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Agricultural production and children's diets: Evidence from rural Ethiopia

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ABSTRACT

We study the relationship between pre-school children's food consumption and household agricultural production. Using a large household survey from rural Ethiopia, we find that increasing household production diversity leads to considerable improvements in children's diet diversity. However, we also document how this non-separability of consumption and production does not hold for households that have access to food markets. These findings imply that nutrition-sensitive agricultural interventions that push for market-integration are likely to be more effective in reducing undernutrition than those promoting production diversity.

Keywords: agricultural household models, child dietary diversity, food markets, count data

JEL codes: O12, Q12, Q18, D12

1. INTRODUCTION

Improving the diet of children has intrinsic and instrumental value. Intrinsic because improving the wellbeing of children is of value in its own right. Instrumental because healthy diets are important for the development of well-nourished and healthy children who in turn become healthy and economically productive adults. Globally approximately 165 million children under five years of age are chronically undernourished or stunted. Black et al (2013) note that there is strong evidence that the promotion of appropriate diets and complementary feeding in the first two years of life reduces the incidence of stunting. There is growing evidence that the quality of children's diets – specifically the consumption of nutrient rich legumes and animal source foods as well as vitamin-rich fruits and vegetables – is as important as the quantity of calories consumed. Arimond and Ruel (2004), Mallard et al. (2014), and others find that diverse diets are associated with reductions in chronic undernutrition. It is not surprising, therefore, that improving the diets of children has attracted attention from policymakers and researchers.

In developed countries, improving children's diets has focused on two broad sets of interventions: income and in-kind transfers, and nutrition education. In the United States, for example, there are studies of the effectiveness of school breakfasts (Bhattacharya, Currie, and Haider 2006), school lunch programs (Campbell et al. 2011), food stamps (Jolliffe et al. 2005), and maternal knowledge of good nutrition practices (Variyam et al. 1999). A common, though implicit, theme of this work is that constraints to improving children's diets all lie on the demand side. Put another way, food markets are sufficiently integrated that production and consumption decisions are separable (Singh, Squire, and Strauss 1986). But in developing countries, separability may not hold. If markets are not integrated, food production will affect what foods are available for consumption. Non-separability has important policy implications. If agricultural assets or inputs in some crop or livestock product influence nutrition more than others, there may be a case for either policies that promote these assets and inputs – even if their income effects are comparable to less nutritionally relevant investments – or those that facilitate value chain development that leads to improved market access (Hoddinott, Headey, and Dereje 2015). As Ruel and Alderman (2013) note, in the context of developing countries nutrition, agriculture plays a dual role – a source of income and a mechanism by which healthy and diverse foods are made available for consumption.

In this paper, we examine the relationship between the diversity of household agricultural production and the diversity of pre-school children's food consumption in rural Ethiopia, controlling for a variety of household characteristics, including wealth and the level of agricultural production and the endogeneity of production diversity. Ethiopia is a good site for such a study. Its diverse agro-climatic conditions mean that it is possible to grow an enormous variety of foods across the country – the survey instrument used to collect our production data lists 80 different items. But rugged terrain and poor infrastructure mean that, while urban grain markets appear to be integrated (Rashid and Negassa 2011), access to non-staple foods, such as dairy products, varies widely (Headey 2014). Chronic undernutrition is widespread and many children eat monotonous, undiversified diets (Central Statistical Agency and ICF International 2012).

We find that increasing household production diversity leads to considerable improvements in children's diet diversity. This finding – remarkably robust to different econometric modelling techniques – implies that household production and consumption decisions are non-separable in this context. This is likely due to the poor market integration in rural Ethiopia: most households in our sample live far away from markets where they can buy and sell food products. Indeed, further tests show that the non-separability in production and consumption breaks down in those households that have reasonably good access to a food market.

2. DATA AND DESCRIPTIVE ANALYSIS

Making progress on this topic requires data on both agricultural production and children's diets. Agricultural production surveys typically have rich information on the commodities that households produce but usually lack detailed information on consumption, particularly the consumption of individual household members. Surveys of health and nutrition, such as the Demographic and Health Surveys fielded in many developing countries, collect data on anthropometry and children's diets, but do not contain information on agricultural production. We draw on a data set which, unusually, contains both. It also includes GPS coordinates for the location of the residence of the survey sample households.

We use cross-sectional survey data collected between June and July 2013 in five regions of Ethiopia: Amhara, Oromiya, SNNPR[1], Somali, and Tigray. The purpose of the survey was to obtain pre-intervention (baseline) information in localities that were to receive investments to improve agricultural production and nutrition under the Feed the Future (FtF) program funded by the United States Agency for International Development (USAID) or in localities that were to act as comparison sites for the evaluation of FtF. [2] While these data are not representative of these regions, the sample is large – 7,011 households – and widespread, the survey having been implemented in 252 villages in 84 *woredas.*[3] We have 4,214 children aged 6 to 71 months in our sample.

Diets of children were assessed using the protocols recommended by the World Health Organization for assessing infant and young child feeding (IYCF) practices. Mothers were asked a series of yes/no questions about foods consumed by children younger than 72 months who currently reside in the household. These were grouped into seven categories: Grains, roots and tubers; Legumes and nuts; Dairy products (milk, yogurt, cheese); Flesh foods (meat, poultry and fish products); Eggs; Vitamin A rich fruits and vegetables; and Other fruits and vegetables. Consumption of a diverse set of foods is necessary if children are to meet both their energy and their micronutrient needs. For example, Allen (2013) notes that, while meat has much more iron and zinc than milk and eggs, milk has more folate and calcium, and eggs have more Vitamin A. Children who consume from at least four groups during the previous day have a high likelihood of consuming animal-source foods and at least one fruit or vegetable as well as a staple food, such as a grain, root, or tuber (WHO 2008).

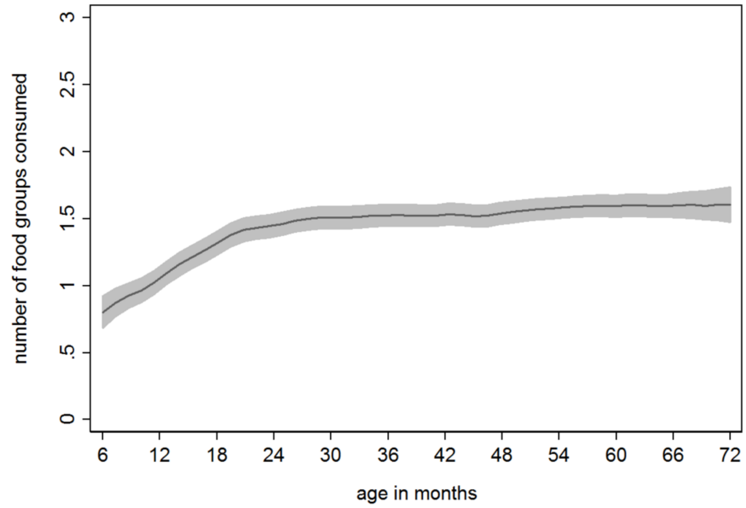
Figure 2.1 shows a locally weighted regression of the association between child age and the number of food groups consumed by that child in the previous 24 hours for the children in our study sample. Children's diets are poor at all ages. At ages six to 12 months, children consume from only one food group, rising to 1.5 groups at age 24 months and staying constant after that. Few children 6 to 24 months of age or 25 to 71 months of age consume from at least four food groups (3.1 and 4.4 percent respectively). There are no significant gender differences in the mean number of food consumed by children of different ages or of the percentage consuming from four or more groups.

Table 2.1 shows the contents of this highly monotonous diet for the full sample and disaggregated by age, sex, and region. Just over half of all children (56 percent) consume a staple grain, root, or tuber. A third consume a legume or nut food and just over 20 percent consume dairy products and vitamin A rich fruit or vegetables. Virtually no children consume meat, poultry, fish, or eggs. There is little difference when we disaggregate by age or

[1] SNNPR stands for Southern Nations, Nationalities, and Peoples' Region.
[2] For more details of the survey, see Bachewe et al. (2014).
[3] *Woreda* corresponds to district and is the third highest administrative unit in Ethiopia (after region and zone).

sex, but there are marked regional differences, especially in the percentage of children consuming legumes (53 percent in Tigray; two percent in Somali), dairy (50 percent in Somali; six percent in Amhara) and vitamin A rich fruits and vegetables (55 percent in SNNPR; six percent in Tigray and Somali).

Figure 2.1—Diet diversity by age



Notes: The shaded area represents the 95%-confidence interval
Source: Feed the Future Survey 2013

Table 2.1—Food group consumption by age, sex and region, by percent of households with young children

	Grains, roots and tubers	Legumes and nuts	Dairy products	Poultry, fish, meat	Eggs	Vitamin A rich fruits & vegetables	Other fruits and vegetables
All children	56	32	22	3	4	26	3
By age:							
6-24 months	43	26	22	2	5	16	3
25-71 months	60	34	22	3	4	29	3
By sex:							
Girls	56	32	21	3	5	25	3
Boys	56	32	23	3	4	27	3
By region:							
Tigray	45	53	15	6	6	6	5
Amhara	29	42	6	1	2	10	0
Oromiya	62	42	27	2	7	27	4
SNNPR	71	9	24	2	2	55	3
Somali	67	2	50	8	4	6	2

Source: Feed the Future Survey 2013

We then map household agricultural production data, both crops and livestock, to these seven groups. Table 2.2 provides information on household production diversity for all households and disaggregated by region. Nearly all households produce staple foods, while more than one third of the households produce legumes and nuts. About 23 percent of the households produce dairy products and 22 percent produce meat. The production of other food groups is somewhat less common, ranging between 9 and 15 percent. Looking at the regional data, there are some suggestions that production is correlated with child food consumption; for example, consumption of dairy products is highest in the two regions, Oromiya and Somali, where dairy production is highest.

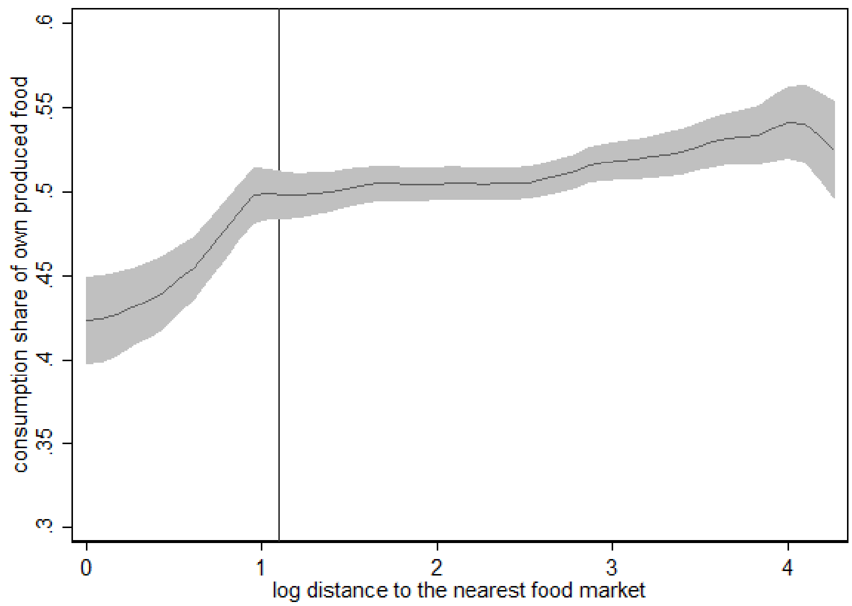
Table 2.2—Food group production by region, percent of households with young children

	Grains, roots and tubers	Legumes and nuts	Dairy products	Poultry, fish, meat	Eggs	Vitamin A rich fruits & vegetables	Other fruits and vegetables
All children	93	37	23	22	15	9	10
By region:							
Tigray	94	36	29	48	38	0	17
Amhara	95	55	4	21	6	3	9
Oromiya	94	36	32	22	21	6	5
SNNP	97	29	16	8	7	24	17
Somali	63	10	52	28	9	3	4

Source: Feed the Future Survey 2013

The survey also included a standard household level food consumption module based on a 7-day recall. Looking at the sources of food consumption reveals that, for an average household in our sample, 50 percent of the total food consumption comes from own production,[4] 44 percent of foods are purchased, and the remaining six percent come from gifts, food aid, or other sources. Figures 2.2a and 2.2b study how these consumption sources differ by access to food markets. The mean distance to the nearest food market in our sample is 10.9 kilometers (median: 8 km). Figure 2.2a shows locally weighted regressions of the association between the share of own produced food in total food consumption and the household's distance to the nearest food market. Figure 2.2b uses the share of purchased food instead of own produced food. We see that households living near food markets consume less own produced and more purchased food than households living farther away from the food markets. Of note is that the share of own produced food remains below the 50 percent mark until about 3-kilometre distance from the nearest food market (the vertical line in Figure 2.2a). The opposite pattern emerges for purchased food share (Figure 2.2b).

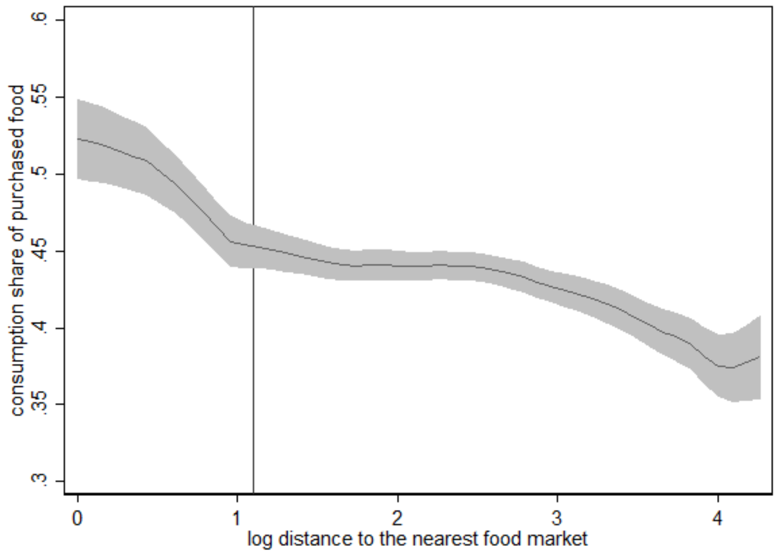
Figure 2.2a—Share of own produced food in total food consumption and access to food markets



Notes: The vertical line refers to 3 km distance to the food market. The shaded area represents the 95%-confidence interval.
Source: Feed the Future Survey 2013

[4] For comparison, the 2010/11 Household Consumption and Expenditure Survey finds that for rural households, 44 percent of the total household expenditure came from own production (Central Statistical Agency [Ethiopia] 2012).

Figure 2.2b—Share of purchased food in total food consumption and access to food markets

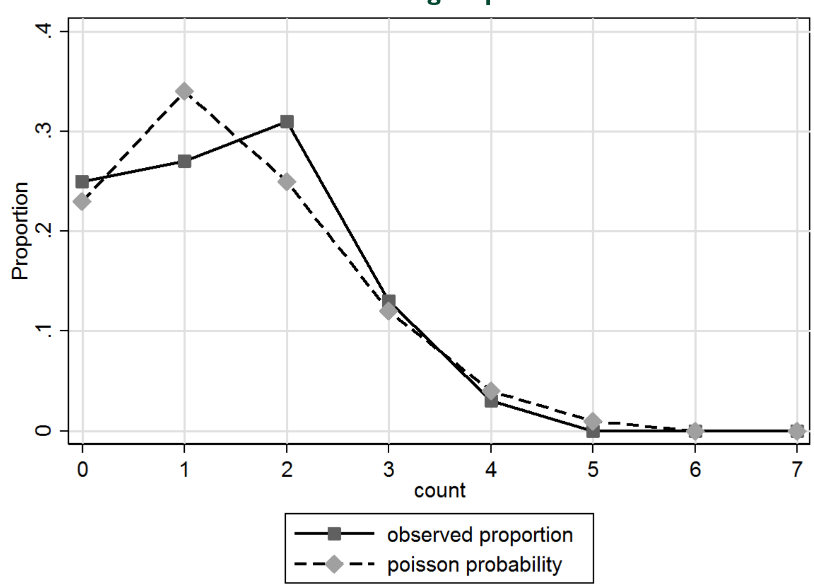


Notes: The vertical line refers to 3 km distance to the food market. The shaded area represents the 95%-confidence interval.
Source: Feed the Future Survey 2013

3. ECONOMETRIC APPROACH

The econometric analysis focuses on the relationship between children's diets and the diversity of household food production. We control for other factors that could affect children's diets: child sex and age; household education, income, and wealth; access to markets; and food prices. Means and standard deviations for these variables are found in Table 3.1. Our dependent variable, the number of food groups consumed by the child takes only non-negative integer values. This apparent departure from normality warrants a count-data modelling approach.[5] The Poisson model is a natural starting point as it accommodates the discrete nature of the dependent variable. Figure 3.1 shows that the Poisson distribution fits the unconditional distribution well. It is particularly reassuring that excess zeroes or other forms of over-dispersion do not seem to be a concern in our outcome variable.

Figure 3.1—Fitting a Poisson distribution on number of food groups consumed



Source: Feed the Future Survey 2013

[5] Note that log-transformation of count data will result in biased and inconsistent estimates (King, 1988) and therefore is not an appropriate strategy here.

Table 3.1—Summary statistics

	mean (std. dev.)		mean (std. dev.)
number of food groups consumed	1.458	**Community level characteristics:**	
	(1.153)	market within 3km range	0.168
Household level characteristics:			(0.374)
number of food groups produced	2.088	(log) price of barley (kg)	2.132
	(1.134)		(0.791)
(log) total value of livestock production	3.259	(log) price of wheat (kg)	2.732
	(4.107)		(1.057)
(log) total value of crops harvested	8.271	(log) price of maize (kg)	1.715
	(2.536)		(0.543)
(log) land size in acres	0.596	(log) price of sorghum (kg)	2.331
	(1.153)		(1.195)
(log) value of durable assets	3.629	(log) price of onions (kg)	2.340
	(3.490)		(0.669)
males 0-5 years	0.904	(log) price of tomatoes (kg)	2.863
	(0.794)		(1.108)
males 6-15 years	0.866	(log) price of cabbage (kg)	0.827
	(0.989)		(1.646)
males 16-60 years	1.062	(log) price of teff (kg)	2.601
	(0.621)		(0.650)
males 61+ years	0.0344	(log) price of egg	0.701
	(0.182)		(0.327)
females 0-5 years	0.905	(log) price of beef (kg)	4.491
	(0.792)		(0.486)
females 6-15 years	0.855	(log) price of milk (liter)	1.411
	(0.965)		(0.756)
females 16-60 years	1.132	village has electricity	0.181
	(0.443)		(0.385)
females 61+ years	0.0214	village has piped water	0.482
	(0.148)		(0.500)
highest level of education (in years) among adult members (>15 years)	2.745	Tigray region	0.102
	(3.477)		(0.303)
age of head	36.46	Amhara region	0.227
	(10.57)		(0.419)
female head	0.142	Somali region	0.067
	(0.349)		(0.251)
Muslim	0.293	Oromiya region (reference)	0.368
	(0.455)		(0.482)
Orthodox	0.432	SNNP region	0.236
	(0.495)		(0.424)
other Christian religion (reference)	0.250	**Excluded instruments:**	
	(0.4330)	average temperature (°C)	19.71
other religion	0.0252		(2.905)
	(0.157)	(average temperature) * (elevation)	38.02
Child level characteristics:			(8.868)
male child	0.502	elevation (in km)	1.983
	(0.500)		(0.537)
age-in-month-splines:		village has steep-sloping land (≥ 40 degrees)	0.0233
less than 12 months	11.79		(0.151)
	(0.917)		
12 to 24 months	10.10		
	(3.984)		
more than 24 months	17.55		
	(15.18)		

Notes: Sample size is 4,214 children
Source: Feed the Future Survey 2013.

We model the number of food groups consumed by child i from household h located in village v (d_{ihv}) as a function of the number of food groups produced by the child's household (p_{hv}):

$$d_{ihv} = \exp(\beta p_{hv} + c_{ihv}{}'\gamma + x_{hv}{}'\delta + k_v{}'\vartheta) + \varepsilon_{ihv}, \qquad (1)$$

where $x_{hv}{}'$ is a vector of household level characteristics including the (log) value of crops harvested, (log) value of livestock slaughtered and livestock products produced, demographic characteristics (including household size), highest level of education in the household, (log) value of durable assets, and head's characteristics (age, sex, and religion). Child specific controls $c_{ihv}{}'$ include sex and age. The community level variables (k_v') attempt to capture households' access to food. These include a vector of prices for 11 food items, and a dummy variable (0/1) if the community has a market within a 3 km range. We also control for community's access to electricity and piped water, and include dummy variables for each region to capture unobserved region level characteristics that may affect diet diversity. The error term ε_{ihv} enters the specification additively.[6] Finally, the standard errors are clustered at the *woreda* level.

The coefficient β captures the main relationship of interest: the impact of production diversity (number of food groups produced by the household) on children's diet diversity (the number of food groups consumed by the child). However, there are at least two reasons to believe that estimates of β might be biased. First, if there is (classical) measurement error in our estimate of production diversity, β will be biased downwards. Second, despite our inclusion of a rich set of control variables, the relationship described in (1) may be affected by unobserved characteristics that are correlated with household's production diversity but also with diet diversity. For example, households that have diversified production may share a common trait of caring more (or less) about their children's health (and hence their diet diversity). As we are not able to observe such traits in the data, this would lead to a biased estimate on the impact of production diversity on diet diversity. In the presence of such unobservables $\mathrm{corr}(p_{hv}, \varepsilon_{ihv}) \neq 0$, and therefore the estimated parameter of interest (β) would be biased. It is not possible to tell beforehand whether this leads to a positive or negative bias in our estimate. Fortunately, we can think of credible instruments to address this endogeneity concern.

Our instrumental variables (IV) strategy is based on two observations. First, households' production choices are constrained by various agro-ecological factors, such as climate and terrain. This is particularly the case for Ethiopia – a vast country characterised by large heterogeneity in agricultural potential (Chamberlin and Schmidt 2012). Second, as there are no private land markets in Ethiopia, households are restricted in terms of where they can live. All land is owned by the state. Individual farmers have usufruct rights granted by local government authorities who provide privileged access to those who already live in that locality (Ambaye 2012). With this being absent, households seeking a certain level of production diversity could migrate to localities providing the conditions for that degree of diversity. But in Ethiopia, this relocation is simply not possible.

We have four instruments to predict household's production diversity. First, farmers adapt their production choices according to the local climate. We use long-term temperature to proxy for climatic conditions in the village. The data for this variables come from NASA's Modern-Era Retrospective analysis for Research and Applications (MERRA). MERRA is a global gridded data set based on retrospective analysis of historical weather data obtained from satellite images and weather stations (Rienecker et al. 2011). We use GPS coordinates to link the gridded temperature data to the FtF villages. The data set provides daily temperature measures aggregated into grids that are 1/2° in latitude × 2/3° in longitude (roughly 55 km × 75 km at the equator). We take the data from 1981 to 2013 to construct the mean temperature in the village over the past 32 years.

Second, the Ethiopian topography is extremely diverse ranging from lowlands in the south to large elevated plateaus in the central part to rugged highlands in the north. Elevation above sea level determines how much temperature varies within a day. In high elevation locations, temperatures can vary enormously between

[6] The error structure can also be assumed to be multiplicative where the first term is multiplied with the error term: exp( )ε_{ihv}. In the standard Poisson model, the two formulations are equivalent but this is no longer the case if one (or more) of the regressors is endogenous (e.g. Windmeijer and Santos Silva 1997; Winkelmann 2008, p. 159). Our IV-results are robust to assuming a multiplicative error structure (see Appendix B).

day and night. As certain crops are more resistant to cold (e.g. barley) than others (e.g. maize), elevation poses another constraint to production choices.

Third, as described above, the impact of temperature on production choices varies with elevation. To capture this relationship, we interact elevation with the temperature variable.

Finally, the slope of the land affects drainage and the level of erosion. Production choices are more limited on steep sloping plots. Our fourth IV captures villages located on steep-sloping lands (40 degree slopes or more). The slope data come from the Harmonized World Soil Database (FAO/IIASA/ISRIC/ISSCAS/JRC 2012). We link these data to our survey data using GPS coordinates.[7]

4. RESULTS

Table 4.1 shows our regression results. Columns 1 and 2 provide the OLS and the Poisson coefficients that treat production diversity as exogenous. All Poisson model estimates are marginal effects at the means. The regression diagnostics suggest that the Poisson model provides a good fit to the data. The Poisson coefficient on the household's production diversity is significant at the 5 percent level. However, the magnitude of the association between household production diversity and children's diet is small: one food group increase in household's production diversity improves the diversity of the diet of children 6-71 months by only 0.09 (Poisson model) to 0.11 food groups (OLS model).

Table 4.1—The impact of production diversity on child diet diversity

Dependent variable: number of food groups consumed	OLS	Poisson	Linear-IV (GMM)	Poisson-IV (GMM)
	(1)	(2)	(3)	(4)
Number of food groups produced	0.107**	0.089**	0.729***	0.574***
	(0.045)	(0.037)	(0.263)	(0.155)
Controls:	Yes	Yes	Yes	Yes
R^2	0.222	-	-	-
Pearson goodness-of-fit test	-	3250	-	-
--- p-value	-	1.00	-	-
Weak-identification tests:				
Cragg-Donald F-statistic	-	-	21.00	-
Angrist-Pischke F-test of excluded instruments	-	-	2.65	-
--- p-value	-	-	0.040**	-
Over-identification test:				
Hansen-J	-	-	1.638	2.049
--- p-value	-	-	0.651	0.562

Notes: Standard errors clustered at the woreda level in parentheses. The standard errors for the marginal effects at the means in columns 2 and 4 are computed using the delta-method. *** p<0.01, ** p<0.05, * p<0.1. Sample size is 4,214.

Source: Feed the Future Survey 2013

Columns (3) and (4) provide the IV estimates. For the least squares estimates, we use a linear Generalized Method of Moments (GMM) IV-model [8] while for the Poisson model, we apply a non-linear instrumental variable technique based on the GMM framework (Mullahy 1997). Table A1 of Appendix shows the first stage results based on the linear model. The coefficients on the four instruments appear with *a priori* correct signs. Fixing the

[7] Since all our instruments are defined at village level, they may also affect food availability in the village. This would violate the exclusion restriction. We address this issue by including a number of village level characteristics in our models to control for food availability (see above).

[8] The two-step GMM implemented here is more efficient than the conventional two-stage least squares model when standard errors are heteroskedastic and the equation is over-identified (Cameron and Trivedi 2005, p. 187-8). The two conditions are satisfied in our application. First, the number of instruments (4) exceeds the number of endogenous regressors (1). Second, the null of homoscedasticity is rejected in our application: the White (1980) test yields 1,467.4, exceeding all the conventional critical values. This rejection of the homoscedasticity in the OLS model is not surprising given the count nature of the data.

elevation to the average level in the sample (1.98 km), an increase in the average annual temperature by 1 degree increases production diversity by 0.04 products, on average *ceteris paribus*. However, the positive impact of temperature diminishes in higher elevations.[9] Similarly, the influence of elevation on production diversity varies with temperature. The coefficient on the slope variable also appears with a correct sign but is not statistically significant from zero at conventional levels (p=0.28). Furthermore, the usual IV-diagnostic tests in the linear IV-framework are passed: the Cragg-Donald test yields 21.0 and according to the Hansen-Sargan test, we cannot reject the null of zero correlation between the instruments and the error term.

The IV-estimates are considerably larger than in Columns 1 and 2 that treat production diversity as exogenous. Controlling for a wide range of household level characteristics, including the value of crops harvested, livestock production, household wealth and demographic characteristics, food prices, market access, regional fixed effects, and child sex and age, these estimates show that a one food group increase in household's production diversity leads to a 0.57 – 0.73 food group improvement in child's diet diversity score. These estimates are statistically significant at the one percent level.

4.1. Robustness and extensions (1): Alternative controls, estimators and samples

We assessed the robustness of our results in several ways. First, we included alternative sets of controls. We included age-in-months and ethnicity fixed effects, but the inclusion of these does not alter our findings. We experimented with alternative sets of controls for crop and livestock production, such as dropping the variables measuring crop and livestock output value and replacing the variables measuring crop and livestock output value with value of productive assets and income shocks. Our findings are robust to these changes (results are available on request).

Second, we considered a series of alternative estimators. Instead of the Poisson model, we tried a Negative Binomial model which is less sensitive to over-dispersion. This yielded near-identical coefficients to those reported for the Poisson model (results are available on request). Our Poisson results are also robust to the assumption of a multiplicative error structure in the IV-Poisson instead of an additive one (see Table A2).

Next, we considered several disaggregations, estimating results separately for girls and boys, for children aged 6 to 24 months and aged 25 to 71 months and by whether the mother had any formal schooling. Results are reported in Table 4.2. There are some suggestive differences; point estimates are higher for boys, and for children whose mothers have no schooling. However, differences in these point estimates are not statistically significant.

[9] The turning point is estimated at 3.5 km. This is just outside the elevation distribution in our sample where the maximum is 3.3 km.

Table 4.2—The impact of production diversity on child diet diversity by child sex, age and maternal schooling

	(1) Linear-IV (GMM)	(2) Poisson-IV (GMM)	(3) Are group differences statistically significant?
All children	0.729***	0.574***	-
	(0.263)	(0.155)	
By sex:			
Girls	0.505	0.443*	No
	(0.368)	(0.231)	
Boys	0.780***	0.5712***	
	(0.207)	(0.154)	
By age:			
6-24 months	0.702*	0.387	No
	(0.368)	(0.287)	
25-71 months	0.492*	0.278	
	(0.274)	(0.232)	
By maternal education:			
Mother has no schooling	0.924***	0.619***	No
	(0.213)	(0.115)	
Mother has some schooling	0.617***	0.399*	
	(0.236)	(0.232)	

Notes: See Table 4.1.

Source: Feed the Future Survey 2013

Finally, the survey also collected information about mothers' diets using the same battery of questions as for the children. Table A3 in the Appendix re-runs Table 4.1 using these data. The size of the coefficients on the production diversity variable are similar to the ones obtained in Table 4.1, but less precise, possibly due to the smaller sample size.

4.2. Robustness and extensions (2): Access to food markets

We have established a statistically strong and causal relationship between household production and children's diets. This rejection of the separability of household production and consumption decisions suggests that in order for rural households to improve their children's diets, they need to produce a wider range of agricultural outputs. As this is a fairly strong implication, we conduct a further robustness check by disaggregating our sample by market access.

Specifically, we interact p_{hv} in Equation (1) with a variable that equals one if household h is located within a three kilometre range from a food market, zero otherwise.[10] Table 4.3 reports results. As before, the first two columns treat the household's production diversity – and its interaction term with the market variable – as exogenous. Accounting for the presence of market access in the interaction term (production diversity x market), at low levels of production diversity, the diets of children residing near markets are more diverse (when households produce zero or one food group) than, or as diverse (at 2-3 food groups) as the diets of the children without market access.[11] Second, the coefficient on the non-interacted production variable appears positive and significant, while the coefficient on the interaction term appears negative and significant. The test on the joint significance of the coefficients cannot reject the null hypothesis that they add up to zero. This suggests that the dependence between production and diet diversity, as documented earlier, breaks down in villages with access to food markets.

[10] Households typically carry heavy food sacks to and from the nearest market either by themselves or using donkeys, mules or horses. Figures 2.2a and 2.2b suggest that a market within a 3-km distance is still accessible for households. We also experimented with other distance thresholds near the 3 km cut-off point and our findings are robust to setting the threshold to 2, 4 and 5 km (results available upon request).

[11] The mean (and median) for this variable is 2 food groups. Nearly 90 percent of the households produce 3 or fewer food groups.

Table 4.3—The impact of production diversity on diet diversity by access to markets

Dependent variable: number of food groups consumed	OLS	Poisson	Linear-IV (GMM)	Poisson-IV (GMM)
	(1)	(2)	(3)	(4)
Number of food groups produced (*A*)	0.128***	0.104***	0.525*	0.425**
	(0.047)	(0.037)	(0.271)	(0.167)
Number of food groups produced *x* market (*B*)	-0.160***	-0.135***	-0.223	-0.258
	(0.047)	(0.043)	(0.366)	(0.248)
Market is less than 3 km distant	0.374**	0.343**	0.599	0.699
	(0.149)	(0.149)	(0.731)	(0.505)
Other controls	Yes	Yes	Yes	Yes
χ^2-test: joint significance: (*A*)+(*B*) = 0	p=0.49	p=0.48	p=0.36	p=0.53
Weak-identification tests:				
Cragg-Donald F-statistic	-	-	14.05	-
Angrist-Pischke F-test: (*A*)	-	-	1.90	-
p-value	-	-	0.081*	-
Angrist-Pischke F-test: (*B*)	-	-	6.64	-
p-value	-	-	0.000***	-
Over-identification test:				
Hansen-J	-	-	4.847	5.446
p-value	-	-	0.56	0.49

Notes: See Table 4.1.

Source: Feed the Future Survey 2013

The last two columns provide the results based on IV-regression models. The analysis is somewhat complicated by the fact that by interacting the endogenous variable with an exogenous one results in two endogenous variables. To account for the possibility that the instruments work differently for villages with and without market access, we also interacted the four instruments with the market variable. As a result, we now have eight excluded instruments. Columns 3 and 4 provide the results. For both variables, the Angrist and Pischke (2009, p. 217-218) F-statistic rejects the null that the endogenous regressor is weakly identified. However, as expected, instrumenting two endogenous variables takes a toll on the efficiency, resulting in inflated standard errors. The estimated coefficient on the production variable remains positive but is significant only at 5 or 10 percent level, depending on the estimator. The coefficient on the interaction term is negative, but the standard errors are large rendering the estimate insignificant. However, the joint significance test implies that the production coefficient for the children residing near market villages is not statistically different from zero at conventional levels. This again suggests that the non-separability between consumption and production decisions breaks down in villages that are located close to markets.

5. CONCLUSIONS

In this paper, we examine the relationship between the diversity of household agricultural production and the diversity of pre-school children's food consumption in rural Ethiopia. While its diverse agro-climatic conditions mean that an enormous variety of foods are grown across the country, pre-school children consume a monotonous diet with adverse consequences on their nutritional status. Our unique data allow us to show that, after controlling for a variety of household characteristics, including wealth, the level of agricultural production, and the endogeneity of production diversity, children's diets strongly depend on households' production choices. This relationship is particularly strong for households with limited access to food markets, but does not hold for households that do have good access to markets where they might buy and sell food products.

Does this imply that all households should be encouraged to produce a diverse basket of foods? We think not. Such an approach would seem to neglect the basic economic notion of production based on comparative advantage, to say nothing of the limits imposed on production choices by agro-climatic conditions. Rather, the results suggest that agricultural interventions that encourage increased productivity (so as to increase household incomes), together with deepening market integration in remote areas (so as to make available foods that are not easily produced in these localities) and behaviour change communication (to provide information to caregivers on the importance of feeding children a diverse diet), are more likely to result in improved pre-school diets and nutritional status. But further work, ideally through rigorous evaluation of interventions along these lines, is needed to confirm the robustness of these ideas.

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APPENDIX TABLES

Table A1—First stage regression results for Column 3 in Table 4.1

Dependent variable: number of food groups produced	(1)
Excluded instruments:	
Average temperature (°C)	0.095***
	(0.032)
(average temperature) * (elevation)	-0.027*
	(0.015)
Elevation (in km)	0.745**
	(0.337)
Village has steep-sloping land	-0.198
	(0.182)
Included instruments:	Yes
Observations:	4,214

Note: Standard errors clustered at the *woreda* level in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Source: Feed the Future Survey 2013

Table A2—IV-Poisson regression results based on multiplicative error structure

Dependent variable: number of food groups consumed	1	2	3	4
error structure:	additive	multiplicative	additive	multiplicative
Number of food groups produced (*A*)	0.574***	0.600**	0.425**	0.394*
	(0.155)	(0.302)	(0.167)	(0.239)
Number of food groups produced *x* market (*B*)			-0.258	-0.163
			(0.248)	(0.356)
Market is less than 3 km distant			0.699	0.466
			(0.505)	(0.683)
Other controls	yes	yes	yes	yes
χ^2-test: joint significance: (*A*)+(*B*) = 0	n/a	n/a	p=0.53	p=0.57
Hansen-J	2.049	1.572	5.446	4.424
--- p-value	0.562	0.67	0.49	0.62

Notes: Columns 1 and 3 replicate column 4 in Table 2 and 3, respectively. Standard errors clustered at the *woreda* level in parentheses. The standard errors for the marginal effects at the means are computed using the delta-method. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Source: Feed the Future Survey 2013

Table A3—Impact of production diversity on mothers' diet diversity

Dependent variable: number of food groups consumed by the mother	OLS	Poisson	Linear-IV (GMM)	Poisson-IV (GMM)
	(1)	(2)	(3)	(4)
Number of food groups produced	0.076**	0.063**	0.667*	0.405
	(0.039)	(0.031)	(0.375)	(0.311)
Controls:	Yes	Yes	Yes	Yes
R^2	0.236	-	-	-
Pearson goodness-of-fit test	-	2252	-	-
--- p-value	-	1.00	-	-
Weak-identification tests:				
Cragg-Donald F-statistic	-	-	14.08	-
Angrist-Pischke F-test of excluded instruments	-	-	2.65	-
--- p-value	-	-	0.039**	-
Over-identification test:				
Hansen-J	-	-	4.469	5.975
--- p-value	-	-	0.215	0.113

Notes: Standard errors clustered at the woreda level in parentheses. The standard errors for the marginal effects at the means in columns 2 and 4 are computed using the delta-method. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Sample size is 3,144.

Source: Feed the Future Survey 2013

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