Crop Diversification and Child Health: Empirical Evidence From Tanzania

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ABSTRACT. Malnutrition is a major issue in developing countries with long-term implications for economic development. Agricultural diversification has been recognized as a strategy to improve nutrition and human health, and a risk coping strategy in the face of climate change. We use the 2008-2010 Tanzania National Panel Survey, which includes about 3,700 children, to investigate the effect of crop diversification on child health. We use an instrumental variable approach and estimate the effect of crop diversification on child growth by controlling for unobserved heterogeneity. We show that crop diversification has a positive and significant impact on long-term child nutritional status.

Keywords: crop diversification, food security, health, nutrition, development

JEL Classification: I12, I15, Q18

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1. Introduction

Improving children nutrition has become an important goal for most developing countries' governments given its long-term implications for health, human capital formation, productivity and income during adulthood, and economic development (World Bank, 2006; Victora et al. 2008). Malnutrition is recognized as a major issue among low-income households in developing countries (Black et al., 2008; FAO, 2011; WFP, 2012; and IFAD, 2012). In Tanzania, despite the improvements of the last two decades, child malnutrition is still prevalent, in particular in rural areas where self-sufficient farming is the main source of food (Ecker et al. 2011). About 42% of children under age five are stunted in Tanzania making the country one of the ten worst affected in the world (World Health Organization, 2012).

Children nutritional status can be improved by implementing different strategies such as nutrition educational activities and breastfeeding (Christiaensen and Alderman, 2004; Bhutta et al., 2008). In Tanzania, for example, NGOs have been introducing community driven supplementary feeding of young children and feeding posts (Alderman, 2006). Recently, the diversification of agricultural food production has been recognized as a way to improve nutrition and health (Frison et al., 2006; Johns and Eyzaguirre, 2006; Ecker et al., 2011). However, to the best of our knowledge, there is no systematic empirical evidence on the role played by crop diversification in improving the health status of adults and children. Most of the empirical evidence analyses the short-term effects of income changes on the nutritional status of children (Haddad et al. 2003); the correlation between crop diversification and dietary diversity (e.g., Burlingame, Charrondiere, and Mouille, 2009; DeClerck et al., 2011; Remans et al., 2011), or the relationship between dietary diversity and anthropometric outcomes (e.g., Arimond and Ruel, 2004; Kennedy et al., 2007; Moursi et al., 2008; and Steyn et al., 2006). This paper fills the gap in the literature by investigating the effect of crop diversification on child health in Tanzania.

Monoculture production has proven to endanger food security in particular in view of the increasing climate variability (Di Falco and Chavas, 2008; Di Falco, Yesuf, and Veronesi 2011).[1] Moreover, in areas of prevalent subsistence farming, limited crop diversification discourages dietary diversity, and so might increase children malnutrition (Arimond and Ruel 2004). This latter aspect is of particular importance in Tanzania given the high prevalence of small-scale subsistence agriculture and the volatility and lack of integration of local food markets (Ecker et al., 2011). Crop diversification is also widely recognized as a risk coping strategy used by farmers in the face of climate change (Di Falco and Veronesi, 2013). Despite being advocated by many international organizations as an easy-to-implement response to climate variability (UNFCCC, 2009), crop diversification still remains scarcely adopted in many parts of Sub-Saharan Africa. By analysing the potential effects of crop diversification on children health in rural areas, this paper can provide additional support for the adoption of such resilience strategy in most impoverished areas.

We use the Tanzania National Panel Survey (TZNPS), an integrated survey on agriculture covering about 3,700 children in years 2008 and 2010 to investigate the effect of crop diversification on child health. The use of panel data allows us to account for potential omitted variable bias, i.e. time invariant unobservable factors such as parents' child-bearing abilities. In addition, we account for the non-random household choice of crops by using an instrumental variable approach. In particular, we use as an instrument for household-level diversification the neighbouring crop diversification, that is changes in within-district averages of crop diversification. We find that crop diversification has a positive and

[1] A historic example of the negative effects of monoculture is the potatoes famine experienced in Ireland during the period 1845-52.

significant effect on long-term child nutritional status, in particular for girls. An increase in crop diversification has a positive and significant effect on children's height, while it has no effect on weight, and body mass (BMI). Results are robust to alternative specifications, and they are stronger for self-sufficient households.

The paper is organised as follows. Section 2 describes the data, the health and diversity measures used; Section 3 presents the econometric model, and Section 4 presents the results. Section 5 provides concluding remarks and directions for future research.

2. Data Description

The empirical analysis uses child-level data provided by the Tanzania National Panel Survey conducted in years 2008/2009 and 2010/2011 (round 1 and round 2) by the Tanzania National Bureau of Statistics (NBS) as part of the World Bank Living Standards Measurement Study - Integrated Surveys on Agriculture. The survey collects information on more than 3,000 households (8,000 children under 17) and is representative at the national level. Sample attrition is very low; about 97% of the households were re-interviewed in the second wave. The survey assembles a wide range of information on agricultural production, non-farm income generating activities, consumption expenditures, and other socio-economic characteristics.

In particular, it collects information on anthropometric measures for all children aged seven months and older that allows us to compute a set of standard anthropometric measures: height-for-age z-score (HAZ), weight-for-age z-score (WAZ), and BMI-for-age z-score (BAZ) as measures of child health (Delgado et al., 1986). These measures indicate the number of standard deviations above or below the reference mean value provided by the WHO according to the age and gender of the child. WHO provides reference values for children age 0 to 19 (de Onis 2006; de Onis et al. 2007). HAZ measures long-term nutritional status, while BAZ measures short-term health status and WAZ is considered a combination of both (Caulfield et al. 2006; Delgado et al. 1986).

Crop diversification is measured by using the Margalef index (e.g., Benin et al. 2004; Di Falco et al. 2010), and is calculated as follows:

$$M_{jt} = \frac{C_{jt} - 1}{\ln(A_{jt})}$$

where *C* represents the number of crops grown by the household and *A* is the total area cultivated. The survey collect information on 50 different types of crops and more than 30 permanent crops, the classification is consistent across years, and distinguishes between short and long rainy seasons. We compute the Margalef index considering the total number of seasonal and permanent crops grown in both seasons and excluding non-edible cash crops such as cotton, coffee, tobacco, and spices. As robustness check we also estimate a model where crop diversification is simply measured by the number of crops grown by the household (excluding non-edible cash crops).

We also excluded some children for whom anthropometric measures were not collected (about 12% of all children), and households that split between waves. Table 1 reports the descriptive statistics for the main variables used in the empirical analysis. The statistics refer to 3,719 children (1,436 households; 7,440 observations) that were interviewed in both years and were living in households that report growing crops in both waves. As robustness check, we also restrict the analysis to self-sufficient households, that is households that do not sell the crops grown. This sub-sample accounts for 20% of total households (1,480 observations).

About 50% of the sample are boys and 50% are girls. The average child is eight years old, 116 centimetres tall and weighs 22 Kilos. About 84% of children are severely underweight children (BMI<17.6), 7.3% are underweight (17.5<BMI<18.6), and 9% have an optimum weight (18.5<BMI<25.1). The HAZ is the anthropometric indicator with the lowest average; hence of greater concern. We observe a significant improvement overtime of HAZ and WAZ but not of BMI. About 13% and 24% of the children in 2008/2009 and 2010/2011, respectively, have worked on the farm while about half of them have attended school in the last 12 months. Average land size is six hectares per household in 2008/2009 and increases to 9.5 hectares in 2010/2011. The most common seasonal crop is maize followed by beans and paddy. The number of crops grown increases overtime: households cultivate on average four different crops in 2008/2009 (minimum 1 and maximum 16) and five crops in 2010/2011 (minimum 1 and maximum 19). The descriptive statistics are not significantly different when we consider the sub-sample of households that do not sell crops.

Table 1 – Descriptive Statistics

	Pooled		2008/2009		2010/2011	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Dependent variables						
HAZ (Height-for-age z-score)	-1.728	1.371	-1.786	1.506	-1.670	1.219
WAZ (Weight-for-age z-score)	-1.164	1.089	-1.151	1.151	-1.179	1.006
BAZ (BMI-for-age z-score)	-0.410	1.091	-0.303	1.128	-0.516	1.042
Explanatory variables						
Margalef	0.336	0.225	0.280	0.201	0.392	0.234
Number of crops	4.644	2.618	3.959	2.262	5.330	2.767
Age (in months)	96.705	50.315	84.851	48.986	108.559	48.818
Male (1/0)	0.487	0.500	0.486	0.500	0.487	0.500
Worked on farm (1/0)	0.182	0.386	0.128	0.334	0.236	0.425
Attending school (1/0)	0.518	0.500	0.460	0.499	0.576	0.494
Children 0-5	1.721	1.572	1.743	1.429	1.698	1.703
Children 6-12	2.011	1.391	1.949	1.425	2.072	1.354
Children 13-17	1.061	1.037	1.001	1.033	1.120	1.038
Elderly (1/0)	0.224	0.417	0.210	0.408	0.237	0.425
Total consumption (US$)	1,704	1,520	1,550	1,619	1,858	1,396
Parents' health	0.123	0.362	0.098	0.312	0.148	0.404
Siblings' HAZ	-1.749	1.365	-1.793	1.476	-1.703	1.242
Livestock (1/0)	0.767	0.423	0.766	0.423	0.768	0.422
Land (Ha)	7.783	17.283	6.034	15.953	9.532	18.354
Number of observations	7,440		3,720		3,720	

Notes: [a]Number of observations is 4,864 in pooled sample (2,690 in 2008/2009; 2,174 in 2010/2011).
[b]Number of observations is 7,377 in pooled sample (3,683 in 2008/2009; 3,694 in 2010/2011).

3. Econometric Model

We estimate the effect of crop diversification on children health using the following specification:

$$H_{ijt} = \beta M_{jt} + \mathbf{X}_{ijt}\boldsymbol{\gamma} + \mathbf{Z}_j\boldsymbol{\theta} + \boldsymbol{\mu}_i + \varepsilon_{ijt}, \qquad (1)$$

where H is a measure of the health of child i living in household j at time t; M is a measure of crop diversification (i.e., Margalef index or number of crops), $\boldsymbol{\mu}$ represents children fixed effects, and ε is the individual error term. We control for a set of time-variant child characteristics, $\mathbf{X}$, that include binary indicators of whether the child worked on farm and attended school in the last 12 months. We also include the age of the child (in months) at the time of the survey since surveys were undertaken at different point in time during a two-year period (2008-2009 and 2010-2011). In addition, our base specification controls for household level characteristics, **Z**, including a binary indicator of whether the household owns livestock and variables measuring parents' health and household size. In particular, we control for the number of elderlies in the household, and the number of children in different age groups. While an increase in household members could imply that fewer resources are allocated to a child, it is also possible that larger families provide better quality child care. We also control for total household consumption (a proxy for income) since crop choices could be related to income levels, which in turn could affect the quality of food and healthcare for children.

While the inclusion of child fixed effects allows to control for unobservable time-invariant heterogeneity such as parental and community characteristics, we are still concern with the presence of potential time-variant unobservable variables that could bias our results. In the following sections, we perform some robustness checks by introducing additional control variables that vary overtime to investigate the extent of the omitted variable bias. In addition, we implement an instrumental variable approach where the average crop diversification at the district-level (excluding a household own level of crop diversification) is used as an instrument for household-level crop diversification.

4. Results

The results of the base specification (1) are presented in Table 2. Robust standard errors are clustered at the household level and presented in parenthesis. We find that crop diversification measured by the Margalef index positively affects children's height (HAZ) while we do not find any significant effect of crop diversification on children's weight (WAZ) and body-mass index (BAZ) as reported in columns (1)-(3). The HAZ result is robust to the inclusion of additional child- and household-level explanatory variables (columns (4) and (5)). Similarly, we do not observe substantial changes for the other two measures of health, which remain unaffected by changes in crop diversification. This can be explained by the fact that BMI-for-age z-score and the weight-for-age z measures tend to be more sensitive to short-term shocks and therefore less likely to capture longer-term nutritional status (Delgado et al., 1986). Therefore, the remaining of the section will focus on the effect of crop diversification on the height-for-age measure only.

As robustness check, in the last column of Table 2 we measure crop diversification by the number of crops grown by the household. We found a similar effect. Expanding the portfolio of crops has a positive impact on child health. One extra crop induces an improvement in health equivalent to almost 0.5% increase in total household consumption.

Table 2 – Crop Diversification and Child Health – Fixed Effect Model

	(1) HAZ	(2) WAZ	(3) BAZ	(4) HAZ	(5) HAZ	(6) HAZ
Margalef index	0.439***	0.168	-0.068	0.439***	0.420***	
	(0.125)	(0.116)	(0.084)	(0.126)	(0.126)	
Number of crops						0.036***
						(0.011)
Age (in months)	-0.003**	-0.007***	-0.009***	-0.003**	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Worked on farm				-0.028	-0.024	-0.025
				(0.039)	(0.039)	(0.039)
Attending school				0.065	0.060	0.061
				(0.044)	(0.044)	(0.044)
Children 0-5					0.043	0.043
					(0.034)	(0.034)
Children 6-12					0.031	0.030
					(0.027)	(0.027)
Children 13-17					-0.029	-0.029
					(0.032)	(0.032)
Elderly					0.141	0.140
					(0.102)	(0.101)
Tot consumption (log)					0.081*	0.079*
					(0.048)	(0.048)
Parents' health					0.094*	0.094*
					(0.055)	(0.055)
Livestock					-0.054	-0.054
					(0.051)	(0.051)
Child fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7440	4864	7377	7432	7420	7420
Number of children	3719	2700	3719	3719	3719	3719

Notes: Robust standard errors clustered at the household level in parenthesis. * significance at 10% ** at 5% and *** at 1% level.

4.1 Heterogenous effects

In this section we explore whether the effect of crop diversification varies according to the gender of the child. Table 3 reports the results of estimating our base specification (1) separately for boys and girls. The results show similar effects for boys and girls in the pooled sample. When restrict the sample to those households that did not sell any own produced crop (columns (2) and (5)), the effect is almost doubled and stronger for girls. This is likely to reflect the fact that these households are more likely to base their food consumption on the basket of own produced goods, and girls might rely more on homemade food. Relatively to the impact of a change in total consumption, however, the effects are similar to those obtained on the entire sample.

Table 3 – Effects by Child Gender and Self-sufficient Households

	Boys			Girls		
	All	Self-sufficient households		All	Self-sufficient households	
Dep variable: HAZ	(1)	(2)	(3)	(4)	(5)	(6)
Margalef index	0.431***	0.705**		0.430**	0.974**	
	(0.167)	(0.305)		(0.173)	(0.386)	
Number of crops			0.057**			0.087**
			(0.026)			(0.035)
Tot consumption (log)	0.121*	0.185	0.180	0.034	0.180	0.177
	(0.071)	(0.140)	(0.140)	(0.061)	(0.145)	(0.145)
Child fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3610	765	765	3810	713	713
Children	1831.000	386.000	386.000	1930.000	359.000	359.000

Notes: Fixed effect model. Robust standard errors clustered at household level in parenthesis. * significance at 10% ** at 5% and *** at 1%. All specifications include all the additional control variables considered in column (5) of Table 2.

In Table 4 we explore the effect of crop diversification across different age groups for boys and girls. The results reveal that the effect of crop diversification increases with the age of the child although the impacts on the youngest groups are not statistically significant. The largest effect is on boys and girls aged between 10 and 15.

Table 4 – Effects by Child Gender and Age-group

	Boys			Girls		
	0-5	5-10	10-15	0-5	5-10	10-15
Dep variable: HAZ	(1)	(2)	(3)	(4)	(5)	(6)
Margalef index	0.271	0.381	0.560***	0.174	0.233	0.514**
	(0.399)	(0.343)	(0.160)	(0.456)	(0.225)	(0.260)
Tot consumption (log)	0.282*	0.003	0.071	0.117	0.089	-0.092
	(0.146)	(0.106)	(0.090)	(0.115)	(0.079)	(0.100)
Child fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	994	1338	1278	1067	1414	1329
Children	504	680	645	540	717	671

Notes: Fixed effect model. Robust standard errors clustered at household level in parenthesis. * significance at 10% ** at 5% and *** at 1%. All specifications include all the additional control variables considered in column (5) of Table 2.

4.2 Robustness Checks

In this section, we try to address some remaining endogeneity concerns. One possible concern is that changes in crop diversification could be related to changes in land size and, therefore, reflect an actual increase in agricultural output. While this issue should already be accounted for by using the Margalef index, which considers the amount of land cultivated, and by controlling for total consumption, in columns (1)-(3) of Table 5 we also explicitly control for changes in land size over the period. The coefficient is reduced in size but it remains large and significant.

Table 5 – Additional Control Variables

	Entire sample			Self-sufficient households
Dep. variable: HAZ	(1)	(2)	(3)	(4)
Margalef index	0.387***	0.277**	0.267**	0.419*
	(0.131)	(0.125)	(0.122)	(0.235)
Land (ha)	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Avg. rainfall		-0.002**	-0.002**	-0.004*
		(0.001)	(0.001)	(0.002)
Health siblings			0.082*	0.057
			(0.043)	(0.080)
Child fixed-effects	Yes	Yes	Yes	Yes
Observations	7420	7065	6430	1219
Households	3719	3719	3440	668

Notes: Standard errors clustered at household level in parenthesis. * significance at 10%, ** at 5% and *** at 1%. All specifications include all additional control variables considered in Table 3.

In column (2) we control for changes in average rainfall which could be correlated with farming choices but also with health. In column (3) we include the average health conditions (average HAZ) of a child's siblings. This will allow for shocks that are correlated with both crop diversification and a child health to be capture by their effects on his/her brothers and sisters.

Table 6 shows instrumental variable estimates. The instrument is the average Margalef index at the cluster level, computed excluding a household own products choice. Farming decisions of neighbouring households are likely to have an influence on a household choice of crop variety and, at the same time, both are likely to be affected by the same agri-environmental conditions. This is confirmed in our first stage estimations which are strong for all specifications (the F-statistics are reported at the bottom of the table).

In columns (2) and (3) we include some additional controls to account for changes in district-level conditions (water access and treatment, access to electricity and solar energy) that could confound the effect of the instrument if omitted. Finally, we also include a measure of the intensity of agricultural extension officers visits at the district level to deal with the potential correlation between extension services, crop choices, and health. The negative coefficient of this variable suggests that extension services might be targeting relatively poorer and less healthy households.

Table 6 – Instrumental Variables Estimates

	Full sample			Self-sufficient households
	(1)	(2)	(3)	(4)
Margalef index	3.326***	3.469***	3.637***	4.229***
	(0.581)	(0.632)	(0.634)	(1.181)
Pipe water (district)		-0.142	-0.139	1.485**
		(0.183)	(0.184)	(0.585)
Treated water (district)		0.847***	0.930***	0.433
		(0.161)	(0.163)	(0.355)
Elect/solar (district)		0.594	0.271	-0.059
		(0.453)	(0.459)	(0.825)
Agricultural extension (district)			-0.006***	-0.008***
			(0.001)	(0.003)
Child fixed-effects	Yes	Yes	Yes	Yes
Observations	6614.000	6614.000	6614.000	1280.000
First stage F statistic	154.734	133.701	134.132	43.763

Notes: Robust standard errors in parenthesis. All specifications include all additional control variables considered in Table 5.

5. Conclusions

Although poverty and children malnutrition are predominant in developing countries, and agricultural diversification has been recognized as a strategy to improve nutrition and human health, and a risk coping strategy used by farmers in the face of climate change, very little empirical evidence exists on the links between agriculture, nutrition, and health. This is the first paper to show a positive correlation between crop diversification and child health. We use panel data from the Tanzania National Panel Survey conducted in 2008/2009 and 2010/2011 to investigate the impact of crop diversification on child health. This study shows that crop diversification has a positive impact on child height while it does not affect weight and BMI. The positive effect of crop diversification on long term nutritional status suggests that agricultural policies should have a greater focus on agricultural diversification in general, and on crop diversification and nutritional quality of the production in particular.

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