How Does Composition of Household Income Affect Child Nutrition Outcomes? Evidence from Uganda

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Abstract

This study attempts to fill the knowledge gap between the cross-country analyses that explore the links between income and nutrition without insights on micro-level determinants, and the numerous microeconomic studies that suggest mechanisms of impact but are hindered by some combination of small sample size, incomplete data, and questionable approaches to impact estimation. The analysis uses the three annual waves of the Uganda National Panel Survey, and features panel regressions of child anthropometric outcomes controlling for time-invariant child-level heterogeneity and other time-variant observables. The paper starts by looking at how the outcomes correlate with short-term changes in rural household income. The impact is subsequently differentiated by sector of income, first between agricultural and non-agricultural sectors, and by type of agriculture. The analysis documents no impact of short-term changes in total gross income on weight-related measures but documents positive effects on height-related outcomes. Sector-differentiated analyses indicate that only the share of income originating from non-farm self-employment exerts positive and statistically significant effects on both height and weight measures. For height, the income shares pertaining to (i) consumption of own crop production and (ii) low-protein crop production appear to be underlining the negative effect of the share of income originating from crop production. The results suggest stickiness of crop production to own consumption, and while this may be nutrition-supporting in some contexts, income growth in the production of low-nutrient crops in Uganda may crowd out consumption of other goods and services that have the potential to serve as better nutritional investments.

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1. Introduction

In the quest for widespread and sustainable welfare gains, not all income may have equal effects. Growth within some sectors or accruing to certain individuals within a population may be relatively more effective at reducing poverty and improving specific welfare outcomes in developing countries. Child under-nutrition, targeted directly by the first of the Millennium Development Goals and related to others, is an aspect of poverty that is often argued to be sensitive to growth in the agricultural sector, with potential for both gains and losses. In recent years, there has been a growing movement to pull together evidence on the links among agriculture, income, nutrition and health for the design of multi-sectoral interventions that target nutritional deficiencies.[2]

All income has the potential to benefit children's nutrition, and if the restrictive case of "separation" holds, income from any source or sector would be equally beneficial.[3] Empirically observed deviations from separation may originate from multiple sources: distribution of poverty across sectors, relative food production and consumption prices due to markups and transaction costs, risk preferences, and intra-household bargaining outcomes, to name a few. The direction and relative weights of these channels of impact would lead to very different prescriptions for policymaking and allocation of scarce resources meant to boost nutrition-supporting growth. Empirically, however, validation of the claims regarding whether and how household sectoral involvement and gains in productivity can contribute to changes in nutritional status and health has been hindered by data limitations and by methodological concerns.

A large collection of microeconomic studies attempting to determine the links to nutrition through specific mechanisms provide mixed and often conflicting results. The investigated mechanisms include (i) commercialization (reviewed by DeWalt, 1993; Kennedy, Bouis, & Braun, 1992, von Braun & Kennedy, 1994), (ii) gender dynamics (reviewed by Kurtz & Johnson-Welch, 2007; Peña, Webb, & Haddad, 1996; Quisumbing, Brown, Feldstein, Haddad, & Peña, 1995; Quisumbing & Maluccio, 2000), and (iii) nutrition-sensitive production and education interventions (reviewed by Berti, Krasevec, & Fitzgerald, 2004; Gillespie & Mason, 1994; Leroy & Frongillo, 2007; Masset et al., 2011[4]; Ruel, 2001; Soleri, Cleveland, &

[2] Some examples include (i) the International Food Policy Research Institute (IFPRI) "2020 Conference: Leveraging Agriculture for Improving Nutrition and Health" that was held in New Delhi, India in February 2011, and (ii) the United States Agency for International Development (USAID)'s review of nutrition and food security impacts of agriculture projects, which can be found here: http://pdf.usaid.gov/pdf_docs/PNADY253.pdf.

[3] Assuming complete markets and a utility-maximizing unitary household, the separation property of the farm-household model describes the result that households' production decisions can be modeled as separate from their consumption choices. A corollary is that households' consumption choices depend on production outcomes only via total profits. Empirical failures of separation for households in many developing countries thus motivate study of particular market failures and alternate models of household decision-making.

[4] Masset et al. (2011) narrow down their focus on interventions with an explicit goal of improved child nutrition. The 2011 online version of the publication offer additional details on counterfactual analysis, power, intermediate outcomes, and heterogeneity of impacts, and can be found here:

Frankenberger, 1991). While some differences could be due to context-specific dynamics, numerous reviews in recent years express concerns regarding (i) the validity of the empirical methods used for impact estimation, and (ii) the inconsistency in the types of data used across studies which often lack information on income and have information on only consumption or anthropometry but not both (Arimond et al., 2011; World Bank, 2007; Leroy et al., 2008).

Despite these challenges, the sheer number of studies conducted over the last few decades speaks to the long-standing and urgent demand for insights on how to effectively leverage growth for nutritional improvement. While researchers and key policy players overwhelmingly assert that there is a strong potential for agricultural development to support nutrition and health, they also lament the lack of insight into the specific conditions necessary and sufficient to achieve improved nutritional outcomes efficiently and at broad scale. Herforth (2013) synthesizes the current state of knowledge cites general consensus on many best practices for improving nutrition through agriculture but highlights two questions that are yet to be settled: (i) what are the relative nutritional impacts of agricultural production for own consumption vis-à-vis agricultural production for sales? and (ii) what agricultural products households should focus on, for example staple crops vs. animal-source foods? To this list, we add a third, overarching question that stem from the literature: Even if agricultural growth can be leveraged effectively for nutrition, is it more effective than non-agricultural growth at micro level?

With these questions in mind, we take advantage of the three waves of the household survey data from the Uganda National Panel Survey in an attempt to fill the knowledge gap between the cross-country analyses that explore the links between income and nutrition but cannot explore determinants at a micro level and the numerous smaller microeconomic studies that point to mechanisms of impact but are often hindered by some combination of sample size, data incompleteness, and other methodological considerations. We start by looking at how child nutritional outcomes correlate with *short-term* changes (1-2 years) in household income regardless of source. Subsequently, we explore heterogeneity by source of income, first between agricultural and non-agricultural sources and then further within type of agriculture, according to the priorities set previously in the literature.

There are three key findings. First, we document no impact of short-term changes in total gross income on weight measures but document positive effects on height-related outcomes. Second, sector-differentiated analyses indicate that only the share of income originating from self-employment exerts positive and statistically significant effects on both height and weight measures. Third, for height specifically, the income shares pertaining to (i) consumption of own crop production and (ii) low-protein crop production, rather than crop production alone, appear to be driving the negative effect of the share of income originating from crop production.

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http://r4d.dfid.gov.uk/PDF/Outputs/SystematicReviews/Masset_etal_agriculture_and_nutrition.pdf.

The remainder of the paper is structured as follows. Section 2 presents the theoretical mechanisms through which income growth and sector and subsector of growth can influence nutrition in the context of the existing body literature. Sections 3 describes our data sources; Section 4, empirical strategy and results. Section 5 concludes.

2. Linking Income and Agriculture to Nutrition: Theory and Literature

The factors that are commonly understood to interact to that hinder nutrition are 1) household food insecurity, which encompasses food availability as well as quality, 2) inadequate care, and 3) unhealthy environment (UNICEF, 1990; Behrman & Deolalikar, 1988).[5] The direction of these biologically-based impacts is well established in the literature, and we take them as given: any positive or negative impacts of agriculture on nutrition must act through these channels. Descriptively, we offer a health production function for nutritional outcomes:

$$H_i = H(f_i, n_i, s_i, X_i),$$

which over time accumulate as:

$$H_{it} = H(f_{it}, n_{it}, s_{it}, X_i, H_{it-1})$$

where time t-indexed food consumption f_{it}, care/nurturing n_{it}, and sanitary environment s_{it} as well as a vector of individual or household characteristics X_i and previous nutritional health outcomes H_{it-1}. Lack of any factor, such as food, care, sanitation, may be sufficient to induce under-nutrition, and the provision of each is expected to complement the others in producing health (while competing through the budget constraint), so we would expect the true production function will contain interactions of these terms, likely with non-linearities and minimal subsistence terms.

Connecting the dots conceptually from income to nutrition, households may value health directly or may value consuming inputs that contribute to health (food, care, sanitation) as well as other consumption c_{it} and leisure l_{it}, according to household characteristics X_{it}:

$$U_{it} = U(f_{it}, n_{it}, s_{it}, c_{it}, l_{it}, X_{it}).$$

The household wants to maximize utility subject to a budget constraint such as

[5] There is a large literature establishing the importance of all three factors for nutritional outcomes, which we take as given, though a precise nutrition production function is widely absent, given measurement difficulties and identification challenges that arise from reliance on observational data.

$$p_f f_{it} + p_s s_{it} + p_c c_{it} - w(n_{it} + l_{it}) \leq I_{it}$$

where p_f, p_s, p_c, w are the prices of food, sanitation, other consumption, and the wage rate; and income I_{it} comprises represents farm profits, non-agricultural enterprise profits, and the value of household labor and land endowments.[6]

Under the simplest and most restrictive case of separability, income only affects these nutrition-inducing consumption choices by setting the budget constraint, with no other characteristic of income having influence. By relaxing the budget constraint, increases in income from any source may lead to greater food consumption; nutritional gains may be further facilitated by higher marginal consumption of food among the poor (Engel's Law) especially in terms of consumption of calories and essential micronutrients (Skoufias, Tiwari, & Hassan, 2012; Strauss & Thomas, 1995; Subramanian & Deaton, 1996). At the same time, income gains enable greater consumption of complementary health inputs such as sanitation improvements and healthcare services, and the income elasticity of health and sanitation expenditures can remain quite high throughout the income distribution (von Braun et al., 1991). Income can be used for childcare services or otherwise improve the quality of care given as well. For example, higher expenditure on education allocated to girls as a result of increased income eventually translates into higher maternal education, shown to improve child nutritional outcomes (Behrman & Wolfe, 1984; Umapathi, 2008; Webb & Block, 2004), though this can take years or decades to materialize.

Empirical studies using pooled cross-sectional data show that nutritional outcomes do improve alongside long-run, aggregate economic growth (Cole, 2003; Haddad & Smith, 2002; Headey, 2013;[7] Webb & Block, 2010). Yet this relationship is not guaranteed, depending on duration and distribution of growth. Under the permanent income hypothesis and consumption smoothing, short-term income fluctuations may be less likely to induce consumption of food or sanitation when compared to longer-term gains (Hall & Mishkin, 1982). Clearly, a household must be able to participate when there is aggregate growth in order to benefit from it. Looking at "nutritional episodes" with an average duration of 4.7 years, Heltberg (2009) looks at income growth across countries but finds less improvement in child stunting rates compared to longer term studies, with nutrition improving less in more unequal societies. Relatedly, Webb and Block (2010), with data largely drawn from Sub-Saharan Africa, find that growth from structural transformation fails to support nutrition for the rural poor in the short run but point to agriculture effectively lowering stunting by reaching the rural poor. Headey (2013) finds that once India is excluded in cross-country regressions, agricultural growth corresponds to a stronger reduction in stunting than non-agricultural growth in the medium term. Again, even if a household is able to

[6] Given the limitations of nutritional science to define the biological relationships more precisely, and acknowledging the admonitions of Behrman and Deolalikar (1988), we do not detail a functional form of utility on health or of health on the relevant inputs. We will rely on multiple specifications and robustness checks rather than claiming a structural form.

[7] Headey (2013) is able to point to greater food production, though not consumption in particular.

participate in income growth, conversion to nutrition through the mechanisms of food, care, and sanitation may take time.

Agriculture for income. Is agricultural growth the most effective way forward to support nutrition? These income results for nutrition above need not be specific to agricultural income. Yet since many of the world's rural poor are dependent on agriculture as their main livelihood, growth in agriculture has the potential to be relatively more effective in reducing income poverty (Chen & Ravallion, 2007; de Janvry & Sadoulet, 2010), a strong determinant of under-nutrition. At the macro level, Ligon & Sadoulet (2007) find that agricultural income growth exerts a particularly beneficial effect on expenditures among the poorest and that non-agricultural growth boosts expenditures in a more modest fashion among these households. Also using cross-country studies, Heltberg (2009) suggests the explanation that non-agriculture growth associated with structural transformation tends to be geographically exclusive of the rural poor, and Loayza and Raddatz (2010) provide evidence that the gains arise through agriculture providing labor-intensive income opportunities to the unskilled. Christiaensen et al. (2011) find that the benefits from agricultural growth are more concentrated among the extreme poor (less than $1 a day) than among the better-off poor. Extending from poverty outcomes to nutrition outcomes, if agriculture is more accessible to the poor, then agricultural income could have more potential to improve nutrition-supporting consumption.

***Agricultural sub-sectors: commercialization vs. own consumption, and crop choice*.** Within agriculture, too, the type of agricultural growth may have important implications for pass-through to nutrition. Agricultural commercialization is often favored for its ability to facilitate specialization, technological growth, and higher expected returns, thus allowing households to convert in-kind income to cash income, which can in turn be used to purchase greater food security and other health-supporting goods and services (Kennedy, 1994; Pingali, 1997; Pingali & Rosegrant, 1995; Romer, 1993, 1994; Timmer, 1997; von Braun, 1995).[8] Yet findings from various studies suggest that increased income through commercialization haven't always yielded nutritional improvements and sometimes have been associated with nutritional declines among farming households (DeWalt, 1993; Dewey, 1981; Fleuret & Fleuret, 1980; Kennedy, Bouis, & von Braun, 1992; von Braun & Kennedy, 1986, 1994). Theoretical mechanisms for this possibility reflect that cash income can facilitate substitution toward non-food consumption or toward consumption of less nutritious foods through changing preferences or shifting of resources and/or control among household members with different expenditure preferences (Bouis & Haddad, 1990; von Braun et al., 1991; von Braun, 1995). Other studies offer an alternative explanation in which labor inputs necessary for commercialization may in some cases detract from health-supporting efforts in the home (e.g. breastfeeding or other childcare) (Abbi, Christian, Gujral, & Gopaldas, 1991; Kennedy & Cogill, 1987; Popkin, 1980) or increase exposure to hazardous chemical inputs or zoonotic disease (Mullins, Wahome, Tsangari, &

[8] See Timmer (1997) and Strasberg et al. (1999) for a general discussion and a discussion on Kenya, respectively.

Maarse, 1996). Access to commercialization may also offer household investment opportunities that increase the opportunity costs of current consumption, potentially suppressing food expenditures in the short run.

By contrast, agricultural production for own consumption (subsistence agriculture) has been viewed traditionally as a last-resort, low-productivity option for those who face high transaction costs and missing markets or who are highly risk averse (Timmer, 1997). Yet there is a growing momentum for promoting own production as a direct support of food security, dietary diversity, and nutrient-dense consumption. An implicit assumption in these interventions is that food production income will be more likely to "stick" as food consumption relative to other kinds of income. For example, von Braun et al. (1991) found that even after controlling for total income level, households with higher ratios of subsistence food production as a proportion of total income show higher food consumption. Designed with this stylized fact in mind, interventions that encourage dietary diversity and protein or micronutrient consumption through home-production channels – home gardens, biofortified varieties, and animal-sourced foods – do appear to successfully effect improvements in relevant biomarkers in some cases, with the caveats mentioned above (Masset et al., 2011).

The "stickiness" of gains in own food production may bear out in part through price effects and risk aversion.[9] The Food Price Crisis of 2007-08 has served as a reminder that the production of food crops can help insure vulnerable groups' consumption against food price risk, since rising food prices also raise the income value of the crop at the same time (de Janvry & Sadoulet, 1995; Headey, 2013). Especially in rural areas, where households face shallow markets, seasons of high and geographically correlated production will lower relative food prices, inducing substitution toward food consumption. Price risk aversion and transaction costs can further increase consumption of own production by driving a wedge between the effective sale and purchase prices, again making consumption of own food relatively more attractive (de Janvry et al., 1991, Jensen, 2010; Key et al., 2000; Svensson & Yagaizawa, 2009). Completely missing markets for the purchase of nutritious foods represents the extreme case of transaction costs, in which the only means of acquiring necessary micronutrients and achieving dietary diversity is own production.

In a more mechanical sense similar to the general argument for income, improved productivity in food cropping for own consumption may be differentially good at boosting food consumption and then nutritional outcomes because it is often the very poor and women who engage in subsistence agriculture and who may be most likely to convert gains into increased food intake.
Aside from the distinction between commercialization and own production, the nutritional qualities of the particular crop (or animal) associated with income growth may also be relevant.

[9] Many interventions also incorporate educational components to try to increase preference for nutrition-supporting consumption, a mechanism outside of what we can test using the current dataset.

At the macro level, Headey (2013) goes further than previous cross-country analyses to show that the nutritional gains are strongest where agricultural growth manifests as increased food production and in countries whose food production was low initially.[10] And to explain part of India's failure to convert economic growth to nutrition, pooled cross-sectional studies point to non-food agricultural production and price effects that shift consumption from more protein-rich pulses toward cheaper and less nutrient-rich grain (Deaton & Dreze, 2009; Headey, Chiu, & Kadiyala, 2012). Given the level of geographic aggregation, however, none of these studies are able to offer insight on whether for the individual or the households, it is important to produce for one's own consumption, or whether in the presence of sufficiently deep markets for nutritious foods, households may be better of maximizing the income value rather than the nutritional value of their agricultural portfolios. Clearly, the nutritional benefit derived from consumption from own crop production will depend on the nutritional quality of crops being produced, and the benefit from other sources of income must depend on the nutritional value of food being purchased.

3. Data

To explore the links between income and child nutrition, we make use of three rounds of the nationally-representative Uganda National Panel Survey (UNPS) collected in 2009/10, 2010/11 and 2011/12. The UNPS is implemented by the Uganda Bureau of Statistics with financial and technical support from the World Bank Living Standard Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) program.[11] In each round, the survey collects anthropometric measures (height and weight) for children under five years of age and detailed information on household consumption, income, and agricultural activities. Having individual-level nutrition and household-level consumption and income offers the opportunity to analyze the pass through (or not) from income to nutrition via consumption.[12] Specific to the UNPS, the panel nature (at the household and individual levels) and the short period between the survey rounds allow us to conduct within-household analyses over time, and to control in our estimations for unobserved time-invariant child attributes that may be missed in cross-sectional or pooled cross-sectional investigations.

Given the different income and consumption patterns between urban and rural populations, the specific focus on agricultural income, and the relatively smaller sample size for the urban population, we focus on the rural subsample of households in each round and on children that

[10] It is unclear whether these changes arise through agricultural growth among the poor or through falling food prices economy-wide.
[11] The UNPS data and documentation are publically available on www.worldbank.org/lsms.
[12] Income measures have been constructed following the cross-country comparable Rural Income Generating Activities (RIGA) income aggregate methodology. More information on RIGA is available on http://www.fao.org/economic/riga/rural-income-generating-activities/en/.

appear in at least two of the three survey rounds. The latter restriction allows for the inclusion of child-specific fixed effects in our estimations, and leads to 748, 924, and 653 child observations in 2009/10, 2010/11, and 2011/12, respectively, to be part of the analysis sample. Table 1A provides summary statistics for the sample across the three panel waves. Within this sample, the median household has approximately seven members, including four children under the age of 15 and two children less than five years of age. 53 percent of the children in the sample are male, with higher levels of stunting (35-38 percent across three years) than underweight (11-16 percent).

Table 1B presents income and consumption statistics for the sample, deflated to the first survey round in 2009/10 and converted to US dollars. While rural households derive their income from multiple sources, nearly all households participate in crop farming in each round, and the vast majority also engages in livestock activities. Approximately half report non-agricultural self-employment, with average self-employment (for the whole population) approximately equal to average crop income. Agricultural and non-agricultural wage employment each count one-quarter of the households, with greater income coming from non-agricultural wages.

We report initially two alternative crop income calculations that estimate the value of crop production consumed at home either from the agriculture questionnaire (1) or the food consumption section of the household questionnaire (2). The second methodology generates lower total and crop income in the second wave compared to the other rounds: this reflects local and international food price fluctuations that occurred during the span of the survey periods more than changes in production. To minimize the impact of seasonality in food consumption reporting on the calculation of income measures, we elect to focus on the income variables derived using the first methodology for the remainder of the paper.[13]

More than one-third of gross income comes from crops, with approximately one-third of crop income coming from two “low-protein” crops, namely cassava and plantain varieties. We do not classify other crops according to nutritional status but focus on cassava and plantain as two major crops from Uganda that are low in protein as well as many other important nutrients (FAO, 1990), in a context where diets are recognized to be largely deficient in protein and vitamin A and zinc, among other micronutrients (FANTA/USAID, 2010). These two crops alone account for 12-16 percent of total gross income. Non-food crops, which include coffee, comprise only a small fraction of the gross income portfolio. The decrease in livestock income in the third year is tied to the decline in the sales, births, and production of byproducts, which may partially be underlined by the outbreak of food and mouth disease during the reporting period (FEWS NET, 2011).

[13] Livestock income is the exception to this. Due to changes in the livestock modules of the agriculture questionnaire during the three waves of the UNPS, the estimated value of livestock and livestock by-product production consumed at home is derived from the food consumption section of the household questionnaire.

To examine the implications of restricting the sample for fixed effects, to include only children who appear in at least two of the three survey rounds,[14] the in-sample and out-of-sample means were compared for the children in the first survey round (2009/2010) for each of the variables reported in Tables 1A and 1B. Table 1C reports only the outcomes for which the differences were statistically significant at the 0.10 level or lower. The included sample is more heavily representative of the Eastern Region, and less representative of the Western Region. The spouse of the head of household tends to have completed a half a year more of schooling. The included sample is slightly more representative of boys, at 53 percent versus 49. Unsurprisingly, the included sample is an average of 13 months younger in the first survey round. In fact, approximately 40 percent of the sample was over the age of 48 months during the first round; most of these would be too old to be measured in any following round and thus drop from the sample. Due the age difference, weight and height are also lower among the included sample; however the respective z-scores are not statistically different. Many of the remaining differences suggest that more heavily agricultural households were more likely to be resurveyed in future rounds, potentially related to greater permanence of residence and lower attrition.

Figure 1 gives the distribution of gross total income for all three year combined.[15] Figures 2a and 2b give a bit more insight into the distribution of income by source. Though income from any particular source does not decrease in levels, as overall income increases, there is a clear pattern of agricultural income (crops, livestock, and agricultural wages) falling as a share of total income, strongly in favor of self-employment income. Except for the top percentage of earners, nonagricultural wage also increases its contribution as total income increases. Breaking down crop income into three types, low-protein (cassava and plantain varieties), non-food (cotton, tobacco, coffee), and other food crops, Figure 3 shows a trend that low-protein crops and non-food crops constitute an increasing percentage of crop income among higher crop income earners, though the sample of farmers who grow nonfood crops at any income level is small.

Nutritional outcomes. For our outcomes of interest, we use children's anthropometric measurements to reflect their nutritional status. According to the World Health Organization guidelines, we use height-for-age (HAZ) and weight-for-age (WAZ) z-scores to normalize height and weight measures by age in order to allow for useful comparisons across children of various ages. For robustness, we include measures for height in centimeters and weight in kilograms directly, which do not depend on potentially-noisy age data.[16] Figure 4a presents kernel

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[14] The out-of-sample population additionally includes (i) children whose birthdates did not match between survey rounds and could not be reconciled using reported age in months, (ii) a small number of observations who were missing household income data, and (iii) eight children who change households within the UNPS sample across survey rounds.

[15] We choose to focus on gross income for a number of reasons, including differences in the ways that expenses were collected across years, small numbers of households reporting any expenditure, and the difficulty of shares in the presence of negative numbers. Gross income may also better represent intensity of income activity by sector.

[16] In all reported results, HAZ and WAZ were calculated using reported date of birth when birth date and reported age in months did not correspond. HAZ and WAZ using reported age in months generally yields similar results.

regressions of HAZ and WAZ on age in months for children between the ages of 6 and 59 months in the rural UNPS sample. Nutritional challenges are readily apparent: average height for age plunges quite steeply during the first 18 months and remains low. While both WAZ and HAZ are below international norms, it is striking that HAZ in particular is more than 1.5 standard deviations below international norms throughout childhood. Given the strong nonlinearities over time, in many specifications we will opt to include controls for age.

To begin looking at the static relationship between income and nutritional status, Figure 4b presents kernel regressions of HAZ and WAZ on age in months split by median income.[17] The top two kernel density plots show weight for age z-scores, which stay relatively flat across ages. The higher plot marks children whose households are above the median income for the sample; the poorer half the sample tracks the same relatively flat trajectory but at a lower score. For height for age, both groups decline during the first two years, but the higher income half declines somewhat less dramatically. In the absence of omitted variables, a first glance would lead us to expect a strong correlation between income and nutritional status.

Figures 5a and 5b show HAZ and WAZ by income shares by source. Households move toward the right on any curve if they specialize in that sector. The highest z-scores are among those most specialized in livestock, with non-agricultural self-employment and non-agricultural wage also looking favorable relative to crops and agricultural wages. These do not speak to changes in income nor total levels of income but might inform initial priors. Similarly, Figures 5c and 5d show z-scores by shares of crops by subtype as a proportion of gross total income. The lowest average z-scores are among those with the highest shares of income from low-protein crops. These figures, however, only describe anthropometric trends based on a static income profile and do not show that increases in low-protein crop income would lower z-scores.

4. Empirical Strategy

Using the subset of households in the UNPS with children under the age of five described above, we test the hypotheses suggested by the theory laid out in the first sections, taking advantage of the child-level panel data. We show our most basic results on income without and then with child fixed effects, and then proceed with the preferred specification with child fixed effects.

We first look for evidence on the central question of whether short-term changes in income can result in observable changes in nutritional outcomes. As a benchmark, we begin with the estimation most available in the literature, treating our panel dataset as a set of repeated cross sections. Thus, we estimate:

[17] Child age has been calculated taking into account the date of birth and the interview date, rather than the reported age in months, when these two measures did not match in the data.

$$H_{it} = \beta_Y \log Y_{it} + \epsilon_{it},$$

where H_{it} represents the health measure (height for age (HAZ) z-score, height in centimeters, weight for age (WAZ) z-score, and weight in kilograms); Y_{it} is income, which can be specified various ways; and ϵ_i is the error term. We use the log of total gross income for interpretation in percentages and to accommodate diminishing marginal returns, after finding qualitatively similar results with a combination of level and square root of gross income. However, there is a possibility of omitted variable bias from observable and unobservable characteristics that may influence both income and the anthropometric measures of children (parental education as one likely candidate). A vector of additional covariates Z_i may be added to capture such observable characteristics along with a survey round fixed effect η_t and seasonal (month) fixed effect s_t to absorb unobservable characteristics that are common to the sample in a particular survey round or a certain month of the year:

$$H_{it} = \beta_Y \log Y_{it} + Z_i \gamma + \eta_t + s_t + \epsilon_{it}.$$

Still, there are likely other unobservable (or simply unobserved) attributes that may bias the estimation results. One example might be tall parents whose height and strength increase wage earnings but also genetically predispose a child to attain greater height or weight than average. Another example could be related to parental intelligence, which can be used for earnings and for providing better care for children. In the absence of a set of convincing instruments for income variables, including a child-specific fixed effect in the specification allows us to control for time-invariant child, household, and community characteristics that might otherwise jointly determine income and child nutrition outcomes.[18]

Thus, to test whether we observe changes in short-term total income corresponding to short-term changes in children's nutrition, we estimate:

$$H_{it} = \beta_Y \log Y_{it} + Z_i \gamma + \eta_t + s_t + \nu_i + \epsilon_{it},$$

where H_{it} represents the health measure (height for age (HAZ) z-score, height in centimeters, weight for age (WAZ) z-score, and weight in kilograms), $\log Y_{it}$ is the log of total gross income income, η_t is a survey round fixed effect, and ν_i is a child fixed effect, and ϵ_i is the error term. Here the vector of covariates Z_i is limited to include age in months (with square and square root to accommodate the age trends) and household size. Even with child fixed effects, however, there remains a possibility of time-variant unobservable factors that may bias these estimates.

[18] A random effects specification was tested against the fixed effects specification, but was rejected in favor of the fixed effects with a Hausman test chi-2 p-value of smaller than 0.0001.

Therefore, we see our estimation as a useful and informative diagnostic exercise but caution overly strong confidence in causal interpretations.

Income by sector. If the impact from changes in overall income is positive, the next step would be to test whether this relationship is separable from the sector of income. We conduct this analysis by looking for differential impacts of income from sectors vis-à-vis total income. We start by adding sector share of total income for the four major income sectors: crops, livestock, nonagricultural self-employment, and wages:

$$H_{ti} = \beta_a(Y_{it}^a/Y_{it}) + \eta_t + \nu_i + \epsilon_i$$

where $\log Y_{it}^a$ is log of gross income from sector a and $\log Y_{it}$ is log of total gross income.[19] If consumption and nutrition are separable from income except for by the budget constraint, we would expect to see no statistically significant coefficients for the sector indicators.
If the poor or other nutritionally-sensitive groups who are more impacted by marginal income are unevenly distributed across the total income distribution, or if one sector is particularly effective because of its accessibility to the poor, we might expect to see the coefficient β_a shift with the inclusion of a control for total income:

$$H_{it} = \beta_a(Y_{it}^a/Y_{it}) + \beta_Y \log Y_{it} + \eta_t + \nu_i + \epsilon_i.$$

Income by crop type. We test in the Ugandan context the idea commonly seen in the literature that type of crop income may influence nutrition. To do so, we break crops into three broad categories based on nutrient availability: 1) low-protein, low-nutrient food crops, 2) other food crops, and 3) non-food crops. We adopt the same shares approach used for sector income, looking at the share of each crop type *a* in total income:

$$H_{it} = \beta_a(Y_{it}^a/Y_{it}) + \eta_t + \nu_i + \epsilon_i$$

Again, by adding controls for total income as above and looking for changes in coefficients, we are able to look for evidence of whether crop type may be important because of the types of crops grown by the poor. It is important to note that the two crops we categorize as low-protein are banana/plantain and cassava – two major staple crops in Uganda (grown by more than 70% of our sample) with lower protein availability than other staples such as cereals and sweet potatoes. Uganda is recognized as maintaining a low-protein diet. As such, income gains that come in the form of additional low-protein food might be less likely to benefit nutrition that other forms of income unless the produce is sold to fund other nutrition-supporting purchases.

[19] An alternate specification is $H_{it} = \beta_a \log Y_{it}^a + \delta_a 1[Y_{it}^a > 0] + \beta_Y \log Y_{it} + \eta_t + \nu_i + \epsilon_i$, where $\log Y_{it}^a$ is log of gross income from sector a and $\log Y_{it}$ is log of total gross income, with the indicator accommodating logs of zero income for a sector and marking entry and exit from a sector. These results are qualitatively similar to those from shares and are available upon request.

Finally, we attempt to address the question of whether agriculture may be more beneficial through production alone or more specifically through own consumption (again, the question of separation). We do so by comparing the above specifications on shares of crop production to specifications on shares of own consumption of production, represented by

$$H_{it} = \beta_a(C^a_{it}/Y_{it}) + \eta_t + \nu_i + \epsilon_i,$$

with C^a_{it} representing the level of consumption originating from own production.

5. Results

Tables 2A and 2B show the results for overall income for weight and height related anthropometric outcomes, respectively. The first two columns each present z-scores as dependent variables, and the last two present weight and height in Table 2A and 2B, respectively. Columns (1) and (3) show the standard pooled-cross sectional results with additional time-varying covariates and with standard errors clustered at the household level. Coefficients for the additional covariates are not reported, for brevity, but these variables include indicators for Round 2 and Round 3, child gender (only relevant for the pooled cross-sectional estimations), age in months in levels, squares, and square roots to accommodate the common non-linear fall of z-scores over time (as observed in Figure 4), interview month fixed effects to reduce seasonally-based statistical noise in income reporting or child health, household size, number of children under 5 and under 15, household head years of education, identifier for and female headship.

The preferred fixed effects specifications are presented in columns (2) and (4) of Tables 2A and 2B with the same set of controls. In contrast to the pooled cross-sectional results, the coefficients on income in fixed effects estimations fall to nearly zero, highlighting the role of unobservable characteristics influences income and anthropometric outcomes. For weight measures, there is no apparent impact of the change in log gross income, perhaps suggesting that there is low correlation between income and calories. These results hold for subsamples below 24 months of age and below the sample median income in 2009/10 (i.e. the first survey round). The results for the height measures, however, suggest that short-term income gains may be nutrition-supporting. While for the whole sample the coefficient β_Y for HAZ loses (marginal) statistical significance once covariates are added, the coefficients in the height specification remain marginally significant.[20] These results are strengthened in the subsample of children who are 24 months or

[20] Note that height and weight measures are unlikely to decrease at these ages, so the coefficients for the two time effects on the z-scores are more telling: average WAZ increases slightly across the three waves, while HAZ falls during that period, as also seen in Table 1A.

younger and in the subsample below the sample median income in 2009/10, with height results increasing in magnitude and statistical significance. Henceforth, all reported findings are based on regressions that control for child fixed effects and the aforementioned time-varying observables.

Income by sector. Tables 3A-3C and 3D-3F present the results for income shares for the dependent variables WAZ and HAZ, respectively. The regressions are estimated for the overall sample, and separately for the subsamples of under 24 months of age, and below the median income at baseline. For WAZ, none of the model or sample specifications suggest any impact associated with shares from crop, livestock and wage income. In Table 3A, the share of gross income originating from self-employment assumes positive and statistically significant coefficients – the effects that seem to be related the dynamics observed among the sub-sample of children below the sample median income in 2009/10 (Table 3C). For HAZ, the crop income share without controlling for gross total income exerts a negative and highly significant impact, which declines in magnitude and becomes insignificant once gross total income is included (Table 3D). These differences seem to reflect the fact that crop income levels are fairly flat over the total income distribution, while crop income as a share of total income falls with total income. On the other hand, the coefficients for self-employment in the same table are persistently large and significant, potentially reflecting self-employment enabling different consumption or care habits, and meriting further investigation in the future.

Income by crop type. Tables 4A-4D and 4E-4H present the results for crop production and consumption of own crop production as shares of gross total income for the dependent variables WAZ and HAZ, respectively. The regressions are estimated for the overall sample, and separately for the subsamples of under 24 months of age, over 24 months of age, and below the median income at baseline. We present total crop production and consumption and then the breakdowns by crop category, with and without controlling for log of total income. The coefficients can be interpreted as the predicted change in z-score from a change from no income coming from that source to 100 percent coming from that source.

We see that increased share of income coming from crop production corresponds to lower HAZ scores, with the coefficient dropping slightly and becoming only marginally statistically significant once total income is included. However, the coefficients for HAZ on the consumption of own crop production are nearly twice the magnitude as for production and highly statistically significant. Thus, consumption of own production rather than production alone seems to drive the negative crop result in the context of Uganda. Households could be better off converting produce into cash for nutrition-supporting purchases.

Production of the low protein crops shows a significant negative coefficient similar to consumption of own crop production, at nearly 0.5 predicted from a shift from 0 to 1, and the coefficient for consumption of own-produced low-protein crops is even more negative, suggesting that on average in the sample, crops may better serve long-term nutrition when converted to cash than through direct consumption. That each coefficient becomes less negative reflects a negative correlation between share of income as own consumption as total income increases.

When the results are broken down by age group, both groups qualitatively support the results of the whole, but the magnitudes are larger and more significant for the older group. One the one hand, this may be surprising, since stunted is expected to occur during the first years, which are considered more critical for nutrition. On the other hand, effects on the younger children may be partially mitigated by breastfeeding or by different levels of care.

In contrast to height, for weight for age, all coefficients are small and insignificant for the whole sample. This zero effect, however, hides large variation by age group. For the younger group, all coefficients are positive, and statistically significant for both production and consumption of own production of low-protein crops. For the older group, all coefficients are negative, and statistically significant for consumption of own crop production, low protein crop production, and consumption of own low protein crop production (marginal, for the latter).

One possible explanation is that because a portion of the younger group is still breastfeeding, complementary feeding with low-protein foods contributes needed supplementary carbohydrates, while for older children, consumption of low-nutrient foods displaces more nutrient-dense consumption. Breastfeeding could also affect level of adult supervision, which may influence total amounts consumed. Given the lack of data on children's individual consumption or care, however, it is not possible to distinguish these or other mechanisms.

Not shown, there is a 0.78 and 0.45 correlation between consumption and production of low protein and other food crops, respectively, pointing to income growth in the form of cassava and plantain production being particularly unlikely to convert into consumption of other foods or nonfoods. These anthropometric score results suggest that this "stickiness" of crop production to own consumption that may, in a context with low-protein staple crops, may render agricultural growth less beneficial for nutrition than other types of growth, and that in Uganda, all else equal, there are likely to be nutritional gains from shifting toward more nutrient-rich crop production.

6. Conclusion

In this study, we have used panel data to explore the potential for short-term income gains to improve children's nutrition in Uganda. The high frequency in the UNPS—three rounds in three years—allow for fixed effect estimations that eliminate time-invariant unobservable factors that may typically confound similar studies. Without convincing instrumental variables for income, one still must take care with causal interpretations, but such exercises can serve as informative diagnostic tools for policy and future research.

Our results show very little relationship between changes in income and weight; but we find larger and more nuanced results for height, which is seen as a better marker of long-term nutrition. Thus it appears that income gains are on average at least partially consumed in nutrient-supporting ways. Contrary to the benchmark case of "separation" between income generation and nutrition, self-employment appears to be relatively more nutrition-supporting than other sectors. Future studies distinguishing the mechanisms behind this trend, potentially dietary or related to proximity to home for childcare, would be worthwhile.

Specific to Uganda, we find the potentially less-expected result that agricultural income appears to be more nutrition-negative than others, through the production of low-nutrient crops and specifically through own consumption. Our results suggest stickiness of crop production to own consumption; while this may be a nutrition-supporting feature in other contexts, income growth in the production of low-nutrient crops may crowd out consumption of other goods and services that could serve as better nutritional investments. These results appear to depend heavily on the agricultural and dietary profile of Uganda and caution against uniform policies to support one sector over another. When data are available, similar diagnostic techniques may be useful for identifying which sectors and interventions may be most nutrition-supporting in other contexts.

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TABLES

Table 1a: Summary Statistics for UNPS 2009/10 - 2011/12
Demographics, Assets, and Child Characteristics
Subset: rural children with at least two observations in the three waves

	2009/10 (748 obs)			2010/11 (924 obs)			2011/12 (653 obs)		
Variable	mean	sd	median	mean	sd	median	mean	sd	median
REGION									
Central w/o Kampala	0.235	0.424	0	0.256	0.437	0	0.27	0.444	0
Eastern	0.32	0.467	0	0.318	0.466	0	0.291	0.455	0
Northern	0.287	0.453	0	0.302	0.459	0	0.309	0.463	0
Western	0.158	0.365	0	0.123	0.329	0	0.13	0.337	0
DEMOGRAPHICS									
Household Size	7.13	2.78	7	7.04	2.56	7	7.11	2.56	7
Number of children <15yrs	4.33	1.93	4	4.37	1.97	4	4.36	1.96	4
Number of children <5yrs	1.95	0.809	2	1.94	0.835	2	1.94	0.886	2
Number of adults 15+	2.81	1.43	2	2.67	1.21	2	2.75	1.24	2
Number of males in household	1.26	0.944	1	1.19	0.804	1	1.26	0.821	1
%Female-headed household	0.168	0.375	0	0.18	0.384	0	0.176	0.381	0
Dependency ratio	1.83	0.992	1.59	1.95	1.12	1.67	1.9	1.12	1.67
Head's years of school	5.61	4.32	6	6.28	4.63	6	5.75	4.32	6
Spouse's years of education	3.88	3.77	4	4.51	4.24	4	4.26	3.93	4
Average years of education for members>21	4.54	3.15	4	5.01	3.45	4.4	4.6	3.16	4
Highest years of education in household	7.17	4.26	7	7.99	4.64	7	7.38	4.2	7
ASSETS									
Has Improved Roof	0.523	0.5	1	0.527	0.5	1	0.545	0.498	1
Has Improved Walls	0.634	0.482	1	0.642	0.48	1	0.688	0.464	1
Has Improved Floor	0.148	0.356	0	0.162	0.369	0	0.164	0.37	0
Treats Water	0.357	0.479	0	0.339	0.474	0	0.315	0.465	0
Has Improved Water Source	0.686	0.464	1	0.697	0.46	1	0.741	0.438	1
Has Improved Toilet Facility	0.893	0.309	1	0.878	0.328	1	0.888	0.315	1
Has Hand Washing Station	0.098	0.297	0	0.042	0.201	0	0.075	0.264	0
CHILD									
Age of Child (in months)	25.2	11.5	25	33.3	14.3	33	40.5	11.1	41
Gender: 1 = Male	0.528	0.5	1	0.532	0.499	1	0.531	0.499	1
Height, cm	81.4	9.33	81.4	86.8	10.7	87	91.4	8.19	91
Weight, kg	10.8	2.56	10.6	12.3	2.92	12.4	13.5	2.43	13.4
Height for Age Score	-1.55	1.48	-1.59	-1.58	1.4	-1.56	-1.71	1.25	-1.69
Weight for Age Score	-0.908	1.17	-0.855	-0.792	1.1	-0.775	-0.817	1.02	-0.81
Weight for Height Score	-0.078	1.18	0.015	0.138	1.13	0.14	0.216	1.09	0.21
% Stunted (HAZ < -2)	0.368	0.482	0	0.354	0.478	0	0.38	0.486	0
% Wasted (WHZ < -2)	0.159	0.366	0	0.116	0.32	0	0.104	0.306	0
% Underweight (WAZ < -2)	0.059	0.236	0	0.031	0.175	0	0.02	0.14	0

Notes: Sample includes only rural households with children whose birthdate was consisent across panel waves. Z-scores calculated from date of birth rather than reported age in month when not in agreement.

Table 1b: Summary Statistics for UNPS 2009/10 - 2011/12
Income and Consumption

Subset: rural children with at least two observations in the three waves

	2009/10 (748 obs)			2010/11 (924 obs)			2011/12 (653 obs)		
Variable	mean	sd	median	mean	sd	median	mean	sd	median
INCOME									
Net Total Income (1)	892	1,198	578	968	1,085	623	1,105	1,416	703
Net Total Income (2)	1,084	1,215	775	1,075	1,100	764	1,230	1,420	893
Gross Total Income (1)	1,399	1,679	870	1,459	1,578	954	1,548	1,891	988
Gross Total Income (2)	1,589	1,705	1,103	1,569	1,587	1,076	1,673	1,884	1,153
PARTICIPATION									
% Agriculture Wage Employment > 0	0.286	0.452	0	0.237	0.425	0	0.193	0.395	0
% Non-Ag Wage Employment > 0	0.242	0.429	0	0.215	0.411	0	0.225	0.418	0
% Crop Production (1) > 0	0.939	0.24	1	0.926	0.261	1	0.928	0.259	1
% Crop Production (2) >0	0.949	0.22	1	0.944	0.231	1	0.939	0.24	1
% Livestock Production > 0	0.762	0.426	1	0.728	0.445	1	0.689	0.463	1
% Non-Ag Self Employment > 0	0.537	0.499	1	0.522	0.5	1	0.489	0.5	0
% Transfers > 0	0	0	0	0	0	0	0.006	0.078	0
SECTOR INCOME									
Self-employ, Net	192	585	3.55	264	641	1.84	292	762	0
Self-employ, Gross	494	1,242	22.8	559	1,215	26.2	604	1,399	0
Crop Income (1), Net	282	416	171	279	349	178	373	506	234
Crop Income (2), Net	358	456	226	357	381	252	441	546	275
Crop Income (2), Gross	474	466	386	386	389	295	499	524	395
Crop Income (2), Gross	548	502	442	467	416	361	565	559	447
Livestock Income, Net	115	237	53.2	127	252	63	91.7	188	29.8
Livestock Income, Gross	242	281	149	239	290	146	150	210	74.5
Wages:	294	886	0	287	753	0	332	1,056	0
Ag Wages	84.6	263	0	61.3	176	0	71.3	256	0
Non-ag Wages	210	820	0	226	746	0	260	1,034	0
CROP SHARES									
% of Gross Income from Crops	0.355	0.285	0.289	0.360	0.295	0.292	0.401	0.313	0.345
% Gross Crop Income, Low Protein Crop	0.306	0.302	0.237	0.333	0.294	0.29	0.34	0.309	0.31
% Gross Income, Low Protein Crop	0.121	0.168	0.051	0.136	0.177	0.069	0.16	0.193	0.087
% Gross Crop Income, Other Food Crop	0.575	0.342	0.604	0.529	0.336	0.527	0.531	0.34	0.539
% Gross Income, Other Food Crop	0.21	0.217	0.139	0.195	0.206	0.131	0.215	0.218	0.137
% Gross Crop Inc, Nonfood Crop	0.057	0.141	0	0.067	0.146	0	0.057	0.136	0
% Gross Income, Nonfood Crop	0.024	0.068	0	0.028	0.07	0	0.026	0.068	0
CONSUMPTION									
Total Annual Food Consumption	694	509	579	835	619	685	804	640	639
Total Annual Crop Food Consumption	246	196	196	261	221	194	256	236	201
Total Annual Low Protein Food Consumption	27.6	58.5	0	25.7	61.8	0	36.1	74.5	0
Total Annual Livestock/Byproduct Consumption	97.5	118	51	131	145	90.3	135	149	96.8
Total Annual Food Consumption, Purchases	333	251	272	400	307	321	380	310	308
Crop Income, Own Consumption (1)	170	176	112	180	175	131	229	233	153
Crop Income, Own Consumption (2)	360	266	313	294	246	239	360	280	329
Low Protein Crop Income, Own Consumption (1)	90.6	127	43	99.4	125	55.8	131	163	71.7
Low Protein Crop Income, Own Consumption (2)	126	134	89.2	119	160	71.8	126	147	67.8
Livestock Income, Own Consumption (2)	43.1	93.2	0	52	112	0	44.5	102	0

Notes: Sample includes only rural households with children whose birthdate was consisent across panel waves. Total income and crop income (1) with value of consumption from own production calculated from agricultural module. Total income and crop income (2) calculated from conumption module. All income and consumption values are deflated to 2009/2010 and converted to USD using March 1, 2010. "Low protein crops" are cassava and plantain, two staple food crops in Uganda.

Table 1c: Comparative Statistics
In Sample vs Out of Sample, 2009/2010 Survey Wave
Subset: rural children

	Means				Means		
	In Sample	Out of Sample	Difference		In Sample	Out of Sample	Difference
REGION				ASSETS			
Eastern	0.32	0.268	.052**	Has Improved Roof	0.522	0.598	-.075***
	(0.02)	(0.02)	(0.02)		(0.02)	(0.02)	(0.02)
Western	0.157	0.256	-.098***	Has Improved Walls	0.63	0.55	.078***
	(0.01)	(0.02)	(0.02)		(0.02)	(0.02)	(0.02)
DEMOGRAPHICS				PARTICIPATION			
Spouse's years of education	3.89	3.41	.477**	% Crop Production (1) > 0	0.94	0.88	.064***
	(0.14)	(0.13)	(0.19)		(0.01)	(0.01)	(0.01)
CHILD				% Crop Production (2) >0	0.95	0.90	.046***
Age of Child (in months)	25.10	38.00	-12.9***		(0.01)	(0.01)	(0.01)
	(0.42)	(0.58)	(0.71)	% Livestock Production > 0	0.76	0.72	.042*
Gender: 1 = Male	0.53	0.49	.041*		(0.02)	(0.02)	(0.02)
	(0.02)	(0.02)	(0.03)	SECTORINCOME			
Weight, kg	10.80	13.00	-2.13***	Livestock Income, Net	116.00	96.20	20.0*
	(0.09)	(0.11)	(0.14)		(8.69)	(8.17)	(12.00)
Height, cm	81.30	89.50	-8.20***	Ag Wages	84.00	60.60	23.4**
	(0.35)	(0.45)	(0.59)		(9.51)	(6.60)	(11.30)
				% Gross Crop Income, Other Food Crop	0.57	0.52	.052***
					(0.01)	(0.01)	(0.02)

Only significant differences are presented, from comparisons of all variables presented in Tables 1a and 1b. Std errors in parentheses. In Sample includes children in at least two rounds, with matching or reconcilable birthdates and income data. Sample size: In Sample, 756 obs; Out of Sample 895 obs.

Table 2A: Weight-for-Age and Weight on Total Income & Controls

Whole Sample				
	WAZ		Weight	
	(1)	(2)	(3)	(4)
Ln Gross Total Income	0.112***	-0.00300	0.151***	0.0209
	(0.0330)	(0.0227)	(0.0526)	(0.0318)
Child Fixed Effects	NO	YES	NO	YES
R-Sq	0.0366	0.0752	0.687	0.855
Adj R-Sq	0.0270	0.0659	0.683	0.854
Sub-sample: Under 24 Months				
	WAZ		Weight	
	(1)	(2)	(3)	(4)
Ln Gross Total Income	0.146***	-0.00706	0.186***	0.0301
	(0.0445)	(0.0401)	(0.0533)	(0.0507)
Child Fixed Effects	NO	YES	NO	YES
R-Sq	0.0578	0.135	0.599	0.865
Adj R-Sq	0.0370	0.116	0.591	0.862
Sub-sample: Below Median Income in the First Year				
	WAZ		Weight	
	(1)	(2)	(3)	(4)
Ln Gross Total Income	0.0673*	-0.00138	0.0941	0.0243
	(0.0407)	(0.0314)	(0.0651)	(0.0451)
Child Fixed Effects	NO	YES	NO	YES
R-Sq	0.0365	0.0929	0.691	0.839
Adj R-Sq	0.0222	0.0794	0.687	0.837

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 2325 observations in 757 clusters for whole sample, 1069 observations in 496 clusters for sample under 24 months, 1574 observations in 577 clusters for below the median income in the first year; Controls include indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

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Table 2B: Height-for-Age and Height on Total Income & Controls

	HAZ		Height	
Whole Sample				
	(1)	(2)	(3)	(4)
Ln Gross Total Income	0.136***	0.0559	0.473***	0.201*
	(0.0379)	(0.0350)	(0.131)	(0.107)
Child Fixed Effects	NO	YES	NO	YES
R-Sq	0.0661	0.198	0.794	0.900
Adj R-Sq	0.0568	0.190	0.792	0.899
Sub-sample: Under 24 Months				
	HAZ		Height	
	(1)	(2)	(3)	(4)
Ln Gross Total Income	0.165***	0.123*	0.496***	0.373**
	(0.0565)	(0.0679)	(0.162)	(0.187)
Child Fixed Effects	NO	YES	NO	YES
R-Sq	0.118	0.343	0.712	0.904
Adj R-Sq	0.0989	0.329	0.705	0.902
Sub-sample: Below Median Income in the First Year				
	HAZ		Height	
	(1)	(2)	(3)	(4)
Ln Gross Total Income	0.114**	0.0804*	0.416**	0.292**
	(0.0490)	(0.0473)	(0.171)	(0.141)
Child Fixed Effects	NO	YES	NO	YES
R-Sq	0.0642	0.260	0.788	0.895
Adj R-Sq	0.0503	0.249	0.784	0.894

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 2325 observations in 757 clusters for whole sample, 1069 observations in 496 clusters for sample under 24 months, 1574 observations in 577 clusters for below the median income in the first year; All regressions include the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 3A: WAZ on Income Shares
(Shares of Gross Sector Income & Child Fixed Effects)
Whole Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Crop	-0.0383	-0.0542						
	(0.0753)	(0.0870)						
% Livestock			-0.135	-0.140				
			(0.0951)	(0.0943)				
% Self Employ					0.144**	0.157**		
					(0.0695)	(0.0783)		
% Wage							-0.0176	-0.00543
							(0.0887)	(0.0925)
Ln Gross Total Income		-0.00895		-0.00669		-0.0168		-0.00162
		(0.0261)		(0.0233)		(0.0249)		(0.0238)
Joint P-value		0.823		0.332		0.134		0.995
R-Sq	0.0733	0.0621	0.0747	0.0635	0.0756	0.0644	0.0731	0.0618
Adj R-Sq	0.0660	0.0527	0.0675	0.0541	0.0684	0.0551	0.0659	0.0524

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 2325 observations in 757 clusters; Joint P-value is associated with the test of joint significance of the income shares variables and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 3B: WAZ on Income Shares
(Shares of Gross Sector Income & Child Fixed Effects)
Sub-sample: Under 24 Months

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Crop	0.0781	0.0975						
	(0.134)	(0.153)						
% Livestock			-0.220	-0.237				
			(0.169)	(0.170)				
% Self Employ					0.164	0.187		
					(0.120)	(0.135)		
% Wage							-0.129	-0.118
							(0.150)	(0.149)
Ln Gross Total Income		0.00851		-0.0117		-0.0249		0.00278
		(0.0461)		(0.0398)		(0.0448)		(0.0393)
Joint P-value		0.808		0.359		0.381		0.731
R-Sq	0.134	0.131	0.137	0.134	0.136	0.133	0.135	0.131
Adj R-Sq	0.119	0.112	0.122	0.115	0.121	0.114	0.120	0.112

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 1069 observations in 496 clusters; Joint P-value is associated with the test of joint significance of the income shares variables and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 3C: WAZ on Income Shares
(Shares of Gross Sector Income & Child Fixed Effects)
Sub-sample: Below Median Income in the First Year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Crop	-0.115	-0.169						
	(0.0882)	(0.116)						
% Livestock			-0.175	-0.149				
			(0.111)	(0.108)				
% Self Employ					0.161*	0.179*		
					(0.0893)	(0.0998)		
% Wage							0.147	0.151
							(0.106)	(0.113)
Ln Gross Total Income		-0.0291		-0.00594		-0.0207		-0.0148
		(0.0386)		(0.0320)		(0.0336)		(0.0340)
Joint P-value		0.343		0.384		0.200		0.404
R-Sq	0.0851	0.0794	0.0862	0.0784	0.0862	0.0796	0.0854	0.0785
Adj R-Sq	0.0745	0.0657	0.0757	0.0648	0.0756	0.0659	0.0748	0.0648

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 1574 observations in 577 clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 3D: HAZ on Income Shares
(Shares of Gross Sector Income & Child Fixed Effects)
Whole Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Crop	-0.227**	-0.172						
	(0.111)	(0.119)						
% Livestock			-0.115	-0.0704				
			(0.122)	(0.123)				
% Self Employ					0.311**	0.263**		
					(0.131)	(0.126)		
% Wage							0.0553	0.000112
							(0.105)	(0.123)
Ln Gross Total Income		0.0357		0.0554		0.0330		0.0577
		(0.0376)		(0.0361)		(0.0333)		(0.0395)
Joint P-value		0.103		0.205		0.0656		0.221
R-Sq	0.194	0.176	0.192	0.175	0.197	0.178	0.191	0.175
Adj R-Sq	0.188	0.168	0.185	0.167	0.190	0.170	0.185	0.167

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 2325 observations in 757 clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 3E: HAZ on Income Shares
(Shares of Gross Sector Income & Child Fixed Effects)
Sub-sample: Under 24 Months

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Crop	-0.390**	-0.203						
	(0.195)	(0.218)						
% Livestock			-0.239	-0.162				
			(0.209)	(0.211)				
% Self Employ					0.462**	0.300		
					(0.220)	(0.201)		
% Wage							0.106	-0.00206
							(0.179)	(0.214)
Ln Gross Total Income		0.0980		0.121*		0.0937		0.126*
		(0.0749)		(0.0680)		(0.0620)		(0.0746)
Joint P-value		0.0975		0.118		0.116		0.109
R-Sq	0.337	0.340	0.333	0.339	0.340	0.342	0.332	0.339
Adj R-Sq	0.326	0.325	0.321	0.325	0.329	0.327	0.320	0.324

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 1069 observations in 496 clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 3F: HAZ on Income Shares
(Shares of Gross Sector Income & Child Fixed Effects)
Sub-sample: Below Median Income in the First Year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Crop	-0.214*	-0.118						
	(0.121)	(0.136)						
% Livestock			-0.169	-0.115				
			(0.142)	(0.140)				
% Self Employ					0.195	0.0845		
					(0.175)	(0.155)		
% Wage							0.249*	0.162
							(0.141)	(0.176)
Ln Gross Total Income		0.0583		0.0743		0.0678		0.0644
		(0.0536)		(0.0479)		(0.0429)		(0.0557)
Joint P-value		0.166		0.216		0.278		0.0338
R-Sq	0.245	0.239	0.244	0.239	0.244	0.239	0.245	0.240
Adj R-Sq	0.237	0.228	0.235	0.228	0.236	0.228	0.237	0.228

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 1574 observations in 577 clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 4A: WAZ - Crop Production and Own Consumption
(Shares of Gross Total Income & Child Fixed Effects)
Whole Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Income, Crops	-0.0383	-0.0542						
	(0.0753)	(0.0870)						
% Income, Consumption of Own Crops			-0.0781	-0.107				
			(0.0916)	(0.108)				
% Income, Low Protein Crop Production					-0.0614	-0.0794		
					(0.112)	(0.120)		
% Income, Consumption of Low Protein Crop Production							0.0252	0.00138
							(0.127)	(0.139)
Ln Gross Total Income		-0.00895		-0.0131		-0.00521		-0.00196
		(0.0261)		(0.0263)		(0.0237)		(0.0241)
Joint P-value		0.823		0.617		0.802		0.996
R-Sq	0.0733	0.0621	0.0736	0.0625	0.0733	0.0621	0.0731	0.0618
Adj R-Sq	0.0660	0.0527	0.0663	0.0531	0.0660	0.0527	0.0659	0.0524

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 2325 observations in 757 clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 4B: WAZ - Crop Production and Own Consumption
(Shares of Gross Total Income & Child Fixed Effects)
Sub-sample: Under 24 Months

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Income, Crops	0.0781	0.0975						
	(0.134)	(0.153)						
% Income, Consumption of Own Crops			0.109	0.136				
			(0.163)	(0.182)				
% Income, Low Protein Crop Production					0.349**	0.380**		
					(0.175)	(0.183)		
% Income, Consumption of Low Protein Crop Production							0.417**	0.462**
							(0.201)	(0.210)
Ln Gross Total Income		0.00851		0.0103		0.0116		0.0174
		(0.0461)		(0.0442)		(0.0399)		(0.0404)
Joint P-value		0.808		0.754		0.116		0.0903
R-Sq	0.134	0.131	0.134	0.131	0.139	0.136	0.141	0.138
Adj R-Sq	0.119	0.112	0.119	0.112	0.124	0.117	0.126	0.119

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 1069 observations in 496 clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 4C: WAZ - Crop Production and Own Consumption
(Shares of Gross Total Income & Child Fixed Effects)
Sub-sample: Over 24 Months

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Income, Crops	-0.108	-0.124						
	(0.0763)	(0.0920)						
% Income, Consumption of Own Crops			-0.237**	-0.286**				
			(0.0980)	(0.126)				
% Income, Low Protein Crop Production					-0.369**	-0.385**		
					(0.145)	(0.152)		
% Income, Consumption of Low Protein Crop Production							-0.288*	-0.314*
							(0.163)	(0.176)
Ln Gross Total Income		-0.00339		-0.0172		-0.00273		-0.000116
		(0.0263)		(0.0276)		(0.0227)		(0.0234)
Joint P-value		0.276		0.0398		0.0270		0.145
R-Sq	0.0602	0.0696	0.0638	0.0738	0.0676	0.0772	0.0624	0.0721
Adj R-Sq	0.0481	0.0543	0.0518	0.0585	0.0557	0.0621	0.0504	0.0568

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; XXXX observations in XXX clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 4D: WAZ - Crop Production and Own Consumption
(Shares of Gross Total Income & Child Fixed Effects)
Sub-sample: Below Median Income in the First Year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Income, Crops	-0.115	-0.169						
	(0.0882)	(0.116)						
% Income, Consumption of Own Crops			-0.161	-0.257*				
			(0.106)	(0.139)				
% Income, Low Protein Crop Production					-0.0153	-0.0638		
					(0.130)	(0.143)		
% Income, Consumption of Low Protein Crop Production							-0.0583	-0.138
							(0.149)	(0.168)
Ln Gross Total Income		-0.0291		-0.0350		-0.00683		-0.00987
		(0.0386)		(0.0381)		(0.0329)		(0.0333)
Joint P-value		0.343		0.178		0.901		0.711
R-Sq	0.0851	0.0794	0.0856	0.0808	0.0832	0.0765	0.0834	0.0772
Adj R-Sq	0.0745	0.0657	0.0750	0.0672	0.0726	0.0628	0.0728	0.0635

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 1574 observations in 577 clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 4E: HAZ - Crop Production and Own Consumption
(Shares of Gross Total Income & Child Fixed Effects)
Whole Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Income, Crops	-0.227**	-0.172						
	(0.111)	(0.119)						
% Income, Consumption of Own Crops			-0.440***	-0.418**				
			(0.145)	(0.169)				
% Income, Low Protein Crop Production					-0.464**	-0.453**		
					(0.184)	(0.189)		
% Income, Consumption of Low Protein Crop Production							-0.625***	-0.627***
							(0.211)	(0.219)
Ln Gross Total Income		0.0357		0.0144		0.0395		0.0319
		(0.0376)		(0.0404)		(0.0362)		(0.0365)
Joint P-value		0.103		0.00953		0.0143		0.00411
R-Sq	0.194	0.176	0.198	0.180	0.197	0.180	0.199	0.183
Adj R-Sq	0.188	0.168	0.192	0.172	0.190	0.172	0.193	0.174

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 2325 observations in 757 clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 4F: HAZ - Crop Production and Own Consumption
(Shares of Gross Total Income & Child Fixed Effects)
Sub-sample: Under 24 Months

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Income, Crops	-0.390**	-0.203						
	(0.195)	(0.218)						
% Income, Consumption of Own Crops			-0.445*	-0.229				
			(0.244)	(0.294)				
% Income, Low Protein Crop Production					-0.518*	-0.391		
					(0.308)	(0.319)		
% Income, Consumption of Low Protein Crop Production							-0.586*	-0.423
							(0.335)	(0.349)
Ln Gross Total Income		0.0980		0.100		0.109		0.105
		(0.0749)		(0.0793)		(0.0687)		(0.0696)
Joint P-value		0.0975		0.0951		0.0830		0.0814
R-Sq	0.337	0.340	0.337	0.340	0.336	0.341	0.337	0.341
Adj R-Sq	0.326	0.325	0.325	0.325	0.325	0.327	0.326	0.327

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 1069 observations in 496 clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 4G: HAZ - Crop Production and Own Consumption
(Shares of Gross Total Income & Child Fixed Effects)
Sub-sample: Over 24 Months

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	HAZ	HAZ	HAZ	HAZ	HAZ	HAZ	HAZ	HAZ
% Income, Crops	-0.129	-0.101						
	(0.105)	(0.121)						
% Income, Consumption of Own Crops			-0.358**	-0.392**				
			(0.146)	(0.179)				
% Income, Low Protein Crop Production					-0.397**	-0.411**		
					(0.190)	(0.195)		
% Income, Consumption of Low Protein Crop Production							-0.597***	-0.619***
							(0.208)	(0.223)
Ln Gross Total Income		0.0198		-0.00741		0.0168		0.00903
		(0.0339)		(0.0366)		(0.0301)		(0.0305)
Joint P-value		0.367		0.0404		0.0601		0.0112
R-Sq	0.0829	0.0880	0.0892	0.0946	0.0879	0.0940	0.0926	0.0987
Adj R-Sq	0.0712	0.0730	0.0775	0.0797	0.0762	0.0792	0.0810	0.0839

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; XXXX observations in XXX clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

Table 4H: HAZ - Crop Production and Own Consumption
(Shares of Gross Total Income & Child Fixed Effects)
Sub-sample: Below Median Income in the First Year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Income, Crops	-0.214*	-0.118						
	(0.121)	(0.136)						
% Income, Consumption of Own Crops			-0.425***	-0.370*				
			(0.153)	(0.189)				
% Income, Low Protein Crop Production					-0.290	-0.284		
					(0.187)	(0.189)		
% Income, Consumption of Low Protein Crop Production							-0.449**	-0.453**
							(0.214)	(0.219)
Ln Gross Total Income		0.0583		0.0315		0.0649		0.0578
		(0.0536)		(0.0566)		(0.0485)		(0.0486)
Joint P-value		0.166		0.0198		0.0836		0.0313
R-Sq	0.245	0.239	0.250	0.243	0.245	0.241	0.247	0.243
Adj R-Sq	0.237	0.228	0.242	0.232	0.236	0.230	0.239	0.232

Notes: Standard errors in parentheses, clustered at the household level; * p<0.1, ** p<0.05, *** p<.01; 1574 observations in 577 clusters; Joint P-value is associated with the test of joint significance of the income shares and log gross total income; All regressions include the child fixed effects and the following time-varying controls: indicators for the survey rounds, household size, number of children under 15 and under 5, identifier for female headed household, head's education, survey month fixed effects, and age in months (with square and square root).

FIGURES

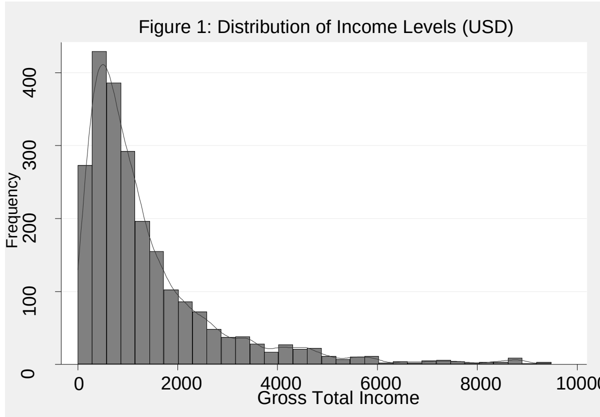

Figure 1: Distribution of Income Levels (USD)
Frequency
0
100
200
300
400
0
2000
4000
6000
8000
10000
Gross Total Income

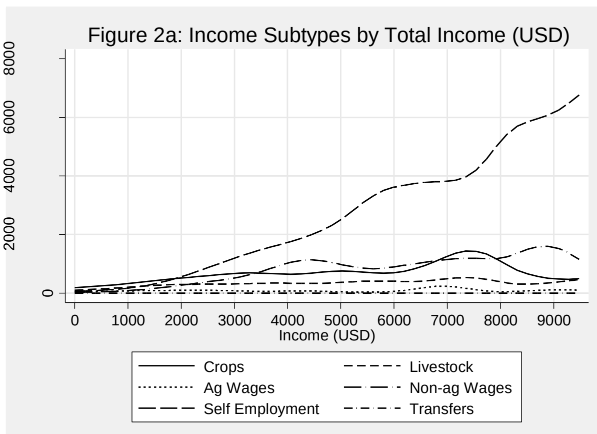

Figure 2a: Income Subtypes by Total Income (USD)
0
2000
4000
6000
8000
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Income (USD)
Crops
Livestock
Ag Wages
Non-ag Wages
Self Employment
Transfers

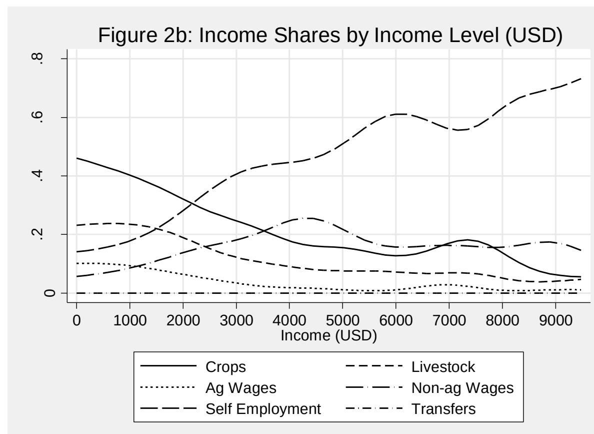

Figure 2b: Income Shares by Income Level (USD)
0
.2
.4
.6
.8
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Income (USD)
Crops
Livestock
Ag Wages
Non-ag Wages
Self Employment
Transfers

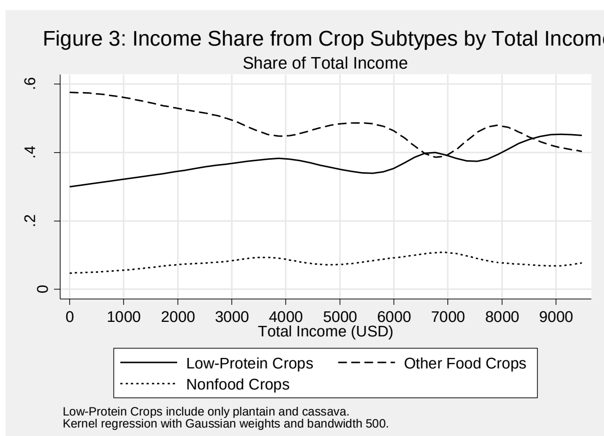

Figure 3: Income Share from Crop Subtypes by Total Income
Share of Total Income
0
.2
.4
.6
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Total Income (USD)
Low-Protein Crops
Other Food Crops
Nonfood Crops
Low-Protein Crops include only plantain and cassava.
Kernel regression with Gaussian weights and bandwidth 500.

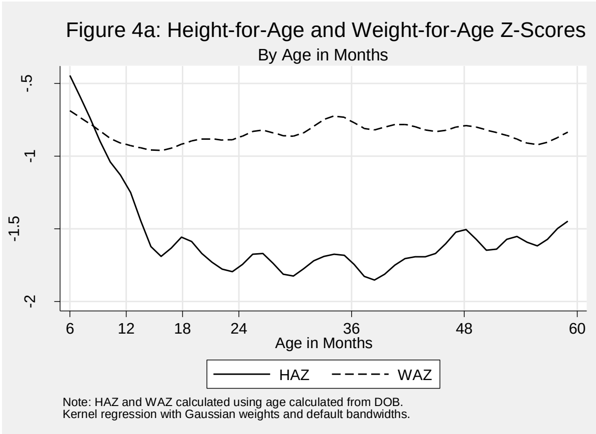

Figure 4a: Height-for-Age and Weight-for-Age Z-Scores

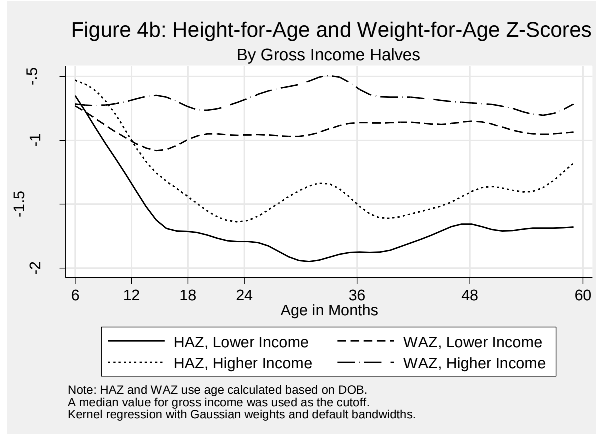

Figure 4b: Height-for-Age and Weight-for-Age Z-Scores

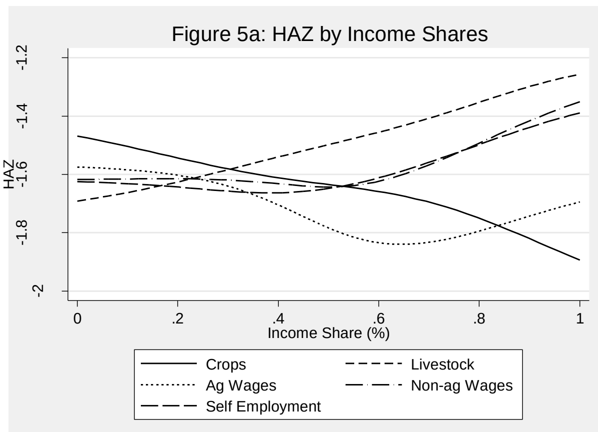

Figure 5a: HAZ by Income Shares

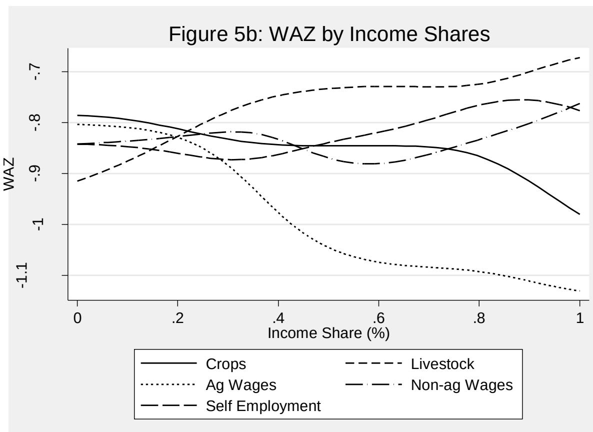

Figure 5b: WAZ by Income Shares

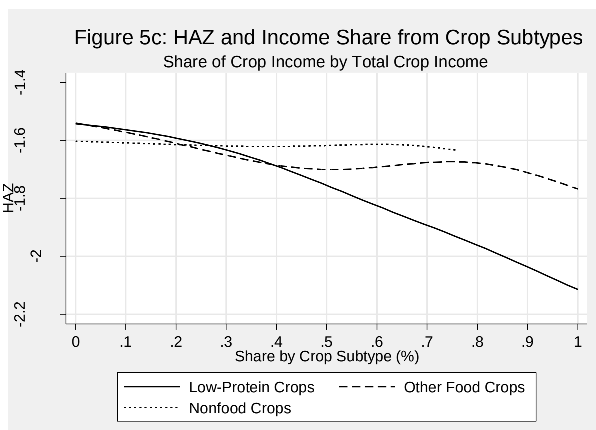

Figure 5c: HAZ and Income Share from Crop Subtypes

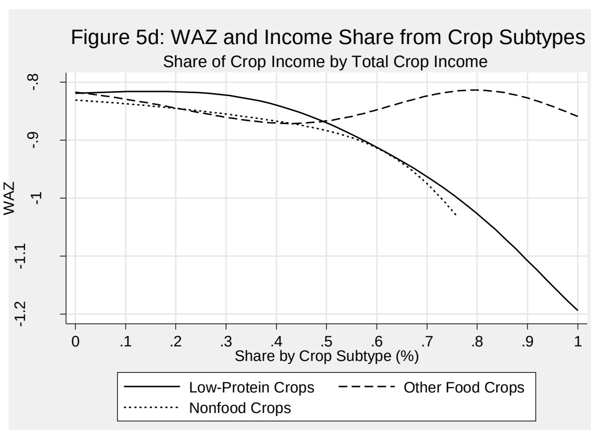

Figure 5d: WAZ and Income Share from Crop Subtypes