The Role of Agricultural Growth in Reducing Child Malnutrition

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THE ROLE OF AGRICULTURAL GROWTH IN REDUCING CHILD MALNUTRITION[1]

The Food and Agriculture Organization (FAO) and the World Bank suggest that agricultural growth is the most effective way to fight (child) malnutrition. Whether this is indeed the case is still very much debated, partly because there is little direct evidence on this topic. Using a dataset of 50 MDG1 countries observed between 1991 and 2009, this paper estimates and compares the impact of agricultural growth on child stunting against those of industrial growth and services growth. We find that, to achieve a 1 percentage point reduction in child stunting, a 11.1% increase in agricultural GDP per capita is necessary, against a 9.7% increase in industrial GDP per capita and a 7.8% increase in services GDP per capita. In other words, contrary to the policy narrative developed by many international development organizations, the services sector is the most effective engine towards reducing child stunting. Finally, we find weak evidence of the impacts of food prices on child stunting and no evidence of the impacts of food prices volatility for the period observed.

Keywords: child stunting, agricultural growth, food prices, price volatility.
JEL codes: O11, O13

Introduction

There has been renewed policy and research interest on the links between economic growth and nutrition, emphasized by the context of high and volatile food prices of the last years. As the deadline for the Millennium Development Goal 1 (i.e. to halve the number of people affected by hunger between 1990 and 2015) is looming, it is now clear that a significant number of developing countries will fail to reach the objective (Stevens et al., 2012) and that global food insecurity will keep presenting great challenges for many people across the planet. Among those, child malnutrition is one of the ugliest faces of global food insecurity, as it directly causes about a third of child deaths (Black et al. 2010). To add insult to injury, the lower cognitive ability and physical development resulting from food deprivation indirectly hinders the economic growth potential of countries affected (e.g. Horton and Ross, 2003). Malnutrition is a complex phenomenon that is intertwined within the economic, social and political spheres and there is no consensus on which drivers are most important and what policies are most effective to address child underweight and stunting (e.g. Headey, 2013).

There exist several conceptual frameworks that identify and distinguish a number of groups of causal factors to help us comprehend this phenomenon; for example, the UNICEF framework (1998) classifies the factors which impact on malnutrition in three categories: immediate, basic and underlying determinants. Beyond the critical role of immediate nutrition factors, e.g. dietary intake and child health, that we acknowledge, the scope of the paper is on the most structural factors, i.e. basic and underlying determinants (non-nutrition). Those may include food availability, political systems or health and economic environments. The literature examining these structural aspects of child malnutrition has found that increased food supplies have resulted in decreased malnutrition and that other factors, such as women's education and status and the health environment are also important (Smith and Haddad, 2001; Smith et al., 2005). The level of democracy has also significantly affected malnutrition rates through direct and indirect impacts (Smith and Haddad, 2000). Furthermore, Levine and Rothman (2006) find that trade openness reduces child stunting.

[1] The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

Higher food prices have also been found to increase the prevalence of stunting (e.g. Arndt et al., 2012).

Most of these factors are broadly recognized among economists and policymakers; however, the role of economic growth is still highly debated. In particular, the controversial issue relates to the type of economic growth that is the most favorable to reducing child malnutrition. It is generally accepted that economic growth causes decreases in child malnutrition, yet, whether agricultural growth is more effective than non-agricultural growth remains disputed. From a theoretical perspective, the logical argument, pushed forward by many international organizations, is that agricultural growth, involving smallholders mostly based in rural areas and directly affected by malnutrition, shall be most effective in reducing hunger (World Bank, 2007; FAO et al., 2012). However, that view, placing agriculture as a centerpiece of the fight against malnutrition, has been questioned, because, for example, it does not account for the heterogeneity of economic contexts across developing countries (Dercon, 2013).

In a related literature on sectoral growth and poverty, Loayza and Raddatz (2010) find that agriculture is the most poverty-reducing sector, mainly through employment effects. On the contrary, other authors have emphasized that services growth is found to be a stronger driver of employment than agricultural and industrial growth (e.g. Fox and Gall, 2008; Kapsos, 2005). Accounting for the importance of each sector in the economy (and implicitly the level of development), Ravallion and Chen (2007) and Ravallion and Datt (1996) find that agricultural growth has been the most effective at reducing poverty in China while the services sector has been found the most effective in India. Using cross-country evidence, Christiaensen et al. (2011) show that the agricultural sector is significantly more effective in reducing poverty among the poorest (of the poor) and that non-agricultural growth is more effective in helping the poor (but not the poorest). Given the divergences in the related evidence base, the question of which economic sector contributes most to fighting child malnutrition still remains unresolved. This paper aims to assess whether agricultural growth is indeed the most effective vector of child stunting reductions.

A partial explanation to the absence of consensus on this issue may lie in the fact that the situation has been misrepresented by the combination of several elements: the development of conceptually elegant, but often unproven, policy narratives; the absence of internationally comparable, reliable and long databases on agricultural statistics; and the use of inappropriate modelling frameworks. While the existing policy narratives tend to overstress the role that agriculture plays in development (Dercon, 2013) and data problems are a well-known problem for researchers, the use of inappropriate econometric models is a consistently ignored issue in the literature. In fact researchers have paid very little attention to the specific nature of data on child malnutrition. Traditionally, research focusing on the causes of malnutrition is based on linear regression models (e.g. Fixed Effects panel estimation). Despite the existence of contrasting evidence (e.g. Webb and Block, 2012) the adoption of linear models for fractional data, i.e. strictly between 0 and 1[2], in the empirical literature (e.g. Smith and Haddad, 2001; 2002; Smith et al., 2005; Levine and Rothman, 2006), ignoring the bounded and therefore non-linear nature of the dependent variable, has potentially resulted in

[2] A common strategy for addressing the problem of skewness in the distribution of the proportion (or rate) under study has been to use its logarithmic transformation but this does not consistently succeed in eliminating the issues relative to proportions. In fact, it may even increase the degree of asymmetry observed in the data. The Logit regression model suffers from the same issue. Finally, the Tobit regression has the same drawbacks than the linear model (Kieschnick and McCullough, 2003).

biased estimates with respect to the causal factors of malnutrition[3] (e.g. Paolino, 2001; Kieschnick and McCullough, 2003) and directly distorted the current debate.

Solutions to these problems have been developed in the statistical and econometrics literature but have been rarely implemented in the empirical literature. Generalized Linear Models (GLM) extend the linear regression model in that they allow for a non-linear relationship between independent and dependent variables by generalizing the possible distributions of residuals to the exponential family of distributions, which includes the normal, the binomial, the Poisson or the gamma distributions. However, in the presence of correlated data, GLM that assume independence among observations of a same country may result in misinterpreting existing causal relationships (e.g. Zeger et al., 1988). On the contrary, Generalized Estimating Equations (GEE) models (Liang and Zeger, 1986) extend GLM by allowing and accounting for the existence of correlated data (i.e. for non-independence among the observations of a same country) and fit better the relative persistence of child malnutrition. GEE estimation also presents the advantage of not requiring assumptions on the data-generating distribution, which may sometimes lead to misleading estimates and biased inference (Hubbard et al., 2010). Another strength of the approach is that it provides robust inference even if the correlation structure (between observations) is misspecified.

Using this GEE approach and data observed between 1991 and 2009 for a sample of 50 least-developed and low-income countries, we estimate the impacts of sectoral growth on child stunting. Unlike previous studies, this paper decomposes further non-agricultural growth into industrial and services growth, and allows for a direct comparison of the impacts of each economic sector's growth on child stunting. Overall, this paper sheds light on the relationship between sectoral economic growth and child stunting and directly contributes to the policy debate with respect to the sectoral dimension of investments needed to promote malnutrition-reducing growth. The main findings, contrary to the policy narrative commonly shared by the FAO and the World Bank, suggest that services growth is the most effective type of economic growth to reduce child stunting. The remainder of the paper is as follows. Section 2 describes the empirical model. Section 3 discusses data. Section 4 presents and analyses the results. Section 5 concludes.

Modelling child malnutrition

As explained above, previous studies have implicitly assumed a linear relationship between, typically, child underweight or stunting, and a set of (causal) factors (e.g. Smith and Haddad, 2001; Smith et al., 2005). However, the relationship between economic growth and nutrition is unlikely to be linear (Webb and Block, 2012)[4]. Moreover, previous studies have assumed that observations for a same country are independent one from another and have thus ignored an important feature of child malnutrition; that is, the existence of correlation in the data. Instead, here, we develop and estimate a GEE model accounting for both non-linearity and correlation. GEE estimation requires choosing a link function and a correlation structure. For each specific distribution, there is at least a function of the conditional mean of the dependent variable whose relationship with the independent variables is linear (that is, the link function). The dependence of an observation with the others is specified through the structure of the working correlation matrix. It is typically possible to specify several types of correlation structures.

[3] Although Headey (2013) uses first differences of stunting, the same criticisms apply to this study as the first-difference of a bounded variable will be bounded (-1,1).
[4] In a related literature Easterly (2009) also notes that the relationship between poverty and economic growth is highly nonlinear.

The empirical model can be expressed as:

$$g(E[y_{it}]) = x_{it}'\beta \qquad (1)$$

Where countries are indexed by i and time is indexed by t; y_{it} is the prevalence of child stunting of country i in year t; x_{it} is a vector of independent variables, β is a vector of regression parameters and $g(.)$is the link function. The list of independent variables x_{it} includes weighted logarithms of agricultural GDP per capita, industrial GDP per capita and services GDP per capita to study the impact of sectoral components of economic growth. Following Headey (2013), to account for the size of each sector at the country level and implicitly for the stage of economic growth in which the country is, each sector's logged GDP is weighted by its share in total GDP. The impact of a given increase in agricultural GDP per capita, i.e. agricultural growth, is likely to be small (large) in a country with a small (large) agricultural sector such as Chile (Cameroon). The introduction of sectoral weights thus implicitly accounts for the (more or less advanced) country's stage of development. As a test of robustness and for fitting the best model (i.e. best set of covariates), additional explanatory variables include the level of domestic food prices and a measure of food prices volatility[5].

The estimation of the GEE model uses the Poisson family for the distribution of child stunting, with the logarithmic link function and identity variance function. This characterization is most appropriate, especially because the application of a generalized Poisson model captures the under-dispersion property of the data (Islam et al., 2013). Given such settings, Equation (1) implies that the mean function is:

$$E[y_{it}] = \exp(x_{it}'\beta) \qquad (2)$$

With respect to the correlation structure, we report the results using a Markov working correlation matrix. The variability of spacing of stunting measurements makes the Markov structure of the correlation matrix particularly appropriate. The estimation of the correlation parameters within the framework of the GEE approach is implemented through the Quasi-Least Squares (Schults et al., 2007).

Data

In this study we initially collect a dataset on malnutrition and several potential determinants for a sample of 63 MDG1 countries between 1991 and 2009. The sample is originally identical to the one used in Smith and Haddad (2001). We then exclude countries with less than three observations on child stunting over the period and the final sample includes 50 countries. The full list is available in Appendix (Table A1). For the dependent variable, data for the prevalence of children under five who are stunted is taken from the World Health Organization (WHO). We use stunting (height for age) measures as the variable for child malnutrition because they better capture the process of malnutrition in the medium run than underweight or wasting measures.

For agricultural growth, industrial growth and services growth, we use data from the World Bank database. Following Christiaensen et al. (2011), the decomposition of Gross Domestic Product is based on the calculation of each sector's GDP (per capita) and the size of each sector within the economy. Information on domestic food prices is taken from the publicly available Food and Agriculture Organization Food Security Indicators. The measure of volatility of food prices is calculated as the coefficient of variation of monthly food prices

[5] We originally included variables to control for the social and infrastructural environment; women's status and access to improved sanitation facilities. However, as will be further explained in Section 4, both variables were excluded for fitting the best model.

that are taken from the International Labor Organization (ILO) database. Descriptive statistics can found in Table A2 in appendix.

Table 1. Description of key variables

Variable name	Definition	Source
Child stunting	Prevalence of children under five who are stunted[6] (%).	WHO
Agricultural growth	Weighted logarithm of per capita agricultural GDP	World Bank
Industrial growth	Weighted logarithm of per capita industrial GDP	World Bank
Services growth	Weighted logarithm of per capita services GDP	World Bank
Food prices	Annual domestic food price index, as the division of Food Purchasing Power Parity by the general Purchasing Power Parity	FAO
Food prices volatility	Coefficient of variation of monthly food prices	ILO

Moreover, we run multicollinearity diagnostics on all variables as multicollinearity often affects macroeconomic data (e.g. GDP, prices). It is especially important to run those diagnostics because multicollinearity can lead to biased inference. The condition index is approximately 6.2, which is well below the threshold value indicating potential issues (around 15), confirming that the analysis is not affected by multicollinearity.

Results

This paper aims to estimate and compare the impacts of each economic sector on the prevalence of child stunting. Table 2 displays the GEE estimation results[7] from the model developed in Equation (1). Estimation results are based on the sandwich-type robust sandwich covariance matrix. Constant terms, regional and year dummies are included in the estimations. First, we examine whether our *ex ante* choice of the correlation structure is correct because an inappropriate correlation structure would result in inefficient parameter estimation. As observations are collected for a number of countries for several years, we argue that a specification with time dependence is required. Even though the Markov specification fits better our data, we compare it to another time-dependent structure, $AR(1)$, which could also be fitting. Hardin and Hilbe (2003) suggest calculating the quasilikelihood under independence model information criterion (QIC) developed by Pan (2001) to determine which correlation structure is preferred. However, Hin and Wang (2009) develop a correlation information criterion (CIC) that improves the QIC performance for correlation selection. Therefore we calculate the CIC for all models and confirm that the Markov specification is the most suitable because it gives the lowest CIC.

We now turn to the estimation results of Model 1. We calculate and report the average marginal effects of sectoral growth on the prevalence of child stunting because they are

[6] Stunting is defined as having a height (or length)-for-age more than two standard deviations below the median of the NCHS/WHO growth reference set by the WHO in 1995.

[7] Also, as we acknowledge that there is missing data in the dataset, we assume that stunting data are missing completely at random, therefore the GEE estimation provides consistent coefficient estimates (Horton and Lipsitz, 1999).

directly comparable with estimates obtained with traditional linear estimations. The average marginal effects for sectoral growth are all significant and of expected sign, i.e. negative. For example, the average marginal effect of services growth on stunting is about -0.110 and is significant at 1 per cent. In other words, a 1 percentage point increase in services GDP per capita is expected to reduce the prevalence of child stunting by approximately 0.13 per cent. Given the well-acknowledged importance of women in food security (e.g. Smith and Haddad, 2001), this linkage is not surprising as the services sector is arguably biased towards female employment in developing countries, because employers often pay women less as they are seen as a second and complementary income earner. In addition, the average marginal effects of industrial growth (-0.100) and agricultural growth (-0.086) are significantly negative, suggesting stunting-reducing impacts, though lower than for services growth. These results seem to indicate that the services sector is the most effective in reducing child stunting. Wald tests validate our finding as we find that the impacts of services growth are significantly larger than those of industrial or agricultural growth, and that those of industrial growth are larger than that of agricultural growth, confirming that agriculture is the least effective sector for generating decreases in child stunting. The lower employment intensity of agriculture may result in lower impacts of agricultural growth on child malnutrition (e.g. Kapsos, 2005). In particular, we find that a 1 percentage point reduction in child stunting is achieved by a yearly per capita growth rate of 12.3 per cent in the agriculture sector. Meanwhile, to achieve similar results, industrial growth and services growth rates only need to reach, respectively, 10.47 per cent and 9.5 per cent annually. These results are consistent but nonetheless much higher than the one found in Headey (2013) who finds that it would take a per capita growth rate of 6.5% in non-agricultural GDP per year to reduce stunting prevalence by 1 percentage point per year.

Further, we estimate an extended model as a test of robustness and for choosing the best set of covariates. We compute the QIC for covariate selection and find that the QIC for Model 2 (264.37) is much lower than the QIC for Model 1 (371.34). This means that Model 2, which includes food prices and food prices volatility as well as the sectoral growth variables, is the preferred model[8]. First, the main pattern of results holds. A 1 percentage point increase in services GDP per capita is expected to decrease the prevalence of child stunting by 0.13 percentage point. Again, though the estimated effect of agricultural and industrial growth is significant and negative, the magnitude of their impacts appears relatively small, suggesting limited impacts towards reductions in child malnutrition. Again, Wald tests confirm the significance of the differences observed. In other words, services growth seems to be the most effective way to reduce child stunting and the role of agriculture in reducing child stunting seems limited. Second, it is noteworthy that the average marginal effects of sectoral growth on child stunting from Model 2 are somewhat larger than those for Model 1. For example, the coefficient for the impact of services growth is -0.133 (and significant at 1 per cent) against -0.110. Overall, these estimates imply that the necessary rate of agricultural growth to decrease child stunting by 1 per cent is approximately 11.1%, against 9.7% for industrial growth and 7.8% for services growth. While these estimates for industrial and services growth are lower than those found with Model 1, they remain relatively greater than the one for non-agricultural growth found in Headey (2013).

[8] The full model also included access to improved sanitation facilities and women's status (e.g. Smith and Haddad, 2001). We exclude variables one at a time and calculate the QIC to fit the best model,

Table 2. Impacts of sectoral growth on child stunting

	Model	
	(1)	(2)
Weighted Log (Agriculture GDP per capita)	-0.086**	-0.095**
	(0.033)	(0.042)
Weighted Log (Industry GDP per capita)	-0.100***	-0.107***
	(0.018)	(0.018)
Weighted Log (Services GDP per capita)	-0.110***	-0.133***
	(0.021)	(0.025)
Food prices		0.020[#]
		(0.012)
Food prices volatility		0.016
		(0.042)
Constant	0.168**	0.181**
	(0.074)	(0.087)
QIC	371.34	264.37
CIC	0.80	0.58
N	275	191
Number of countries	50	39

Source: Authors' calculations. Notes: *, **, ***: significant at 1, 5 and 10 per cent. [#]: marginally insignificant. Robust standard errors in parentheses. Regional and yearly dummies are included.

Finally, the effect of food prices is, as expected, positive but is only marginally insignificant (p-val.: 0.107). This result provides some weak evidence of the impacts of food prices on stunting. If domestic food prices increase by 1 per cent, the prevalence of child stunting is expected to increase by approximately 0.05 per cent. Although these impacts seem particularly small, they are somewhat consistent with Arndt et al. (2010), who report very small impacts. The coefficient for food prices volatility is also of positive sign but is however insignificant.

Conclusions

The question of how to fight child malnutrition is back high on the agenda, as a period of high food prices has increased the attention for food security and hunger (Squicciarini et al., 2013), and the MDG timeline is reaching its end. Many developing countries will fail to meet the objective on reducing malnutrition. The FAO and the World Bank believe that the agricultural sector is the most important sector for fighting malnutrition. While this policy narrative may appear at first logical, the evidence base to support the prioritization of agriculture towards reducing malnutrition is weak and some economists and policy makers have been questioning the putative superior role of agriculture in development (e.g. Dercon, 2013).

Given this background, this paper fills the gap in the literature and estimates the comparative impacts of increases in GDP per capita of each sector (i.e. sectoral growth), on the prevalence of child stunting. Our findings show that the necessary rate of agricultural growth to decrease child stunting by 1 per cent is approximately 11.1%, against 9.7% for industrial growth and 7.8% for services growth. Hence, contrary to the widely accepted view on the central role for agriculture in fighting hunger, our results show that the agricultural sector is the least effective in reducing child stunting. In addition, we find that the impacts of food prices on child stunting are very limited. For example, an increase in domestic food prices of 1% is expected to increase child stunting by approximately 0.05%. This figure is somewhat consistent with previous research (Arndt et al., 2012). Last, we find no evidence that food price volatility affects child stunting over the period observed.

Our results are of interest for policy makers and economists involved in the fight against malnutrition in that they challenge the overstated role of agriculture in fostering development and in fighting food insecurity. They may have clear policy implications with respect to the sectorial dimension of investments in developing countries and may suggest a relative prioritization of investments in the services sector. However, given how sensitive such conclusions are, some caution is required when interpreting our results and in drawing general rules for economic policy. Although the development of the tertiary and secondary sectors will in principle improve the environment in which farmers operate by lessening some of the market failures and reducing high transaction costs that affect agriculture in developing countries, it is unlikely that it can alone (and case-independently) resolve more structural issues relating to the farming process; consequently agricultural investments should keep being an integral part of any program fighting child malnutrition even if they may be partially substituted by industrial and services investments in proportions that will vary in each specific case. In other words, in general investment strategies should be supportive of all economic sectors, because of the existence of numerous, diverse and complex linkages between sectors.

From a methodological perspective, we have demonstrated that the use of GEE models may be a relevant alternative to traditional linear approaches for empirical studies treating with fractional data (which are common in food security and nutrition) and thus help towards understanding the relationships between sectoral growth and child nutrition. Yet, the paper suffers from a caveat in that it does not incorporate the dynamic nature of the relationship between economic growth and malnutrition. This is left for future research that could aim at explicitly introducing the existing (nonlinear) pathways between the different economic sectors and nutrition over time. Finally, one could explore the issue of intra-sectorial growth and disaggregate economic growth to look at which activities are the most efficient within each economic sector.

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Appendix

Table A1. List of MDG1 countries

Africa	Arab States	Asia and Pacific	Latin American and the Caribbean
Benin	*Algeria*	Bangladesh	Bolivia
Burkina Faso	Egypt	China	Chile
Cameroon	Jordan	India	Colombia
Comoros	Morocco	Indonesia	*Dominican Republic*
Cote d'Ivoire	Tunisia	Lao PDR	*El Salvador*
Democratic Republic of the Congo		Nepal	*Guatemala*
Guinea		Pakistan	*Guyana*
Kenya		Philippines	*Honduras*
Lesotho		Sri Lanka	*Jamaica*
Madagascar		Thailand	*Nicaragua*
Malawi		Viet Nam	*Panama*
Mauritania			Peru
Nigeria			Venezuela
Rwanda			
Senegal			
Sierra Leone			
United Republic of Tanzania			
Togo			
Uganda			
Zambia			
Zimbabwe			

Table A2. Descriptive statistics

	Mean	Std.dev.	Min	Max
Prevalence of child stunting (%)	34.35	16.49	2.00	76.70
Weighted Log (Agricultural GDP per capita)	1.08	0.65	0.09	3.56
Weighted Log (Industrial GDP per capita)	1.61	0.93	0.30	5.20
Weighted Log (Services GDP per capita)	3.05	1.02	0.91	6.50
Food prices	1.87	0.40	1.16	4.33
Food prices volatility	0.05	0.36	0.00	11.27

Note: based on the sample of 39 countries.