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THE IMPACT OF THE FOOD AND FINANCIAL CRISES ON CHILD MORTALITY: THE CASE OF SUB-SAHARAN AFRICA

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The Impact of the Food and Financial Crises on Child Mortality: The Case of sub-Saharan Africa

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Abstract. The paper analyzes the causes of the decline of the under-5 mortality rate (U5MR) in sub-Saharan Africa over the years 1995-2007 by estimating an aggregate econometric model for a panel of 40 countries. This model is then used to compute the impact of the 2008-09 global economic crisis on child mortality, by comparing the number of child deaths which would have occurred under a 'no-crisis counterfactual scenario' with those computed under the actual 'crisis scenario'. The results suggest that in sub-Saharan Africa the economic slowdown – and in some countries the negative economic growth – generated by the global crisis caused an additional 27000 child deaths. However, if changes occurring during 2008-09 in other determinants of U5MR are factored in, the number of child deaths declined by 15000 units in relation to the counterfactual scenario. A protective effect on U5MR was played by the surge in food production and the increase of public expenditure and foreign aid to health. The countries most negatively affected by the impact of the crisis were the Sudano-Sahelian and Eastern African ones, while Coastal West Africa and Southern Africa generally experienced a steady decline in child deaths. Starting from the U5MR estimates for 2009, the model is also used to assess what values the determinants of U5MR should take over 2009-2015 in order for the countries of the region to meet the MDG4 target as closely as possible. Finally the paper analyzes the determinants of U5MR inequality by wealth quintiles by making use of both aggregate and DHS data on access to services, family characteristics, income per capita, and other variables.

Keywords: infant mortality, economic crisis, food prices, sub-Saharan Africa, economic simulations

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1. INTRODUCTION AND MOTIVATION OF THE STUDY

The years 2000-2007 witnessed an average decline in U5MR in sub-Saharan Africa (SSA) faster than that recorded during the prior two decades, including in countries with high HIV prevalence rates due to the spread of preventative and curative measures. Despite their gravity, a comprehensive analysis of the impact of the 2008-2009 crises on child mortality is still lacking, and estimates of the number of additional child deaths caused by the crises in SSA vary enormously, i.e. from 30,000-50,000 (Friedman and Schady, 2009) to 700,000 (forecasts released by the World Bank in early 2009[1]). While interesting, these studies rely on methodologies which are based exclusively on IMR-GDP elasticity and country-specific time trends, while ignoring the impact of other determinants of U5MR which may change rapidly during the crisis, such as income inequality, the prices of food and drugs, public health expenditure, access to private health care, coverage of vertical health programmes, international aid to the health sector, mother's time for child care and food production, or of structural determinants of U5MR, such as female literacy, which may cushion children during crisis periods. In addition, much of this literature is based on theoretical frameworks derived from the developed countries which do not reflect well the reality of poor SSA countries.

In view of the above, Part 2 of this paper develops an aggregate model for explaining the levels and changes in U5MR adjusted to reflect the situation of SSA which includes variables affecting child mortality over both the long and short term. This model is then used to simulate the impact of the 2008-09 economic crisis on child mortality. In Part 3, the paper discusses the determinants of inequality in U5MR making use of DHS data on access to services, family characteristics, and some nationwide variables used in the estimation of the aggregate U5MR model. This model allows the identification of policies and measures which could help to reduce U5MR inequality both during crisis periods and under normal circumstances. Part 4 presents tentative policy recommendations.

2. ESTIMATING AN AGGREGATE LONG TERM MODEL OF U5MR FOR SUB-SAHARAN AFRICA

2.1 Background to recent changes: long-term trends in U5MR and lessons from prior crises

Though the current global economic crisis is considered the most serious since the Great Depression, it goes without saying that between 1960 and late 2007, most SSA countries were affected by several other crises. This brief review aims at putting the current crisis into perspective. In this regard the 1960-2007 trends in U5MR can be broken down into three different sub-periods:

[1]See:http://blogs.worldbank.org/africacan/infant-mortality-rates-in-africa-will-increase-by-30000-50000-girls-will-fare-worse (accessed 18 April 2011).

(i) a fairly rapid U5MR decline during the early independence years of the 1960s and 1970s. At independence all SSA countries exhibited an underdeveloped colonial economy, extremely low levels of literacy, a weak and dualistic health care infrastructure and very high childhood mortality. Yet, between 1960 and the early 1980s, most of them realized substantial progress in terms of income growth, coverage of health care, literacy, vertical campaigns against infectious diseases and, to a lesser degree, access to drinking water. With an average regional annual per cent decline[2] of 1.5 points a year in the 1960s and 1.9 in the 1970s, progress in reducing IMR and U5MR was faster than in South Asia, though slower than in East Asia and MENA (Cornia and Menchini 2006).

(ii) U5MR stagnation or increase during the recession and adjustment crisis of the 1980s. After the gains of 1960-80, the average yearly regional decline in IMR and U5MR fell to a meager 0.5 per cent a year in the 1980s and 0.6 per cent in the 1990s (*ibid*). During the first half of the 1990s, U5MR stopped declining in Zaire (now DR Congo), Sierra Leone, Niger, Nigeria, Madagascar and Tanzania, and recorded an increase in Angola and Zambia (Cornia and Mwabu 1997).

This slowdown was caused by the sharp economic downturn experienced by the region over 1981-4, and the subsequent period of weak or negative GDP growth. Indeed around half of the SSA countries experienced negative growth in GDP per capita during the 1980s and 1990s (Cornia, Rosignoli, Tiberti 2009). In turn, income inequality rose in 4 of the 7 countries with available data (WIDER 2008). The 1980s also experienced a fiscal crisis which led to drastic cuts in public health expenditure, the introduction of user fees and other community-based health financing mechanisms, and the privatization of public hospitals (Cornia and Mwabu, 1997). However, greater efforts by international donors and domestic governments led to an increase of vaccination coverage between 1980 and 1990 from 20 to about 50 per cent in SSA as a whole. Yet, in the 1990s the vaccination rate leveled off or was reversed, as in Central Africa, as a result of stagnant or declining allocations of aid and budgetary resources to priority health interventions (Ahmad et al. 2000). In addition, during the 1980s, cuts in public outlays on education and adult literacy programmes and the introduction of user fees in public schools depressed enrolment rates and female literacy in Southern and Eastern Africa, while they stagnated in the rest of the continent (Cornia and Mwabu 1997). The cuts in social expenditure were compounded by a worsening in public governance, a weakening of the state, growing corruption, and erosion of social cohesion. The depth of the health crises in Nigeria and the Congo in the 1990s, for instance, cannot be comprehended fully without considering the misuse of public resources in these failed states.

During the 1980s and 1990s, SSA was also affected by droughts and famines which affected – *inter alia* – the Horn of Africa, Sudan and South-Eastern Africa, as well as by a growing number of conflicts. By 1994 there were in the region no less than 13 fully-fledged wars and about five internal conflicts which massively raised the number of refugees and internally displaced people without adequate access to food, water and health care. Finally, the 1990s were characterized by the spread of HIV and AIDS which, in the entire SSA region, are

[2] The regional decline in U5MR conceals large variations in both levels and rates of change across sub-regions. U5MR was lowest in Southern Africa and highest in West Africa, while Central and Eastern Africa fell in between.

estimated to have killed 1.3 million people in 2009 compared to 0.2 million in 1990 (UNAIDS 2010). Children were also hit by vertical transmission of the virus and rising AIDS-induced poverty.

(iii) a rapid decline of U5MR during the 'African Renaissance' of 2000-7. The dawn of the new century seems to have reversed the negative trends recorded during the prior two decades. As a result of improvements in the international demand and prices of the commodities exported by the region, between 2001 and 2007 the average GDP per capita in SSA rose to 3.2 per cent a year (see Annex 1 Table 2), slower only than that recorded during the 1960s. The return to growth and an increase in government revenue generated a fall in income inequality in 12 countries out of the 21 with available data (PovcalNet[3]). With a stable macro-economy, a rise in tax/GDP ratio in several countries of the region[4], and the new emphasis placed by international organization on MDGs, the share of public health expenditure on total Government expenditure rose moderately since 2000 in 22 of the 41 SSA countries analyzed in this paper (see Annex 1 Table 1). The weighted SSA average of public health expenditure/GDP rose from 2.4 to 2.6 per cent between 2001 and 2007 (*ibid*). The return to stable conditions also produced a reversal of the prior stagnation in female literacy and immunization rates. Per capita food resources slightly increased between 2001 and 2007 in the region with a weighted annual growth of 0.4, driven in part by a rise in food imports. In turn, the prevalence of HIV stabilized in many countries, while from around 2003-5 it started declining in the highly affected countries of Eastern and Southern Africa. Indeed, according to UNAIDS (2010), between 2001 and 2009 the incidence of HIV infection declined by more than 25 per cent in 22 SSA countries and the adult prevalence in the whole region decreased from 5.9 to 5.0 per cent, with 32 per cent fewer children being newly affected. In addition, in Southern Africa, the most affected sub-region, AIDS-related deaths decreased by 18 per cent, passing from 740,000 in 2004 to 610,000 in 2009 (*ibid*), partly as a result of a significant increase in the coverage of anti-retroviral treatment.[5] Finally, during this period, part of the region experienced an improvement in governance as suggested by the shift to fair-and-free elections and rule of law in seven additional countries (out of 41). The Polity 4 index indicates that by 2008 at least 17 countries had a governance score equal or greater than 7.[6] This improvement may have affected the level and utilization of public health resources and generated a more stable economic environment, which indirectly contributed to a reduction in U5MR.

The main lesson of this cursory review is that prolonged crises (i.e. crises spanning a few years) in economic, social and political conditions do affect the aggregate U5MR trend by

[3] PovcalNet is a web application providing distributional data and a user-defined poverty line/PPP to estimate the poverty and inequality measurements for a selected country or group of countries (see http://go.worldbank.org/NT2A1XUWP0 accessed 18 April 2011.

[4] IMF-GFS data indicate that tax and non-tax revenue as a share of GDP rose between 2000 and 2007 in 28 countries of the region, stagnated in 10 and fell in seven (Angola, Nigeria, Gabon, Guinea Bissau, Gambia, Zambia and Zimbabwe) including because oil-producing countries were affected by low oil prices.

[5] As discussed in the 2010 UNAIDS global report (*ibid*, p. 29), "the scaling up of treatment is profoundly affecting sub-Saharan Africa". At the end of 2009 37 per cent of adults and children eligible for antiretroviral therapy were receiving it (41 in Eastern and Southern Africa and 25 in Western and Central Africa), compared with only 2 per cent in 2002. Conversely, the estimated number of children who lost one or both parents due to AIDS increased from 8.9 million in 2001 to 14.8 million in 2009.

[6] The Polity 4 index varies between 0 (lack of governance and democracy) and 10 (full democracy and governance).

either slowing down its rate of improvement or causing its reversal. It is important to underscore, however, that the extent of a crisis or recovery cannot be proxied exclusively by changes of GDP/c (the variable used in most of the recent literature to predict the impact of the 2008-09 crisis). Variations in other fast-changing determinants of child mortality must also be taken into account, as changes in these variables can play an important offsetting or aggravating effect and lead to a decline/increase in child mortality despite an opposite variation in GDP per capita.[7]

2.2. Recent literature on the impact of economic crises on U5MR in developing countries

The literature on the health impact of economic crises in developing countries follows different approaches but unanimously confirms that child mortality and malnutrition increase during severe and lasting crises and decreases - though less than proportionally - during recoveries. For instance, Cutler et al. (2002) show that in Mexico child mortality rose by 9.2 per cent during the 1982-84 debt default crisis, 10.3 per cent during the crisis of 1985-89, and 6.9 per cent during the 1994-96 banking crisis. In turn, Rukumnuaykit (2003) analyzed the impact of the Indonesian crisis of 1997-8 and suggested that infant mortality rose from 30 to 48 per 1,000 live births between 1996 and 1998 with increases recorded in 22 of the country's 26 provinces, despite only a moderate cut in public health expenditure, much of which was made up by donor assistance to the health sector. Meanwhile, in a study of the protracted economic decline which hit Cameroun between 1991 and 1998, Pongou et al (2006) showed that weight-for-age malnutrition rose by 9 percentage points for boys and 3 for girls, with higher increases for children of mothers with no education, living in rural areas and belonging to households with limited assets. In turn, Paxson and Schady (2005) found that that the crisis of the mid 1980s in Peru raised IMR from 50 to 75 per 1,000 live births. This resulted in 18,000 excess deaths, which were mainly caused by a 60 per cent drop in public health expenditures per capita and declines in health service utilization by impoverished households. Likewise, Baird, Friedman and Schady (2007) show that income shocks have large negative effects on infant mortality. They investigate the relationship between short-term fluctuations in aggregate income and infant mortality on the basis of 59 DHS covering developing countries accounting for over 1.7 million births. They show that a 1 per cent decrease in per capita GDP is associated with a rise in mortality of between 0.24 and 0.40 infants per 1,000 live births.

Similar results are arrived at by Bhalotra (2010) who made use of DHS in a broader multi-causal approach. Her study shows that in India child health deteriorated during economic contractions, though the impact is clearer in rural than in urban areas. In the former, attended births, antenatal care, child vaccinations and the probability of treatment for infectious diseases were found to be lower in downturns. This was due in part to a lower supply of

[7] For instance, during the crisis of the 1980s, most Latin American countries experienced a decline in incomes and health expenditure. Yet, child health continued to improve while in SSA it worsened. Possible explanations of this divergence centre around the poor coverage of the health care systems in Africa; a faster expansion of child-survival interventions in Latin America; lower political instability and HIV and AIDS spread; and the existence of a network of NGOs which replaced in part a weakened public health sector. Of course, there were exceptions to this rule, as shown by Ferreira and Schady (2009) who analyze the impact on IMR of the cuts in health expenditures experienced by Peru during the crisis of the late 1980s.

public health services, and in part to a lower demand for healthcare, as earnings dropped but also because mothers worked harder and did not have as much time to seek healthcare for their children. Her estimates imply that a negative income shock of median size (4.4) is associated with an infant mortality rise of approximately 1.4 per 1,000 live births, i.e. approximately half of the total annual decline in infant mortality in India over the period she studied (1970-1997). The study shows that the responsiveness of infant mortality to income changes is highly sensitive to the sign and extent of the income shock.

Currently there are few studies on the impact of the 2008-2009 crisis. In early 2009 the World Bank used a single worldwide IMR-GDP elasticity estimated over the long period (1975-2005). Based on this elasticity, and assuming a large uniform economic collapse of GDP in all SSA countries, it forecast that the crisis would have caused an additional 700,000 infant deaths in SSA (see note 2). In contrast, Friedman and Schady (2009) estimated for SSA an increase of 30,000-50,000 infant deaths due to the crisis of 2009. Yet, as noted in the introduction, while of interest, these studies rely on highly simplified models. For instance, Friedman and Schady (2009) base their estimations only on an IMR-GDP elasticity, country-specific time trends and the April 2009 IMF projections of GDP, but ignore changes in other important factors which affected child mortality recently.

In contrast, Brinkman et al. (2010) analyzed the impact of the food and financial crises on food consumption, nutrition, and health by relying on a variety of approaches such as the 'cost of the food basket', surveys on food intake, and regression analysis of food consumption scores (FCS) (which reflect diet frequency and diversity). Their study shows that the increase in the cost of the food basket over 2006–2010 forced households to reduce the quality and quantity of food consumed in nearly all developing regions. The social groups most affected were the 'biologically vulnerable groups' (children, pregnant and lactating women, the chronically ill) and the 'economically vulnerable households' (i.e. the urban poor, landless, pastoralists, and food-deficit small-farmers) who spend 50-80 per cent of their incomes on food. The African middle class (for which food accounts for 35-65 per cent of total expenditure) was affected as well between the last quarter of 2007 and of 2008, when the cost of the food basket rose on average by 20 per cent in West and Central Africa and 57 per cent in East and Southern Africa. Brinkman et al (2010) also reviewed 24 household-level food security assessments (ten of them in SSA) conducted by the World Food Programme in 2008, which consistently produced evidence of reductions in the quality and quantity of food consumed as well as reductions in health care visits or health expenditures in response to increased food prices and reduced income. All this is particularly worrying for child malnutrition which is the cause of an estimated 2.2 million under-5 child annual deaths worldwide (*ibid*). The impact was greatest among children of households which were spending a high proportion of their incomes on cheap calories, as they sacrificed the intake of micronutrients (including salt and sugar) before reducing energy intake, with effects on the prevalence and severity of micronutrient deficiencies.

2.3 Theoretical framework: traditional and non-traditional determinants of U5MR in SSA

(i) Theoretical models commonly used to assess the impact of crisis on U5MR. Recent works (Ferreira and Schady 2008, Baird et al. 2009) provide stylized theoretical frameworks of the impact of economic crises on child health in both developing and developed countries. The main variables they consider are the consumption of health-enhancing goods (which depends on household income), the parental time dedicated to child care, and public expenditure on health (which acts as a shift variable). A high initial level of income per capita of the family has a moderating impact on the effect of the crisis. Based on this framework, the authors conclude that the impact of such shocks is theoretically ambiguous, as final outcomes basically depend on the initial level of GDP/c and on the 'substitution effect' between increases in time dedicated to child care by parents who lose their jobs and the drop in their income which entails a lower consumption of food, medicines and clothing by children. Studies of developed countries confirm the validity of this theoretical approach and provide evidence that mortality risks for children are *lower* in recessions (Ruhm, 2000). However, this model does not capture well the SSA situation. To start with, the 'substitution effect' between family income and time allocated to child care by unemployed family members is not observed in low income SSA countries where a decline in family income triggers an expansion of the labour supply of women, adolescents and the elderly, with the effect of reducing adult time for child care and health-promoting activities, as shown for instance by Sollis and Moser (1991) in their classic study on Guyaquil and by Balhotra (2010) on India. Thus, in these countries, a recession tends to raise U5MR, despite attempts to offset the loss of income of the breadwinner with an increase in family labour supply. Ferreira and Schady (2008) also underscore that middle income families try to moderate the effect of crises through a second 'substitution effect', i.e. by reducing savings and non essential consumption, and by switching from expensive to cheap calories. Yet, also this second substitution effect is of limited importance in Sub-Saharan Africa where 30 per cent of the population already suffers from chronic poverty and under-nutrition, and where - because of low income per capita - the average family already spends 60-80 per cent of its income on cheap calories and other essential items. For instance, a study by Bibi et al. (2009) suggests that as a consequence of the 2006-8 food price hike, the food poverty rate and caloric poverty rate among Malian children rose by around 10 and 8 percentage points. Children in rural areas were most affected (due to the incompressible nature of their non-food consumption), but children in the capital city were able to maintain their caloric intake due to the much higher initial share of non-food consumption which left them greater room to cut such expenditures in order to preserve food consumption. As a result, in Bamako the budget share for food consumption was predicted to increase from 44.5 to 53.9 while in rural areas it was predicted to rise from 65.6 to only 66.2.

In addition, the framework of Ferreira and Schady (2008) omits explanatory variables which are key in a context like that of SSA, i.e. subsistence food production, the prices of food and medicines, and conflicts (that often are the cause or the effect of recessions). Furthermore, while their paper considers the impact of overall public health expenditure, it neglects the role of foreign aid to health, as well as the composition of health expenditure, in particular the share of resources assigned to low-cost and high-impact measures such as vaccination

campaigns, delivery care, and rural water supply. Finally, unlike in richer countries, in low-income countries a dip in aggregate income often entails - *ceteris paribus* - a fall in public health expenditure, as governments are often unable to adopt countercyclical fiscal policies. Thus, in these countries, the state offers limited insurance to its citizens. At the same time, the poor are unable to borrow to smooth their consumption and are thus forced to cut back on nutrition and health expenditure, to take their children out of school, and to increase female labour supply.

(ii) Structure of the African economies and U5MR. A more realistic modelling of the impact of the recent crises on U5MR in SSA must take into account the specific features of the region. In this regard it is necessary to underscore that most African economies are highly dualistic. With the exception of a few nations in Southern Africa, between 45 and 90 per cent of the population lives in often remote rural areas where it is mostly engaged in subsistence agriculture. Market exchange and the monetization of the economy remain limited. Because of the absence of storage capacity, consumption credit and cereal banks which would permit them to smooth their annual food consumption, many rural households sell part of their food crops at low prices immediately after harvest and purchase them during the lean season at prices of up to three times higher. In addition, with the exception of the southern and some eastern African countries, where many landless labourers work in large farms, land and agricultural output are generally distributed in a fairly egalitarian way. This means that average food output data reflect reasonably well the welfare of most rural households. All this suggests that the latter and their children are in part sheltered from changes in food prices and aggregate economic downturns, though – because of lack of crop insurance and weak safety nets – they are more exposed to climatic shocks and the related fall in food production. Remoteness and the 'urban bias' of public policy also mean that health services are less easily accessible than in urban areas, while the spread of infectious diseases (malaria above all) is generally higher. A weakening of health services or increase in their usage cost during economic crises is therefore likely to generate a greater impact in rural areas, where there exist few private substitutes for public health services. All in all, it would appear that, regardless of average income per capita, a high share of the population in rural areas may be reflected in a higher impact of fiscal and production crises on U5MR, but moderate that of price increases and economic recessions.

(iii) An econometric model of the impact of the 2008-09 crisis on child mortality. Given all this, the mortality model which best explains changes in U5MR during crisis is the *material deprivation model* which emphasizes the lack of private and public resources for health. Indeed, in SSA – between 30 to 40 per cent of all deaths take place in childhood due to lack of health-enhancing resources, as opposed to just one per cent in the advanced economies and about six per cent in middle income countries (Cornia, Rosignoli and Tiberti, 2008). The immediate (epidemiological) causes of child deaths are perinatal conditions, measles and other infectious diseases, diarrhoea, malaria and malnutrition. These causes account for around two-thirds of total child deaths (Black et al. 2010). In turn, the proximate causes are poor maternal and delivery conditions, limited access to clean water, poor housing and sanitation and indoor air pollution, limited personal illness control (both curative and

preventative, such as immunization and malaria spaying), poor nutrition and limited parental time for child care.

Finally, these proximate causes depend on a set of underlying causes such as household income per capita, its instability and unequal distribution, limited subsistence food production (especially relevant in little monetized rural areas), dependency on food imports, and the price of food and medicines. These variables affect the availability of nutrients, clean water, adequate housing and sanitation, and the ability to adopt appropriate personal illness control. Other key underlying causes are the community and family structure and the level of education of the parents (of the mother in particular), as well as the mother's time for childcare, feeding and seeking health care. In addition, one should also consider that the current public expenditure on health, housing, water and sanitation, child care, food subsidies and nutritional support affect U5MR over the short term, while public expenditure on investment in infrastructure and education affects it over the long term. In the African context, an additional determinant of U5MR is the international aid to these sectors, as public health and sanitation expenditure crucially depends on foreign aid for up to fifty per cent (see Annex1 Table2). A major problem is that only a tiny share of public expenditure and foreign aid is allocated to primary health care (PHC) programmes like basic health services, immunization, promotion of breastfeeding, maternal and delivery care, malaria and AIDS control, and rural water supply which are cost-efficient and well targeted on the poor.[8]

In addition, as noted above, since the mid 1980s SSA was affected by a wave of conflicts which raised the number of refugees and internally displaced people, and the related number of child deaths due to violent causes, starvation and infectious and waterborne diseases.[9] Our model also includes the prevalence of HIV. Unlike other epidemics that produce their effects quickly, the impact of HIV extends over two decades, with the result of shifting upwards the long term mortality curve of adults and, to a lesser degree, of children. Finally, for the reason noted in section 2.1, our model includes an index of democracy (an improvement in which is expected to reduce U5MR) and a conflict dummy (which is expected to have the opposite effect).

A key methodological choice concerns the selection of the explanatory variables to be used to explain the U5MR changes over time. The main choice is between the proximate and underlying causes of U5MR. Though the distinction between these two sets of U5MR causes adds clarity to the analysis, the meta-production function linking immediate and underlying causes of child mortality is far from precise. For this reason, as well as for reasons of data availability, our model mainly uses as explanatory variables the underlying causes of mortality, though it also includes the coverage of immunization and improved water and sanitation which are proximate causes of child mortality, as - for the reasons given above -

[8] Up to 90 per cent of public health expenditure is allocated to administrative tasks and urban referral and university hospitals which cover only part of the urban population while PHC remains underfunded. A similar pattern is observed for the ODA to the health sector. In this regard, in 1998 UNICEF launched the '20/20 Initiative' which aimed at ensuring that at least 20 per cent of public health expenditure and ODA was allocated to PHC.

[9] Such rises are of limited duration and U5MR usually returned to pre-crisis levels in 2-3 years after the shock. However this is not true in countries such as Congo and Sudan where internal conflicts become endemic, while the displacement of refugees and distress migration took a long time to solve.

public expenditure on health proxies only in part the coverage of these interventions. In view of all this, the explanatory variables retained for our theoretical model are the following (noting in parenthesis their impact on U5MR based on theory): per capita GDP in constant international prices, which takes into account changes in economic activity and prices (-); Gini coefficient of the distribution of income (+); ratio of food prices to consumer price index (CPI) (+); per capita food availability, i.e. domestic production plus imports (-); the share of food imports on food availability (+); government expenditure on health as a share of GDP (-); per capita external aid on health (-); private health expenditure as a share of GDP (-); immunization coverage (-); coverage of improved water sources (-); infectious diseases (HIV and malaria prevalence) (+); literacy among 15-44 year old females (-); parental time for child care (-); democracy index (-); and conflicts dummy (+).

(iv) Data limitations. The U5MR data used in this paper do not come from national death registration systems (which in SSA vastly under-report the number of deaths) but from time series estimated by the Inter-agency Group for Mortality Estimation (IGME).[10] These time series are obtained by interpolating a spline trend across the (relatively few) U5MR data computed on the basis of WFS, DHS, and MICS surveys and – in a few cases (e.g. South Africa) – national registration systems. However, since there are typically 2 to 4 surveys per country spread over a 15-20 year period, and since only seldom do such surveys coincide with years of crisis, the IGME time series are highly trended, and thus are more appropriate for capturing long term changes in U5MR than its short term variations. In addition, survey-based U5MR estimates are usually constructed as averages of U5MR for five-year periods prior to the survey, and are thus unlikely to capture the impact of a yearly shock occurring over that period. In order to reduce – if in part – these problems, for the estimation of our model it was decided to use only U5MR data lying on the spline computed on the basis of the latest available sources and not data obtained from extrapolations. In other words, if the latest sources used by the IGME to derive the spline of U5MR are dated 2006 for example, this country enters into the regression for the period 1995-2006. Despite these limitations, if used as part of a panel of countries/years, these data offer important information about the variation of U5MR. A decomposition of the total U5MR variability of our panel of 40 countries over 13 years (1995-2007) confirms that 83 per cent of the total variability is due to "cross-country" variations, 9 per cent to changes "over time", and the remaining 8 per cent to an unexplained residual.[11]

[10] The IGME includes experts from UNICEF, the World Bank, WHO and the United Nations Population Division (see http://www.childmortality.org/)

[11] The method used for the decomposition of the variability of U5MR across countries or years is the analysis of variance (Edwards, 1985) and the computation of eta-squared statistic as rate of partial on total sum of square: a measure of the percentage variability due to each categorical variable. The results are presented below

Source	Partial SS	df	MS	F	Prob > F	eta-sq
Model	3166447	67	47260.4069	156.71	0.0000	0.9106
country	2885053	43	67094.2721	222.48	0.0000	0.8297
year	284447	24	11851.9912	39.30	0.0000	0.0894
Residual	310923	1031	301.574923			
Total	3477371.01	1098	3167.00456			

Number of obs = 1099 R-squared = 0.9106
Root MSE = 17.3659 Adj R-squared = 0.9048

Second, the data on the distribution of income, malaria incidence, and parental time for child care are very sparse and of mixed quality. For this reason, these variables could not be introduced in the regression analysis. Third, the impact of changes in the real households' incomes and food prices were proxied by changes in real GDP/c (which reflects both effects) but to fully capture the impact of food prices we also introduced the ratio between the index of food prices and total consumer price index. The latter variable helps to estimate - although only in part - the impact of an upsurge in food prices (relative to total consumer prices) on U5MR. Indeed, when food prices grow faster than non-food prices (as it normally happens during food crises), the real income of households - especially that belonging to the poorest deciles - deteriorates faster as their budget is largely devoted to food items.

As a result of the above data limitations – particularly those related to the measurement of U5MR – the variables used in regression suffer from an unknown measurement error which may bias the regression parameters. In addition, the impossibility to include in regression analysis key determinants of U5MR may cause an omitted variables bias, possibly affecting a few regression coefficients and the unexplained residual. To check whether our model (Table 2) suffers from such omitted variable bias we run the Ramsey RESET test (Ramsey, 1969).[12] The test rejects the null hypothesis that model has no omitted variables. This problem is of difficult solution due to lack of data for a few variables (income inequality, malaria mortality, etc.) particularly for the 1990s. However, the use of country fixed effects estimators reduces this problem and the related bias. An overall description of the data used in the model in provided in Annex1 Table 1.

(v) Regression results. The regression analysis was carried on the basis of a macro-panel of 40 countries and 13 years (1995 to 2007) including a theoretical total of 533 observations which fell to 439 due to missing data.[13] Table 1 presents the correlation matrix among the explanatory variables included in the regression model presented in Table 2. The only variables with a relatively high pairwise correlation (i.e. 0.62) are HIV prevalence and female literacy. This correlation matrix, together with a scree-plot of its eigenvalues that is not so steep (the relative values of all eigenvalues decrease at a low rate), somehow comforts us that the estimation is not affected by serious problems of multi-collinearity.

[12] The test consists of adding new variables (i.e. the model's independent variables at power 2, 3, etc – y_i^2, y_i^3, y_i^4) to the right side of the model and performing an F test to verify if the parameters of these new variables are jointly equal to 0 (i.e. non significant).

[13] Estimation of the short term impact of the crises on U5MR could have been carried out in two other ways. First, by utilizing DHS micro data, as done in Bahlotra (2010) and Friedman and Schady (2009). This approach would have required a huge investment in manipulating 76 DHS available for SSA for the years considered while not allowing totake into account changes in macro variables such as public health expenditure, etc. A second approach is an 'event analysis' in which one tests the relationship between changes in U5MR and its fast changing determinants (GDP/capita, income inequality, and so on) using only the years of crises ('the events'). This approach is not practicable either as the IGME U5MR data vary little in the cases of recession, famine, and price rises.

Table 1: Correlation matrix of explanatory variables of the overall model

	GDP/c (ln)	Improved water& sanit	HIV preval	Food price Index/CPI (ln)	Gvmt exp on health (% gdp)	Food resources/c (prod+ import)	External aid on health/c (ln)	Female literacy (age 15-44)	Food imports (% total food resources)	Immuniz coverage	Democracy index	Conflict dummy variable
GDP/c (ln)	1											
Impr water& sanit	0.59	1										
HIV prev	0.44	0.47	1									
Food price Index/CPI (ln)	0.01	-0.03	0.10	1								
Gvmt exp on health (% gdp)	0.18	0.34	0.47	0.13	1							
Food resources/c (prod+import)	-0.01	-0.10	-0.22	0.09	-0.05	1						
External aid on health/c (ln)	0.02	0.09	0.11	0.24	0.46	-0.01	1					
Female literacy (age 15-44)	0.53	0.56	0.62	0.15	0.42	-0.03	0.25	1				
Food imports (% total food resources)	0.39	0.33	0.17	0.04	0.17	-0.46	0.08	0.27	1			
Immuniz coverage	0.12	0.41	0.25	-0.05	0.39	0.02	0.29	0.29	0.07	1		
Democracy index	0.13	0.14	0.32	0.10	0.38	0.10	0.07	0.27	0.03	0.23	1	
Confilct dummy variable	-0.28	-0.11	-0.21	-0.22	-0.26	-0.13	-0.17	-0.24	-0.17	-0.15	-0.27	1

Source: authors' calculation.

As for the choice of the econometric estimator, the macro panel data collected for this research demand that the procedure chosen for the estimation of U5MR takes into account that each country is observed over 13 periods. The estimation procedure takes therefore the following form:

$$y_{it} = \alpha + x_{it} \cdot \beta + u_i + \varepsilon_{it} \qquad (1)$$

where y is the dependent variable (U5MR, or an invertible transformation of it), x is a vector of explanatory variables, the subscripts i and t represent respectively the countries and years of the panel, ε_{it} is a joint error term (idiosyncratic error) for countries and time periods, and α and β the parameters to be estimated. In turn, u_i takes different meanings depending on the econometric specification adopted: it could be a fixed parameter varying from country to country (under the fixed effect specification) or could be a random variable (under the random effect specification). Generally speaking, for models consisting of panels of aggregate macro data (as in this case), the fixed effect specification is the best choice. The Hausman test (Baltagi, 2008) confirmed that such specification is the most appropriate under these circumstances, and is preferable to a random effect one. Table 2 presents the results of

the best model obtained in regression analysis. Its dependent variable is the logit of under-five survival rate (U5SR), a transformation of the U5MR.[14]

Table 2. Results of the regression analysis on the logit of U5SR for 40 Sub-Sahara African countries, 1995-07

	Dependent variable: logit(U5SR)=ln((1000-U5MR)/U5MR)	
Explanatory variables	**Coefficients**	**p-values**
GDP/c (ln)	0.1295	***
Improved water & sanitation	0.0068	***
HIV prevalence	-0.0210	***
Food price index/CPI (ln)	-0.0194	*
Gvt exp on health (% GDP)	0.0199	***
Food resources pc (production + imports)	0.1263	*
External aid on health pc (ln)	0.0437	***
Female literacy (age 15-44)	0.8239	***
Food imports (% total food resources)	-0.1040	*
Immunization coverage	0.0005	*
Democracy index	0.0086	***
Conflict dummy variable	-0.0154	
Constant	0.0124	
Observations	439	
Countries	40	
F-value	66.82	
Rsq-within	0.6745	
Rsq-between	0.4054	
Rsq-overall	0.5066	

Source: authors' calculations. Note: * p<.10; ** p<.05; *** p<.01

All parameters have the signs expected on the basis of the received theory. An increase in GDP per capita determines a statistically significant improvement in the U5SR. Child survival also increases in correspondence with improved water and sanitation coverage, government health spending as a share of GDP, external aid to health, female literacy, immunization, democracy index, and per capita food availability. With the exception of conflicts, all estimated parameters are statistically significant. In turn, as expected, the prevalence of HIV appears to have a large and statistically significant effect on the survival rate of children of up to 5 years of age. A similar, if less pronounced effect is observed for the ratio between the food price index and the consumer price index, and for the share of food imports on total food availability. Overall, the estimates are satisfactory,[15] although the R^2

[14] Reliance on the logit of U5SR – that is ln((1000-U5MR)/U5MR) – presents a number of advantages: such variable ranges from – infinity to + infinity, the distribution of its residual is normalized, linearization of the time trend, and permits better fitting of the data.

[15] These results are unlikely to be affected by problems of reverse causation. In this case the Granger test is not useful given that in our dataset each variable has at best 13 observations. It is thus more appropriate to deal with

indicates that additional factors could be introduced in the regressions analysis or that a better measurement of the dependent variable would improve the overall fit of the model. Finally, in order to obtain more robust estimates, the model was estimated on all SSA countries, and not on subgroups thereof. The estimated parameters thus represent the mean effect of each variable on U5SR for the entire period 1995-2007 and for the whole continent. However, these parameters are likely to differ by sub-regions and sub-periods. Some prudence in the interpretation of the results is therefore needed.

A Wald test (Phillips, 1988) was carried out also to verify whether there had been a break in the U5MR trend between 1995-2000 and 2001-7. To do so, we computed the interaction parameters between the 2001-7 dummy and the other explanatory variables. The test rejects the null hypothesis that all interaction parameters were 0 and confirms that there was a structural break in the U5MR trend during this period.[16] As shown by the *p* values in Annex1 Table 2, the U5MR determinants which contributed most to the structural break were the drop in HIV prevalence, the rise in GDP per capita, improved water coverage, higher private expenditure on health, external aid to health, female literacy, and improvements in the democracy index.

In particular, we are interested to see to what extent each explanatory variable contributed to U5MR changes over the two periods. We thus calculated the positive or negative impact of each variable on U5MR for the periods 1995-2001 and 2001-2007 by equalizing the change in U5MR over 1995-2001 (and later over 2001-2007) to the sum of the change in each variable multiplied by its parameter, to which we added the error term. In symbols:

$$\Delta U5MR = \sum_{i=1}^{k} \beta_i \Delta X_i + r \qquad (2)$$

Where ΔX_i is the difference of the *i-th* explanatory variable between the end and the start of the period considered (1995-2001 and 2001-2007); β_i is the regression coefficient of the i-th variable and r is the difference between the overall predicted change and the summed changes produced by all explanatory variables in the period considered.

The results of this exercise are revealing. First of all, a comparison of the results obtained for the two periods shows that the factors responsible for the comparatively slower decline in U5MR over 1995-2001 were different from those which caused its rapid decline over 2001-2007. During the first period (Figure 1, top panel) the six most important (positive or negative) changes that affected the change in U5MR were in order of importance: per capita

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this problem in theoretical terms. In this regard, reverse causation makes no sense in the majority of the relations in Table 2. For instance, it is not plausible that an increase in U5SR can improve current (or lagged) GDP per capita, the prevalence of HIV/AIDS, food production, food imports, food availability per capita, the likelihood of conflicts, and improvements in democracy. The only cases in which reverse causation might be plausible are those between foreign aid and public health expenditure. But this would presume a 'rational' aid allocation by donors to countries with low U5SR, while the literature shows that aid does not privilege the LDCs where child mortality is highest. It also shows that aid and government expenditures on health and fresh water supply is poorly targeted on the needs of the poor. As noted above, the RESET test suggests that the parameters might be biased by the omission in regression analysis of variables discussed in the theoretical section - such as income inequality and malaria incidence.

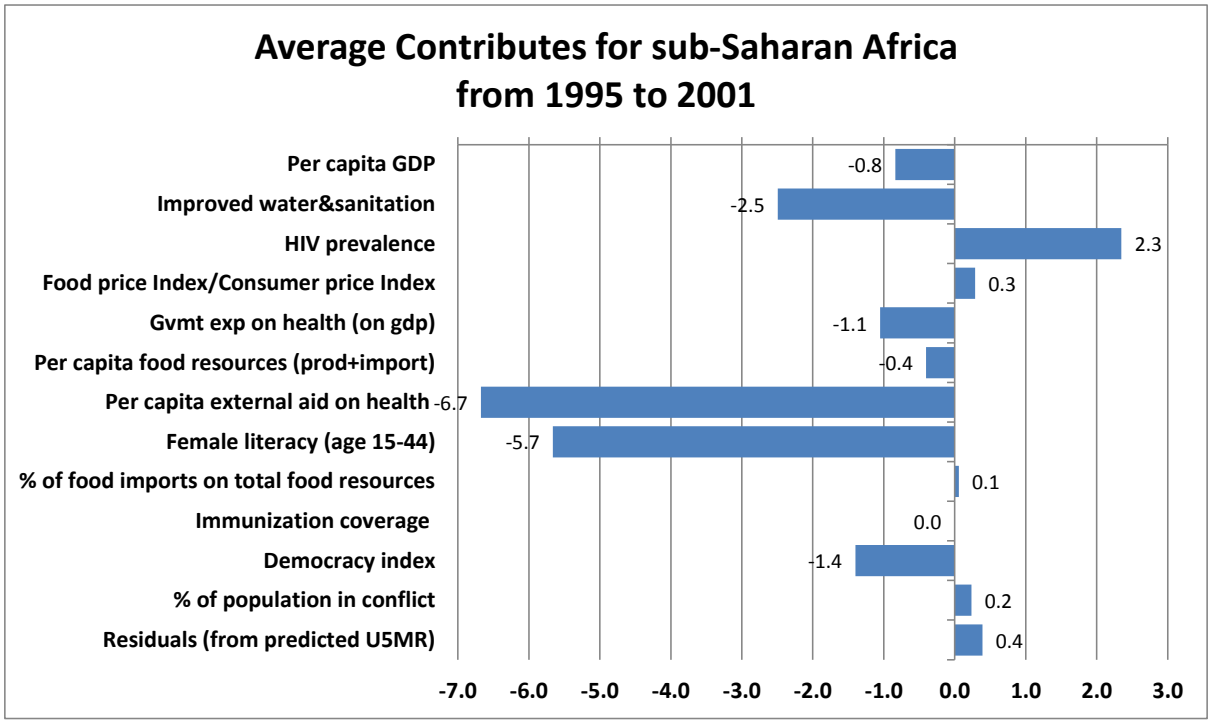
[16] The test is mostly useful to see which explanatory variables affect the most the structural change.

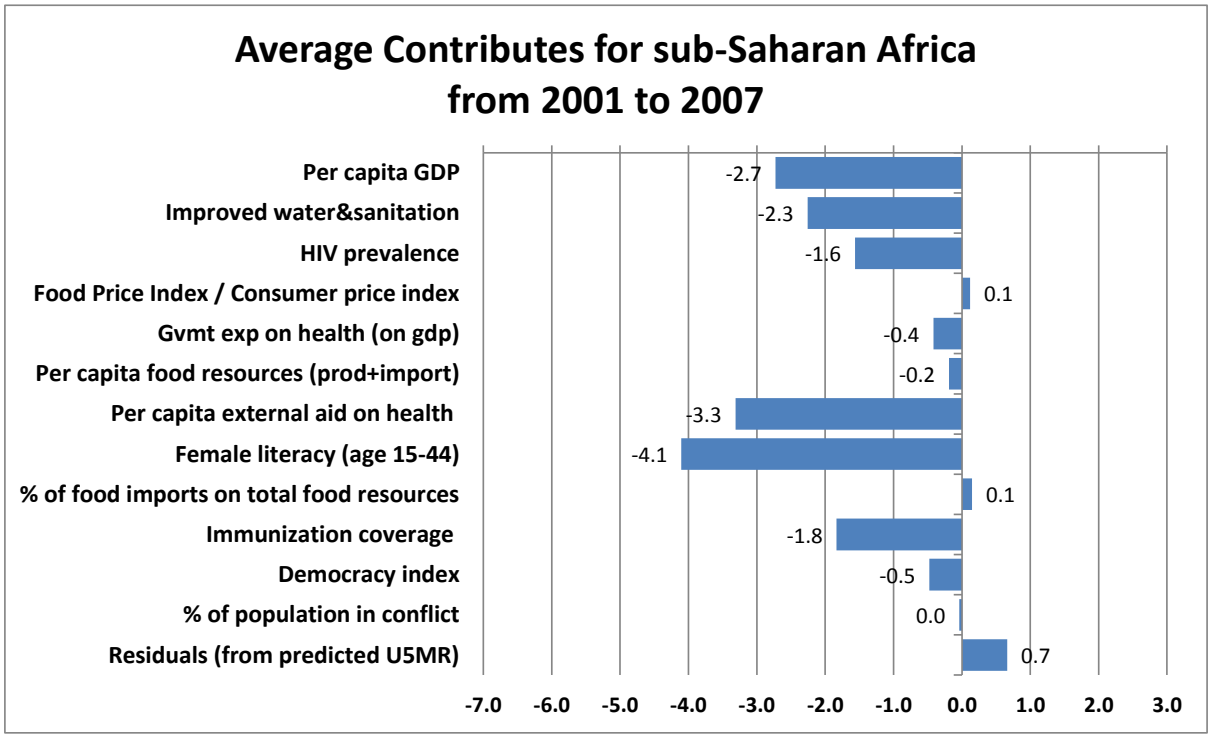
external aid to the health sector (which rose from 1.3 to 4.2 international dollars in constant prices between 1995 and 2001), the increase of female literacy, the expanded coverage of water and sanitation, the rise in HIV prevalence, the improvement in democracy and a moderate increase in government health spending. Because of its poor performance during this period, growth in GDP per capita contributed little to the reduction of U5MR, and the same can be said for vaccination coverage which stagnated or declined.

During the period 2001-7, the ranking of the U5MR drivers changed considerably (Figure 1, lower panel). While gains in aid per capita to health and female literacy (although inverted in comparison with the previous period) remained the most important determinant of U5MR, the GDP growth recovery (followed by improved sources of water and sanitation) and an upswing in vaccination rates too, had a perceptible effect in driving down U5MR. Finally, the decline in HIV prevalence had a large effect on the decline of child mortality in low and middle income African countries, and was no longer a source of its rise in the high income ones.

Figures by sub-regions (not shown here for reasons of space) also show some important variations in terms of the factors that influenced the mortality decline across high, medium and low income African countries analyzed. The first difference concerns - as noted - the importance of HIV in the comparatively high income African countries. The second concerns the negative impact on U5MR of the decline in food availability from 0.350 to 0.328 tons per capita over 2001-7 recorded in low income countries. This decline caused an increase of 2 per thousand live births in U5MR and a further increase in the food dependency. The third difference concerns the relative importance of democracy, which turns out to be higher in the middle income countries of the region.

Figure 1: Contribution of each explanatory variable to the decrease of U5MR per 1000 during the period 1995-2001 (top panel) and 2001-2007 (lower panel)



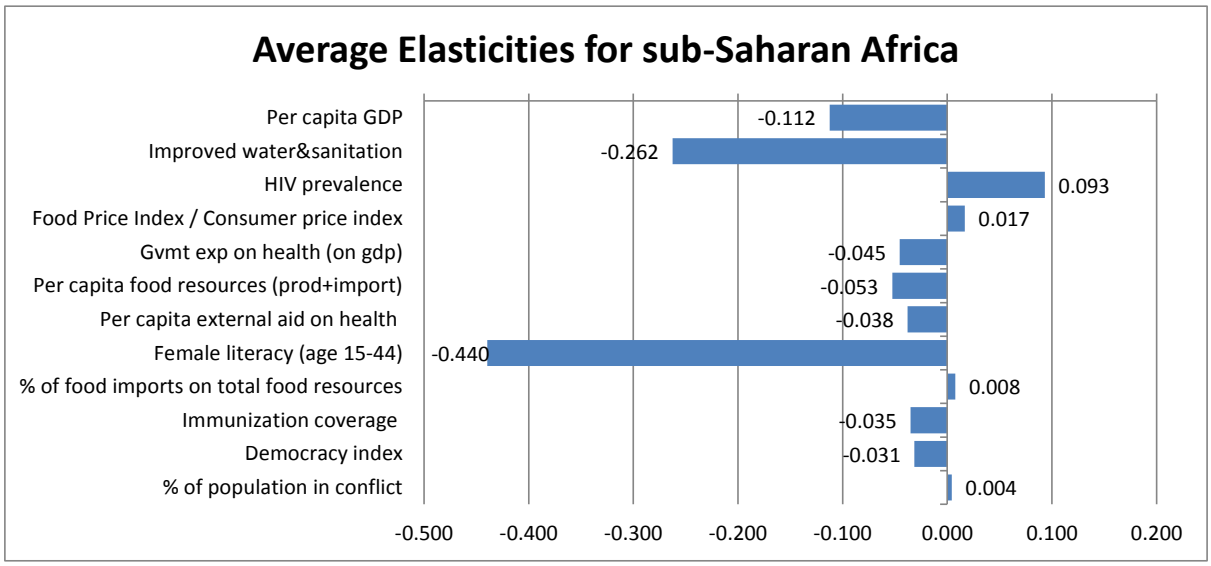


Source: authors' elaboration.
Note: changes in average contributions are expressed in absolute terms (per 1,000 live births) and each determinant's contributionn is estimated by the use of $\beta_i \Delta X_i$ as discussed in (2).

Figure 1 (top panel) provides information about the variables which played a role in reducing U5MR between 1995 and 2007. As noted, the importance of a variable depends on its regression parameter multiplied for the extent of each variable change over the periods of observation. However, Figure 1 does not tell us what the 'elasticities' of U5MR are in relation to its determinants, i.e. the per cent change in U5MR in relation to a one per cent change in each of its determinants. This is precisely the information that the policy makers need *ex-ante* for orienting future interventions. This information is presented as a graph in Figure 2. It broadly confirms the findings of the literature but with a few particular twists. First of all, it appears that female literacy (elasticity(e) = -0.44) dominates by far that of all other variables. For instance, in a country with a U5MR of 200 per 1000 live births and a female literacy rate of 40 per cent, an increase in the latter by 30 per cent (bringing it to 52 per cent, a feasible policy target) would reduce U5MR to 174 (200 – 200*0.3*0.44). Likewise, doubling female literacy (from 40 to 80 per cent – an ambitious target to be achieved over, say, a decade) would reduce U5MR to 112 per thousand live births (200 – 200*1*0.44). However, while increasing female literacy brings about large reductions in child mortality, efforts to raise primary and secondary female school enrolments and broaden the coverage of adult literacy campaigns take a considerable amount of time. The other most efficient (although in the medium term) interventions in lowering child mortality are raising the coverage of improved water and sanitation supply (e = -0.26), reducing the prevalence of HIV (e = 0.9) and expanding immunization coverage (e = -0.04) which can generally be expanded over a shorter period of time. As we will see in the simulation exercise, per capita GDP (e = -0.11) has a significant impact on child mortality but – in a SSA context of a little monetized rural sector characterized by high levels of food self-consumption – changes in the latter should be considered together with variations in per capita food availability (e = -0.05).

Figure 2 also shows that public health expenditure and health aid contribute to reducing U5MR though with lower elasticities (respectively -0.05 and -0.035) than those of specific health interventions such as improved water and sanitation supply which are both more cost-effective and better targeted on poor families whose children face a higher risk of child mortality. In fact, Figure 2 lends concrete support to the policy of restructuring public expenditure and foreign aid to health in favour of primary health care (PHC) interventions that would have a large impact on child mortality. Despite its low elasticity (0.017), the upsurge of food prices relative to the overall CPI increases child mortality; in turn, it is important to stress that improvements in democracy are desirable not only for their own intrinsic value but also in terms of their moderate but important effect on child mortality. Finally, conflicts and dependence on food imports appear to have negative but limited effects on U5MR.

Figure 2: Elasticity of explanatory variables on U5MR measured at their 2004-07 mean values



Source: authors' elaboration.

3. SIMULATING THE IMPACT OF THE FOOD AND FINANCIAL CRISES ON U5MR

(i) Approach to the simulation

We use the econometric model in Table 2 to assess the extent to which the crisis of 2008-09 affected U5MR in SSA.[17] To do so, we estimate the value of U5MR for these two years under the 'crisis scenario' by assigning to the determinants of U5MR their observed values for these two years. This is particularly important for the 'fast changing determinants' of U5MR (i.e. GDP per capita, food prices, public expenditure on health, per capita food production, international aid to the health sector, food imports, immunization coverage and HIV prevalence) but less so for the 'slow moving determinants' of U5MR (female literacy, democracy, conflicts, and coverage of improved water and sanitation infrastructure) which evolve slowly, if at all, over the short term. We then compare the number of under-5 deaths simulated under this scenario with those predicted under the 'no-crisis counterfactual scenario' in which the determinants of child mortality are given the values they would have taken if the favourable trends observed over 2004-2007 had continued also in 2008 and 2009. From the difference we obtain the impact of the 2008-09 crisis on the number of child deaths. The hypotheses followed to determine the changes in the explanatory variables in the two simulation scenarios are summarized in Table 3, while their numerical values are shown in Annex1 Table 3 and are discussed hereafter.

[17] Zimbabwe and Somalia were excluded from the simulations: the first because of the unique and profound nature of the 2006-9 socio-political-economic crisis, the second because of lack of data.

(ii) 'Crisis scenario'

The following assumptions were made on the basis of observed data produced by a few international organizations. We discuss first the changes observed for the fast changing determinants of U5MR. Despite SSA's low international integration,[18] its growth rate of GDP per capita fell from 4.6 per cent over 2004/7 to 3.2 per cent in 2008, and -0.1 per cent in 2009 to return to 2.6 per cent in 2010 (IMF 2010). The decline in GDP per capita was more pronounced among the middle income than the low income countries of the region (*ibid*). The IMF attributes the region's relative resilience to the sound economic policies (low inflation, sustainable fiscal balances, rising foreign exchange reserves, and declining public debt) implemented during the last decade, which allowed the adoption of expansionary policies to offset the effects of declines in world trade, commodity prices, and capital flows. Such real GDP growth data incorporate the effects of higher food prices (which increase the GDP deflator and therefore reduce the real GDP) as well as of the decline in GDP due to the recession.

Under the 2008-09 crisis scenario food prices grew faster than the consumer price index and this contributed to an additional decline in households' food purchasing power. Over the period 2004-07 the food price and consumer price indexes grew annually by 6.5 and 7.7 per cent respectively, while in 2008-2009 their annual growth was by 7.7 and 4.9 per cent respectively. This faster increase in food prices in relation to the Consumer Price Index can be highly detrimental to child health as, during crises, households devote a larger share of their consumption budget to food (see Bibi et al., 2009) and - as a consequence - are more affected by an upsurge in food prices. The health of children – especially those belonging to households in the poorest income deciles – is also likely to be more affected by changes in the prices of food items than of non-food items.

In turn, food availability (production plus imports) rose in three quarters of the countries of the region in 2008 and in half of them in 2009. Public expenditure on health as percentage of GDP was assumed to evolve in line with total government expenditure on GDP, which continued growing in the majority of the SSA countries as a result of the new global emphasis on protecting the social expenditure and on fiscal stimulus in 2009 (see Annex1 Table 3).

[18] SSA is on average less integrated than other developing regions. Its increasing trade integration with China and East Asia somewhat shelters it. Because of this, the region was slightly less affected by the crisis. However, SSA is far more dependent on international aid which was affected by the crisis in the OECD countries (see later).

Table 3. Hypotheses (and related data sources) made about the 'crisis scenario' and counterfactual 'non crisis scenario' to simulate the potential effects of the food price rise and financial crisis of 2008 and 2009

Explanatory variables	**Changes in the 'crisis scenario'**	**Changes in the counterfactual scenario (i.e. no crisis)**
Per capita real GDP (ln)	IMF estimates for per capita GDP (real) in international dollars	Average 2004-2007 growth rate for IMF estimates for per capita GDP (real) in international dollars
Food Price Index/Consumer Price Index (ln)	Constructed based on food price index and consumer price index collected by the National Statistical Offices (and surveyed by ILO LaborSta)	Average 2004-2007 growth rate constructed based on food price index and consumer price index collected by the National Statistical Offices (and surveyed by ILO LaborSta)
Per capita major food availability (domestic production + imports)	Constructed based on GIEWS (FAO) dataset for cereals	Average 2004-2007 growth rate constructed based on GIEWS (FAO) dataset for cereals
Ratio of food imports on food availability	Constructed based on GIEWS (FAO) dataset for cereals	Average 2004-2007 growth rate constructed based on GIEWS (FAO) dataset for cereals
Government expenditure on health (% of GDP)	IMF estimates for General Government Total Expenditure on GDP	Average 2004-07 growth rate of IMF estimates for General Govt. Total Expenditure on GDP
Per capita external aid on health (ln)	Constructed based on OECD Development Assistance Committee dataset	Average 2004-2007 growth rate constructed based on OECD Development Assistance Committee dataset
Immunization coverage	UNICEF-WHO estimates	Average 2004-2007 growth rate (ceiling at 100 - full coverage)
Improved water & sanitation	Average 2004-2007 growth rate	Average 2004-2007 growth rate
HIV prevalence	UNAIDS estimates for 2008 and 2009	Average 2004-2007 growth rate
Private exp on health (as % of GDP)	Average 2004-2007 growth rate	Average 2004-2007 growth rate
Female literacy (age 15-44)	Average 2004-2007 growth rate	Average 2004-2007 growth rate
Democracy index	As in 2007	As in 2007
Conflict dummy variable	As in 2007	As in 2007

Source: authors' compilation.

In this regard, a recent UNICEF study which reviewed 126 IMF country programmes (Ortiz et al. 2010) confirms that out of 45 SSA countries, 30 increased the total public expenditure/GDP over 2008-09, while in 38 out of 44 real total public expenditure increased during the same period.[19] In turn, foreign aid to the health sector was assumed to evolve as suggested by the OECD Development Assistance Committee dataset, i.e. it declined in 11 out of 42 SSA countries in 2008 and by as many as 25 in 2009 (see Annex1 Table 3). In turn, DPT3 immunization coverage declined or stagnated in half of the SSA countries in both 2008 and 2009 as suggested by the UNICEF-WHO estimates. Finally, HIV prevalence was assumed to have changed as suggested by the UNAIDS estimates of December 2010, i.e. with no change in relation to 2004-7 in about half of the countries, and with a greater number of declines than increases in incidence rates for the remaining countries (Annex1 Table 3). As for the slow changing determinants of U5MR, we assumed that access to drinking water supply, and female literacy evolved according to the trend observed over 2004-07. Also the

[19] The same study suggests that total public expenditure/GDP will increase in 2010-11 in 25 out of 45 SSA countries. In turn, total public expenditure in real terms is expected to rise in 36 out of 45 countries.

number of conflicts and the level of democracy were assumed to remain at the same level of 2007.

(iii) Counterfactual 'no crisis scenario'

In the counterfactual scenario it is assumed that the determinants of U5MR continued developing according the trend observed during the period 2004-07 (see Table 3, last column, for the detailed hypotheses followed under this scenario). In particular, concerning the fast changing determinants of U5MR, it was assumed that the real GDP per capita as well as food and consumer prices were assumed to grow at the average annual rate observed over 2004-07. Likewise, food production (and availability) as well as the share of food imports on total food availability continued to evolve at the same rate observed over 2004-07. At the same time, also government health expenditure as a share of GDP, per capita foreign aid to health, immunization coverage (with a ceiling of 100 per cent) and HIV prevalence were projected to evolve at the rate observed during 2004-07. As for the slow changing determinants of U5MR, we assumed – as in the other scenario – that access to drinking water supply and female literacy evolved according to the trend observed over 2004-07, while the number of conflicts and level of democracy were assumed to remain at the same as in 2007.

(iv) Simulation results: how large was the crisis impact on U5MR?

The results of the simulation are summarized in Table 4 which provides, country by country,[20] the changes in the level of U5MR over 2008-09 in relation to the counterfactual scenario (column 1) and the number of additional child deaths in relation to the counterfactual scenario for 2008, 2009, and 2008 plus 2009 (columns 2 to 4). Table 4 provides also data on the increase or decline in the number of child deaths (always in relation to the counterfactual scenario) due to each of the fast changing determinants of child mortality (columns 5 to 12). This information is provided separately for countries and regions which experienced an overall increase in child deaths in relation to the counterfactual scenario and for those which experienced a decline.

Table 4 shows that – contrary to most expectations – over 2008-09 there was a slight decrease in the absolute number of under-5 deaths in comparison with the counterfactual scenario. This unexpected overall outcome results from two mutually offsetting effects, i.e. the negative impact of the food-financial crisis, and the positive impact of improvements recorded in 2008-9 in several determinants of child mortality in relation to the counterfactual scenario.

Indeed, if we disaggregate these overall decreases in child mortality by U5MR determinant, we find that the decline (in comparison with the counterfactual) in GDP per capita growth recorded in 2008 and, to a larger extent, in 2009 did cause an increase of 20 thousand child deaths for SSA as a whole, while the upsurge of food prices compared to total consumer prices generated an additional 7 thousand child deaths in relation to the counterfactual situation (Table 4). The joint impact of the food price shock and international recession (around 27 thousand additional child deaths) represents, however, only 0.6 per cent of the 4.2 million annual child deaths in SSA, and can therefore be considered well within the margin of

[20] Zimbabwe was excluded as it experienced hyperinflation in 2008 and a 19 per cent drop of GDP (IMF 2010),

error of the estimated model. As shown by Table 4, the impact of the food and financial crises varies considerably across the region. Indeed, the increase in child deaths due to the 2009 recession affected the African countries in very different ways, because – as noted – not all of them experienced a sizeable slowdown of GDP per capita growth in 2009, while in 2008 only seven countries experienced a negative GDP growth.[21]

However, our simulation shows that the food price and financial shocks were not the only factors affecting child mortality in 2008 and 2009. Indeed, the SSA countries witnessed also changes in other fast changing determinants of child mortality. In both groups of countries (panels A and B of Table 5), a slow down or stagnation in immunization rates (whether related to the crisis or to other factors) in relation to the counterfactual appears to have caused some increase in child deaths. In the second group of countries, i.e. those which recorded an overall increase in child deaths (panel B Table 5), child mortality was affected also by a slower than expected decline in HIV prevalence (possibly due to a slower than expected increase in the coverage of anti-retroviral drugs due to the crisis), a decline in external aid to health, and an increase in food imports. However, in both groups of countries an increase in food production and the preservation of public health expenditure counterbalanced the increase in child mortality due to the food price crisis and financial recession, the stagnation in immunization and other factors. In addition, in the first subgroup (panel A Table 5), rising international aid to health, a decline in food imports and a faster than expected decline in HIV prevalence more than offset the increase in child mortality due to the price and recession shocks of 2008-09.

All in all, Tables 4 and 5 indicate that – as a result of all these effects – the years 2008 and 2009 witnessed a decrease of around 15,000 under-5 deaths in relation to the no-crisis counterfactual scenario (with confidence intervals ranging between -90 and +60 thousand – see Annex1, Table 4), but without the food and financial crises an additional 27,000 children would have been saved from death. In addition, of the 42 countries analyzed only two recorded an increase or no change in the U5MR in relation to the year 2007 (Eritrea and Madagascar).

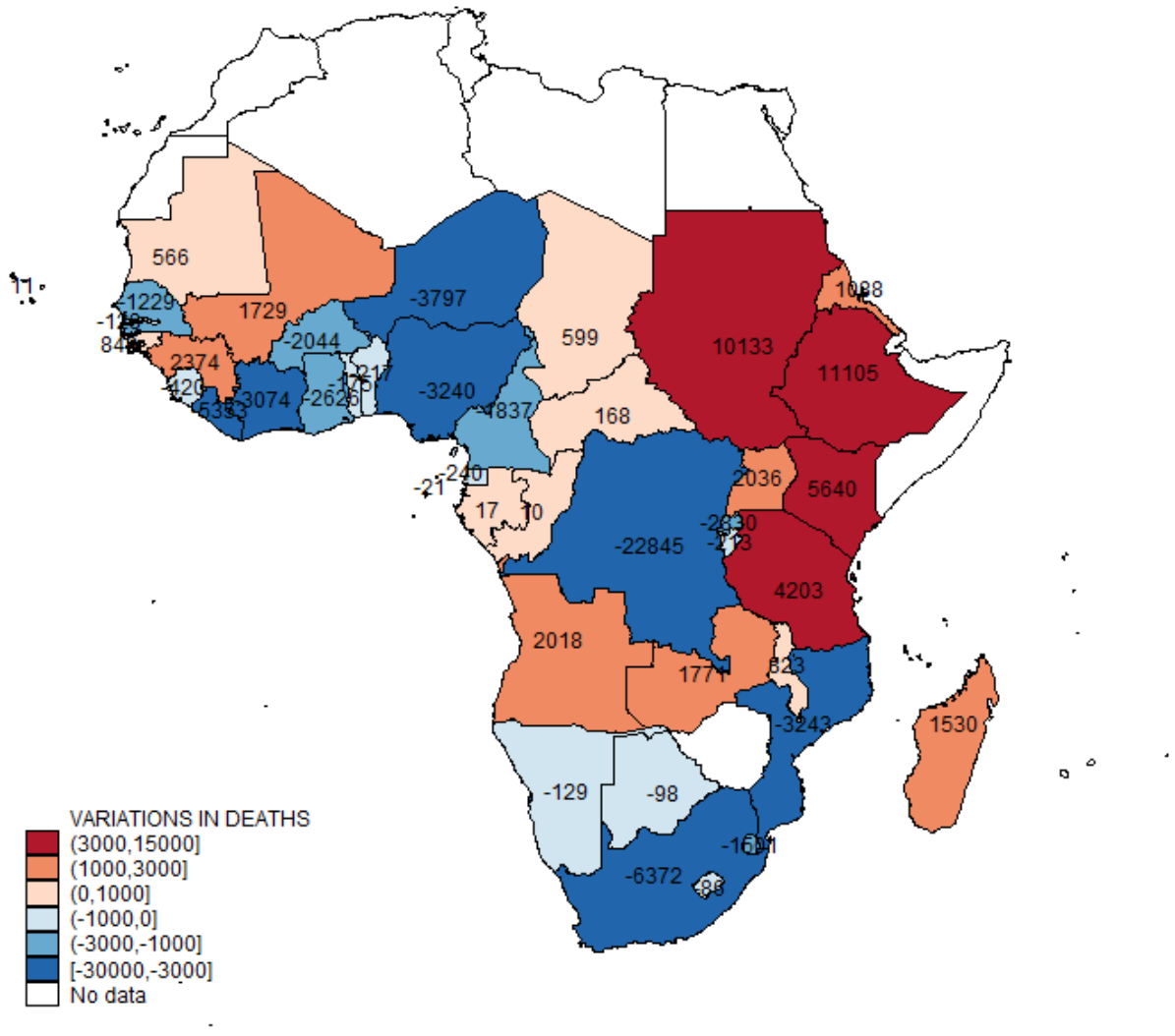
In conclusion, the findings of our simulation exercise suggest that in SSA the impact of the food and financial crises was far less pronounced than anticipated by most analysts. Indeed, our simulation results suggest that in 2008-09 the number of children who died before reaching 5 years was slightly lower than that we would have had under a no-crisis scenario. This result is explained by favourable trends observed in 2008 and 2009 in some determinants of U5MR which are usually ignored in most analyses. Indeed, while food prices rose in most SSA countries in 2008 and remained broadly at that level in 2009, the recession induced by the financial crisis had only a limited depth and duration (particularly among the low income SSA countries), public health expenditure was protected in most countries, aid flows to health were maintained or increased in half of the SSA countries, and food production and availability rose in many countries of the region.

[21] In 2009 only 16 countries out of 44 recorded a negative growth in GDP/c, and of these six saw their GDP drop by less than one per cent (IMF 2010).

The limited impact of the 2008-09 crisis on child mortality is due also in part to the unavoidable limitation of our model. Firstly, the parameters of the econometric model presented in Table 2 were estimated over 1995-2007, i.e. a period during which there were no major economic downturns and food price crisis. Such parameters may therefore not fully capture the impact of the 2008-09 crises, while it is likely that the U5MR elasticities of the observed changes in GDP per capita and food prices increased during the crisis. An 'event approach' to the estimation of the crisis (which was not feasible due to data problems) would have generated substantially higher elasticities and a higher number of child deaths during 2008 and 2009. In this sense, our estimates of the additional child deaths due to the 2008-09 crises should be considered a 'lower bound' of a range of estimates obtained with alternative econometric approaches. In addition, as noted in subsection 2.3, while the IGME U5MR data are the best available, they are nevertheless unable to fully capture the short term impact of crises. Yet, even assuming that the GDP per capita and food price elasticity of U5MR were three times greater than those estimated by our model, the impact of the 2008-09 food and financial crises on child mortality would have remained very modest, i.e. they would have generated an additional 81,000 (27,000*3) child deaths in relation to the counterfactual scenario. This would have increased to 39,000 (81,000 minus 42,000) the number of child deaths due to changes in all variables. Thirdly, our econometric model used for the simulation of the impact of the crisis does not take into account – because of lack of data – the changes in income inequality and other variables, i.e. phenomena which vary markedly during the business cycle, and which may have aggravated the impact on child mortality.

Our analysis shows also (Figure 3) that the impact of the food and financial crisis of 2008-09 varied considerably across countries. The countries reporting an absolute increase in child deaths in comparison with the counterfactual scenario (Tables 4 and 5, panel B) mainly belong to the Sudano-Sahelian region, the Horn of Africa, as well as non-Coastal Central Africa and Eastern Africa. In these 19 countries, the years 2008-09 witnessed a surge of 47,000 child deaths in relation to the counterfactual scenario. In a second group of 23 countries – mainly from Coastal West Africa and Southern Africa – in 2008-09 there were 62 thousand fewer child deaths in comparison with the counterfactual scenario (panel A Tables 4 and 5). A comparison of Panel A and B of Table 5 shows that this differential child mortality behaviour of these two subregional groups is due to the different intensity of the 2008-09 crisis they experienced as well as to the differential impact of other determinants of child mortality (food production, food imports, public expenditure on health, foreign aid to health, HIV, immunization rates and so on) that can affect, both positively and negatively, child mortality even under economic upheavals. While the relation between the crisis and these variables is a complex one, ignoring their impact on child mortality leads to a distorted picture of the health impact of the crises.

Figure 3: Map of Africa representing the variations (negative or positive) in child deaths due to the 2F crises in relation to the no-crisis counterfactual scenario.



Source: authors' elaboration

Table 4. Changes in U5MR, number of child deaths, contribution of main U5MR determinants for 2008 and 2009 combined (all in relation to the counterfactual scenario).

	Δ U5MR 2008-9	ΔU5 deaths 2008	ΔU5 deaths 2009	**ΔU5 deaths 2008+9**	GDP/c	Food price index/ CPI	Gov health outlays (% gdp)	Total food resource	External aid to health	Food import on domestic food prod	Immuniz rate	HIV prevalence	Resid
A. Countries (23) which experienced a decline in the number of child deaths in relation to the counterfactual scenario													
Swaziland	-21.6	-109	-1392	-1501	15	4	-138	-28	-1192	-145	-68	-23	74
Liberia	-18.3	-2582	-2771	-5353	51	13	-1455	364	-4423	-94	126	-15	80
Equ Guinea	-4.8	-103	-137	-240	133	9	-172	-3	-15	1	-129	-62	-2
D.R. Congo	-3.9	-12901	-9945	-22845	1277	412	-4878	-472	-24334	-212	5419	0	-58
Rwanda	-3.5	-1498	-1333	-2830	-267	1	-621	-1153	-1277	-118	261	328	15
South Africa	-3.0	-2734	-3637	-6372	617	96	-1559	-1859	-872	-2102	-351	-436	94
Niger	-2.4	-4886	1089	-3797	-1142	873	1134	-2674	-1047	-163	-1150	341	31
Côte d'Ivoire	-2.1	-808	-2266	-3074	-394	210	-41	-1462	-2084	-101	1047	-253	3
SaoTome&Princ	-2.1	-6	-16	-21	3	1	-8	3	-19	0	-1	0	0
Mozambique	-1.8	-1012	-2231	-3243	527	202	-805	-1214	-108	358	-905	-1305	7
Ghana	-1.7	-1809	-817	-2626	-48	-27	397	-3021	-311	-71	535	-68	-11
Burkina Faso	-1.4	-708	-1337	-2044	183	398	2710	-1735	-3617	-134	99	93	-42
Senegal	-1.3	-1326	97	-1229	335	27	678	-1171	252	-2082	740	17	-23
Cameroon	-1.3	-1074	-762	-1837	23	166	-699	-17	-1362	-11	285	-223	0
Namibia	-1.1	99	-228	-129	58	8	-78	-18	-83	15	-9	-22	1
Botswana	-1.0	-89	-9	-98	54	11	-236	-41	144	-14	-25	15	-6
Gambia	-1.0	-14	-114	-128	9	1	-63	-119	193	-121	-13	-14	-2
Sierra Leone	-0.9	-235	-186	-420	157	28	-798	149	650	-165	-229	-207	-5
Lesotho	-0.7	-88	2	-86	24	6	-191	3	-86	-26	112	74	-2
Togo	-0.4	-212	38	-175	32	79	192	-324	-245	-30	149	-24	-4
Burundi	-0.4	-524	310	-213	-80	1	-319	-35	-210	-4	310	124	0
Benin	-0.3	98	-314	-217	-159	177	217	-397	-262	-49	203	55	-1
Nigeria	-0.3	12251	-15492	-3240	6273	1787	-3487	-25920	-6444	-355	23934	1247	-276
***B**. Countries (19) which experienced an increase in the number of child deaths in relation to the counterfactual scenario*													
Rep. of Congo	0.0	-116	126	10	-126	-4	169	33	-90	-1	18	12	-1
Gabon	0.2	44	-27	17	17	8	-40	-6	-21	1	61	-2	-1
Cape Verde	0.4	-2	13	11	3	0	-2	-2	17	-5	0	0	0
C. African Rep	0.5	-5	173	168	39	19	-183	59	-444	8	619	57	-7
Chad	0.6	1026	-426	599	2925	92	-2919	649	-1462	369	1428	-428	-54
Uganda	0.7	2089	-52	2036	719	639	-601	789	-121	-404	-771	1796	-10
Malawi	0.7	322	501	823	-642	-41	1331	1258	-1415	-9	-291	654	-22
Madagascar	1.1	-67	1597	1530	45	82	359	-779	1320	-203	705	0	2
Tanzania	1.2	-56	4258	4203	787	120	-1934	-873	3996	952	831	318	5
Angola	1.3	86	1932	2018	3189	122	-2349	-1333	-353	-58	2395	452	-45
Mali	1.6	729	1000	1729	-79	122	925	471	-79	143	242	-18	2
Zambia	1.6	787	984	1771	342	141	-446	-1119	2294	202	377	-9	-12
Ethiopia	1.8	6520	4585	11105	2098	733	956	-726	7464	-620	672	502	25
Kenya	1.8	1849	3791	5640	1892	141	-337	-758	522	2449	356	1339	36
Mauritania	2.6	146	420	566	140	0	48	34	266	21	50	0	5
Eritrea	2.9	441	647	1088	-111	17	-74	138	200	943	-8	-20	3
Guinea	3.0	864	1511	2374	-67	-85	-645	599	1505	75	948	39	4
Sudan	3.9	1855	8279	10133	1027	146	2366	546	3742	1098	564	462	182
Guinea-Bissau	6.5	409	440	849	-40	20	54	-25	678	-30	221	-33	3
SSA	**-0.2**	**-3349**	**-11702**	**-15051**	**19836**	**6754**	**-13538**	**-42190**	**-28732**	**-692**	**38758**	**4765**	**-11**

Source: authors' calculations on the basis of the model in Table 2 and of the hypotheses on the 'no crisis counterfactual scenario' and the 'crisis scenario' presented in Table 4. Note: Countries are ordered by the decreasing to increasing number of "ΔU5MR in 2008 and 2009".

Table 5. Disaggregation of the impact on child deaths due to changes in determinants of U5MR

Year		**Total**	GDP/c	Food Price Index/ CPI	Gov health outlays (% GDP)	Total food resources	External aid to health/c	food import (% total food resources)	Immuniz rate	HIV prevalence	Resid
A. Countries with a decline in the number of child deaths (2008+2009)											
2008	abs change in child deaths	**-20270**	64	1691	-2505	-21295	-11949	-2453	16655	-421	-55
2009		**-41451**	7615	2791	-7713	-19850	-34802	-3170	13685	65	-72
08-09		**-61720**	7679	4482	-10218	-41145	-46751	-5623	30340	-357	-127
B. Countries with an increase in the number of child deaths (2008+2009)											
2008	abs change in child deaths	**16920**	2057	1097	-1475	524	6832	2877	3160	1879	-29
2009		**29749**	10100	1175	-1846	-1568	11187	2055	5258	3243	145
08-09		**46669**	12157	2272	-3320	-1045	18019	4931	8418	5122	116
C. Sub-Saharan Africa											
2008	abs change in child deaths	**-3349**	2120	2787	-3980	-20772	-5117	424	19814	1458	-84
2009		**-11702**	17715	3966	-9558	-21419	-23615	-1116	18944	3307	73
08-09		**-15051**	19836	6754	-13538	-42190	-28732	-692	38758	4765	-11

Source: authors' compilation.

4. VALUES THE U5MR DETERMINANTS SHOULD TAKE TO HIT THE MDG4 TARGET BY 2015

In this section we explore the policy conditions which - despite the impact of the current crisis - would promote achievement of the best possible result for MDG4 (U5MR) by 2015. As is well known, the objective was to reduce by two thirds U5MR between 1990 and 2015. However, even before the onset of the crisis the vast majority of the SSA countries had accumulated a substantial delay in moving towards this target.

To determine the values the policy and non-policy variables should take to reach (or to get as close as possible to) MDG4 by 2015, we utilize the econometric model in Table 2, focusing on changes in all variables both fast- and slow-changing. To start with, to avoid unrealistic results, we assumed that the number of conflicts and the democracy index cannot change their 2009 observed values (Annex1 Table 6). For the remaining ten instruments X_i we assumed a standard procedure (with the exceptions described in Annex1 Table 5) which consisted of setting a 'plausible standard range of variation' for each of them in which the lower-bound is $(\overline{X}_i - \alpha \cdot \sigma_i / 2)$ and the upper-bound $(\overline{X}_i + \alpha \cdot \sigma_i / 2)$, where $\bar{X}_i$ is the country's mean *i* yearly growth between 2004 and 2007 of X_i and σ_i is the country's mean *i* standard deviation of X_i's yearly growth between 2004 and 2007 (*ibid*). α takes value 0.842 which corresponds to a confidence interval at 60%. This procedure was followed for the growth rate of GDP per capita, food availability, share of food imports on total availability, female literacy and access to an improved water source (the last two with some adjustments

for the upper bound). The determination of a 'plausible range of variation' for government expenditure on health followed an *ad hoc* procedure where the country's hypothesized yearly changes need to meet the Abuja target by 2015 (see note Annex1 Table5). Finally, we assumed that food prices will grow at the same pace as consumer prices.

Given the upper and lower bounds imposed on the values that the explanatory variables can take (as summarized in Annex1 Table 5), we solved a minimization problem in which the objective is to reach the U5MR target set by MDG4 by 2015, or to get as close as possible to it. To solve this minimization problem we used the Non Linear Generalized Reduced Gradient algorithm (Lasdon and Waren, 1978; Dantzig and Thapa, 2003). Specifically, the minimization procedure illustrated below calculates the annual change the determinants of U5MR need to take in order to get as close as possible to the 2015 U5MR target, subject to the constraints discussed above and given the econometric model presented in Table 2 which links the nine flexible instruments to U5MR. The minimization procedure takes the following form:

(3)

$$\begin{cases} \min Y = \sum_{i=1}^{k}\left(\dot{X}_{i,c}\right)^2 = \sum_{i=1}^{k}\left(\frac{X_{i,c,t} - X_{i,c,t-1}}{X_{i,c,t-1}}\right)^2 \\ s.t. \\ \dot{U5MR}_{c,t} \le \dot{U5MR}_{c,MDG} \quad \text{and} \quad \dot{LBX}_{i,c} \le \dot{X}_{i,c} \le \dot{UBX}_{i,c} \end{cases}$$

$$s.t. \frac{U5MR_{i,c,t+1}}{U5MR_{i,c,t}} - 1 \le \dot{U5MR}_{\iota,c,MDG}$$

Where $X_{i,c,t}$ $X_{i,c,t}$ is the value taken by each flexible determinant of U5MR X_i in country c at time t; $\dot{LBX}_{\iota,c}$ $\dot{LBX}_{i,c}$ and $\dot{UBX}_{i,c}$ $\dot{UBX}_{\iota,c}$ are the lower and upper bounds imposed on every X_i 's annual growth rate respectively; $\frac{U5MR_{i,c,t+1}}{U5MR_{i,c,t}} - 1 \dot{U5MR}_{c,t}$ is the growth rate in U5MR in country i between time t-1and t while $\frac{U5MR_{i,c,t+1}}{U5MR_{i,c,t}} - 1 \dot{U5MR}_{c,MDG}$ is the U5MR annual growth rate necessary to reach MGD4 by 2015 starting from 2009. The minimization was run under two separate scenarios: the first does not take into account the impact of the 2008-09 crisis, and the starting value of U5MR is its simulated value under the no-crisis scenario in which the explanatory variables took their projected value in 2009; the second scenario takes into account the impact of the crisis and by setting the starting value of U5MR in 2009 at the value simulated under the crisis scenario, where the U5MR determinants took their observed values.

The outcomes of the minimization exercise are thus prevalently determined by the recent past performance of each country and other plausible hypotheses. The yearly changes in U5MR and in its determinants as predicted by this exercise are average yearly changes over the period 2009-2015 (Table 6).

Table 6. Best potential U5MR attainment predicted for 2015 compared to MDG4 target and annual changes (in %) in U5MR determinants needed to reach the best potential attainment

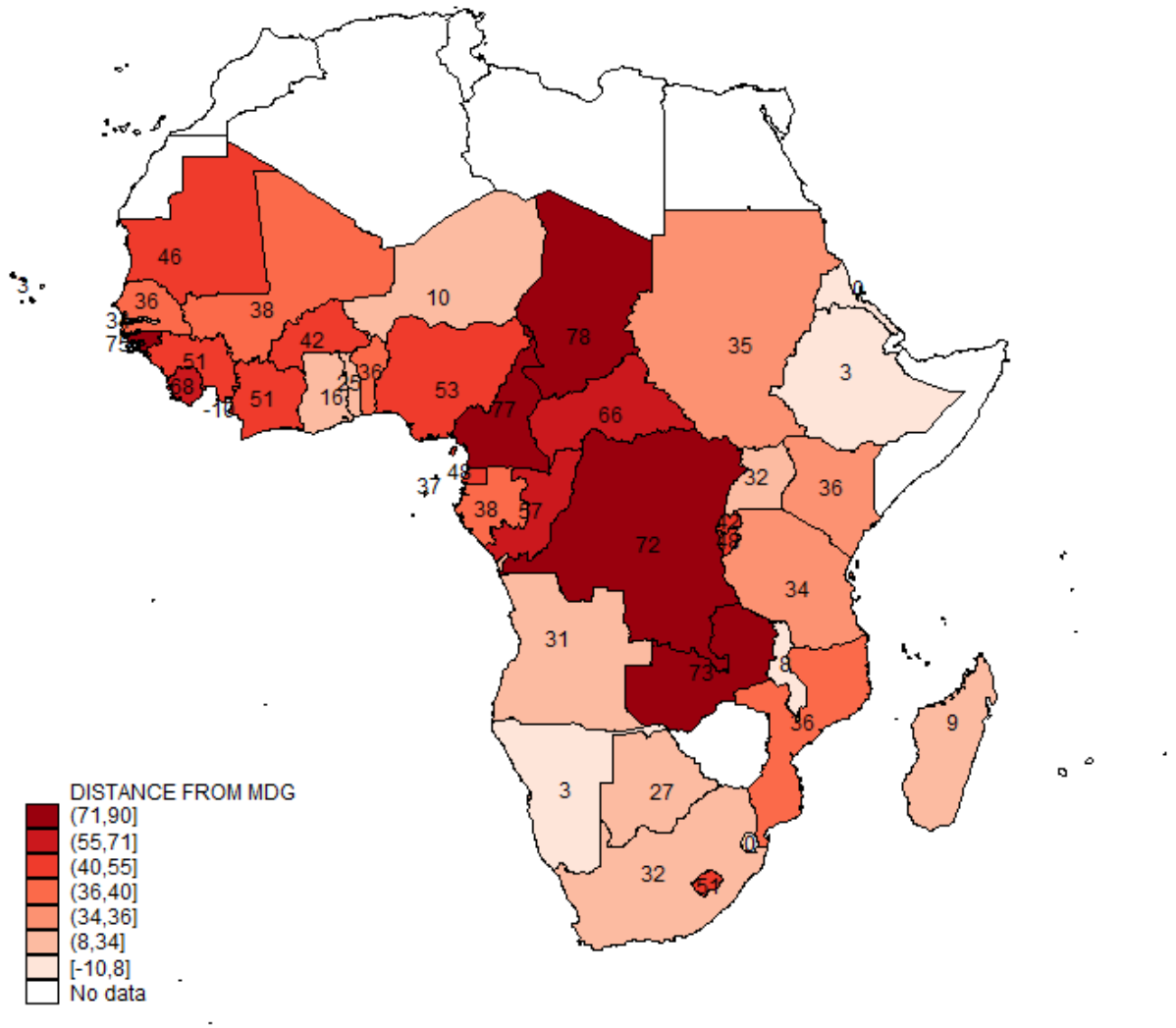
Country	**U5MR-MDG4 gap (no crisis) per 1,000**	**U5MR-MDG4 gap (crisis) per 1,000**	GDP /c	Improved water & sanitation	HIV prevalence	Gvmt exp on health (% gdp)	Food resources/c (prod+imp)	External aid on health/c	Female literacy (age 15-44)	Food imports (% total food resource)	Immuniz coverage
			Annual percentage changes (2009-2015) under the crisis scenario								
Angola	**32.1**	**31.3**	5.8	3.5	0.0	18.9	8.7	11.2	0.5	-14.6	4.9
Burundi	**46.5**	**47.7**	3.3	0.1	-5.8	3.1	0.0	31.5	0.8	-12.4	0.9
Benin	**37.5**	**36.4**	1.2	1.9	-3.6	5.9	0.0	4.4	4.1	0.0	0.6
Burkina Faso	**45.1**	**42.4**	2.9	3.1	-6.7	2.1	1.0	9.6	9.6	-24.7	0.2
Botswana	**25.2**	**26.7**	4.2	1.0	-1.1	2.4	12.4	13.4	0.1	-34.9	0.9
C. African Rep	**66.4**	**66.4**	2.2	2.3	-8.8	5.4	1.1	1.8	2.5	-6.4	2.7
Côte d'Ivoire	**55.0**	**51.5**	1.2	0.4	-8.4	21.1	2.3	1.8	1.9	-5.6	5.1
Cameroon	**78.4**	**76.9**	0.6	1.1	-0.8	10.7	4.0	0.2	0.8	-10.6	4.5
Rep.of Congo	**55.3**	**57.0**	7.5	0.1	-2.0	19.6	0.3	20.3	3.2	-14.4	3.1
Cape Verde	**1.6**	**2.9**	5.6	1.0	0.0	6.1	0.0	14.8	0.4	-3.2	5.4
Eritrea	**0.0**	**0.0**	0.0	1.9	-6.8	10.3	7.4	0.0	3.1	-19.4	3.3
Ethiopia	**1.7**	**3.5**	6.6	4.1	-2.1	6.6	4.2	25.5	2.3	-39.9	4.5
Gabon	**39.7**	**37.9**	4.4	0.1	-0.9	1.1	3.3	4.3	0.3	-5.2	6.3
Ghana	**16.5**	**15.7**	7.5	2.2	-3.7	5.8	0.0	0.0	2.3	-12.4	1.1
Guinea	**47.3**	**50.9**	1.6	1.9	-4.9	21.2	4.3	15.1	1.9	-19.6	2.5
Gambia	**34.4**	**33.6**	3.2	1.0	0.0	4.4	0.0	5.1	4.3	-7.9	1.6
Guinea-Bissau	**67.9**	**75.3**	1.9	1.3	0.0	24.5	0.8	7.8	3.7	-23.5	3.7
Equ Guinea	**54.5**	**47.5**	13.8	0.0	0.0	13.7	0.0	10.1	0.2	-2.7	4.8
Kenya	**34.3**	**35.8**	4.4	1.4	-4.4	11.5	3.5	9.3	0.6	0.0	5.0
Liberia	**0.0**	**-10.1**	4.9	0.8	-8.8	0.0	-0.8	18.5	1.5	5.2	0.0
Lesotho	**53.3**	**51.4**	3.3	1.3	-0.9	11.3	0.8	7.4	0.1	-25.5	5.9
Madagascar	**7.3**	**8.8**	0.5	1.4	0.0	0.2	7.2	0.0	0.5	-17.3	2.3
Mali	**36.5**	**37.7**	3.8	2.4	-7.5	4.1	9.6	9.4	8.6	-32.7	2.3
Mozambique	**38.6**	**36.4**	5.8	2.0	0.0	3.0	0.5	7.0	3.2	-0.3	5.8
Mauritania	**42.7**	**46.2**	4.4	2.7	0.0	19.1	11.2	0.0	3.2	-0.8	8.4
Malawi	**6.7**	**7.9**	5.4	2.3	-3.5	3.9	21.4	0.3	2.2	-48.1	1.3
Namibia	**8.9**	**3.1**	5.7	1.6	-4.1	5.2	5.8	27.2	0.0	-27.2	3.9
Niger	**8.5**	**10.5**	3.6	1.9	-8.0	3.3	8.5	33.8	2.7	-23.5	1.8
Nigeria	**57.2**	**52.9**	5.7	0.4	-1.3	15.0	4.0	0.0	1.7	-11.0	4.7
Rwanda	**45.2**	**41.7**	4.1	1.4	-4.5	0.0	0.0	8.8	0.9	0.0	0.9
Sudan	**25.9**	**34.5**	4.7	0.1	0.0	16.1	11.4	32.5	1.8	-14.2	2.3
Senegal	**36.9**	**36.4**	2.6	1.1	0.0	3.6	2.4	0.1	1.7	0.0	3.3
Sierra Leone	**67.4**	**67.6**	2.7	0.1	0.0	11.5	12.6	7.3	4.7	-34.1	1.4
SaoTome&Prin	**39.9**	**37.0**	3.9	1.9	0.0	2.1	2.8	0.0	0.0	-3.8	1.0
Swaziland	**44.0**	**0.0**	2.2	2.2	0.0	2.6	0.9	14.5	0.0	-1.4	1.0
Chad	**78.4**	**77.7**	7.6	1.7	0.0	1.4	8.9	0.0	4.8	0.0	3.6
Togo	**24.7**	**25.4**	1.5	0.9	-2.2	11.7	3.1	21.6	3.0	-38.0	3.4
Tanzania	**32.1**	**34.5**	4.8	0.0	-3.1	0.0	18.3	13.1	0.6	-23.4	2.4
Uganda	**32.7**	**32.3**	3.3	1.7	-1.8	7.3	0.0	10.1	1.6	0.0	2.2
South Africa	**35.1**	**31.6**	2.5	0.7	-0.2	5.6	3.4	25.4	0.5	-1.7	0.2
DR Congo	**78.2**	**72.2**	4.3	1.9	0.0	15.4	0.0	10.2	0.0	-14.8	2.0
Zambia	**71.1**	**72.7**	4.7	1.1	-0.7	0.6	3.1	3.6	0.4	-49.7	0.9

Source: authors' elaboration based on coefficients shown in Table 2 and on the hypotheses shown in Annex1 Table 4. Countries in Italics (Eritrea, Liberia and Swaziland – under the crisis scenario only) are the only ones who may potentially (according to their performance in 2004-2007) reach the MDG4 by 2015. For the other countries the best potential performance (according to their performance in 2004-2007) is shown. Note: the initial year of these projections is 2009 while the final year is 2015. Only determinants supposed to change are shown.

Finally, U5MR for 2015 predicted in this way are to be considered as the "best potential performance" given the performance trends of the determinants recorded over 2004-2007. In a way, this approach allows us to calculate the 'catching-up policy' needed to offset the losses of 2008-09. The results of this policy exercise are presented below.

Table 6 illustrates the gap between the MDG4 and the best value U5MR can take in 2015 taking as a base the year 2009. This gap was obtained through the minimization procedure illustrated above. This allows us to verify whether and to what extent the recent food and financial crises set back the SSA countries' progress towards MDG4. As can be seen from Table 6, it appears that the 2008-09 crises generally had a modest retarding effect in a few countries on the achievement of MDG4. Only in a few countries (Cape Verde, Ethiopia, Guinea-Bissau, Madagascar, Malawi, Niger, Sudan,) do they appear to have induced a delay greater than 10 per cent in the value that U5MR can reach by 2015 in relation to the scenario which assumes that the two crises had not occurred, while in other countries the impact of the crisis was minimal or even positive.

Figure 4: Absolute MDG4-U5MR gap (per thousand) by 2015



Source: authors' elaboration.

5. WHAT EXPLAINS INEQUALITY IN U5MR?

Although in SSA inequality in child survival is not as marked as in other regions of the world, the gap in the survival changes of children living in the poorest households compared to those living in the richest ones is still large and is a cause of the slow progress towards MDG4. As discussed in childinfo.org[22] – a UNICEF sponsored website aiming at monitoring the situation of children and women – and as shown by surveys carried out between 2000 and 2008, the ratio between the U5MR of the poorest quintile and that of the richest quintile is 1.9 in SSA, while it reaches 2.1 in Central and Eastern Europe and the Commonwealth of the Independent States, 2.6 in the Middle East and North Africa, 2.7 for South Asia and 2.8 in East Asia and Pacific excluding China. The same website shows that in countries with at least two DHS surveys, 18 out of the total 26 experienced a decline of at least 10 per cent in U5MR between the two latest surveys; however this was accompanied by an increase or stagnation in the ratio of the U5MR of the poorest to the richest quintiles. However, in the case of the SSA countries with at least 3 DHS surveys (see Annex1 Table 6) there is no clear relationship between the average U5MR progress and U5MR inequality (measured by the ratio of the U5MR of the bottom to the top quintile). Indeed, most of these countries experienced a sharp increase in U5MR inequality during the 1990s followed by a decline in the 2000s. The faster improvement in average U5MR over 2001-2007 compared to the years 1995-2001 has therefore boosted a faster decline in U5MR amongst the poorest quintile. Though detailed data are not yet available, these findings may help to anticipate the impact of the food prices and financial crises of 2008 and 2009 on U5MR inequality in SSA countries.

In view of all this, this section attempts to shed some light on the determinants of inequality in order to help the policy maker and the international community to introduce effective interventions in terms of reduction in child mortality inequality and, more specifically, to understand whether and through which pathways the recent food and financial crises affected U5MR inequality. Given the evidence mentioned in the above paragraph, it is plausible that in the SSA countries which experienced an increase in child mortality in relation to the counterfactual scenario, the health impact of the crisis was particularly severe for the children of households belonging to the bottom asset quintiles. This would suggest that there are at work structural mechanisms which amplify the effect of crises on the mortality risk of children belonging to the bottom quintiles of the population.[23] It is imperative therefore to

[22] See http://www.childinfo.org/mortality_disparities.html

[23] Growing U5MR differentials by income quintiles were found by Minujin and Delamonica (2003) for the 1980s and 1990s on the basis of DHS for 24 developing countries. The ratio of the U5MR of children of families belonging to the bottom 20 per cent relative to that of households belonging to the top 20 per cent worsened in 11 of the 24 countries analyzed, did not change in 10, and improved in three. A worsening of U5MR differentials was observed both in countries where average U5MR worsened and in several of those where the average fell, suggesting that most of the U5MR reduction was concentrated in the top income group. Similar results were obtained by Cornia and Menchini (2006) who analyzed changes in IMR and U5MR differentials between the early 1990s and the early 2000s on DHS data for 15 countries. Similar results were obtained for the rural-urban IMR differential, which broadened in 11 cases, remained unchanged in four, and narrowed in six, suggesting that most of the IMR and U5MR decline was recorded in urban areas.

disentangle the factors that drive U5MR inequality, so as to enable the national and international policy-makers to introduce appropriate policy and programme measures. To do so we developed a theoretical model in which U5MR inequality (measured by the ratio of U5MR of the bottom wealth quintile to that of the top quintile) depends on three sets of variables:

(a) the inequality in the distribution of the proximate causes of U5MR (delivery care, access to clean water, personal illness control – such as immunization, breastfeeding and ORS treatment – and child malnutrition) and of some underlying causes (female illiteracy). An increase in the inequality of the distribution of these determinants is expected to raise U5MR inequality. Indeed, inequality in child mortality among different socio-economic groups is likely to mirror inequalities in mother's education, access to health care and coverage of health insurance schemes, child morbidity, vaccination and so on. Past evidence shows that the concentration index of the distribution of U5MR (another measure of child mortality inequality) is highly correlated to the concentration index in the prevalence of stunting, underweight, diarrhoea and acute respiratory infection among children (Wagstaff, 2002), as the average Pearson and Spearman correlation coefficients between such variables were both 0.60. In other words, countries with a high level of U5MR inequality show consistently higher levels of inequality in these immediate determinants of child mortality. Information about these variables are collected directly from the DHS Stat Compiler tool, which includes data at both the aggregate national level and for a few disaggregated breakdowns (urban/rural, wealth of quintiles, gender of the child, level of education, region, etc).

(b) the average level of these U5MR determinants as - beyond a given point - a rise in their mean value may reduce by itself the inequality among wealth quintiles.[24] However, we were forced to drop this set of variables as the dataset at our disposal included only 76 observations, i.e. not enough to insert also the average value of these variables without risking an excessive loss of degrees of freedom.

(c) aggregate variables (belonging to the group of underlying causes of U5MR) which generate overall external effects not captured by the DHS data. Indeed, these data affect the overall economic and social environment of all families and, through that, the disparities in U5MR. These include (in parenthesis the sign expected *ex-ante* on the basis of the theory): the food production index (-), food import/total food availability (+), overall HIV prevalence (+), GDP per capita (-), government health expenditure/GDP (-), the government health expenditure as a share of the total health expenditure (-). Many of these aggregate variables were used also in the estimation of the econometric model reported in Table 2.

The econometric estimation of U5MR inequality poses however a number of statistical problems. Indeed, in order to obtain stable estimates of U5MR by wealth quintiles (Filmer and Pritchett, 1998) the survey estimates normally refer to the 10 years preceding the date of the survey. This constitutes a major problem for our regression analysis, as the time subscript (period of reference) of the dependent variable differs markedly from that of the explanatory variables (several of which refer only to the year of the survey), possibly determining in this

[24] This suggests that the relation between the mean coverage of variables such as immunization, delivery care, etc. and its variability takes the form of an inverted U, with the inequality rising until a give threshold and declining thereafter.

way a weak causality nexus and biased estimates of the parameters. This problem can, to some extent, be solved (as we did) by using the average value for the 3-5 years preceding the survey for both the explanatory variables derived from the DHS surveys and those derived from the aggregate national statistics.

As noted, inequality in U5MR is measured by the ratio between the U5MR of the poorest quintile and that of the wealthiest quintile. Also the explanatory variables belonging to the first group (which measure the inequality in the distribution of health inputs) are expressed as a ratio between the values of the poorest and richest quintiles and between the rural-urban areas. As for the variables of group (c), these are expressed in absolute levels or rate for the entire country, and – as noted – are expressed as their average over the 5 years preceding the survey.

Table 7 presents the results of the regression analysis carried out on a panel of the 76 DHS for 35 SSA countries (see Annex1 Table 6 for the list of countries and years). The regression was carried out by means of the random effect estimator, as the Hausman test refused the hypothesis that the model specification contains fixed effects.

The results are generally in line with the theoretical expectations highlighted above. Amongst the explanatory variables expressed as ratio between the first over the fifth quintile, for variables with an expected negative impact on U5MR (such as stunting), a positive change in their ratio (that is an increase in the 1-to-5 quintile ratio) should increase U5MR inequality, while we expect the opposite for variables with a positive effect on U5MR (such as the duration of breastfeeding), where a positive change in their ratio (that is a decrease in the 1 to-5 quintile ratio) should decrease U5MR. For instance, an increase in the ratio between the duration of breastfeeding of children belonging to the poorest quintile and those living in the richest households, reduces U5MR inequality; a positive variation in the 1-to-5 quintile ratio of children not covered by vaccination against measles, of the prevalence of children under 5 years suffering from moderate stunting, and of female illiteracy rate, increase U5MR inequality. However, the quintile ratio of the rate of children whose delivery was not attended by a health practitioner as well as the rate of children affected by diarrhoea or who were not treated with ORS show the expected sign but their coefficients are not statistically significant.

As for the impact of the aggregate variables, an increase in the index of domestic food production (2000 = 100) decreases the U5MR 1-to-5 quintile ratio, suggesting that, for the SSA countries, a rise in food production benefits more than proportionately the poor and their children. A negative sign is also found for the share of imported food on the total food available in a country. A reasonable interpretation of this result is that an increase in a country's dependency on imported food is likely to hit disproportionately the richest children (mostly living in urban areas where self-production is not feasible) than children belonging to the poorest quintile who mostly live in rural areas, where production for self-consumption is higher and dependency on imports (and the effects of volatility in price and quantity) is more limited.

Table 7. Regression analysis of the determinants of inequality in U5MR

Dependent variable: U5MR ratio between the poorest (first) and richest (fifth) quintiles

Explanatory variables	**Coefficient**	**P-value**
Breastfeeding_1/5_ratio	-0.155	**
No Immunization_1/5_ratio (measles)	0.060	**
No Assisted Birth_1/5_ratio	0.002	
Moderate Stunting_1/5_ratio	0.339	***
Female Illiteracy_1/5_ratio	0.028	***
No ORS treatment_1/5_ratio	0.033	
No Improved Water_R/U_ratio	0.012	*
Food Production Index	-0.003	*
Food Import/Total Food Resources	-1.025	**
HIV prevalence	-0.029	***
Government Exp Health (% of GDP)	0.165	**
Government Exp Health (% of Total Health Exp)	-0.010	*
Per capita GDP (ln)	0.283	***
Constant	-0.495	
Number of observations: 76		
Number of groups: 35		
R-sq: Within: 0.37, Between: 0.76, Overall: 0.65		
Rho: 0.34		

Source: authors' calculations. Note: * p<.10; ** p<.05; *** p<.01

The HIV prevalence is negatively associated to U5MR inequality: this might be explained by the fact that the prevalence rate (and, as a consequence, AIDS-related child mortality) in urban areas is more widespread than in rural areas (the median urban/rural ratio of HIV prevalence in the region is 1.7:1.0 as estimated from household surveys between 2001 and 2005 – UNAIDS 2009), as noted at least during the 90's. This is why children in the richest quintile might be affected relatively more than the poorest children. In turn, the coefficient of government expenditure on health as a share of GDP seems to suggest that this variable is, on average, regressive and that rich children benefit proportionally more from public health interventions than poor children. Finally, a higher share of the government health expenditure on total health spending decreases inequality in child survival.

A higher rural-to-urban ratio of the rate of households without access to improved water worsens, and thus increases, the U5MR ratio between the first and fifth quintiles. Finally, an increase in per capita GDP is associated with a deterioration of U5MR inequality. As the GDP variable is expressed in logarithm terms, the relation between the two variables seems to be concave by indicating a faster increase in the 1-to-5 quintile ratio of U5MR at lower level of per capita GDP.

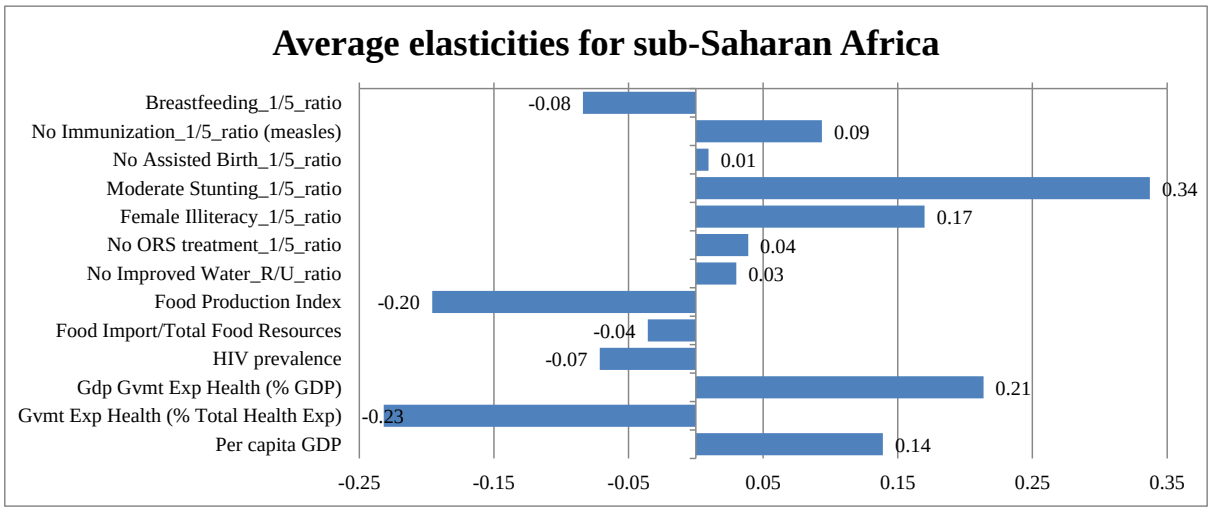
Figure 5 provides the elasticities of all independent variables vis-à-vis the U5MR inequality ratio. To start with, it appears that the variables which most influence U5MR inequality are food production and stunting. Reducing inequality in stunting and increasing food production (which may also affect indirectly inequality in stunting) are thus priority interventions. As

expected, reducing the inequality in the provision of standard 'Health for All'-type measures reduces U5MR inequality. These measures (ordered according to the value of the elasticity) are the following: reducing inequality in female illiteracy, breastfeeding, immunization, and to a much lesser extent care delivery. Reducing ORS inequality is, however, non significant in regression.

As noted, an increase in GDP per capita (which in many cases in SSA is accompanied by a worsening in income inequality, as the growth often takes place in mining enclaves or urban areas), tends to exacerbate U5MR inequality as does, for the reasons discussed above, an increase in public health expenditure as a share of GDP, while a higher share of the public component of total health expenditure largely decreases U5MR inequality. Obviously, solution of this problem does not entail reducing growth and public health expenditure (in terms of GDP), but a better targeting of the latter and the promotion of a model of 'pro-poor development'. In addition, Figure 5 also shows that an increase in the share of public expenditure in total health expenditure tends to substantially reduce inequality in U5MR.

In conclusion, we cannot precisely detect the effects of the food and financial crises on U5MR inequality as we have no information on disaggregated changes in the relevant variables. However, we can anticipate that the crises might have negatively affected, and thus increased, inequality in child survival by withdrawing resources for vaccination (as we saw in the previous sections) and to combat (or prevent) malnutrition – which was exacerbated by food prices increase. Past experiences suggest that the poorest, especially those in remote rural areas, are the first to be affected by a withdrawn of public resources. The remaining disaggregated variables are likely to deteriorate – if any negative political interventions have occurred – over a longer period. Aggregate variables, according to the changes we discussed in the previous sections, have led to a mixed impact on U5MR inequality.

Figure 5. Elasticities of explanatory variables on U5MR 1-to-5 quintile ratio



Source: authors' elaborations based on the coefficients in Table 7, estimated on the DHS sample of Annex1 Table 6.

6. CONCLUSIONS, LIMITATIONS OF THE STUDY, AND POLICY RESPONSES

The paper has shown that starting from 2000 U5MR in SSA declined on average at a faster rate than during the 1980s and 1990s. Contrary to the initial expectations, in 2008 and 2009 U5MR continued to improve in the many SSA countries at similar rates to those observed over the previous seven years. While the food and financial crises – characterized by a rapid and permanent rise in food prices and a slowing down in GDP per capita growth rates – caused an additional 27 thousand child deaths in relation to a no-crisis counterfactual scenario for SSA as a whole, the offsetting effect of other variables more than counterbalanced this impact, thus leading to an estimated reduction of 15,000 child deaths in relation to the no-crisis counterfactual scenario. The paper has also shown that the crisis has had only an insignificant effect in reaching the achievement of MDG4. Yet, even assuming that in the years ahead the determinants of U5MR will assume the best values observed over 2004-07, MDG4 will be achieved in the region with an average delay of 16.6 years with respect to 2015. Finally, in view of the possible differential impact of the crisis on the mortality risks of children belonging to different economic and social groups, the paper has shown that - as expected - an unequal distribution of health inputs among children belonging to different wealth quintiles and locations has a negative effect on U5MR. In turn, the growth rate of GDP and public expenditure on health (both of which are likely to favour the richer urban areas) have a negative effect on U5MR inequality (and thus require a change in the broad pattern of development), while an increase in food production, greater food self-sufficiency, a decline in HIV, and a rise in the share of public health expenditure on total health spending, have the opposite effect.

Though we collected and exploited all possible sources of data and modelled child mortality in an SSA-specific way, our econometric estimates and the resulting simulation results suffer from several data and estimation problems, and should therefore be viewed with this in mind. The main problem concerns the data on U5MR. The IGME time series data are the least worse available, but are heavily trended and on occasion show limited variations of economic, climatic and social shocks. In addition, lack of data precluded the inclusion in our econometric model of income inequality and parental time for child care, i.e. two variables that several micro studies show affect child survival and vary markedly during economic crises. Thirdly, the limitation of the IGME U5MR data did not permit us to adopt an 'event approach' to the estimation of the parameters linking U5MR to its determinants in periods of crisis. This approach, which is the most preferable when trying to assess the impact of rapid short term changes, generates short term U5MR elasticities of its main determinants which are three to four times greater than those estimated on the basis of long term models. Finally, it is possible that, despite the corrections we introduced in the econometric estimates, the discrepancy in time subscripts between DHS-based U5MR and its determinants may have somewhat biased the parameters of the relation between inequality in U5MR and its determinants.

Yet, as argued in the paper, a fairly plausible message seems to emerge from our analysis. The first is that the crisis has had a lower than generally expected impact on child mortality.

Even assuming U5MR elasticities of food prices and GDP/c are three times greater (as the highest elasticities found in the literature) than those estimated by our model, the impact of the crisis (limited to these two variables) would have been modest (about 80,000 additional child deaths in comparison with the "non-crisis scenario", i.e. less than 0.5 per cent of the 4.2 million annual child deaths taking place in SSA every year, and well within the margin of error of our estimates. The reasons for such findings have to be found in the fact that the recession was much less severe than originally anticipated. Several countries, including a number of large (Ethiopia, Nigeria, Mozambique and Uganda) and low income ones recorded no, or only a very mild, recession. In turn, while food prices increased three times on the international market, their domestic rise was - while still worrying - much more limited. Furthermore, at least half of the increase in child mortality just mentioned would have been compensated by progress in other determinants of U5MR, such as an increase in food production and imports, sustained health expenditure by many SSA governments, and international aid to the health sector.

It is beyond the scope of this paper to identify the full array of policy responses to be introduced at the national and international level to respond to the problems posed by the current crisis. Yet these measures need serious re-thinking in order to prepare for future shocks, including the new rise in food prices which started taking shape at the end of 2010 and which is already intensifying in 2011, and the persistence of a highly volatile financial environment in several industrialized and developing countries. In view of this, this section provides only a cursory mention of the measures that need to be introduced over the short and long term to offset the impact of food price rises and economic recessions on child mortality.

(i) Global interventions: the shocks that affected SSA over 2008 and 2009 were generated by problems affecting the financial markets in the advanced economies, and by global macroeconomic imbalances among main economies. Adequate responses need therefore to be found first of all at this level. Measures in this area are just briefly mentioned for sake of completeness but will have to be developed in other analyses. Overall, there is a need for a new Bretton Woods agreement which ought to focus on a more effective global and national regulation of financial markets (including restrictions on speculative investments and future contracts for food items) by a new World Financial Authority; a New Deal on the environment (including limits on the production of bio-fuels), a new overall emphasis on agriculture, including in terms of bringing large swathes of fertile land under production - in Russia, Kazakhstan, Ukraine, Argentina, Mozambique, and Angola - which at the moment lie idle; and a strengthening of international aid and safety nets.

(ii) Greater domestic emphasis on SSA agriculture, as food demand in this region will continue growing at 4-5 per cent a year due to rising incomes and population, with possible upward effects on food prices. Increases in food output will depend on improvements in R&D on African crops, new investments, price support measures, subsidies for small farmers (as in the case of the Malawi package), and reduction in transport-storage cost via the development of infrastructure. The increase in domestic food supply observed in several African countries during the last three years might herald a new tendency which needs strengthening.

These long-term measures will need to be accompanied by short term measures to control the health impact of possible or likely food price increases. Among the interventions to control the domestic food prices one could consider: export taxes and export restraints in surplus countries (hardly any in SSA), reductions in tariffs, VAT in food deficit countries (though this will entail a loss of revenue). Access to food can also be enhanced by means of targeted food subsidies (as in the case of India's PDS), price caps and controls, public procurement agreements with wholesalers, reductions in trade margins by improving trading, the creation of buffer stocks and, in extreme situations, free food distribution. Concrete measures depend on local economic and administrative strength.

(iii) raising the income of the poor via targeted cash transfers (which require a good administrative capacity), self targeted public works (workfare – same as above), other safety nets (child allowances) and greater attention to social budgeting and social protection. This paper argues that preserving (or even increasing) social budgets and providing adequate protection for vulnerable children will be critical ingredients in efforts to respond to these aggregate shocks and break the cycle of poverty. In the African context, increasing the incomes of the rural poor will often mean higher food prices accompanied by some subsidies to shelter the urban poor and food-deficient farmers.

(iv) the protection of public health expenditure and foreign aid to health, and – in particular – the protection of highly efficient and cost-effective interventions in the field of primary health care, the management of malaria and HIV/AIDS. As shown in Table 7, it is important that such measures reach in particular the bottom 40 per cent of the population, whose children are exposed to a higher mortality risk.

(v) Nutritional interventions may also be needed in extreme cases. School/clinic-based feeding programmes have been shown to be very effective for children and pregnant mothers, while in-situ feeding can be adopted for severely malnourished children.

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ANNEX 1

Annex 1 Table 1. Description of variables used in regression analysis and their data sources

Variable	Definition	Source
U5MR	Under-5 mortality rate	Inter-Agency Group for Mortality Estimations
GDP/c (ln)	Logarithm of GDP/c in 2005 PPP $	World Development Indicators 2010
Improved water and sanitation	Average rate of people with access to safe sources of water and sanitation	WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation
HIV prevalence	HIV prevalence amongst adults (15-49 years old)	UNAIDS database (last accessed December 2010)
Food price index/Consumer price Index (ln)	Food and consumer price indexes (base year 2000)	National Statistical Offices (surveyed by ILOstat)
Gvt exp on health (% GDP)	Government expenditure on health as % of GDP	WHO database
Food resources/c (prod+import)	Sum of domestic production and imports of cereals, pulses, roots&tubers, vegetables&melons (in tonnes), per capita	FAOstat
External aid on health/c (ln)	Logarithm of international resources per capita on health	WHO database – National Health Accounts
Female literacy (age 15-44)	Female literacy rate (age 15-44)	Barro and Lee database
Food imports (% total food resources)	Ratio between imports per capita of imports of cereals, pulses, roots &tubers, vegetables&melons, and food resources/c (as defined above)	FAOstat
Immunization coverage	Average of children (12-23 months) who received DPT3 and measles vaccinations (%)	WHO database
Democracy index	Democracy index (1= lowest level of democracy; 10=highest level of democracy)	World Development Indicators 2010
Conflict dummy variable	Conflict variable (0=no conflict; 1=in conflict)	Centre for the Study of Civil War (CSCW) database

Annex 1 Table 2: Wald test of structural change in U5MR trend between 1995-2000 and 2001-7

	chi2	Degrees of freedom	p-value
GDP/c (ln)	2.35	1	0.1258
Improved water and sanitation	9.95	1	0.0017
HIV prevalence	10.43	1	0.0013
Food Price Index/CPI (ln)	0.11	1	0.7379
Gvt exp on health (% GDP)	3.44	1	0.0646
Food resources/c (prod+import)	0.23	1	0.6304
External aid on health/c (ln)	10.97	1	0.001
Female literacy (age 15-44)	6.82	1	0.0094
Food imports (% total food resources)	2.09	1	0.1489
Immunization coverage	3.94	1	0.0478
Democracy index	12.11	1	0.0006
Confilct dummy variable	2.45	1	0.1186
Wald-statistic	2.35	1	0.1258

Source: authors' calculations on sample included in Table 1.

Annex 1 Table 3. Simulated percentage yearly changes of the U5MR determinants in the 'no crisis scenario' (top panel) and 'crisis scenario' (lower panel)

A	**NO CRISIS (as of 2004-07 mean yearly change)**							
	GDP/c (real, PPP)	Food Prices Index/CPI	Gov health outlays (gdp)	Total food resource	External aid to health/c	Food import (% total food resources)	Immuniz rate	HIV prevalence
Angola	14.3	2.4	-6.1	-1.9	9.7	-2.9	12.2	0.0
Benin	0.3	-1.1	3.2	0.7	15.3	-1.4	2.7	-2.0
Botswana	3.0	-0.1	-7.2	-0.3	24.5	0.9	-1.1	-1.0
Burkina Faso	1.5	-0.3	6.7	-6.5	-6.6	2.5	4.8	-6.5
Burundi	0.6	1.7	2.5	-1.1	13.4	4.8	3.1	-5.4
Cameroon	0.8	-0.3	0.6	-2.1	2.8	5.6	3.9	-0.5
Cape Verde	5.7	-0.1	1.7	0.2	16.0	2.7	-1.3	0.0
C. African Rep.	0.9	-0.2	0.6	-0.1	10.9	-1.5	30.0	-8.4
Chad	8.5	1.2	-7.9	-2.7	-18.9	1.2	8.0	0.7
DR Congo	3.0	-0.2	5.8	-1.9	18.6	8.3	12.7	0.0
Rep. of Congo	1.7	1.9	0.1	2.1	-5.4	0.1	10.1	-1.4
Côte d'Ivoire	-0.8	-0.8	1.1	-4.1	6.3	1.5	10.8	-7.9
Equatorial Guinea	13.7	0.1	4.9	-0.2	17.2	0.2	0.3	13.0
Eritrea	-2.5	1.2	-12.1	0.4	-16.3	-21.0	1.6	-4.9
Ethiopia	9.0	1.5	-6.5	-2.4	16.9	8.9	9.5	-1.2
Gabon	0.8	0.1	-2.2	-0.2	5.2	0.2	16.7	-0.5
Gambia	3.2	1.0	2.0	0.5	13.5	0.4	0.6	17.0
Ghana	3.6	-0.9	6.3	5.3	2.3	2.6	4.3	-2.5
Guinea	0.4	5.0	-7.7	10.6	6.8	-8.4	6.8	-3.3
Guinea-Bissau	-0.1	0.0	4.0	-10.2	22.0	-3.7	6.3	2.1
Kenya	3.4	3.7	2.9	0.7	12.2	-1.0	2.7	-3.9
Lesotho	3.6	1.7	0.9	-3.3	3.4	7.7	10.0	-0.6
Liberia	2.5	1.1	16.2	3.2	-0.4	-1.7	19.1	-8.8
Madagascar	2.4	2.1	-2.4	-5.4	8.2	-6.6	2.6	0.0
Malawi	3.3	-0.3	7.2	0.5	2.4	1.2	1.4	-3.2
Mali	2.0	-0.1	1.4	11.4	20.9	-7.6	4.9	-5.9
Mauritania	3.3	1.5	7.2	11.3	-2.7	0.9	-0.9	0.0
Mozambique	5.4	0.5	2.0	2.5	9.7	-3.9	-4.6	1.8
Namibia	4.8	0.6	-4.5	0.0	11.1	-4.4	-1.1	-3.5
Niger	0.1	1.0	6.6	0.6	6.6	10.6	5.7	-5.4
Nigeria	4.6	-0.5	-4.2	-5.9	31.2	1.6	19.7	-0.7
Rwanda	4.7	1.7	1.9	-4.3	28.6	-2.0	1.3	-3.9
SaoTome&Princ	4.5	1.6	-3.1	2.4	-9.8	0.2	0.3	0.0
Senegal	2.0	0.7	6.0	0.8	-8.1	9.6	7.6	3.4
Sierra Leone	3.5	1.1	-10.0	3.3	12.4	-1.4	3.0	5.3
South Africa	4.0	1.3	0.5	-1.0	-0.1	12.6	0.4	0.0
Sudan	5.9	1.2	14.6	0.7	40.5	5.9	4.4	12.5
Swaziland	1.8	1.7	1.2	0.2	-5.5	6.9	-9.6	0.7
Tanzania	4.1	1.8	4.6	-4.2	27.2	-10.8	3.9	-2.8
Togo	0.0	0.1	7.8	-5.3	27.8	1.0	1.1	-1.5
Uganda	4.6	1.1	-4.3	5.4	-5.2	2.2	-2.6	-1.2
Zambia	3.4	-2.5	-5.8	-3.2	4.0	-30.9	2.8	-0.7

B	CRISIS yearly change 2007-08							
	GDP/c (real, PPP)	Food Prices Index/CPI	Govt health outlays (gdp)	Total food resource	External aid to health/c	Food import (% total food resources)	Immuniz rate	HIV prevalence
Angola	10.2	5.4	21.8	-6.8	30.3	8.4	-6.4	5.3
Benin	1.8	9.3	-8.7	5.4	20.9	-2.0	-4.2	0.0
Botswana	1.6	6.7	22.7	47.8	9.8	-0.7	5.1	-0.8
Burkina Faso	1.5	11.5	-17.1	32.2	22.8	-23.9	2.6	-7.7
Burundi	1.4	0.8	14.7	-0.8	36.7	6.0	-11.1	-2.8
Cameroon	1.1	3.6	17.5	2.4	12.4	3.9	5.1	-1.9
Cape Verde	5.0	2.2	5.6	6.6	2.5	-5.6	2.6	0.0
C. African Rep.	0.3	1.9	22.3	0.8	56.9	0.1	-38.8	-7.3
Chad	-2.9	5.7	6.6	-11.5	9.3	29.4	-34.0	-2.9
DR Congo	3.3	1.9	21.9	-1.2	99.5	3.1	-3.6	0.0
Rep. of Congo	3.7	0.7	-20.8	0.7	25.6	-0.2	14.3	0.0
Côte d'Ivoire	0.0	4.7	3.2	11.0	13.2	-0.8	-4.2	-9.8
Equatorial Guinea	8.4	2.5	14.0	3.1	38.9	0.9	92.3	6.8
Eritrea	-1.0	5.7	5.5	-27.3	-12.2	114.9	3.1	-11.1
Ethiopia	7.9	10.9	-8.7	-0.2	-22.1	2.1	12.3	0.0
Gabon	0.5	2.5	-3.3	3.1	-15.9	0.9	4.2	0.0
Gambia	3.2	1.6	1.6	33.6	-22.3	-13.1	4.5	13.3
Ghana	5.1	-1.2	11.4	30.8	15.2	-7.2	-8.5	-5.3
Guinea	2.4	1.9	18.1	6.1	-10.3	0.8	-14.4	0.0
Guinea-Bissau	1.0	5.0	-4.5	-11.7	-44.1	-16.9	-18.8	0.0
Kenya	-1.0	5.6	4.3	13.5	7.1	93.2	8.7	-1.6
Lesotho	3.0	4.7	19.1	-9.2	32.9	-2.2	0.0	0.4
Liberia	2.4	9.9	89.0	-19.1	283.2	-15.1	2.2	-11.1
Madagascar	4.5	1.1	-0.3	1.2	1.4	-38.2	-6.8	0.0
Malawi	6.7	-1.6	2.6	-19.9	38.1	21.8	5.3	-1.8
Mali	2.4	3.5	-13.6	8.5	22.7	47.8	10.1	-9.1
Mauritania	1.2	2.1	3.5	16.1	-28.7	0.6	-2.1	0.0
Mozambique	4.3	3.6	-0.9	11.0	9.4	14.4	10.0	0.0
Namibia	0.9	6.0	5.9	6.5	-62.9	11.1	0.6	-4.2
Niger	5.3	7.6	-1.6	40.7	32.6	-24.5	16.6	0.0
Nigeria	3.6	4.0	-1.3	8.2	2.9	-6.0	-19.4	0.0
Rwanda	8.2	0.8	7.6	6.9	76.2	-30.1	-3.6	0.0
SaoTome&Princ	4.1	4.5	-16.9	-1.1	60.4	0.1	4.9	0.0
Senegal	0.6	3.7	-3.7	43.5	18.4	-29.4	-7.3	0.0
Sierra Leone	2.9	9.9	17.8	-2.2	6.8	-23.7	8.7	0.0
South Africa	2.5	4.5	11.5	28.9	9.4	-54.3	1.7	-0.6
Sudan	4.5	5.7	-10.6	9.6	32.2	20.9	1.2	25.0
Swaziland	1.0	4.7	21.8	9.9	-38.0	-21.4	18.3	0.4
Tanzania	4.4	2.2	12.6	1.9	19.1	23.1	-1.2	-1.7
Togo	-0.7	10.8	-12.5	3.4	68.9	-6.8	-8.8	-3.0
Uganda	5.2	6.9	1.0	-0.7	-26.1	-5.2	0.6	1.6
Zambia	3.1	1.2	-2.0	13.2	-23.8	95.8	-2.6	-0.7

C	CRISIS yearly change 2008-09							
	GDP/c (real, PPP)	Food Prices Index/CPI	Gov health outlays (gdp)	Total food resource	External aid to health/c	Food import (% total food resources)	Immuniz rate	HIV prevalence
Angola	-2.3	2.3	-6.1	23.1	-24.1	-33.0	-6.3	0.0
Benin	0.6	3.4	16.6	1.8	20.3	-9.1	6.0	0.0
Botswana	-7.4	5.8	20.5	-23.2	-51.3	-5.5	3.3	-0.4
Burkina Faso	0.1	-0.1	13.4	-19.3	25.9	10.7	0.0	0.0
Burundi	0.6	3.7	-11.0	0.8	-18.5	0.1	8.0	-5.7
Cameroon	0.1	2.0	-0.3	-10.4	20.7	6.9	-6.1	0.0
Cape Verde	1.4	1.0	1.5	1.1	-54.2	1.1	-8.2	0.0
C. African Rep.	0.5	0.9	-7.4	-9.1	-27.9	9.0	51.8	-7.8
Chad	-1.1	-1.1	35.3	-10.3	-29.6	31.0	67.0	0.0
DR Congo	0.0	0.9	20.0	0.0	-4.6	-0.9	11.3	0.0
Republic of Congo	5.6	2.4	3.5	-0.3	-50.8	0.2	-0.6	-2.9
Côte d'Ivoire	1.4	2.2	-0.4	-7.3	53.7	-5.6	8.0	-8.1
Equatorial Guinea	-7.8	9.8	126.7	-3.1	-15.7	-0.2	0.7	6.4
Eritrea	0.6	-1.1	-27.9	14.2	-57.5	-16.8	0.0	0.0
Ethiopia	5.9	-4.8	-8.9	-0.3	43.4	-29.7	-0.6	0.0
Gabon	-2.7	9.8	23.5	-3.1	63.5	-0.2	-6.7	-1.9
Gambia	1.8	0.7	22.1	8.3	13.1	-15.2	-2.7	17.6
Ghana	1.4	-3.0	-11.3	6.4	-10.1	-8.8	8.1	0.0
Guinea	-2.7	2.3	37.9	2.6	-25.6	-10.8	7.5	-7.1
Guinea-Bissau	0.8	1.0	3.9	2.2	-0.6	0.1	12.6	0.0
Kenya	-0.5	6.3	6.9	-4.1	12.3	-11.6	-14.9	0.0
Lesotho	1.3	1.7	11.0	6.4	-19.8	4.0	-17.0	0.0
Liberia	0.3	-11.1	12.1	-3.3	28.4	-2.7	0.0	-6.3
Madagascar	-2.2	11.9	-17.9	6.4	-29.5	-30.1	-2.8	0.0
Malawi	4.8	-1.0	-1.0	23.3	-17.8	-42.3	3.4	-1.8
Mali	1.9	0.8	13.1	7.3	19.5	-55.3	-10.7	0.0
Mauritania	-3.4	0.4	-0.1	-8.9	-10.4	4.7	-11.5	0.0
Mozambique	3.9	3.4	18.1	5.9	12.3	-8.1	-13.3	0.9
Namibia	-0.9	1.7	10.1	1.9	220.4	-0.6	1.9	-4.4
Niger	-2.9	26.6	7.3	-29.3	-25.7	72.1	6.5	0.0
Nigeria	0.6	2.1	3.2	-3.6	106.6	2.1	21.6	0.0
Rwanda	2.4	3.7	4.2	19.3	-3.5	-37.3	0.0	0.0
SaoTome&Princ	2.4	3.6	53.6	-7.4	-36.6	-1.1	-2.1	0.0
Senegal	-1.1	-1.9	1.7	-6.3	-73.4	-12.8	0.0	12.5
Sierra Leone	1.5	-11.1	10.7	6.3	-15.4	-13.0	5.1	0.0
South Africa	-2.8	2.2	9.1	-0.5	10.0	9.5	8.2	-0.6
Sudan	1.7	-1.1	-12.2	-28.3	-16.1	32.1	0.6	10.0
Swaziland	-1.0	1.7	13.6	7.3	1057.9	-0.4	-3.4	0.0
Tanzania	2.5	4.8	3.8	-7.2	-7.2	21.8	4.2	-3.4
Togo	0.0	0.5	19.7	8.2	-26.4	-9.3	5.1	0.0
Uganda	3.6	10.6	-3.4	8.7	38.2	-40.1	1.1	1.6
Zambia	3.7	0.8	-4.0	17.3	-16.3	-77.1	3.3	-0.7

Source: authors' calculations based on the hypotheses and sources cited in Table 3

Annex 1 Table 4: Confidence intervals of the impact simulations shown in Tables 4 and 5

Country	Estimated difference of U5MR 2008/2009	Standard error of difference estimates	Lower limit (95% confidence interval)	Upper limit (95% confidence interval)	Estimated difference of deaths in 2008/2009	Standard error of difference estimates	Lower limit (95% confidence interval)	Upper limit 95% confidence interval)
Angola	2.6	2.4	-2.1	7.3	2018	1864	-1635	5671
Burundi	-0.8	0.7	-2.2	0.6	-213	201	-608	181
Benin	-0.6	0.8	-2.3	1.0	-217	292	-790	356
Burkina Faso	-2.7	2.2	-7.0	1.5	-2045	1605	-5190	1101
Botswana	-2.1	1.8	-5.7	1.5	-98	86	-266	70
C. African Rep.	1.1	2.3	-3.4	5.6	168	353	-524	860
Côte d'Ivoire	-4.2	1.5	-7.1	-1.3	-3075	1075	-5181	-968
Cameroon	-2.6	0.4	-3.5	-1.7	-1837	323	-2469	-1205
Republic of Congo	0.1	0.6	-1.0	1.2	10	71	-130	149
Cape Verde	0.9	0.4	0.2	1.6	11	5	2	20
Eritrea	5.8	3.3	-0.8	12.3	1088	627	-142	2317
Ethiopia	3.6	0.5	2.6	4.5	11105	1505	8155	14055
Gabon	0.4	0.9	-1.3	2.2	17	35	-52	85
Ghana	-3.5	2.4	-8.1	1.2	-2626	1804	-6162	910
Guinea	6.0	1.9	2.4	9.7	2374	735	933	3815
Gambia	-2.1	2.0	-5.9	1.8	-128	122	-367	111
Guinea-Bissau	12.9	2.5	8.1	17.8	849	162	532	1166
Equatorial Guinea	-9.5	4.9	-19.0	0.1	-240	123	-481	2
Kenya	3.7	1.1	1.6	5.7	5640	1621	2462	8817
Liberia	-36.7	4.4	-45.4	-28.0	-5353	646	-6619	-4086
Lesotho	-1.5	1.4	-4.2	1.3	-86	83	-248	76
Madagascar	2.2	1.0	0.3	4.1	1530	673	211	2849
Mali	3.1	0.8	1.6	4.7	1729	426	894	2564
Mozambique	-3.7	1.2	-6.0	-1.3	-3243	1045	-5291	-1195
Mauritania	5.2	0.6	4.0	6.3	566	63	442	689
Malawi	1.4	1.5	-1.5	4.2	823	874	-890	2537
Namibia	-2.2	0.7	-3.6	-0.8	-129	43	-213	-45
Niger	-4.9	2.3	-9.4	-0.3	-3797	1856	-7435	-159
Nigeria	-0.5	3.3	-7.0	6.0	-3242	20226	-42884	36401
Rwanda	-7.0	1.9	-10.8	-3.3	-2830	768	-4337	-1324
Sudan	7.8	1.0	5.9	9.7	10133	1246	7692	12575
Senegal	-2.6	3.6	-9.6	4.4	-1229	1701	-4562	2104
Sierra Leone	-1.8	1.4	-4.6	0.9	-420	327	-1060	220
Sao Tome&Principe	-4.1	0.7	-5.6	-2.7	-21	4	-29	-14
Swaziland	-43.3	6.6	-56.3	-30.3	-1501	230	-1952	-1050
Chad	1.2	2.7	-4.1	6.6	599	1387	-2119	3318
Togo	-0.8	1.1	-3.0	1.4	-175	239	-642	293
Tanzania	2.3	0.6	1.1	3.5	4203	1098	2051	6355
Uganda	1.4	0.6	0.2	2.6	2036	921	231	3841
South Africa	-5.9	2.0	-9.9	-2.0	-6371	2184	-10652	-2091
DR Congo	-7.9	1.6	-10.9	-4.8	-22845	4576	-31815	-13876
Zambia	3.2	1.4	0.5	6.0	1771	771	260	3282
SSA	**-0.5**	**1.22**	**-2.9**	**1.9**	**-15052**	**38226**	**-89975**	**59871**

Source: authors' calculations based on the hypotheses and sources cited in Table 3.

Note: Since the difference between the "crisis" and the "non-crisis" scenario is a nonlinear transformation of the under-five survival rate, its variance and standard error were computed by the use of the "delta method" (an approximation of the variability estimate for a nonlinear transformation of random variables based on the Taylor series approximation).

Annex 1 Table 5. Maximization exercise for MDG4 - hypotheses on lower and upper bounds on yearly growth

N°	**Explanatory variables**	**Lower bound**	**Upper bound**
1	Per capita GDP (ln) – real, PPP	As for standard procedure except for yearly growth, here equal to IMF 2011 projections – negative values replaced by 0	As for standard procedure except for mean yearly growth, here equal to IMF 2011 projections
2	Improved water	As for standard procedure	As for standard procedure except for countries where the 2007 variable exceeded 80, for which the 2004-2007 mean yearly growth rate was used. Negative values were replaced by growth rates of countries with a similar coverage in 2007 (es: BDI replaced with BEN)
3	HIV prevalence	As for standard procedure	Set to 0 if the standard procedure would result in a positive value
4	Food Price Index/CPI (ln)	Set to 0	Set to 0
5	Government exp on health (on gdp)	As for standard procedure	Set to the yearly growth rate needed to reach the Abuja target – LBR, RWA and TZA in 2007 had already reached that goal (it was then set to 0)
6	Per capita external aid on health (ln)	As for standard procedure	As for standard procedure
7	Female literacy (age 15-44)	As for standard procedure	As for standard procedure except for countries where the 2007 variable exceeded 80, for which the 2004-2007 mean yearly growth rate was used
8	Immunization coverage	As for standard procedure	Set to the yearly growth rate needed to reach full coverage by 2015
9	Democracy index	Set to 0	Set to 0
10	Conflict dummy variable	Set to 0	Set to 0
11	Per capita major food availability (domestic prod+import)	As for standard procedure	As for standard procedure
12	Rate of food imports on food availability	As for standard procedure	As for standard procedure

Note: In April 2001 in Abuja, the Heads of State and Government of the Organization of African Unity pledged to allocate at least 15% of their annual budget to the improvement of health.

Annex 1 Table 6: list of countries and years for which a DHS survey is available

Country	year of DHS survey				Country	year of DHS survey			
Benin	1996	2001	2006		Mali	1995/96	2001	2006	
Burkina Faso	1992/93	1998/99	2003		Mauritania	2000/01			
Cameroon	1991	1998	2003		Mozambique	1997	2003		
C.African Rep	1994/95				Namibia	1992	2000	2006/07	
Chad	1996/97	2004			Niger	1998	2006		
Rep. of Congo	2005				Nigeria	1990	2003	2008	
DR Congo	2007				Rwanda	1992	2000	2005	2008
Cote d'Ivoire	1994	1998/99			SaoTome&Princ	2008/09			
Eritrea	1995	2002			Senegal	1997	2005		
Ethiopia	2000	2005			Sierra Leone	2008			
Gabon	2000				South Africa	1998			
Ghana	1993	1998	2003	2008	Swaziland	2006/07			
Guinea	1999	2005			Tanzania	1996	1999	2004	
Kenya	1993	1998	2003	2008/09	Togo	1998			
Lesotho	2004				Uganda	1995	2000/01	2006	
Liberia	2007				Zambia	1996	2001	2007	
Madagascar	1997	2003/04	2008/09		Zimbabwe	1994	1999	2005/06	
Malawi	1992	2000	2004						