Child dietary diversity is poor in much of rural Africa and developing Asia, prompting significant efforts to leverage agriculture to improve diets. However, growing recognition that even very poor rural households rely on markets to satisfy their demand for nutrient-rich non-staple foods warrants a much better understanding of how rural markets vary in their diversity, competitiveness, frequency and food affordability, and how such characteristics are associated with diets. This article addresses these questions using data from rural Ethiopia. Deploying a novel market survey in conjunction with an information-rich household survey, we find that children in proximity to markets that sell more non-staple food groups have more diverse diets. However, the association is small in absolute terms; moving from three non-staple food groups in the market to six is associated with an increase in the number of non-staple food groups consumed by ~0.27 and the likelihood of consumption of any non-staple food group by 10 percentage points. These associations are similar in magnitude to those describing the relationship between dietary diversity and household production diversity; moreover, for some food groups, notably dairy, we find that household and community production of that food is especially important. These modest associations may reflect several specific features of our sample which is situated in very poor, food-insecure localities where even the relatively better off are poor in absolute terms and where, by international standards, relative prices for non-staple foods are very high.

Key words: Food market diversity, child nutrition, diet diversity, Ethiopia.

JEL codes: I15, O15, Q18.
operations (Ruel, Quisumbing, and Balagamwala 2018). The logic of these approaches is twofold. First, child undernutrition still remains a predominantly rural problem in low-income countries, especially Africa (Headey and Masters 2018). In Ethiopia, for example, we estimate that around 91% of the country’s 7.15 million stunted preschoolers are rural. Second, since most rural households in low-income countries still predominantly depend on farming, agricultural diversification could improve diets either through increasing cash income from the sale of high-value foods or through improving access to non-staple foods that are expensive or unavailable in markets (Haselow, Stormer, and Pries 2016).

There are countless programs aimed at diversifying household food production and more than forty studies that document associations between household production diversity and diversity of household diets. Systematic reviews of this literature find “small but consistent associations” (Jones 2017), but “little evidence to support the assumption that increasing farm production diversity is a highly effective strategy to improve smallholder diets” (Sibhatu and Qaim 2018).

For economists, the relatively weak association between farm production diversity and consumption diversity is unsurprising given the economic returns to specialization and the relatively basic preconditions for efficient markets. At the same time, development economists have long stressed that markets in low-income countries, particularly in rural areas, can be characterized by systematic and widespread failures (de Janvry, Fafchamps, and Sadoulet 1991; Fafchamps 2003), which may be particularly important in the context of highly perishable nutrient-dense foods. In the presence of market failures, household decisions on food production and consumption may become non-separable (Singh, Squire, and Strauss 1986). Hoddinott, Headey, and Dereje (2015), for example, argue that dairy markets in rural Ethiopia are highly underdeveloped, with virtually no market for processing and storing highly perishable cow’s milk in isolated rural areas. Absent access to markets, access to dairy therefore comes through dairy cow ownership. Consistent with this hypothesis they find that in households owning dairy cattle, children six to twenty-three months of age are more likely to drink milk, but that this association does not hold when households live close to a food market. Other studies in Ethiopia also confirm the importance of market access in shaping diets and conditioning the relationship between production patterns and dietary patterns. Hirvonen and Hoddinott (2017) find that increases in household level production diversity leads to increased dietary diversity in children six to twenty-three months but not when households live in close proximity to a food market. Hirvonen et al. (2017) find that better nutrition knowledge leads to considerable improvements in children’s dietary diversity but only in areas with relatively good market access. Finally, Sibhatu and Qaim (2017) use nationally representative expenditure survey data for Ethiopia to study the extent of consumers’ dependence on own production and markets. They find that while rural Ethiopians are indeed highly dependent on consuming their own production of staple foods, their diversification away from staples is mainly based on market purchases.

Despite this more nuanced analysis of the interactions between household food production and access to markets, economists have arguably done a poor job of conceptualizing and measuring market access (Chamberlin and Jayne 2013). In Ethiopia alone, Chamberlin and Jayne note that market access has been measured as “the distance or walking time to the nearest district administrative seat (woreda town), market town (which may be different than the woreda town), all-weather road, seasonal road, bus service, development agent, input supply shop, or grain mill; whether access to a road had improved in the recent past; whether an all-weather road passes through the woreda; and road density in the woreda.” These types of proxies for market access may be very poor indicators of the latent quality of a

1 Source: The 2016 Ethiopian Demographic Health Survey, which reports a 39.9% stunting rate in rural areas and 25.4% rate in urban areas, and an overall rate of 38.4%. The United Nations estimate that there are 18.26 million pre-school children in Ethiopia (aged 0–5 years), implying that there are 7.15 million stunted children, 6.66 million of whom are rural.

2 Relatedly, Mulmi et al. (2016) assess whether Nepalese households have access to food from elsewhere than their own farm production, by using their district share of total food consumption that is purchased or received in-kind. Studies elsewhere in the literature also explore the importance of markets for buffering the adverse nutritional impacts of environment or weather shocks (Ambikapathi et al. 2019; Darrouzet-Nardi and Masters 2017; Mulmi et al. 2016).
market, particularly the nutritional dimensions of market quality. Despite sizeable literatures on market integration and specific value chains (Fafchamps and Gavian 1996; Minten et al. 2014) and the emergence of supermarkets in low-income countries (Reardon et al. 2003), which predominantly serve urban populations at much less risk of undernutrition, in many settings we know little about such basic constructs as the availability of different types of foods.

In this article, we seek to redress some of these knowledge gaps through a more granular analysis of rural food markets and the associations between food market characteristics and the quality of children diets. Specifically, we address three novel and policy-relevant research questions: First, how do rural food markets vary in terms of a range of potentially important characteristics such as the frequency of their opening, the availability of different foods, food prices, and location and infrastructure characteristics? Second, are market characteristics—particularly the diversity and affordability of foods—associated with the quality (diversity) of children’s diets, even after we control for the diversity of foods produced by the household? And third, what sorts of factors condition the relationship between market quality and dietary quality?

Data and Descriptive Results

We use longitudinal data combining child, household and market surveys conducted by the authors to understand the determinants of nutrition in food-insecure areas of rural Ethiopia (Berhane et al. 2017). Our sample consists of children aged six to thirty months living in households residing in the highland regions of Ethiopia: Amhara; Oromia; Southern Nations, Nationalities and Peoples’ (SNNP); and Tigray. These households live in woredas (districts) selected for inclusion in ongoing (2016–2020) impact evaluations of the fourth phase of Ethiopia’s Productive Safety Net Programme (PSNP). Beginning in 2018, this fourth phase of the PSNP includes a suite of nutrition-sensitive activities, centered around the provision of information on improved maternal and child nutrition practices (GFDRE 2014). Consequently, the evaluation work has two components: (1) an assessment of the impact of the PSNP on food security, assets and livelihoods; and (2) an assessment of its impact on maternal and child nutrition. Baseline data for the second component, collected in March and August 2017, form the basis of this study, augmented by an unusually extensive survey of the nearest food market for each community.

Within each region, probability proportional to size sampling was used to select twenty-two woredas from a list of woredas where the PSNP was operational as of January 2016, the proportions being derived from population size and program coverage. Within each woreda, three kebeles (subdistricts) were selected at random (corresponding to the enumeration areas), yielding a sample of 88 woredas and 264 kebeles (online supplementary appendix figure A1 shows the locations of these kebeles). For the first component of the impact evaluation, lists of PSNP and non-PSNP participant households within each kebele were obtained and random samples of twenty-eight households were drawn from each group (sixteen PSNP; twelve relatively poor non-PSNP). As this sample did not contain enough children needed for the second component of the impact evaluation (on maternal and child nutrition), using the same selection process, additional households with children aged zero to twenty-three months were sampled (Berhane et al. 2018). Surveys were fielded in March (when children were zero to twenty-three months) and August (when they were six to thirty months). Given the objectives of this article, we use data collected on children six months or older. After dropping households with missing data, we have 4,395 such children in the sample evenly distributed across all four regions: 1,888 (44%) observed in March; and 2,398 (56%) observed in August.3 The sample is 50.1% female with 94% being sons or daughters of the household head. A wide variety of household data were included in the survey (described in more detail below), including information on child diets, farm production, household wealth/assets, maternal nutritional knowledge, and household demographics.

3 The sample size increases over time because children aged 0–5 months in March age into the 6–30 age range in the August survey round; see online supplementary appendix figure A2. Household and child attrition between March and August 2017 were less than 3 percent and was driven largely by insecurity in Oromia which rendered some kebeles inaccessible (Berhane et al, 2018).
Our main outcome of interest is child dietary quality as measured by dietary diversity metrics. Mothers were asked a series of yes/no questions about foods consumed in the previous twenty-four hours by children in our sample. Following recommendations found in World Health Organization (WHO 2008), these were grouped into the following seven categories: Grains, roots and tubers (e.g. barley, enset, maize, teff, and wheat); 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. Summing answers to these questions gives the child’s dietary diversity score (DDS) which ranges in value from zero to seven, with a cut-off of four groups used to define minimum dietary diversity.

Figure 1 shows the results of estimating a weighted local polynomial regression of the child dietary diversity score against child age, with a 95% confidence interval (shown as the shaded area around the regression line). Three features are readily apparent from figure 1. First, dietary diversity rises slowly with age. Second, compared to March, mean dietary diversity score is marginally higher in the August round within each overlapping age group, possibly reflecting better availability of certain vegetables with short growing period (Hirvonen, Taffesse, and Hassen 2016; Hirvonen and Headey 2018). Third, in line with previous work in rural Ethiopia (Hirvonen 2016; Golan et al. 2019), dietary diversity is abysmally low for children at all ages irrespective of season.

Table 1 provides more detail on dietary patterns. The average child consumes 1.6 food groups and only 5% consume the WHO (2008) recommended daily consumption of four groups or more. Basic staples are the most commonly consumed food group (81%) followed by other fruit and vegetables (29%) and legumes and nuts (26%). Less than 15% of children consumed vitamin A rich fruits and vegetables or dairy, and few consume flesh foods or eggs. On average, children consume 0.8 non-staple food groups with dietary diversity being higher in August. Approximately 15% of children in our sample, mostly aged six to eight months, consumed no foods the previous day. If we exclude these children, as shown in the right-hand panel of table 1, we see that virtually all the remaining children consume grains, tubers or roots. Given this fact, what is of interest to us is the consumption of non-staple food groups.

Figure 2 gives the distribution of non-staple consumption patterns by survey round. We see that non-staple food consumption is more prevalent in the August round of data. Nearly 60% of the children in our sample consumed no non-staple foods in the March round. This falls to 35% in the August round. Depending on the survey round, between 27% and 36% consumed one

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4 These groups and their aggregation reflect the need for young children to consume a variety of food groups if they are to meet both energy and micronutrient needs (FANTA 2006; WHO 2008; Allen 2013). They are highly correlated with more detailed and complex measures of food and micronutrient intake (Ruel 2003; FANTA 2006; Moursi et al. 2008; Daniels et al. 2009) and with measures of children’s nutritional status such as height in a number of developing countries including Ethiopia (Ali et al. 2012; Jones et al. 2014). See Hirvonen and Hoddinott (2017) for additional discussion and references.

5 A limitation of this 24 hour recall is that there may be children who consume non-staple foods but do not do so with regularity. This will lead to some attenuation bias, see Thorne-Lyman, Spiegelman, and Fawzi (2014).

6 The March survey round coincided partly with the Lent (Orthodox fasting period), during which Orthodox households follow a vegan diet. Young children are exempted from fasting but their consumption may still be affected as some caregivers are unwilling to prepare animal sourced foods during fasting (Kim et al. 2018).

7 Online supplementary appendix table A1 breaks these data further by children’s age.

8 95% of the children who did not consume foods in the previous day were not yet introduced to complementary foods at the time of the interview; they were either exclusively or intensively (breast milk and liquids such as water, juices) breastfed.

9 The consumption of foods apart from grains, roots or tubers is, for brevity, referred to as “non-staples”.

10 Online supplementary appendix table A2 breaks these data further by child’s age.
non-food group, 11–22% consumed two non-food groups, and 3–7% consumed three or more.

Mean maternal age in this sample is twenty-nine years. Mothers are poorly educated. Maternal mean grades of schooling is only 0.8, and 84% report never attending school. In March and August, we administered short quizzes consisting of twelve questions on complementary feeding (CF). Mean scores were 5.8 in March and 6.0 in August. Schooling levels of the household head are also low with 80% never having attended school. Mean age of the head is thirty-eight years. Only 10% of heads are female. Moreover, 49% are Ethiopian Orthodox Christians, 32% are Muslim, and 16% are Protestant. The mean household size in this sample is 5.8 members.

The poor dietary diversity of children in this sample is consistent with the high levels of food insecurity and low levels of wealth of the households in which they reside. The average months of self-reported food shortages (food gap) is 2.7 months with 28% having a food gap of four months or more. Median land holdings are 0.63 ha; on average, the average households own 3.1 tropical livestock units (TLU).

Averaging over both survey rounds, 41% of households produce no non-staple foods, just 36% produce one nonstaple food group, 17% produce two, and 6% produce three or more non-staple food groups. This very limited variety of foods produced suggests that markets are indeed likely to be an important source of dietary diversification in rural Ethiopia (Sibhatu and Qaim 2017).

In addition to the household survey, we fielded a survey of the market closest to households in each kebele. Apart from collecting price data on 71 different foods, enumerators were instructed to assess whether each of these foods was available anywhere in the market. Data on market characteristics—number of food sellers, days of operation, and descriptions of infrastructure including road quality, availability of cell phone service, electricity and buses—were also collected. These market data were collected at the same time as the household

Table 1. Descriptive Statistics for Child Dietary Diversity by Survey Round

|                     | All Children | Children Who Consumed at Least from One Food Group |
|---------------------|--------------|----------------------------------------------------|
|                     | March        | August     | Both       | March        | August     | Both       |
| Dietary diversity score (count) | 1.4          | 1.8        | 1.6        | 1.7          | 2.1        | 1.9        |
| Four or more food groups (%)      | 3            | 6          | 5          | 4            | 7          | 6          |
| Grains, roots, and tubers (%)     | 77           | 83         | 81         | 96           | 96         | 96         |
| Legumes and nuts (%)             | 21           | 29         | 26         | 26           | 33         | 30         |
| Dairy (%)                       | 7            | 18         | 13         | 9            | 21         | 16         |
| Meat, fish, poultry (%)          | 1            | 2          | 1          | 1            | 2          | 2          |
| Eggs (%)                        | 5            | 5          | 5          | 6            | 6          | 6          |
| Vitamin-A rich fruit/vegetables (%) | 5          | 10         | 8          | 7            | 12         | 10         |
| Other fruits and vegetables (%)  | 19           | 37         | 29         | 24           | 42         | 34         |
| Non-grain food groups (count)    | 0.6          | 1.0        | 0.8        | 0.7          | 1.2        | 1.0        |
| Sample size:                    | 1,940        | 2,455      | 4,395      | 1,565        | 2,140      | 3,705      |

Figure 2. Percent of children consuming from different non-staple food groups, by survey round

Note: *N* = 1,940 children in March; 2,455 children in August.

11 For on-farm crop production we consider the growing season before the survey (meher for March and belg for August and for livestock production, we consider the 3 months prior to the survey.)
surveys in March and August allowing seasonal comparison of food availability.

We use our price data in two ways. First, we calculate the cost of acquiring calories from the cheapest staple in each market to capture how expensive it is to satisfy basic calorie requirements. Lower staple prices have beneficial real income effects for net food consumers. Across our full sample, the mean cost of acquiring 500 calories from the cheapest staple cereal was 0.88 birr in March and 1.05 birr in August (the lean season). Second, we calculate the cost of diversifying away from staple foods. Following Headey, Alderman, and Rao (2017), we measure the ratio of non-staple calories relative to staple food calories (cereals/roots/tuber), the calorie price ratio (CPR). These CPRs are calculated for each food group using the cheapest source of calories within that group and the cheapest source of cereals/roots/tubers in that market.\footnote{12} CPRs have a straightforward interpretation. For example, a CPR of 10.3 for the dairy food group in a particular market means that it costs 10.3 times more to obtain a calorie from a dairy product than it does a calorie from a staple in that market.

Online supplementary appendix table A3 provides some basic information about these markets. Approximately half (53%) of markets operate on a weekly basis with another 30% operating twice a week. The number of vendors selling food in these markets is relatively high with 76% having more than fifty traders selling food and another 14% having twenty-one to fifty, while 77% have bus service and seventy-six have electricity. Cell phone coverage is nearly universal.

Table 2 demonstrates that rural markets in Ethiopia are “incomplete” in terms of the number of markets that do not sell at least one product within a given food group. All markets sell at least one grain, root or tuber, non-Vitamin A rich fruit or vegetable, and virtually all markets (>95%) sell eggs and legumes. However, only 83% sell vitamin A-rich fruits or vegetables, while just 45% sell dairy products. Figure 3 shows that the average market sells 7.6 different staples, 4.2–4.8 legumes or nuts but fewer than one dairy product and between 0.5 and 1.2 flesh foods. There is also limited choice in terms of Vitamin A rich fruits and vegetables. The absence of dairy and meat products in many markets partly accounts for the fact that only 35.2% of markets in the

| Table 2. Market Diversity by Round |
|-----------------------------------|
| Grains, Roots and Tubers | Legumes and Nuts | Dairy | Meat, Fish, Poultry | Eggs | Vitamin-A Rich Fruit/ Vegetables | Other Fruits and Vegetables | Market Diversity | Non-Staple Market Diversity |
|-------------------------------|----------------|-------|-----------------|-----|-------------------|-------------------|-----------------|---------------------|
| March                         | 100 | 97 | 47 | 57 | 98 | 80 | 100 | 5.8 | 4.8 |
| August                        | 100 | 96 | 44 | 31 | 95 | 86 | 100 | 5.5 | 4.5 |
| Both rounds                   | 100 | 97 | 45 | 44 | 97 | 83 | 100 | 5.6 | 4.6 |

\textit{Note:} 264 markets in each survey round.
March round and just 16.7% of markets in the August round sold all six non-staple food groups, although many markets fall short of providing even four non-staple food groups (figure 4). In addition to a number of markets failing to provide a wide range of non-staple foods, in the lean-season (August) market diversity falls.

Table 3 reports calorie price ratios by food groups conditional on being available in the market as well as the market geometric mean by round, including imputed missing price, as described in footnote 12. Nutrient-dense non-staple foods tend to be very expensive in rural Ethiopia. In the March survey, for example, the cheapest dairy-based calorie source was 13.2, while flesh foods and eggs are twenty-four to twenty-seven times more expensive than cheapest staple grains. Vitamin A-rich fruits and vegetables are eleven to eighteen times more expensive, and other fruits and vegetables ten to twelve times more expensive in terms of calories than the cheapest cereal. Legumes and nuts, being much less perishable and relatively calorie-dense, are substantially more affordable, just three times more expensive than staple-based calories.13

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13 We explored associations between CPRs and market characteristics. Controlling for region and round fixed effects, CPRs are lower in markets with more traders and higher in markets that are farther away from urban centers (towns or cities with populations exceeding 10,000 people). Markets that operate more frequently have lower CPRs as do markets that offer more products. CPRs appear to not be associated with market infrastructure as measured by access to electricity, road quality or bus service.
Econometric Approach

Our outcomes are measures of diet (DIET) of child $i$, in households $h$ that reside in woreda $w$ and kebele $k$ observed at time $t$. In addition to market (MARKET) characteristics, which are the focus of this article, we control for vectors of child (CHILD), maternal (MATERNAL), household (HH), and kebele (KEBELE) characteristics. In all models, we also control for woreda (W) and survey round (T) fixed effects. Vectors of estimated coefficients are denoted by $\beta$, while $\varepsilon$ is the disturbance term. We estimate models of the following form:

$$
\text{DIET}_{ihwkt} = \beta_{\text{CHILD}} \text{CHILD}_{ihwkt} + \beta_{\text{MATERNAL}} \text{MATERNAL}_{ihwkt} + \beta_{\text{HH}} \text{HH}_{ihwkt} + \beta_{\text{KEBELE}} \text{KEBELE}_{ihwkt} + \beta_{\text{MARKET}} \text{MARKET}_{kw} + W_w + T_t + \varepsilon_{ihwkt}
$$

Our primary dependent variable (DIET) is the number of non-staple food groups consumed by child $i$ in the last twenty-four hours. We estimate these models using ordinary least square (OLS) regression methods, but because these continuous measures are non-negative counts, we also use a Poisson estimator. We also estimate models where DIET takes a binary form, obtaining a value of one if the child consumed any non-staple food groups in the last twenty-four hours, and zero otherwise. In this case, we use linear regression and probit estimators. In the case of probit and poisson estimators, we convert the coefficients into marginal effects. Moreover, acknowledging the sampling design (Abadie et al. 2017), we cluster the standard errors at the woreda level.

The coefficients on market diversity, $\beta_{\text{MARKET DIVERSITY}}$, are the principal outcome of interest in this study, but we also control for a number of other market characteristics: a dummy variable equaling one if the market has more than twenty vendors selling food; number of days per week the market operates; whether the market has a bus service; and the cost, per calorie, of purchasing the cheapest cereal available in the market. We also control for the market’s (logged) distance to the nearest town of at least 50,000 people. We do not include other infrastructure measures such as electricity or cell phone service because, while they differ across woredas, they rarely differ within woredas and so most of the variation is differentiated out when we estimate our woreda fixed effects models.

CHILD includes child age, sex, and whether the child is the son or daughter of the household head. MATERNAL includes mothers’ education in years, age, and mothers’ score on a twelve question test of her knowledge of complementary foods and feeding. Household (HH) characteristics include head’s grades of education, age, sex, and religion (denoted by two dummy variables for Muslim and for Protestant with Orthodox Christian being the reference category). We control for household size, the food gap, and three measures of household wealth—livestock holdings as measured by tropical livestock units (TLU), land operated (hectares), and an asset index based on ownership of consumer durables constructed using principal components (Filmer and Pritchett 2001). We also control for the travel time (in minutes) between the household and the nearest market using a friction grid built by Schmidt et al. (2018). At the kebele level, we control for the mean level of the food gap, mean maternal knowledge of complementary feeding and the mean of the asset index. These can be thought of as locality level demand side factors that might shift household demands for certain foods through norms shifting or through dispersion of information about what constitutes a good child diet. These controls also soak up some otherwise unobservable locality characteristics that might be correlated with the diversity of foods sold in the market. For example,

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14 Online supplementary appendix figure A3 in shows that the Poisson distribution fits the unconditional (non-staple) dietary diversity distribution extremely well.

15 For probit, the woreda fixed effects are implemented using the so called “brute force” approach in which dummies for each woreda are added into the model and then this model is estimated using a standard probit estimator.

16 Because figure 1 suggests that the relationship between children’s dietary diversity and age is linear, we include the age variable in linear form into the estimated model.

17 Items on this test included questions such as “What are some foods that are rich in iron?” and “What can happen to children if they do not eat enough vitamin A-rich foods?”

18 The food gap is a food security measure used extensively in Ethiopia. A household is considered as food insecure in a given month if it self-reports that it was unable to satisfy its food needs for at least five days in that month.
traders might be more likely to sell high-value products in markets where, on average, households are wealthier or where mothers are more knowledgeable about the importance of different complementary foods. The survey dummy captures the level shift in children’s dietary diversity between survey rounds (see figure 1) and the woreda fixed effects control for observed and unobserved characteristics associated with living in the same woreda. To properly account for the panel nature of our data, we also estimate a specification where these woreda fixed effects are replaced with child level fixed effects. Online supplementary appendix table A4 provides the summary statistics for the variables used in the regressions.

In an observational study such as this, there is concern that there will exist correlation between our variables of interest and the disturbance term. Here of particular concern is the possibility that \( E(\text{MARKET DIVERSITY}_{wkt} \mid \varepsilon_{ihkwt}) \neq 0 \), and thus our estimator for \( \beta_{\text{MARKET DIVERSITY}} \) will be biased. While we cannot rule this out, we note that our model addresses many sources of such a correlation. In addition to controlling for fixed woreda effects and survey round, we control for other market characteristics that might be associated with market diversity (size, cereal price levels, accessibility) and locality demand side characteristics (mean kebele wealth, food security, knowledge of complementary foods). At the household level, we include characteristics that shift demand for child diet quality through taste (maternal age, education, and knowledge of complementary foods) or income (education, food security, wealth).\(^{19}\)

Regression Results

Table 4 gives the results of estimating equation (1). Coefficient estimates for the number of non-staple food groups sold in the market are given in the first row. We also report coefficients for the number of non-staple food groups produced by the household, the number of food vendors in the market and mean kebele scores of maternal knowledge of complementary foods. Drawing on the linear regression woreda fixed effects specification (column 1 in table 4), in the online supplementary appendix table A5 we explore sensitivity of estimates by estimating equation (1) using a different set of control variables. The coefficients on the number of non-staple food groups sold in the market and produced by the household are relatively stable across the different specifications, ranging in value between 0.05 and 0.08 (p-values: .000 to .028). The last column of table A5 also provides the coefficients for all covariates. In line with figure 1, child consumption of non-staple food groups rises with age. There are no well measured associations with maternal characteristics (including her knowledge of complementary foods) or characteristics of the household head. Increases in household food insecurity (food gap) is associated with lower non-staple food consumption; increases in wealth are associated with higher consumption. Market characteristics such as bus service and number of days a market is open have no (independent) association with non-staple food consumption.

Column 1 in table 4 shows that there is a statistically significant association between the number of non-staple food groups available in the market and children’s consumption of non-staple food groups. This association exists after controlling for woreda fixed effects and a wide range of market, kebele, household, maternal and child characteristics.\(^{20}\) Looking across other econometric specifications, this association remains when we use a Poisson specification (column 2), account for child fixed effects (columns 3 and 4) or when we treat our outcome variable as binary (columns 5 and 6).

While statistically significant, the magnitudes of these associations are small in absolute terms, although this is likely due to the fact that we have a sample of exceptionally poor households and communities. Using results from our Poisson woreda fixed effects regression (column 2), moving from three non-staple food groups in the market to six would increase the number of non-staple food groups consumed by 0.27. Considering that the average child in our sample consumed 0.8 non-staple food groups (table 1),

\(^{19}\) We do not include PSNP status in our model but note that many of these characteristics, such as food security and livestock holdings, are correlated with whether the household receives PSNP payments. Including it does not change our findings.

\(^{20}\) Oster (2019) comments that, by itself, coefficient stability is uninformative about whether the addition of controls adequately addresses concerns regarding omitted variable bias. In our models, the \( R^2 \) rises from 0.02 (when we only include market diversity in our regression) to 0.16 (when we include a full set of controls).
this corresponds to a relatively large 33% increase in the non-staple dietary diversity score. The marginal effects reported in column 5 and 6 tell us that such an increase in the availability of non-staple foods would increase the likelihood of consumption of any non-staple food group by 10.5 percentage points. Since 54% of the children in our sample consumed non-staple foods in the previous day, this translates into a 19% increase in the likelihood of a child consuming a non-staple food group.

There is also an association between the number of traders selling food and non-staple food consumption but the precision of this association varies by model specification. The strongest evidence comes from columns 5 and 6 which show that in markets with more than twenty food sellers the likelihood that a child consumes a non-food group rises by about 12 percentage points.

Table 4 also tells us that there are statistically significant associations between the number of non-staple food groups produced by the household and children’s consumption of non-staple food groups. This holds across all model specifications, except in the Poisson model based on child fixed effects. Consistent with the literature cited at the beginning of this article, the magnitudes of these associations are small and are comparable to the magnitudes we observe on market (non-staple) diversity.

Increases in maternal knowledge of complementary foods, as measured by the kebele mean, are also associated with increases in children’s consumption of non-staple food groups. But this association is not precisely measured and it too is small in magnitude.

The existing literature (see, e.g., Hirvonen and Hoddinott 2017) suggests that market and own production may act as substitutes. We assess this by interacting these two variables. As reported in Table 5, the coefficient on the interaction term is negative and statistically significant suggesting that own production serves as a substitute to (lack of) market diversity. However, the estimated coefficient on the interaction term is small in magnitude.

We explored the robustness of these findings in several ways. First, changing the control variables we include in these regressions.
or changing how they are specified (e.g., including dummy variables for child age rather than a linear term; expressing maternal education as a dummy variable) does not affect our findings (see the online supplementary appendix table A6). Our findings are also not sensitive to how we measure market diversity. For example, if we express it as the number of non-staple food items sold in the market rather than the number of food groups, we again see a statistically significant association but one that is small in magnitude (see the online supplementary appendix table A7). Some of the households are extremely remote, raising doubts about their engagement with markets. However, excluding households that reside more than two, three, four, or five hours away from their nearest market does not change our findings (see the online supplementary appendix table A8).

Coefficients reported in the online supplementary appendix tables A9 and A10 suggest that very young children (six to eleven months of age) and girls benefit less from market availability of non-staple foods than other children, but the differences across age groups and sexes are not statistically different from zero.

**Extension (1): Accounting for Locality Production of Non-Staple Foods**

Own production and food markets are not the only sources of food; foods can be purchased, borrowed or received from other households in the same locality. Does accounting for this affect our results? We assess this possibility in two ways.

Using our woreda fixed effects specification, we add as additional controls the percentage of households in each kebele producing different non-staple food groups. For less seasonal foods (dairy, poultry, fish and meat, and eggs) this indicator is based on recalled production in the last three months. For the remaining food groups (nuts and legumes; vitamin A rich fruit and vegetables; other fruit and vegetables), it is based on recalled production in the last twelve months. Table 6 shows that when we do so, our OLS coefficients on market diversity, household production diversity, number of traders and kebele knowledge of complementary feeding remain largely unchanged.

In table 7, we report food-specific results from linear probability models with woreda fixed effects. These regressions model whether the child consumed a specific food group the previous day as a function of whether that food group is available in the market, produced by the household or produced by large numbers of households in the kebele (measured in proportional terms). Strikingly, all three aggregations are associated with consumption of dairy products, suggesting that own consumption, barter/gifts/informal trade, and market interactions may all be important for dairy, a highly perishable product in milk form. Consider two children. Child A lives in a community where dairy is sold in the market and in a household that produces dairy, as do 25% of households in her kebele. Child B lives in a community where dairy is not sold in the market, in a household that does not produce dairy, and where only 10% of households in her kebele do so. Child A is 20 percentage points more likely to consume dairy than Child B. These results, along with the fact that dairy products are frequently missing from food markets (table 1), suggest that dairy products are a special case. Household dairy production is likely to be an important source of child consumption when there are no opportunity for processing, storage, or sale, precisely because fresh milk is so perishable. Moreover, even

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**Table 5. Do Market and Own Production Act as Complements or Substitutes?**

| (1)                                      |        |
|------------------------------------------|--------|
| Number, non-grain food groups sold in market | 0.098*** (0.022) |
| Number, non-grain food groups produced by household | 0.214*** (0.065) |
| Interaction term                          | -0.027** (0.014) |
| Survey round dummy?                      | Yes    |
| Child level controls?                    | Yes    |
| Household level controls?                | Yes    |
| Kebele and market level controls?        | Yes    |
| Woreda fixed effects?                    | Yes    |
| Observations                             | 4,395  |

**Note:** OLS model. The total sample consists of 4,395 child observations living in 2,467 households and 88 woredas. Standard errors clustered at the woreda level in parentheses. Statistical significance denoted by: *significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.

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21 We exclude the market covariate in the legumes and nuts, eggs, and other fruit and vegetable specifications as the percentage of markets where these are available exceeds 95% (see table 2).
when markets are available, they will usually only take milk extracted in the morning; yet lactating cows typically also produce “evening milk” that cannot be sold and must be consumed or processed into butter/ghee or yogurt.

Market availability of flesh foods (poultry, fish, meat) is also associated with a 1.5 percentage point increase in the likelihood of that a child consumed those foods. Considering that only 1% of the children in our sample consumed meat products, this means that the likelihood of consuming meat products more than doubles in localities where markets stock these products. Household egg production is also associated
with a higher likelihood that the child consumed an egg, as does the percentage of households in the kebele who produce eggs. These associations are small if we take them at face value but relatively large if we consider that only 5% of the children consumed eggs in the previous day. Household production of fruit and vegetables increases the likelihood that the child consumes both vitamin-A rich fruits and vegetables and other fruits and vegetables.22

**Extension (2): Child Dietary Diversity and the Price of Non-Staple Foods**

One reason for the limited influence of markets on children’s diets in this sample is simply very poor. A second reason is that, relative to CPRs observed in other settings, CPRs in these Ethiopian markets are exceptionally high. Headey et al. (2018) report that CPRs for animal source foods (cow’s milk, eggs, fish, meat) in high-income countries range from 2.0 to 4.3 and in African countries—where CPRs are highest—from 5.6 to 16.5. By contrast, table 3 shows that in this sample, they range from ten to thirty with the average calorie from a non-staple food approximately twelve times more expensive than a calorie from a staple. With this in mind, we explored the relationship between CPRs and children’s consumption of non-staple foods by replacing the number of non-staple food groups with log geometric mean of CPRs. Results are reported in table 8. The association is negative indicating that higher market prices are associated with lower dietary diversity. Moreover, the estimated coefficients are highly statistically significant ($p < .05$), but the magnitudes small; doubling the mean price ratio is associated with a 0.15 food group decrease in dietary diversity (column 2). The magnitudes in the probability models are somewhat larger; doubling the mean price ratio is associated with a 7.9 percentage point (or 15%) increase in the likelihood that the child consumes from a non-grain food group.23

**Conclusions**

Child stunting remains a predominantly rural problem in much of the developing world, particularly sub-Saharan Africa (Headey and Masters 2018), with a considerable amount of

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22 Averaging across rounds, only about 5% of the households produced vitamin A-rich fruits and vegetables and about 7% produced other types of fruits and vegetables.

23 The variations in the price ratios are quite large across market; the sample mean is 12.2 birr with a standard deviation of 6.9 birr and interquartile range of 5.2 to 7.69 birr. Thus, doubling the mean price corresponds to $\sim 2$ standard deviation increase in prices.
The relatively modest association between market characteristics and dietary diversity may seem surprising. It may reflect several limitations of our data and survey design.
consumption of eggs by just 3 percentage points: on average, egg calories are almost thirty times more expensive than calories from the cheapest staple food in the market. We do, however, find some indirect evidence that dairy and fruit and vegetable promotion might improve children’s consumption of these products, and that some relatively nutritious foods are highly affordable (legumes, nuts and some fruits and vegetables, albeit seasonally), and perhaps underappreciated by parents with limited nutritional knowledge.

Ultimately, however, sizeable improvements in rural diets must be built upon improved access to high-quality markets that deliver a wide array of healthy foods at affordable prices. The agricultural foundations of better rural markets likely stem from increased specialization (rather than production of a wider array of foods), and even greater dependence on markets for both agricultural sales and food purchases. How best to accelerate the development of higher quality rural food markets is not a well-understood question and thus represents a promising line for future research.

**Supplementary Material**

Supplementary materials are available at American Journal of Agricultural Economics online.

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