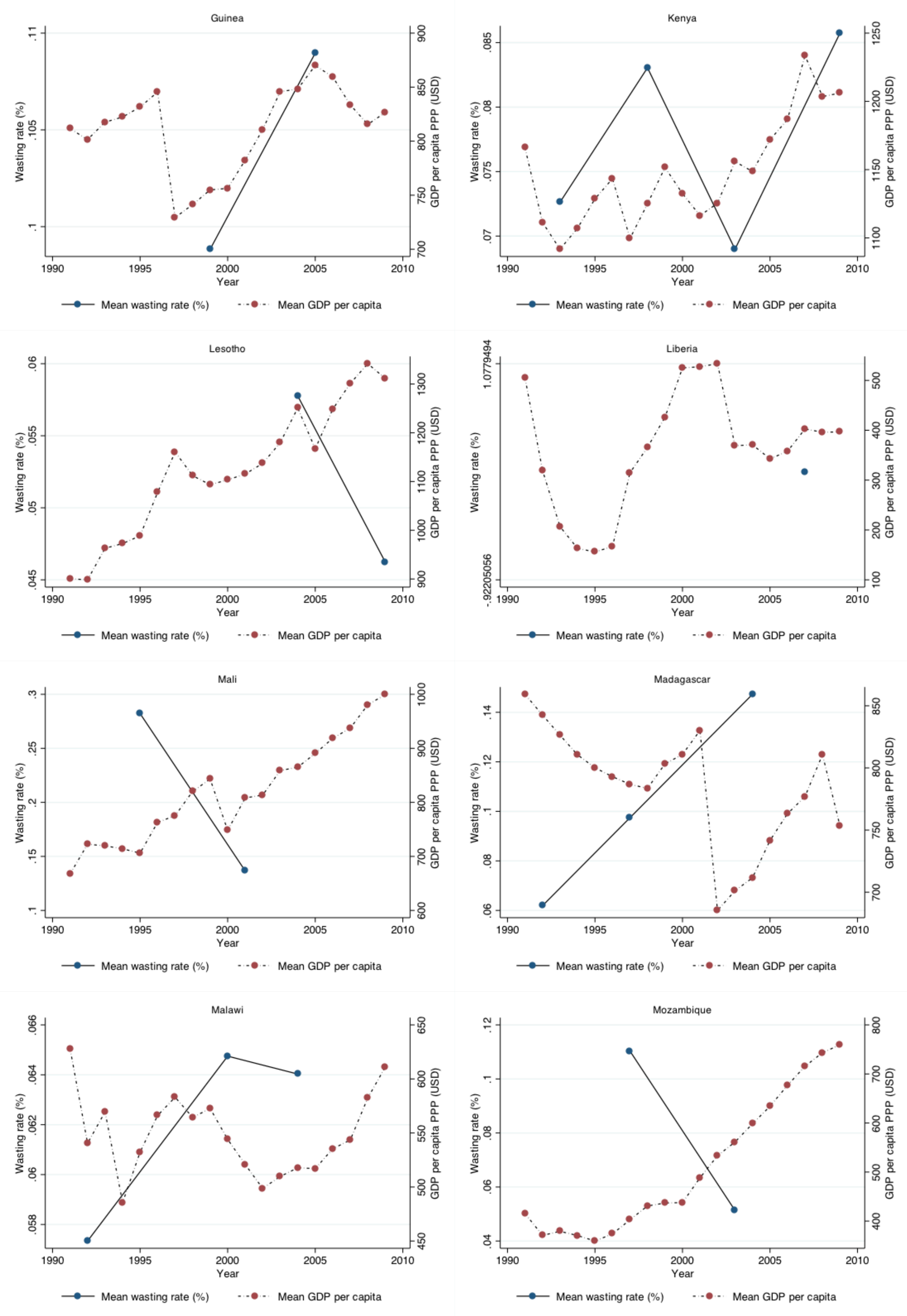

Namibia
Nigeria
Niger
Rwanda
South Africa
Senegal
Sierra Leone
Sao Tome and Principe
Stunting rate (%)
GDP per capita PPP (USD)
Year
Mean stunting rate (%)
Mean GDP per capita

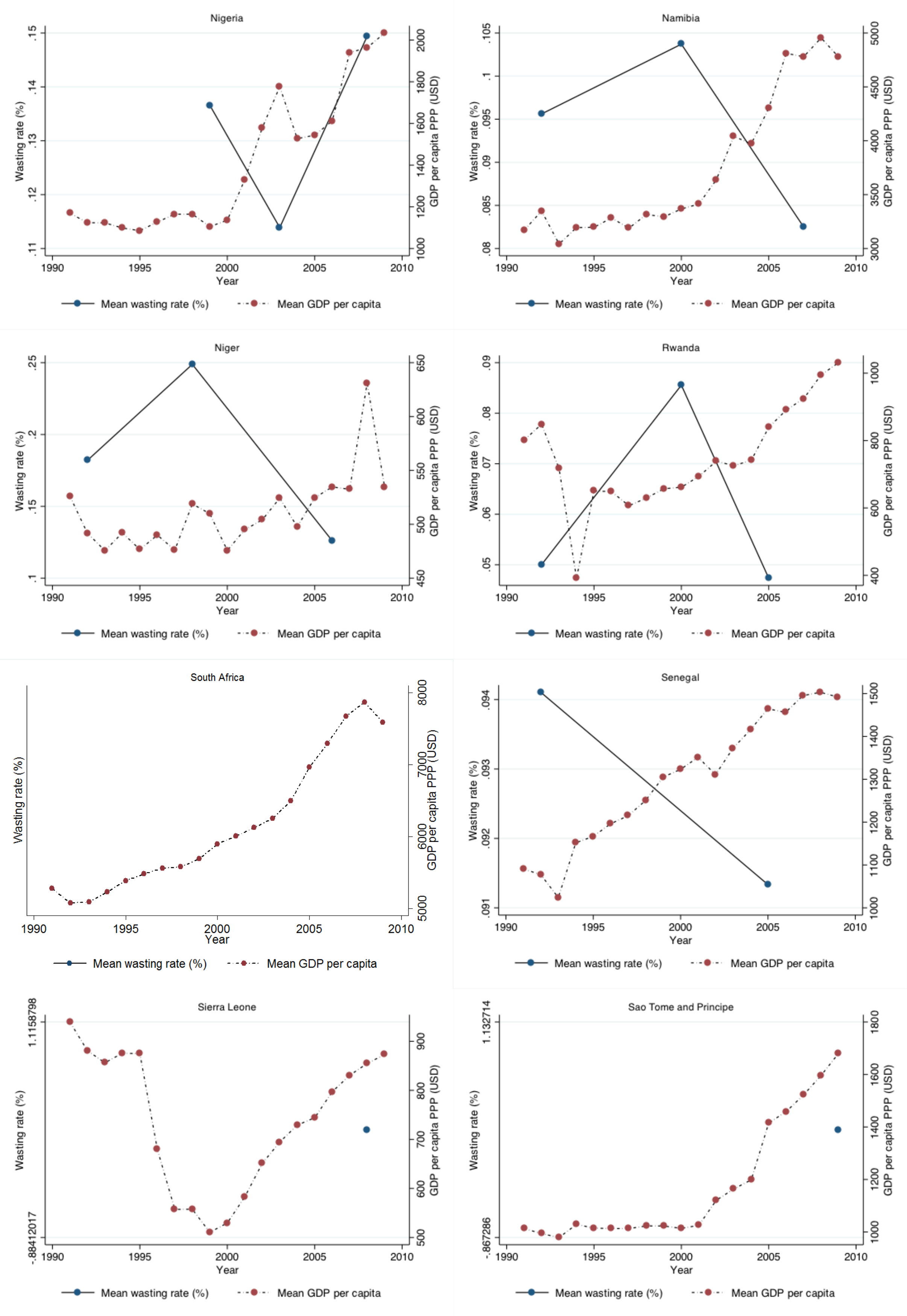


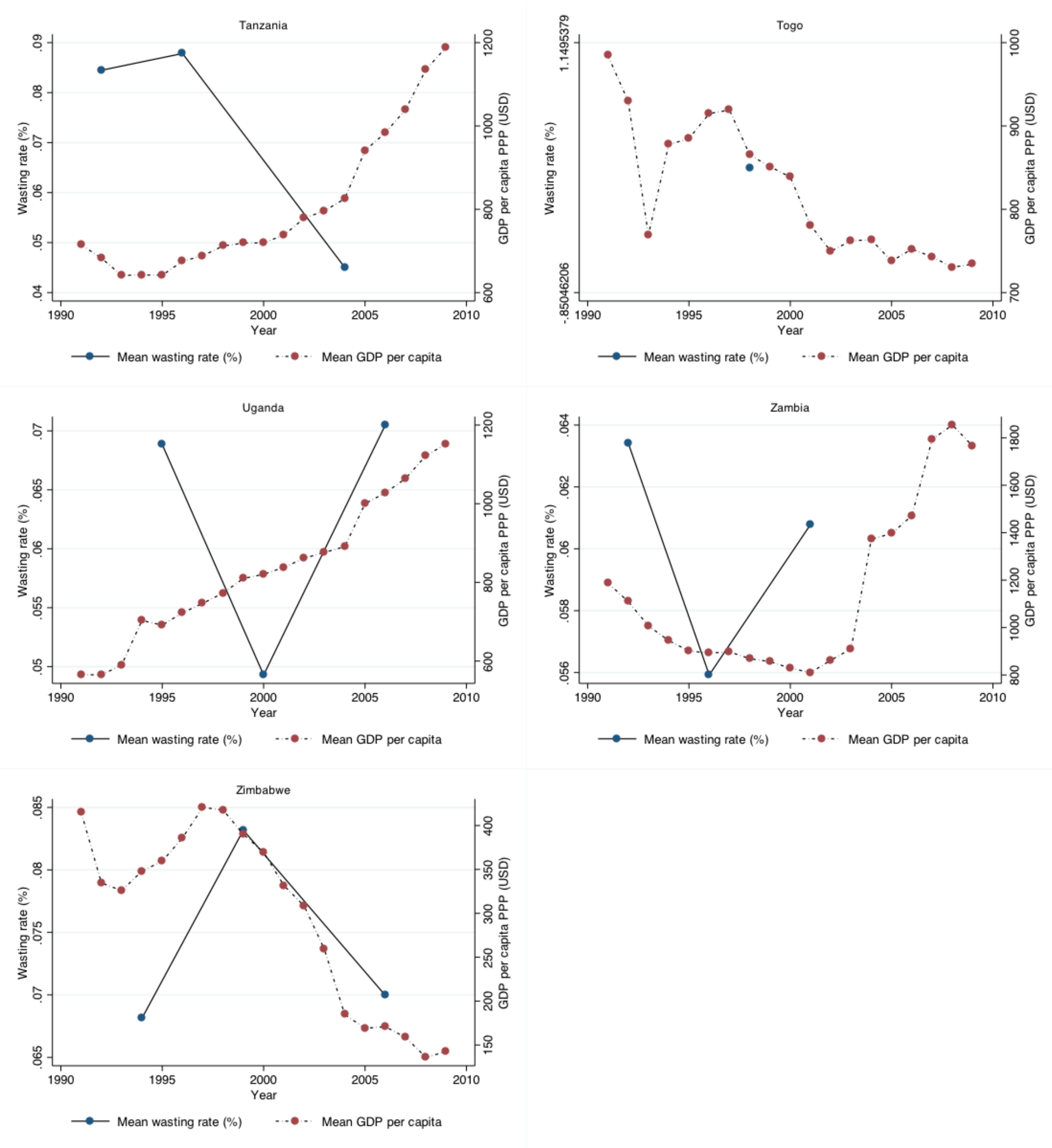
Source: DHS data; author's calculations.

Figure A2: Wasting rate and GDP per capita by country and year



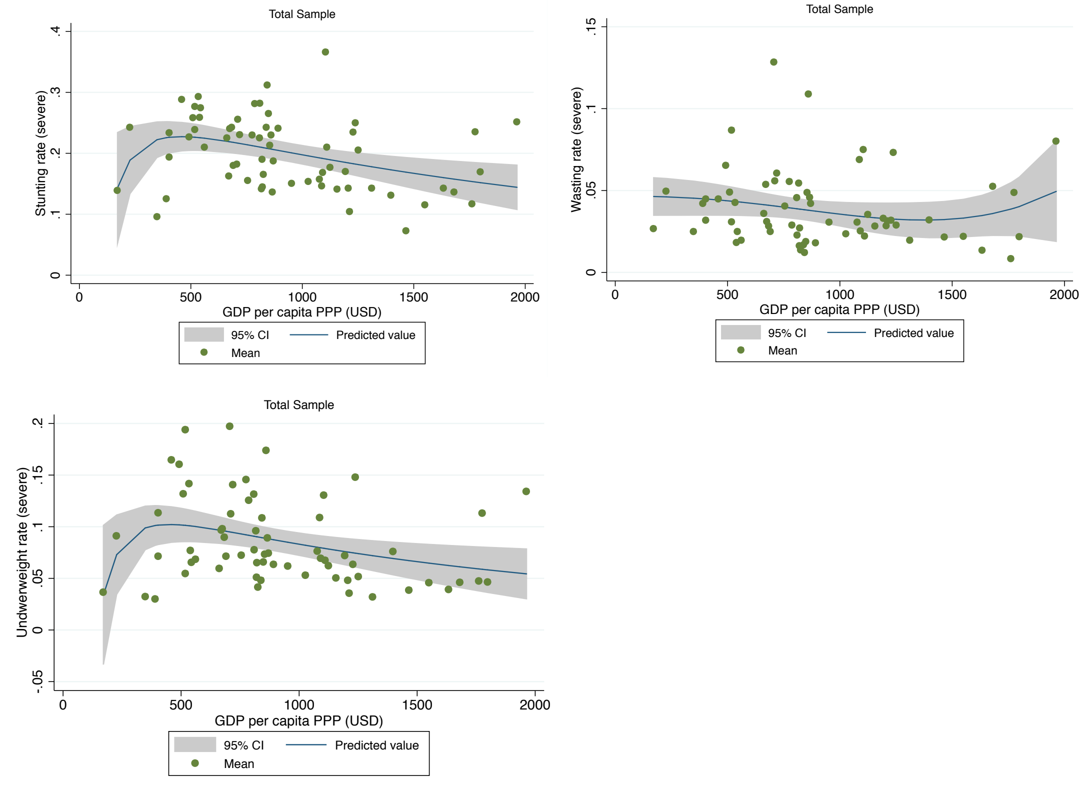

Guinea
Wasting rate (%)
GDP per capita PPP (USD)
Year
Mean wasting rate (%)
Mean GDP per capita
Kenya
Wasting rate (%)
GDP per capita PPP (USD)
Year
Mean wasting rate (%)
Mean GDP per capita
Lesotho
Wasting rate (%)
GDP per capita PPP (USD)
Year
Mean wasting rate (%)
Mean GDP per capita
Liberia
Wasting rate (%)
GDP per capita PPP (USD)
Year
Mean wasting rate (%)
Mean GDP per capita
Mali
Wasting rate (%)
GDP per capita PPP (USD)
Year
Mean wasting rate (%)
Mean GDP per capita
Madagascar
Wasting rate (%)
GDP per capita PPP (USD)
Year
Mean wasting rate (%)
Mean GDP per capita
Malawi
Wasting rate (%)
GDP per capita PPP (USD)
Year
Mean wasting rate (%)
Mean GDP per capita
Mozambique
Wasting rate (%)
GDP per capita PPP (USD)
Year
Mean wasting rate (%)
Mean GDP per capita


Nigeria
Namibia
Niger
Rwanda
South Africa
Senegal
Sierra Leone
Sao Tome and Principe
Wasting rate (%)
GDP per capita PPP (USD)
Year
Mean wasting rate (%)
Mean GDP per capita



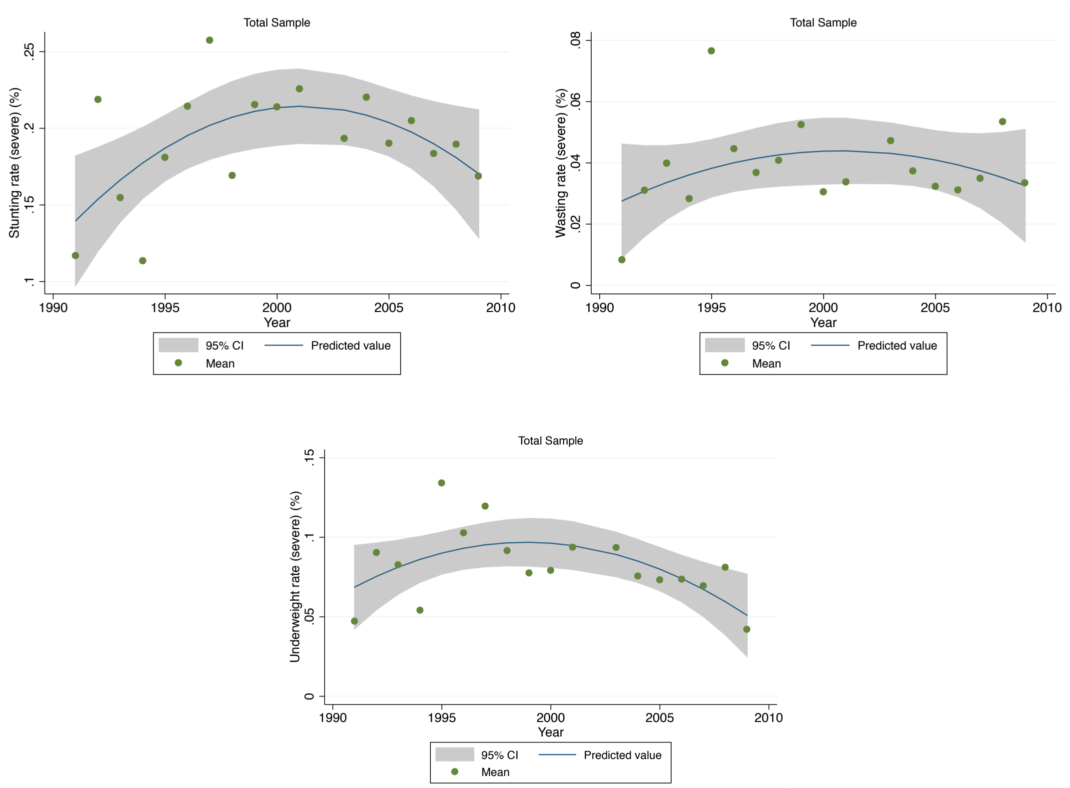
Source: DHS data; author's calculations.

Figure A3: GDP per capita versus severe Undernutrition (total sample - Africa)



Source: DHS data; author's calculations.

Figure A4: Severe Undernutrition rates by year (total sample - Africa)



Source: DHS data; author's calculations.