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Does Market Access Mitigate the Impact of Seasonality on Child Growth?

Panel data evidence from northern Ethiopia

Kibrewossen Abay and Kalle Hirvonen

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DOES MARKET ACCESS MITIGATE THE IMPACT OF SEASONALITY ON CHILD GROWTH? PANEL DATA EVIDENCE FROM NORTHERN ETHIOPIA

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Abstract: Seasonality in agricultural production continues to shape intra-annual food availability and prices in low-income countries. Using high-frequency panel data from northern Ethiopia, this study attempts to quantify seasonal fluctuations in children's weights. In line with earlier studies, we document considerable seasonality in children's age and height adjusted weights. While children located closer to local food markets are better nourished compared to their counterparts residing in more remote areas, their weights are also subject to considerable seasonality. Further analysis provides evidence that children located closer to food markets consume more diverse diets than those located farther away. However, the content of these diets varies across seasons: children are less likely to consume animal source foods during the lean season. This leads us to conclude that households located near these food markets are not able to insulate their children from seasonal weight fluctuations. We discuss some policy options with potential to address this threat to child well-being.

Keywords: child anthropometrics, dietary diversity, food markets, Africa.

JEL codes: I15, O12, Q18, O13.

This paper has undergone peer-reviews by multiple UNICEF Ethiopia Country Office experts as well as at the UNICEF Office of Research Innocenti.

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TABLE OF CONTENTS

1. INTRODUCTION

Child undernutrition remains a major problem in low income countries. In sub-Saharan Africa alone 56.9 million children (40 per cent of all children) are stunted and 31.1 million are underweight (22 per cent) (Black et al. 2013). While a tragedy in its own right, undernutrition leads to enormous economic losses, for example, through reduced human capital (Behrman, Alderman, and Hoddinott 2004). Undernourished children tend to score poorly in cognitive tests and also do not progress as far with their education as their better nourished peers (Glewwe, Jacoby, and King 2001, Alderman, Hoddinott, and Kinsey 2006, Mendez and Adair 1999), and thus become less productive adults. Horton and Steckel (2013) estimate that each year sub-Saharan Africa loses 11 per cent of its Gross National Product due to poor nutrition.

Seasonal energy stress is considered a major contributor to undernutrition in low income settings (Ferro-Luzzi and Branca 1993, Vaitla, Devereux, and Swan 2009). Most farmers in sub-Saharan Africa rely on rain-fed agriculture (Faurès and Santini 2008), resulting in considerable seasonal variations in local food availability and prices (Hirvonen, Taffesse, and Worku 2015, Kaminski, Christiaensen, and Gilbert 2014, Gilbert, Christiaensen, and Kaminski 2015). Moreover, a large body of literature documents how children's and adults' anthropometric outcomes fluctuate across agricultural seasons (Ferro-Luzzi et al. 2001, Maleta et al. 2003, Alemu and Lindtjørn 1995, Leonard 1991, Panter-Brick 1997, Dercon and Krishnan 2000), thus confirming the link between seasonal energy stress and undernutrition. Low energy intakes, even temporary ones, can have serious nutritional implications, especially for young children. Recent evidence from Tanzania suggests that early childhood exposure to consumption seasonality may even shape adult outcomes (Christian and Dillon 2015).

This paper contributes to this vast – though recently somewhat neglected (Devereux, Sabates-Wheeler, and Longhurst 2012) – literature on seasonality by studying how market access interacts with the impact of seasonality on child growth. This focus on market access is motivated by emerging literature that highlights the role of market and road access on household welfare and food consumption patterns. Handa and Mlay (2006) demonstrate that Mozambican households with access to roads are better equipped to smooth their consumption across the agricultural seasons. This could be because households with road access are more likely to engage in non-farm activities (Jacoby and Minten 2009), which could provide them with additional income during the lean season. Less remote farmers are also able to get better prices for their produce in the post-harvest period and are less exposed to seasonal variation in food prices (Minten 1999). Moreover, emerging research evidence from Ethiopia suggests that households located closer to markets enjoy better diets (Stifel and Minten 2015), and their food consumption is less dependent on their own agricultural production (Hirvonen and Hoddinott 2014, Hoddinott, Headey, and Dereje 2015). Therefore, the hypothesis that households that have greater access to markets are better able to meet the nutritional needs of their children seems plausible, but so far (to our knowledge) untested.[1]

[1] A recent study by Darrouzet-Nardi and Masters (2015) focused on the impact of season of birth on height-for-age Z-scores (HAZ)measured later in life. Using two rounds of DHS data for the Democratic Republic of Congo, the authors find that children born in the lean season have systematically lower HAZ scores than other children, and that being located farther away from towns and cities exacerbates this adverse seasonality effect. The focus in the current paper is different. Using high-frequency panel data over a two-year period, we study how seasonality affects children's growth patterns (after their birth) and whether closer proximity to markets mitigates these effects.

In this paper, we attempt to test this hypothesis using high-frequency panel data from eight villages in northern Ethiopia. The survey collected anthropometric measures of children in approximately three-month intervals between 2012 and 2014, resulting in a panel data set spanning seven rounds. Categorizing the interview dates into lean and non-lean (i.e., food sufficient) seasons, we first show how children's weights are subject to considerable seasonal fluctuations. As expected, age- or height-adjusted weight measures are lower in the lean season, verifying earlier findings from Ethiopia and other low-income settings. We then study whether market access mitigates the impact of seasonality on child growth patterns. We find that children residing in households with better access to local food markets have higher Z-scores for weight-for-height (WHZ) and weight-for-age (WAZ).[2] However, while these children are better nourished than the children located farther away from food markets, their (height or age adjusted) weights are also subject to considerable seasonal fluctuations. The seasonal changes in their Z-scores are of similar magnitude to the changes observed in the Z-scores of children residing in more remote areas.

Households with better market access, therefore, are also unable to protect their children from the effects of seasonality. This could be because food prices in these markets are subject to considerable seasonality. A recent study by Gilbert, Christiaensen, and Kaminski (2015) provides support to this hypothesis. The authors document considerable seasonal price gaps – the difference in prices just before and after the harvest – in Ethiopia and in 10 other African countries.[3] This implies that the local food markets are not well integrated, and food products are mainly sourced from nearby localities. As a result, food prices in these markets closely follow the local food production patterns. High food prices in the lean season, together with low incomes and depleted food stocks, compel households to cut back on their food consumption and change the content of their diets (Hirvonen, Taffesse, and Worku 2015).

This paper also speaks to the fast evolving research literature focusing on linkages between agriculture and nutrition (Carletto et al. 2015, Herforth, Jones, and Pinstrup-Andersen 2012). Mainstreaming nutrition into various national agricultural programmes is also a strategic objective in Ethiopia's National Nutrition Programme (GFDRE 2013). However, so far there has been little evidence that agricultural interventions lead to improvements in nutritional outcomes (Ruel and Alderman 2013, Masset et al. 2012, Berti, Krasevec, and FitzGerald 2004, Webb and Kennedy 2014). One reason could be the limited attention to the seasonal nature of food availability in low-income countries in this research to date. Indeed, agriculture-nutrition interventions typically focus on improving agricultural outcomes during the main agricultural season.

[2] The Z-scores measure the distance to the median weight of a healthy and well-nourished reference population of same sex and age/height. This distance is measured in terms of standard deviations of that same reference population. The reference population was taken from WHO (2006) and we computed the z-scores using the zanthro06 command (Leroy 2011) in Stata 14. Z-score observations that were below -5 or above +5 standard deviations were considered outliers and dropped from the analysis.

[3] For Ethiopia, Gilbert el al. use monthly price data for 2003-2012 from 11 wholesale markets. As expected, the prices of perishable food items displayed highest seasonality. For example, the estimated seasonal price gap in Ethiopia for oranges was 21 per cent and for tomatoes more than 35 per cent. However, considerable seasonal price gaps were also found for cereals: for maize the seasonal price gap was estimated to be 20 per cent, for teff 10 per cent, and for sorghum nearly 14 per cent.

The structure of this paper is as follows: in the next section, we provide information on the context and data used in the analysis and offer some descriptive analysis; Section 3 describes the econometric strategy; and Section 4 presents the results. In Section 5 we attempt to corroborate our findings by studying how children's diets and the risk of illness vary across seasons. Section 6 summarizes the findings and offers some policy recommendations.

2. CONTEXT, DATA AND DESCRIPTIVE ANALYSIS

This study focuses on Tigray, the northernmost region of Ethiopia. The undernutrition rates in this region are among the highest in the country: 51 per cent of children are stunted[4], 35 per cent are underweight[5], and 10 per cent are wasted[6] (Central Statistical Agency and ICF International 2012). Tigray is overwhelmingly rural and the mountainous terrain makes travelling difficult and time-consuming.

The data used in this paper come from a household panel survey from the south-eastern part of Tigray conducted between May 2012 and July 2014. These data were collected by the International Food Policy Research Institute (IFPRI), the Institute of Development Studies, and the Department of Economics of Mekelle University. The purpose of the survey was to assess the impact of the Social Cash Transfer Pilot Program (SCTPP) organized by the Regional Government of Tigray and the United Nations Children's Fund (UNICEF). The goal of the SCTPP project was to improve quality of life for vulnerable children, the elderly, and persons with disabilities.

The 'treatment' sample was drawn from a list of beneficiary households. This list consisted of four different household types: the elderly, the disabled, child-headed households[7], and female-headed households. To ensure that a sufficient number of children were in the final sample, the evaluation team oversampled non-elderly households. The final sample consists of three sub-samples: 1) a treatment sample: households that received SCTPP benefits; 2) a control sample: households that met the target criteria but did not receive the SCTPP benefits; and 3) a random sample: households that did not meet the target criteria and did not receive SCTPP benefits.

In this paper we ignore this experimental design in the sampling and instead use these rich data to study the role of seasonality on child nutrition outcomes. The original impact evaluation, reported in Berhane et al. (2015), found that, while the project improved household diets (calories and dietary diversity), it had no statistically significant impact on household (self-reported) food security or young children's nutritional status, (stunting (height-for-age) or wasting (weight-for-height).[8]

The survey was fielded in the two districts *(woredas)* in East Tigray zone where the SCTPP pilot took place; in Abi Adi, an urban district north of the regional capital Mekelle, and in Hintalo Wajirat,

[4] A child is categorized stunted if his or her height-for-age is below -2 standard deviations.
[5] A child is categorized underweight if his or her weight-for-age is below -2 standard deviations.
[6] A child is categorized wasted if his or her weight-for-height is below -2 standard deviations.
[7] This refers to households where the head is less than 18 years of age.
[8] For more information about the survey and the impact evaluation, see Berhane et al. (2015).

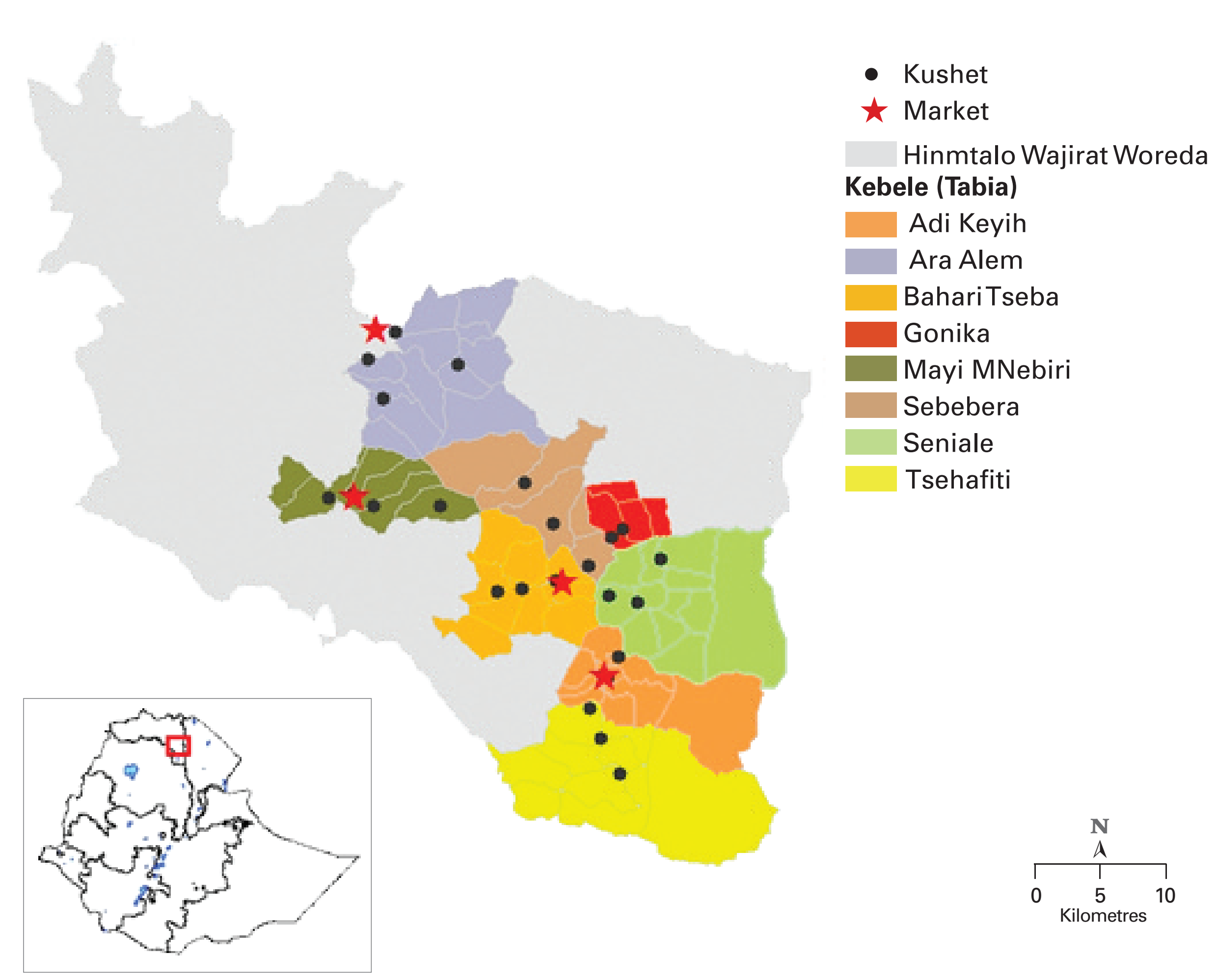
a rural district south of Mekelle. We restrict the analysis to the rural district, Hintalo Wajirat, where 2,387 households from eight *tabias* (sub-districts in the local language) and 27 *kushets* (villages in the local language) were selected for the final sample.[9] The motivation for this restriction is due to the fact that these eight surveyed *tabias* are all rural and located close to each other, thereby sharing the same climate and weather. Moreover, virtually all households in Hintalo Wajirat engage in agricultural production, whereas the opposite is true for the households in the urban sample.[10] The terrain in Hintalo Wajirat is rugged with altitudes ranging between 2,000 and 2,600 metres. Figure 2.1 (page 10) shows where the *kushets* (marked with black dots) are located in the district. Households in this district rely on four food markets (marked with stars). The (Euclidian) distance to the nearest food market varies across the *kushets*, ranging from a minimum of 0.5 kilometres (km) to a maximum of 9 km.[11] About one fourth of the *kushets* are located within a distance of 3.5 km from a food market.

We use these panel data to study seasonality in child health outcomes. With seven rounds of data collected over a 24-month period, this survey is ideal for such an analysis. Regarding attrition, 90.5 per cent of households interviewed at the baseline survey were interviewed at the end-line. This 9.5 per cent attrition was concentrated in two *tabias* where some respondents declined to participate again in the survey citing religious reasons (Berhane et al. 2015). We explored the correlates of this attrition using a probit model and found that it is not correlated with any of the child- or household-level characteristics, including weight-for-height (WHZ) and weight-for-age (WAZ) Z-scores and household wealth. The results from the probit model analysis are not reported in this paper, but are available upon request.

As in other parts of Ethiopia, farming in Hintalo Wajirat is based on rain-fed agriculture, and therefore agricultural production takes place in seasonal cycles. Figure 2.2 (page 11) shows the average rainfall patterns in the area. Farmers grow their crops mainly in the long rainy season *(meher)* that takes place between June and October.[12] This is followed by the harvest period, typically occurring between October and November (Hirvonen, Taffesse, and Worku 2015). After the harvest, households depend largely on their stored food stocks. Figure 2.3 (page 11) shows how consumption from own production is high at 90 per cent in the months immediately after harvest, but declines to 30 per cent during the lean season months. The two figures highlight the extent of seasonality in agricultural production and consumption in this context. Using this information, we categorized the calendar year – and our survey rounds – into a *lean season* period and into a *non-lean* (i.e., food sufficient) period. The lean season period occurs between May and September, whereas the non-lean period is between October and April. Table 2.1 (page 12) shows the survey dates. Three of the seven survey rounds were in the lean season, while the four other rounds were conducted in the non-lean period.

[9] 1,280 households were interviewed in Abi Adi woreda.
[10] As a result, their production is less affected by seasonality in rainfall patterns.
[11] The Euclidian distances are based on GPS coordinates that were recorded for each household and each food market. We calculated the distance to the nearest market and then took the median distance for each kushet to minimize the role of measurement error. However, the results are robust to using distances defined at the household level as well (results available upon request).
[12] The rains during the short rainy season *(belg)* are small in magnitude and not reliable and therefore only little cultivation takes place during this period.

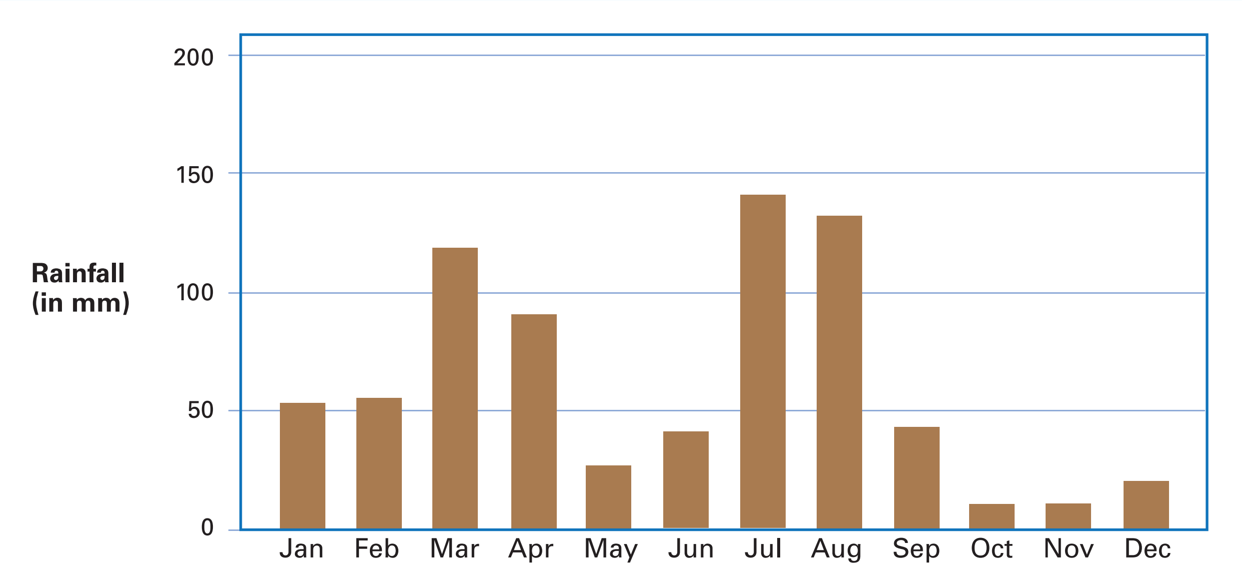
Figure 2.1 – ***Map of the survey area in Hintalo Wajirat, Tigray***



Note: The small map at the bottom-left corner shows the survey location in Ethiopia.
Source: UNICEF Tigray Social Cash Transfer Data.

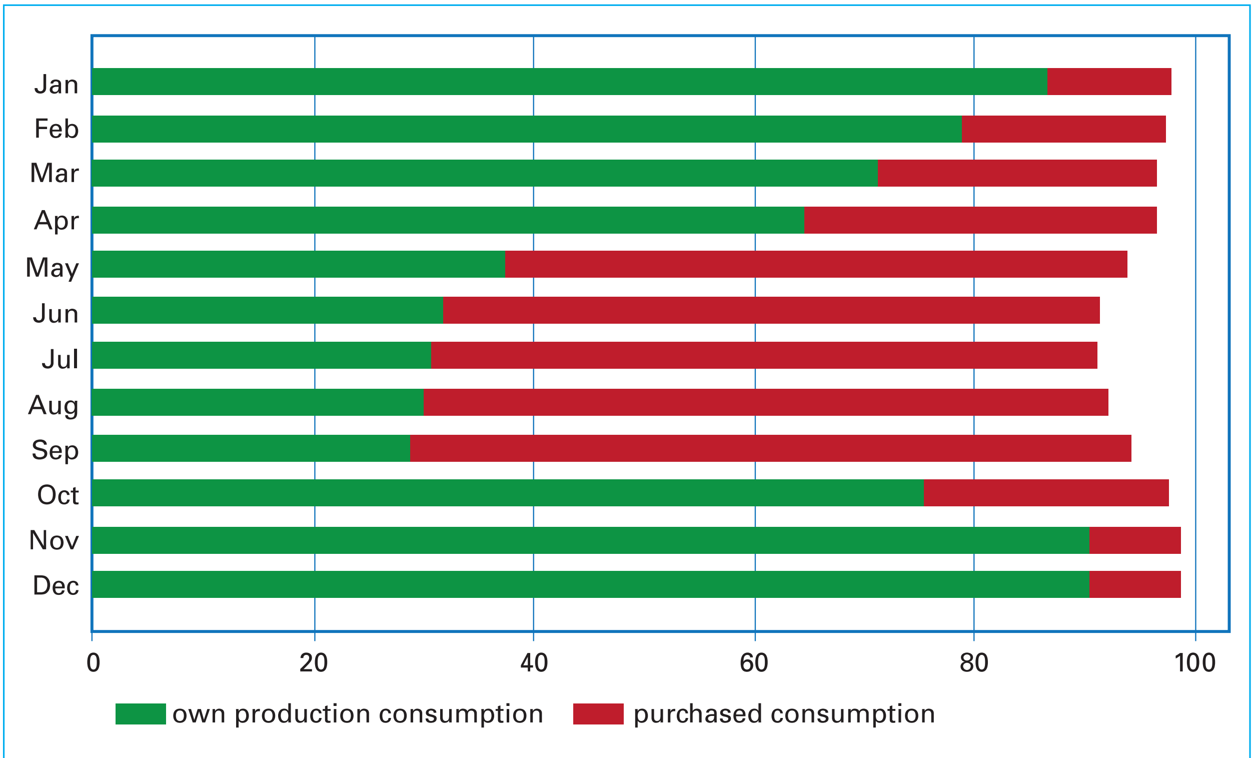
Measurements of the height and weight of each child who was less than five years old were collected in each survey round. We focus on weight-based measures, weight-for-height and weight-for-age Z-scores, that capture the current or recent nutritional status of children, and are therefore considered more responsive to seasonal changes than the often used height-based indicators, i.e. height-for-age Z-score (Khara and Dolan 2014). More than half of the children in the sample are stunted, 27 per cent are underweight, and 8 per cent are wasted (Table 2.2). Therefore, despite the non-representative sampling, the undernutrition rates in this sample are similar to those rates reported for the region (see above). Moreover, Figures 2.4 and 2.5 show that the growth faltering in weight-for-height and weight-for-age follows the typical pattern observed in many other low-income countries (Victora et al. 2010).

Figure 2.2 – ***Rainfall (in mm) by month in Hintalo Wajirat***



Note: Median rainfall in millimetres 1981-2013 for each month.
Source: NASA-MERRA (Rienecker et al. 2011).

Figure 2.3 – ***Primary sources of food consumption by month***



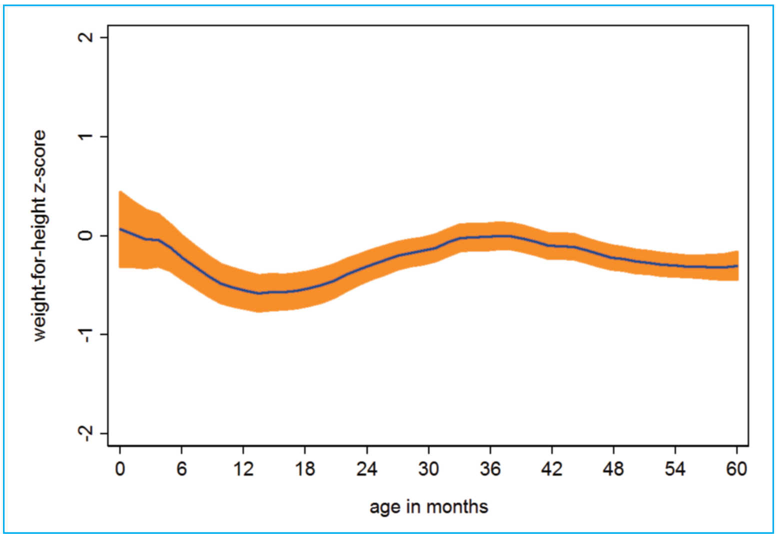
Note: omitted category: gifts and food aid.
Source: UNICEF Tigray Social Cash Transfer Data.

Table 2.1 – *Survey timing by round*

Survey	Start Date	Finish Date	Lean or non-lean season?
Round 1	6 May 2012	26 June 2012	Lean
Round 2	6 October 2012	27 October 2012	Non-lean
Round 3	9 March 2013	29 March 2013	Non-lean
Round 4	20 July 2013	11 August 2013	Lean
Round 5	6 November 2013	26 November 2013	Non-lean
Round 6	3 March 2014	25 March 2014	Non-lean
Round 7	16 May 2014	17 July 2014	Lean

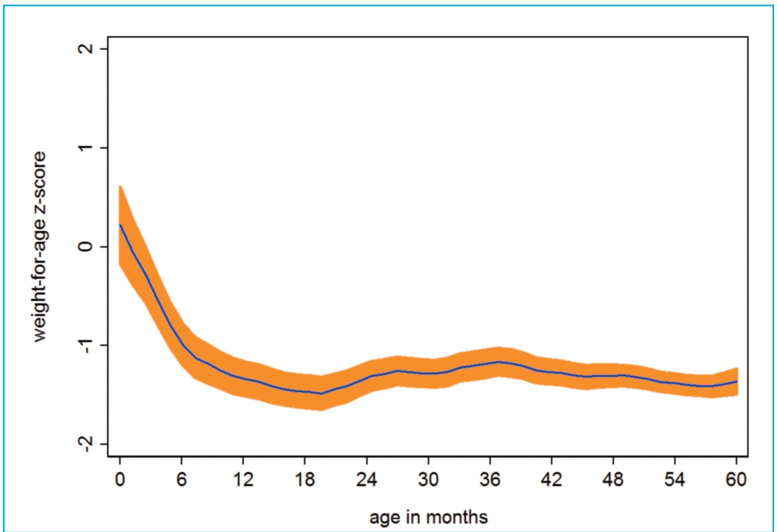
Source: UNICEF Tigray Social Cash Transfer Data.

Figure 2.4 – *Weight for Height Z-scores by age*



Note: Local polynomial regression.
Source: UNICEF Tigray Social Cash Transfer Data.

Figure 2.5 – *Weight for Age Z-scores by age*



Note: Local polynomial regression.
Source: UNICEF Tigray Social Cash Transfer Data.

Table 2.2 – ***Summary statistics***

Variable description	No. of observations	Mean	Standard Deviation
Child anthropometric outcomes			
Weight for age Z Score (WAZ)	1,837	-1.23	1.38
Underweight (WAZ<2)	1,837	0.27	0.44
Weight for height Z Score (WHZ)	1,656	-0.21	1.38
Wasted (WHZ<2)	1,656	0.08	0.28
Height for age Z Score (HAZ)	1,681	-1.94	1.57
Stunted (HAZ<2)	1,681	0.51	0.51
Child level characteristics			
Age of child, in months	1,858	33.88	16.81
=1 if male child	1,858	0.50	0.50
Household level characteristics			
Age of head of household (in years)	1,858	49.34	16.67
=1 if head of household is male	1,858	0.59	0.49
=1 if head is literate	1,858	0.27	0.44
Livestock ownership, principal component analysis	1,858	0.75	2.18
Ownership of durable assets (*)	1,858	-0.83	0.85
Ownership of productive equipment (*)	1,858	1.16	2.53
Number of males 0-5 years	1,858	0.72	0.72
Number of males 6-15 years	1,858	0.83	0.93
Number of males 16-60 years	1,858	0.90	0.92
Number of males 61+ years	1,858	0.20	0.40
Number of females 0-5 years	1,858	0.71	0.69
Number of females 6-15 years	1,858	0.78	0.94
Number of females 16-60 years	1,858	1.37	0.73
Number of females 61+ years	1,858	0.15	0.36
Euclidian distance to market (in km)	1,858	5.48	2.78
=1 if distance to market is less than 3.5 km	1,858	0.24	0.42
Time variables			
=1 if lean season	1,858	0.62	0.48
=1 if lean season and close to market	1,858	0.15	0.35
=1 if lean season and far from the market	1,858	0.48	0.50
=1 if sufficient season and close to market	1,858	0.09	0.29
=1 if sufficient season and far from the market	1,858	0.29	0.45

Source: UNICEF Tigray Social Cash Transfer Data.

(*): Constructed using Principal Components Analysis method.

3. METHODS

We model the anthropometric outcome (y_{ivt}), WAZ or WHZ, for child i at time t residing in village v as a function of the season when the child was measured:

(1) $$y_{ivt} = \beta_1 s_{ivt} + \beta_2 d_{vt} + \beta_3 (s_{ivt} * d_{ivt}) + c_{ivt}{}' \gamma + x_{ivt}{}' \delta + t_t + \varepsilon_{ivt},$$

where s_{ivt} captures the season in which the child was measured; equal to 1 if the interview took place in the lean season, and 0 otherwise. Variable d_{vt} measures the distance to the nearest food market. We also include an interaction term of these two variables ($s_{ivt} * d_{vt}$) to see whether the seasonal fluctuations differ across the distance to the nearest food market. The term x_{ivt}' is a vector of household level characteristics, including characteristics of the head of household (age, sex, literacy), household wealth (productive and non-productive assets), and demographics (number of household members in different age groups by sex). Child specific controls c_{ivt}' include sex and age in months (spline function: knots at 6, 12 and 24 months).[13] Table 2.2 provides the summary statistics for all variables used in the analysis. Finally, the term t_t is the linear time trend to capture general, non-seasonal, trends in children's anthropometric outcomes over the 24-month period and ε_{ivt} is the error term. The standard errors are clustered at the kushet level.[14]

It may be that the distance to markets has a non-linear relationship between children's weights. To account for this possibility, we also estimate the following model:

(2) $$y_{ivt} = \beta_1 SM_{ivt} + \beta_2 SNM_{ivt} + \beta_3 LM_{ivt} + c_{ivt}'\gamma + x_{ivt}'\ \delta + t_t + \varepsilon_{ivt},$$

where SM_{ivt} equals 1 if the season is non-lean (i.e., food sufficient) and the village is located close to a food market (within 3.5 km distance)[15] and 0 otherwise; SNM_{ivt} equals 1 if the season is non-lean and the village is not located close to a food market; and LM_{ivt} equals 1 if the season is lean and the village is located close to a food market. The β coefficients then capture the effect of seasonality for each village type relative to the reference group: lean season and the village is located far from a market. We therefore expect that each β>0.

[13] We use a spline function with knots at 6, 12 and 24 months to model the WHZ/WAZ – age relationships reported in Figures 2.4 and 2.5. Suits, Mason, and Chan (1978) offers an accessible introduction to the use of spline functions in econometrics.

[14] Earlier literature documents considerable month-of-birth effects on children's anthropometric outcomes (Lokshin and Radyakin 2012), implying that changes in food availability affect intra-uterine growth trajectories. The results reported here are not driven by month-of-birth effects. Including month-of-birth dummies to the specification does not affect the main coefficients of interests. Interestingly, we find that the month-of-birth dummies are jointly statistically significant in the case of WAZ but not WHZ. This suggests that month-of-birth affects children's WAZ scores, over and above the contemporaneous seasonal effects.

[15] Our results are robust to using different cut-off points (e.g. 3, 4.5, 5 and 5.5 km). These results are available upon request.

4. RESULTS

Table 4.1 shows the regression results based on Equation 1. The odd columns use WHZ as the dependent variable and the even columns are based on WAZ. In the first two columns, the interaction term is omitted, while the last two columns estimate the full model. We see that seasonality exerts considerable fluctuations on children's weights: during the lean season the weight-for-height Z-scores are, on average, -0.29 units of standard deviation lower than during the non-lean (i.e., food sufficient) season, after controlling for age effects, household wealth, and demographics. The lean season exerts a similar impact on weight-for-age Z-scores: -0.20 unit of standard deviation drop in the WAZ scores. For the average child in our data of 34 months of age, one standard deviation in WAZ translates into 1.7 kilograms (kg). Therefore, the average child in our sample is 0.34 kilograms (0.2 x 1.7 kg) lighter during the lean season relative to the non-lean season.[16] Furthermore, children who are located farther away from a food market have lower WHZ and WAZ scores. In columns 3 and 4 we interact the distance variable with the lean season dummy, thus estimating the full model presented in Equation 1. The coefficient on this variable will tell us whether the impact of seasonality differs across the distance to food market gradient.
The coefficient on the interaction term appears insignificant in both columns, implying that the seasonal fluctuations do not differ between the more or less remote households.

Table 4.1 – *Impact of seasonality on child anthropometric outcomes*

	1	2	3	4
Dependent variable:	**WHZ**	**WAZ**	**WHZ**	**WAZ**
lean season	-0.286*** (0.071)	-0.205*** (0.067)	-0.166 (0.131)	-0.290** (0.123)
(log) distance to the market	-0.075* (0.038)	-0.123*** (0.037)	-0.021 (0.068)	-0.160*** (0.060)
lean season X (log) distance to the market	n/a	n/a	-0.082 (0.079)	0.059 (0.072)
linear time trend?	yes	yes	yes	yes
household level controls?	yes	yes	yes	yes
child level controls?	yes	yes	yes	yes
Number of observations	1656	1837	1656	1837
R^2	0.064	0.069	0.065	0.070

Note: OLS model. Control variables are listed in Table 2.2. Standard errors clustered at the *kushet* level are in parentheses. Statistical significance denoted at *** p<0.01, ** p<0.05, * p<0.1.
Source: UNICEF Tigray Social Cash Transfer Data.

We also estimated Equation 1 using village fixed effects. The distance to market is measured at the village level, and therefore we had to omit this variable from the model. The results are presented in

[16] These seasonal weight fluctuations are of similar magnitude to that found earlier in the south-central part of Ethiopia by Ferro-Luzzi et al. (2001). However, it is worth noting that the z-score values are not directly comparable to the ones reported in the current study as the authors of the earlier study used a different reference population to calculate the weight-for-height and weight-for-age z-scores.

Table 4.2. First, the coefficients in column 1 and 2 are very similar to the corresponding coefficients presented in Table 4.1. This implies that the previous results are not driven by some unobserved time-invariant village characteristics. The coefficients on the interaction terms are also of similar magnitude but the estimated standard errors are somewhat smaller. As a result, the coefficient on the WHZ model appears with a marginally statistically significant (and negative) coefficient. This suggests that the lean season impact on children's WHZ increases as we move away from the food markets. However, the coefficient is statistically significant only at the 10 per cent level. Furthermore, we estimated Equation 1 also using household fixed effects. The results were very similar to those obtained in Tables 4.1 and 4.2 and, therefore, are not presented here.

Table 4.2 – ***Impact of seasonality on child anthropometric outcomes – village fixed effects model***

	1	2	3	4
Dependent variable:	**WHZ**	**WAZ**	**WHZ**	**WAZ**
lean season	-0.278*** (0.054)	-0.199*** (0.046)	-0.169** (0.086)	-0.275*** (0.049)
(log) distance to the market	n/a	n/a	n/a	n/a
lean season X (log) distance to the market	n/a	n/a	-0.075* (0.044)	0.052 (0.034)
linear time trend?	yes	yes	yes	yes
household level controls?	yes	yes	yes	yes
child level controls?	yes	yes	yes	yes
kushet fixed effects?	**yes**	**yes**	**yes**	**yes**
Number of observations	1656	1837	1656	1837
R^2	0.062	0.067	0.063	0.067

Note: OLS model. Control variables are listed in Table 2.2. Standard errors clustered at the *kushet* level are in parentheses. Statistical significance denoted at *** p<0.01, ** p<0.05, * p<0.1.
Source: UNICEF Tigray Social Cash Transfer Data.

Table 4.3 (page 17) presents the regression results based on Equation 2. First, we see that, on average, WHZ scores are 0.185 units and WAZ scores are 0.192 units higher during the lean season in the *kushets* closer to a food market, relative to more remote *kushets*. Second, during the non-lean season, WAZ scores are 0.307 units higher in *kushets* with good market access compared to the *kushets* with poorer market access (0.484 - 0.177 = 0.307, p=0.022). For the average child in our sample (34 months of age), this 0.307 WAZ units translates into 0.53 kilograms. For WHZ, this difference is not statistically significant (p=0.58). Finally, children's weights fluctuate considerably across the two seasons, both in villages with good market access and in villages with poorer market access. In villages closer to the market, WHZ is 0.198 (= 0.383 - 0.185, p=0.005) and WAZ 0.292 (= 0.484 - 0.192, p<0.001) units higher in the non-lean season than in the lean season. Similarly, in villages farther away, WHZ is 0.312 (p<0.01) and WAZ 0.177 (p<0.01) units higher in the non-lean season.

Figure 4.1 (page 17) provides a graphic presentation of the results presented for WHZ in Column 1 in Table 4.3. Figure 4.2 (page 18) summarizes the corresponding results for WAZ in Column 2 in

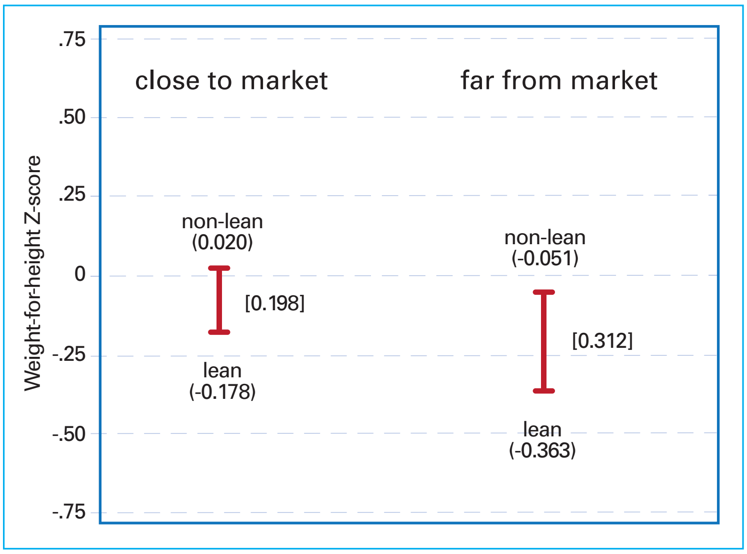
Table 4.3. We see that, while children located near the food markets are better nourished in each season, their WHZ and WAZ scores fluctuate considerably between lean and non-lean seasons. The magnitude of these seasonal changes are similar between children located near the food markets and children located farther away from the markets.

Table 4.3 – ***Impact of seasonality on child anthropometric outcomes by market access***

	1	2
Dependent variable:	**WHZ**	**WAZ**
Sufficient season & close to market (A)	0.383*** (0.117)	0.484*** (0.119)
Sufficient season & far from the market (B)	0.312*** (0.069)	0.177*** (0.054)
Lean season & close to market (C)	0.185** (0.090)	0.192** (0.093)
Lean season & far from the market	reference	reference
Linear time trend?	yes	yes
Household level controls?	yes	yes
Child level controls?	yes	yes
F-test: (A)-(B) = 0	p = 0.580	p = 0.022
F-test: (A)-(C) = 0	p = 0.005	p = 0.000
F-test: (B)-(C) = 0	p = 0.229	p = 0.888
Number of observations	1656	1837
R2	0.064	0.069

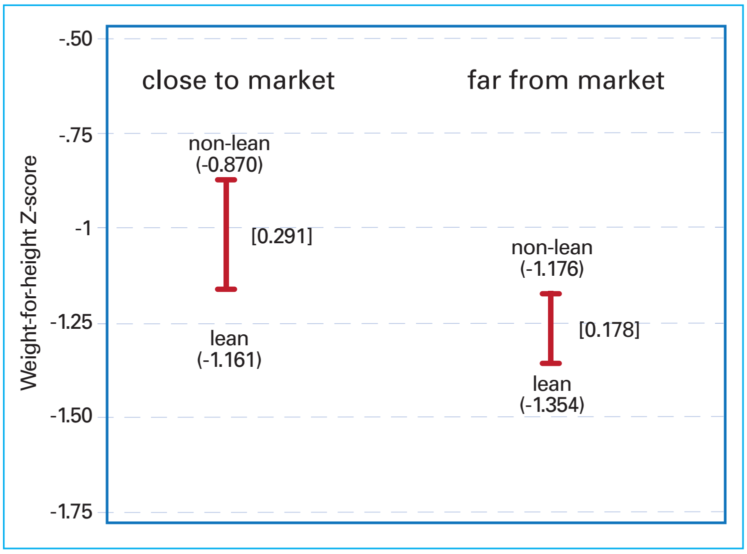
Note: OLS model. Control variables are listed in Table 2.2. Standard errors clustered at the kushet level are in parentheses.
Statistical significance denoted at *** p<0.01, ** p<0.05, * p<0.1.
Source: UNICEF Tigray Social Cash Transfer Data.

Figure 4.1 – ***Predictive margins for Weight for Height Z-scores from Table 4.3***



Note: Predictive margins estimated from Column 1 in Table 4.3. The number in parentheses gives the estimated WHZ score for each season. The number in brackets gives the distance in WHZ units between the estimated average WHZ score in non-lean and lean seasons.
Source: UNICEF Tigray Social Cash Transfer Data.

Figure 4.2 – ***Predictive margins for Weight for Age Z-scores from Table 4.3***



Note: Predictive margins estimated from Column 2 in Table 4.3. The number in parentheses gives the estimated WAZ score for each season. The number in brackets gives the distance in WAZ units between the estimated average WAZ score in non-lean and lean seasons.
Source: UNICEF Tigray Social Cash Transfer Data.

5. EXPLORING POTENTIAL PATHWAYS

The regression results presented in the previous section show two things. First, children's weights are subject to considerable seasonality – irrespective of their proximity to food markets. Second, despite this, children located closer to food markets have higher age- and height-adjusted weights than children living in more remote areas. In this section, we attempt to further understand these two findings. The two most important immediate causes of child malnutrition are inadequate diets and illnesses (UNICEF 1998). In this penultimate section we study how seasonality and market access affect children's diets and the risk of contracting an illness (diarrhoea).

Unfortunately, we do not have information about the quantities of food the children in the sample consumed. However, the survey comprised a series of Yes/No questions about children's consumption of 15 different food items in the last seven days.[17] We used these data to construct a household level dietary diversity score ranging in value from zero to 15.[18] The mean *weekly* dietary diversity in our sample is 3.9 food groups (standard deviation: 2.44), confirming observations from earlier studies that Ethiopian children follow extremely monotonous diets (Headey 2014, Hirvonen and Hoddinott 2014). We then regressed this household level dietary diversity indicator on our seasonality and market access variables, together with the controls used in the previous regressions.

Column 1 in Table 5.1 (page 19) provides these results.[19] First, we see that children located in villages with better market access enjoy more diverse diets during the non-lean (sufficient) season (0.375 food

[17] These food items are: Injera; Other foods made with grains; Roots and tubers; Orange colored vegetables; Leafy dark green vegetables; Other vegetables; Fruit; Meat; Eggs; Fresh, canned or dried fish or other seafood; Legumes; Dairy product; Fats and oils; Sugar, honey, sweets; Coffee, tea, soft drinks.
[18] This type of simple dietary diversity score has been shown to be correlated with children's anthropometric measures in different contexts (Arimond and Ruel 2004, Jones et al. 2014), including Ethiopia (Disha et al. 2012).
[19] The specification here follows Equation (2). Using a specification that is based on Equation (1) yields similar conclusions.

groups; 0.710 - 0.335, p=0.069) as well as during the lean season (0.729 food groups, p<0.01) relative to children residing farther away from food markets. We also assessed whether the likelihood of consuming animal source foods and, more specifically, dairy products changes across the seasons and across the market access dimension.[20] Previous research from Ethiopia shows how children's dairy consumption is associated with better anthropometric outcomes (Hoddinott, Headey, and Dereje 2015). We find that children located closer to food markets are more likely to consume animal source foods, but only during the non-lean season (Column 2). This seems to be driven by dairy product (mostly milk) consumption (Column 3). Columns 1 to 3 then suggest that children who reside closer to food markets consume more diverse diets with no changes seen across the two seasons. However, the content of these diets changes: the consumption of dairy products – that are rich in protein – increases considerably in the non-lean season.

Table 5.1 – ***Impact of seasonality and market access on children's diets and diarrhoea rates***

Dependent variable:	1 Dietary diversity score	2 Animal source foods	3 Dairy	4 Diarrhoea
Sufficient season & close to market (A)	0.710*** (0.197)	0.077** (0.038)	0.127*** (0.032)	0.030 (0.027)
Sufficient season & far from the market (B)	0.335*** (0.118)	0.019 (0.024)	0.010 (0.017)	0.028* (0.014)
Lean season & close to market (C)	0.729*** (0.165)	0.014 (0.031)	-0.006 (0.021)	0.003 (0.022)
Lean season & far from the market	reference	reference	reference	reference
Linear time trend?	yes	yes	yes	yes
Household level controls?	yes	yes	yes	yes
Child level controls?	no	no	no	yes
F-test: (A)-(B) = 0	p = 0.069	p = 0.150	p = 0.000	p = 0.926
F-test: (A)-(C) = 0	p = 0.935	p = 0.158	p = 0.000	p = 0.311
F-test: (B)-(C) = 0	p = 0.025	p = 0.888	p = 0.509	p = 0.296
Number of observations	1852	1852	1852	1705
R^2	0.207	0.041	0.078	0.052

Note: Column 1 is OLS and columns 2 to 4 are estimated using a linear probability model. Control variables are listed in Table 2.2. Standard errors clustered at the kushet level are in parentheses. Statistical significance denoted at *** p<0.01, ** p<0.05, * p<0.1.
Source: UNICEF Tigray Social Cash Transfer Data.

Finally, an alternative pathway in which seasonality can affect children's weight is through an increased illness risk during the lean season. Indeed, earlier findings from the south of Ethiopia suggest that seasonal weight losses in children were driven by diarrhoea episodes rather than changes in food availability (Ferro-Luzzi et al. 2001).[21] To assess this, we use the data on children's diarrhoea episodes in

[20] In the pooled sample, 26.0 per cent of the children consumed animal source foods and 11.9 per cent consumed dairy products in the past 7 days.
[21] It is of note that the southern part of the country has a bi-modal rain pattern so the seasonal availability of foods is less of an issue compared to the north of Ethiopia.

the four weeks prior to the interview.[22] Nearly 10 per cent of the children in our sample were reported to have had diarrhoea in this period. In column 4 in Table 5.1 we regress this binary variable on the seasonality and market access variables (and the controls). Overall, we find little evidence to suggest that the trends in WHZ and WAZ scores observed in the previous section are driven by diarrhoea outbreaks. In contrast, and somewhat puzzlingly, we find suggestive evidence that the probability of a child contracting diarrhoea is somewhat higher in the non-lean season in the more remote *kushets*. However, this estimate is statistically significant only at the 10 per cent level.

6. CONCLUSIONS

In this paper we have documented how children located closer to food markets are healthier and better nourished compared to their counterparts residing in more remote areas. However, we also find that children's (age- or height-adjusted) weights are subject to considerable seasonal fluctuations – irrespective of their households' market access. Further analysis on children's diets reveal that children located closer to food markets consume more diverse diets throughout the year. However, the content of this diet varies: children near markets are much more likely to consume milk or milk products during the non-lean season than in the lean season.

This study has limitations. First, we do not have information about the food quantities consumed by the children. The analysis of dietary diversity suggests that children located closer to food markets enjoy more diverse diets than children located in more remote areas. However, the consumption of animal source foods, and especially dairy products, declines dramatically during the lean season in areas that are closer to market. This could then explain some of the seasonal weight fluctuations among children located closer to food markets. Nevertheless, it is likely that households also cut back on quantities consumed during the lean season (see Hirvonen, Taffesse, and Worku 2015). Unfortunately, due to lack of data we cannot verify this hypothesis. Finally, the analysis focused only on one district (woreda) in the Tigray region, thereby limiting the external validity of this study.

While proximity to food markets facilitates access to more diverse sets of foods, households located closer to these markets are not able to insulate children from seasonal weight fluctuations. One possible explanation for this latter finding is that food prices in these markets are subject to considerable seasonality (Gilbert, Christiaensen, and Kaminski 2015). This points to three policy options. First, investments in better storage technologies could go a long way in decreasing seasonal price volatility, although mainly for less perishable staple food crops. Second, expanding irrigation would allow food to be produced outside the main cropping season, thereby shortening the lean season period and reducing the seasonal energy stress among households (Headey et al. 2015). The third policy option is to improve market integration. The considerable seasonality in food prices implies that food markets in Ethiopia are not well integrated with markets in other regions: local markets are mainly sourcing food products from nearby areas. The geography of Ethiopia, however, offers great potential for improving seasonal

[22] Note that there is no (seasonal) malaria risk in this area due to the high altitude.

food availability through cross-regional trade. The country is large, covering more than one million square kilometres and comprising a number of different agro-ecological zones in which food is being produced. Moreover, the seasonal weather patterns vary across the country, with some areas relying on two agricultural seasons instead of one. Furthermore, better market integration would allow producers to maximize their incomes through specialization while ensuring that households have access to nutritious foods (through properly integrated food markets). Effective behavioral change communication would then play an important role to ensure that the demand for a diverse range of food types remains high so that producers have the incentive to produce such foods.

REFERENCES

Alderman, Harold, J. Hoddinott, and B. Kinsey. 2006. "Long term consequences of early childhood malnutrition." *Oxford Economic Papers-New Series* 58 (3):450-474.

Alemu, Tadesse, and Bernt Lindtjørn. 1995. "Physical activity, illness and nutritional status among adults in a rural Ethiopian community." *International Journal of Epidemiology* 24 (5):977-983.

Arimond, Mary, and Marie T Ruel. 2004. "Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys." *The Journal of Nutrition* 134 (10):2579-2585.

Behrman, Jere R, Harold Alderman, and John Hoddinott. 2004. Hunger and malnutrition. In *Copenhagen Consensus – Challenges and Opportunities*.

Berhane, G, S Devereux, J Hoddinott, J Hoel, K Roelen, K Abay, M Kimmel, N Ledlie, and T Woldu. 2015. Evaluation of the Social Cash Transfers Pilot Programme, Tigray Region, Ethiopia, Endline Report. Washington, DC, International Food Policy Research Institute.

Berti, Peter R, Julia Krasevec, and Sian FitzGerald. 2004. "A review of the effectiveness of agriculture interventions in improving nutrition outcomes." *Public Health Nutrition* 7 (05):599-609.

Black, Robert E, Cesar G Victora, Susan P Walker, Zulfiqar A Bhutta, Parul Christian, Mercedes De Onis, Majid Ezzati, Sally Grantham-McGregor, Joanne Katz, and Reynaldo Martorell. 2013. "Maternal and child undernutrition and overweight in low-income and middle-income countries." *The Lancet* 382 (9890):427-451.

Carletto, Gero, Marie Ruel, Paul Winters, and Alberto Zezza. 2015. "Farm-Level Pathways to Improved Nutritional Status: Introduction to the Special Issue." *The Journal of Development Studies*.

Central Statistical Agency, and ICF International. 2012. Ethiopia Demographic and Health Survey 2011. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International.

Christian, Paul, and Brian Dillon. 2015. Long-Term Consequences of Consumption Seasonality. Paper presented at the Structural Transformation of African Agriculture and Rural Spaces (STAARS) conference in Addis Ababa, December 2015.

Darrouzet-Nardi, Amelia, and William Masters. 2015. "Does Market Access Protect Children against Poor Health Conditions at Birth?" *The FASEB Journal* 29 (1 Supplement):898.22.

Dercon, Stefan, and Pramila Krishnan. 2000. "In sickness and in health: Risk sharing within households in rural Ethiopia." *Journal of Political Economy* 108 (4):688-727.

Devereux, Stephen, Rachel Sabates-Wheeler, and Richard Longhurst. 2012. *Seasonality, rural livelihoods and development*. London and New York: Routledge.

Disha, AD, R Rawat, A Subandoro, and P Menon. 2012. "Infant and Young Child Feeding (IYCF) practices in Ethiopia and Zambia and their association with child nutrition: analysis of Demographic and Health Survey data." *African Journal of Food, Agriculture, Nutrition and Development* 12 (2):5895-5914.

Faurès, Jean-Marc, and Guido Santini. 2008. *Water and the rural poor: interventions for improving livelihoods in sub-Saharan Africa*. Rome, Italy: Food and Agriculture Organization (FAO).

Ferro-Luzzi, Anna, and Francesco Branca. 1993. "Nutritional seasonality: the dimensions of the problem." In *Seasonality and human ecology*, edited by S. J. Ulijaszek and S. S. Strickland. New York: Cambridge University Press.

Ferro-Luzzi, Anna, Saul S Morris, Samson Taffesse, Tsegaye Demissie, and Maurizio D'Amato. 2001. Seasonal Undernutrition in Rural Ethiopia. In *IFPRI Research Report*. Washington, D.C., Rome and Addis Ababa: International Food Policy Research Institute and Istituto Nazionale della Nutrizione in collaboration with Ethiopian Health and Nutrition Research Institute.

GFDRE (Government of the Federal Democratic Republic of Ethiopia). 2013. National Nutrition Programme 2008-2015.

Gilbert, Christopher L., Luc Christiaensen, and Jonathan Kaminski. 2015. Food Price Seasonality in Africa: Measurement and Extent. *Unpublished manuscript*.

Glewwe, Paul, Hanan. G. Jacoby, and Elizabeth. M. King. 2001. "Early childhood nutrition and academic achievement: A longitudinal analysis." *Journal of Public Economics* 81 (3):345-368.

Handa, Sudhanshu, and Gilead Mlay. 2006. "Food consumption patterns, seasonality and market access in Mozambique." *Development Southern Africa* 23 (4):541-560.

Headey, Derek. 2014. An Analysis of Trends and Determinants of Child Undernutrition in Ethiopia, 2000-2011. *ESSP Working Paper* 70.

Headey, Derek, John Hoddinott, Disha Ali, Roman Tesfaye, and Mekdim Dereje. 2015. "The other asian enigma: Explaining the rapid reduction of undernutrition in Bangladesh." *World Development* 66:749-761.

Herforth, Anna, Andrew Jones, and Per Pinstrup-Andersen. 2012. Prioritizing nutrition in agriculture and rural development: guiding principles for operational investments. *HNP Discussion Paper* 74152.

Hirvonen, Kalle, and John Hoddinott. 2014. Agricultural production and children's diets: Evidence from rural Ethiopia. *ESSP Working Paper* 69.

Hirvonen, Kalle, Alemayehu Seyoum Taffesse, and Ibrahim Worku. 2015. "Seasonality and household diets in Ethiopia." *Public Health Nutrition* forthcoming.

Hoddinott, John, Derek Headey, and Mekdim Dereje. 2015. "Cows, missing milk markets and nutrition in rural Ethiopia." *Journal of Development Studies* 51 (8):958–975.

Horton, Sue, and Richard H Steckel. 2013. "Malnutrition: global economic losses attributable to malnutrition 1900–2000 and projections to 2050." *How Much Have Global Problems Cost the Earth? A Scorecard from 1900 to* 2050:247-272.

Jacoby, Hanan G, and Bart Minten. 2009. "On measuring the benefits of lower transport costs." *Journal of Development Economics* 89 (1):28-38.

Jones, Andrew D, Scott B Ickes, Laura E Smith, Mduduzi NN Mbuya, Bernard Chasekwa, Rebecca A Heidkamp, Purnima Menon, Amanda A Zongrone, and Rebecca J Stoltzfus. 2014. "World Health Organization infant and young child feeding indicators and their associations with child anthropometry: a synthesis of recent findings." *Maternal & Child Nutrition* 10 (1):1-17.

Kaminski, Jonathan, Luc Christiaensen, and Christopher L Gilbert. 2014. The end of seasonality? New insights from Sub-Saharan Africa. *World Bank Policy Research Working Paper* (6907).

Khara, T, and C Dolan. 2014. "The relationship between wasting and stunting, policy, programming and research implications." *Washington DC: USAID Technical Brief Paper*.

Leonard, William R. 1991. "Household-level strategies for protecting children from seasonal food scarcity." *Social Science & Medicine* 33 (10):1127-1133.

Leroy, Jef. 2011. "ZSCORE06: Stata module to calculate anthropometric z-scores using the 2006 WHO child growth standards." *Statistical Software Components*.

Lokshin, Michael, and Sergiy Radyakin. 2012. "Month of birth and children's health in India." *Journal of Human Resources* 47 (1):174-203.

Maleta, K, SM Virtanen, M Espo, T Kulmala, and P Ashorn. 2003. "Seasonality of growth and the relationship between weight and height gain in children under three years of age in rural Malawi." *Acta Paediatrica* 92 (4):491-497.

Masset, Edoardo, Lawrence Haddad, Alexander Cornelius, and Jairo Isaza-Castro. 2012. "Effectiveness of agricultural interventions that aim to improve nutritional status of children: systematic review." *BMJ* 344.

Mendez, Michelle A, and Linda S Adair. 1999. "Severity and timing of stunting in the first two years of life affect performance on cognitive tests in late childhood." *The Journal of nutrition* 129 (8):1555-1562.

Minten, Bart. 1999. "Infrastructure, market access, and agricultural prices: evidence from Madagascar." *Report; International Food Policy Research Institute; Wahington, DC*.

Panter-Brick, Catherine. 1997. "Seasonal growth patterns in rural Nepali children." *Annals of Human Biology* 24 (1):1-18.

Rienecker, Michele M, Max J Suarez, Ronald Gelaro, Ricardo Todling, Julio Bacmeister, Emily Liu, Michael G Bosilovich, Siegfried D Schubert, Lawrence Takacs, and Gi-Kong Kim. 2011. "MERRA: NASA's modern-era retrospective analysis for research and applications." *Journal of Climate* 24 (14):3624-3648.

Ruel, Marie T, and Harold Alderman. 2013. "Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition?" *The Lancet* 382 (9891):536-551.

Stifel, David, and Bart Minten. 2015. Market Access, Welfare, and Nutrition: Evidence from Ethiopia. *ESSP Working paper* 77.

Suits, Daniel B, Andrew Mason, and Louis Chan. 1978. "Spline functions fitted by standard regression methods." *The Review of Economics and Statistics*:132-139.

UNICEF. 1998. *The State of the World's Children 1998*. New York: Oxford University Press.

Vaitla, Bapu, Stephen Devereux, and Samuel Hauenstein Swan. 2009. "Seasonal hunger: a neglected problem with proven solutions." *PLOS Med* 6 (6).

Victora, C. G., M. de Onis, P. C. Hallal, M. Blossner, and R. Shrimpton. 2010. "Worldwide timing of growth faltering: revisiting implications for interventions." *Pediatrics* 125 (3):e473-80.

Webb, Patrick, and Eileen Kennedy. 2014. "Impacts of agriculture on nutrition: nature of the evidence and research gaps." *Food and Nutrition Bulletin* 35 (1):126-132.

WHO. 2006. "WHO Child Growth Standards based on length/height, weight and age." *Acta paediatrica* Suppl 450:76-85.