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Kathleen J. Brown, Roos Haer and Gudrun Østby

Worldwide, children are enrolled in primary school in greater numbers than ever before. Nonetheless, school dropout rates are significant in many countries. A crucial factor in a child's education and potential for leaving school is their family's economic insecurity. Low-income households, in particular, are highly sensitive to food prices, and increases in the cost of food staples can force families to sacrifice education to smooth food consumption. While earlier studies have relied on aggregate measures of economic conditions or are restricted to single countries and limited time periods, we take an individual approach and examine how education is affected by local food price volatility. Empirically, we combine individual-level data on school dropout from 40 Demographic and Health Surveys in 14 sub-Saharan African countries between 1992 and 2020 with geo-referenced data on consumer food prices at local markets from the World Food Programme. Our results show that children are up to 8 percent more likely to drop out when local food prices sharply increase. Notably, this effect is strongest for older children, especially for boys. This demonstrates that economic instability during childhood can have long-run adverse effects on individuals and has important implications for understanding the human capital costs of income crises.

Introduction

Access to education is a crucial building block of economic development. Schooling arguably contributes to reducing poverty by increasing productivity and equipping people with the skills they need to participate fully in the economy and society (Julius and Bawane 2011). Truncated schooling is associated with a range of negative outcomes including lower use of health services like family planning, higher fertility rates, and lower agency and decision-making power within households (e.g., Ramanaik et al. 2018). Hence, many international organizations and policymakers

Kathleen J. Brown, Institute of Political Science, Leiden University, 2300 RA Leiden, The Netherlands. Roos Haer, Institute of Political Science, Leiden University, 2300 RA Leiden, The Netherlands. Gudrun Østby, Peace Research Institute Oslo, NO-0186, Oslo, Norway.

invest vast amounts of money in promoting enrollment and reducing dropout rates (Patrinos and Psacharopulos 2011).

Currently, African children are starting school in greater numbers than ever before, but dropout rates are still significant and lead to low levels of primary and secondary school completion in many countries (UN 2020). A recent report by UNESCO (2020) suggests that for primary school, the adjusted net enrollment rate in sub-Saharan Africa increased from 74 percent in 2007 to 78 percent in 2018. However, it is estimated that only around 70 percent of children entering primary education in sub-Saharan Africa complete it. This percentage decreases dramatically when looking at secondary schooling: only around 30 percent (for lower secondary education) and around 14 percent (for higher secondary education) of those children enrolled to complete their education (UN 2020; African Union 2016). Most policy interventions have a strong emphasis on the *supply-side* of education, such as increasing school construction, providing education materials, training teachers, and enhancing curriculum (Grimm 2011). However, several studies have identified the importance of income as the most important *demand-side* factor influencing parents' decisions to withdraw children from school (e.g., Glewwe and Jacoby 2004; Cogneau and Jedwab 2008; Grimm 2011). Due to the limited ability to smooth consumption through credit and savings (e.g., Jacoby and Skoufias 1997), many households in less developed states are forced to find alternative ways of coping with negative income changes. As education is a significant expense for many households, one far-reaching strategy is to withdraw children from school as a mechanism to smooth consumption in the short run (Haer and Bakaki 2022).

Existing research examining how household income might affect school dropout has often relied on indirect and aggregate measures, such as changes in precipitation (e.g., Björkman-Nyqvist 2013) or in primary commodity prices on the international market (e.g., Brueckner and Gradstein 2016) to instrument for income variation. Moreover, they have primarily examined this relationship in individual countries over a limited period (e.g., Beegle, Dehejia, and Gatti 2006). Although these studies provide foundational evidence of the income–education relationship, they are often limited in their generalizability. Furthermore, recently the instruments used to capture income shocks such as rainfall and global price commodity shocks have come under scrutiny as their exclusion restrictions may not hold or may not be sufficiently relevant for localized quantities of interest like education (e.g., Weinberg and Bakker 2015; Schultz and Mankin 2019; Friedman 2012).

To overcome this, our study examines the effect of food price volatility at the local market on primary and secondary school dropout. Empirically, we examine this relationship by combining individual-level education data from 40 geo-referenced Demographic and Health Surveys (DHS) conducted in 14 sub-Saharan African countries with geolocated information on consumer prices of food staples at local markets in the period from 1991 to 2020 from the World Food Programme (WFP; 2022). Beyond a general analysis of the linkage between food price volatility and school disruption, we also provide a more nuanced understanding of how households respond to increases in local food prices by examining how a child's age and gender might influence this relationship. Theoretically, we argue that withdrawing older children from school can recoup a larger share of household expenditure than dropouts among younger children. Moreover, since boys are more likely to be employed in paid labor than girls, they may have a higher opportunity cost of schooling. Our results support this argument, and we find that older boys are most likely to withdraw from school following an increase in local food prices.

We proceed as follows: first, we summarize the existing research on factors influencing school dropout rates, with emphasis on the effect of income changes. In the research design section, we outline our quantitative approach. Our results show that less-developed states may face dual crises; increases in local food prices not only increase poverty but also erode decades of progress in child education. We conclude with a brief discussion of policy implications and directions for future research.

School dropout

In explaining dropout rates or variation in educational attainment across time and space, most scholars have used economic models that argue that the market for education is governed by supply and demand factors. Supply factors are those that promote the provision of (quality) education, such as the availability of schools, teachers, and materials. Most scholars agree, however, that these supply factors are insufficient to augment the level of education (Cogneau and Jedwab 2008): although the supply of education has improved over the last few years, leading to increased enrollment, dropout rates are still relatively high (UN 2020; African Union 2016). For instance, recent estimates suggest that primary enrollment has increased in sub-Saharn Africa with 4 percent in the last decade but that dropout rates are still relatively high, around 30 percent (UNESCO 2020; UN 2020; African Union, 2016). To explain this, most scholars (e.g., Jacoby and Skoufias 1997; Grimm 2008; Björkman-Nyqvist 2013) have embraced the importance of demand-side factors that is, factors that motivate households to send their children to school or to withdraw them.

An important demand factor that is often implicated in school dropout is that of adverse changes in household income or wealth, especially affecting those who are poor (Julius and Bwane 2011). Households may not be able to pay for their children's education following a decline in income. Even though most countries in sub-Saharan Africa now legally guarantee free education at the primary level, survey evidence indicates that school fees often continue to be charged. Furthermore, where there are no school fees, much of the actual cost of education is still covered by the household, rather than the government, such as textbooks, uniforms, transportation, and dues for parent–teacher associations (UNESCO 2022). School fees and other mandatory charges can consume an average of 20–25 percent of an African household's budget (Haer and Bakaki 2022).

In a perfect capital market with functioning credit and insurance possibilities, changes in a household's economic situation might have less of an effect. However, in many less-developed states, household credit and insurance are very limited, and informal risk-sharing mechanisms within communities are often weak (Cogneau and Jedwab 2012).[1] In the absence of these formal coping strategies, households tend to use alternative mechanisms. Given the high cost associated with schooling, they might opt for trading off the future benefits of educating their children against their current consumption needs by withdrawing them from school. This will not only lead to a decrease in education spending but children can also engage in immediate income-generating activities outside the household, thereby increasing the household's income (Grimm 2008).

Studies that have examined the income-education relationship can be divided into three large strands. First, several scholars have estimated the effect of agricultural income on education outcomes by exploiting exogenous variations in rainfall and other weather patterns. This approach allows them to address endogeneity and approach a causal link between income and education. Jacoby and Skoufias (1997) were among the first to conclude that adverse changes in precipitation negatively affected school attendance in India. Further, Jensen (2000) showed that rainfall shocks in Côte d'Ivoire significantly influenced the investment in children; primary school enrollment declined between one-third and a half under adverse agricultural conditions. Björkman-Nyqvist (2013) also examined the effect of income changes on primary education by looking at precipitation levels in Uganda. She finds that negative deviations in rainfall have an immediate negative effect on female enrollment in primary schools, although she finds no effect on boys' academic enrollment and performance. Similar results are found for Zimbabwe (Alderman, Hoddinott, and Kinsey 2006) and Tanzania (Beegle et al.2008).

Second, other scholars have investigated the education–income relationship by looking at the influence of commodity price changes. For example, Cogneau and Jedwab (2012) investigated the impact of the 1990 cocoa price shock on children's primary school enrollment in Côte d'Ivoire. They find that children of cocoa-producing households (in comparison to food crop farmers) were substantially impacted: their enrollment decreased significantly. Grimm (2008, 2011) further examined this relationship in Burkina Faso by leveraging differences in income trends among cotton and food crop farmers in the mid-1990s. He shows that a decline in income of

10 percent causes a decline in enrollment rates among children between the age of 6–13 by about 2.5 percentage points for boys and 3 percentage points for girls.

Lastly, scholars have exploited natural experiments generated by macroeconomic crises (or growth) to measure the effect of income shocks. For instance, Bruckner and Gradstein's (2016) analysis of 138 countries across two generations reveals that a rise in the gross domestic product (GDP) per capita growth increases the likelihood of secondary school enrollment. Rucci (2004), in turn, looks at changes in enrollment rates during the Argentinean economic crisis and finds that the probability of attending school decreased by 4–12 percent for 12–17-year-olds. Thomas et al. (2004) further found that the financial crisis in Indonesia substantially reduced school attainment; however, poorer households tended to protect the education investments of older children at the expense of younger ones. Other scholars have found similar results when looking at the effect of macroeconomic crises on education in single-country cases (McKenzie 2003; Funkhouser 1999), offering further evidence for the robust relationship between economic conditions and school enrollment.

Food prices and education

The literature on educational attainment generally shows that the changes in household income matter for children's schooling (e.g., Filmer and Pritchett 1999; García and Saavdra 2017). However, most of these studies have examined the effect of income shocks on education outcomes in a singular country across a limited number of years (e.g., Chiripanhura and Niño-Zarazúa (2016) on Nigeria; Cogneau and Jedwab (2008) on Côte d'Ivoire; Vásquez and Bohara 2010 on Guatemala). Moreover, they often conceive income shocks as national trends in commodity prices or as changes in precipitation levels that indirectly influence agricultural conditions. While these measures are useful for examining the effect of shocks on national income or large food producers, they are ill-suited for the study of the local economic conditions facing individual households.

Higher international commodity prices might, for instance, only be problematic if the product in question is imported (Weinberg and Bakker 2015). However, over the past three decades, most staple foods consumed across the sub-Saharan region have been produced domestically, and often locally (Moseley and Battersby 2020). Furthermore, domestic political, economic, and social interests prevent or delay the direct transmission of international price fluctuations to domestic consumers. Protectionist tariffs and nontariff barriers to imports, food stockpiles, export constraints, and consumer subsidies all protect consumers from global market fluctuations. This is particularly true across sub-Saharan Africa, where governments have strong political commitments to subsidies, delaying, or restricting the effect of price shocks on local markets (Dionne and Horowitz 2016). Larger, cross-national studies support this claim, showing only minimal transmission of world commodity prices to households and only in a small number of cases (Baffes and Gardner 2003).

Other scholars have used precipitation levels as a way of measuring income shocks (e.g., Agamile and Lawson). However, the measurement of temperature and precipitation can be severely affected by political and economic conditions (Schultz and Mankin 2019). Furthermore, using changes in precipitation levels as an instrument might violate the exclusion restriction as heavy (seasonal) rain makes transportation difficult, thereby directly influencing the likelihood that children can go to school independently of changes in income (Friedman 2012). For instance, Porter et al. (2011) emphasize the importance of cheap, regular, and reliable transport for education and find that more than half of children in Ghana miss a large share of schooling due to rain. Similar conclusions are drawn by Agamile and Lawson () who find that above-average precipitation is associated with more school dropouts in Uganda.

Instead of these commonly used measures, we take a more disaggregated approach and examine how sub-Saharan African households' decision to withdraw their children from school is affected by increases in the food prices that they face at their local market.[2] Changes in local food prices are immediately felt by household consumers, allowing us to estimate the contemporaneous effect on education attainment with more precision than macro-level or supply-side measures of economic shocks. Food prices are likely to alter economic decisions given that food makes up a significant portion of household expenditure, especially in less developed states (e.g., De Matteis 2014; D'Souza and Jolliffe 2012; Naylor and Falcon 2010). Moreover, the demand for locally produced food is inelastic, particularly for staple foods for which there are few or no substitutes (Weinberg and Bakker 2015).

Hence, we argue that when local food prices increase, a household may be forced to withdraw children from school because it can smooth food consumption in two ways. First, it will directly affect a household's budget by reducing the amount of money spent on tuition fees and related costs. Second, those children that are no longer in school can engage in income-generating activities, thereby increasing a household's income and offsetting further increases in food prices.[3] However, the opportunity costs of schooling are not equal across children. Beginning with Becker (1975), economists have long argued that a household's economic condition can affect the differential treatment of children. When households face economic stress, children's characteristics like age and gender may become more important determinants of which children are enrolled in and withdrawn from school.

First, the effect of economic conditions on schooling is likely to vary by age. The marginal utility of a child's contribution to the household's budget rises with age, making it more likely that older children are withdrawn from school (e.g., Shah and Steinberg 2017). Not only do school fees significantly increase with age (secondary school is considerably more expensive than a primary school; Moshoeshoe, Ardington, and Piraino 2019), but the income-generating capabilities of children also increase with age. As children grow up they acquire more experience and more human capital, which creates a prospect of higher wages. This suggests that dropout among older children can recoup a larger share of household expenditure than dropout among younger children. There is some evidence supporting this link. For instance, Björkman-Nyqvist (2013) shows that negative deviations in rainfall have an immediate negative effect on female enrollment in Ugandan primary schools, with the strongest effect on older girls.

Second, when households face a substantial negative income shock due to changes in food prices, a child's gender might play an important role in the decision of whom to withdraw (Østby, Urdal, and Rudolfsen 2016). While conventional wisdom suggests that boys are favored in schooling decisions, recent evidence finds that gender gaps in education are likely to favor girls in less-developed contexts (Grant and Behrman 2010). Boys have a higher short-term opportunity cost of schooling than girls since their income-generating capabilities are generally considered to be higher. Consequently, boys may be more likely to be withdrawn from school and sent to the labor market in times of economic crisis (Vásquez and Bohara 2010). Some studies, especially those that examine the link between child labor and a child's educational attainment, have provided some preliminary evidence for this linkage. For instance, Beegle et al. (2008) show that negative income shocks in Tanzania especially affect boys' education. They argue that girls are likely to be involved in forms of child labor, such as household chores, that interfere less with education than the work that boys do (working on the land or off-farm labor). The study of Branson, Hofmeyr, and Lam (2014) in South Africa mirrors these results and shows that boys suffer the effects of household credit constraints to a greater degree than girls: they are the first to leave school and seek work when income is limited.

In the following section, not only do we test the potential general relationship between food price volatility on dropout rates but also examine the conditional effects of a child's age and gender across a large sample of 14 sub-Saharan countries.

Methodology

To examine the link between food prices and school dropout, we combine individual survey data on educational attainment with data from the WFP on local food prices. Relying on individual survey data has the advantages of specificity and accuracy as individuals are better positioned to report their own school experience than national aggregate statistics on education. We use individual-level DHS data from 14 countries in sub-Saharan Africa, a region that exhibits the lowest level of education worldwide (Psaki, McCarthy, and Mensch 2018). DHS are nationally representative surveys conducted in many countries at different periods. In each DHS, women aged 15–49 are interviewed about a range of socioeconomic and health issues, among others about educational attainment. In some cases, the woman's interview is supplemented by interviewing her husband. Consequently, our dataset includes information on female and male educational attainment. As we are interested in the location of each respondent, and his or her spatial relationship with local markets, we only use the DHS surveys containing GPS coordinates. For this study, we focus on respondents in the men's and women's questionnaires in 40 survey waves conducted in 14 countries between 1992 and 2020 (see Table 1).[4] Moreover, for the analysis presented here, we focus on those respondents who indicated to never have moved from their surveyed location (i.e., they received their education at the survey location), allowing us to match individuals and local food prices with more certainty. In the online Appendix, we extend our analysis to those who have moved before they enrolled in school and analyze the potential differences between these two populations.

Dependent variable

To examine the effect of local food price volatility on the likelihood of school dropout, we take advantage of individuals' responses as adults on a question asking their highest completed grade level of education to determine whether they ever enrolled in school as a child, and how long they remained enrolled.[5] Based on their responses, we create a person-year dataset whereby each person who ever went to school enters the dataset at the country's primary school starting age[6] and is observed yearly until their final year of education (whether due to dropout or the completion of secondary school). For example, consider a 25-year-old respondent surveyed in Malawi in 2015 who reported having eight years of schooling. We create (back-date) observations for the respondent between their first eligible year of school (at the age of six in 1996) and the year after they stopped attending school (2005). Our dichotomous variable *Dropout* measures whether a child drops out from school (coded as 1; and 0 otherwise).[7] This data structure creates 1,809,830 person-year observations between 1991 (the starting year of our food price data) and 2020 (when the last respondents of the most recent 2019 waves were interviewed), with the sample period for each country shown in column 4 of Table 1.

TABLE 1 DHS waves and sample size

Country	DHS wave (year survey began)	Sample size (person-year)	Years in the sample, after back-dating (min-max)	Number of market towns
Benin	1996, 2001, 2011–2012, 2017–2018	2,044	1991–2018	42
Burkina Faso	1993, 1998–1999, 2003, 2010	827	1991–2010	62
Burundi	2010, 2016–2017	2,776	1991–2017	68
Chad	2014–2015	2,062	1991–2015	53
The Gambia	2019–20	3,080	1991–2020	26
Guinea	1999, 2005, 2012, 2018	1,315	1991–2018	16
Kenya	2003, 2008–2009, 2014	333	1991–2014	33
Liberia	2007, 2013, 2019–2020	2,442	1991–2020	20
Madagascar	1997, 2008–2009	360	1991–2009	52
Malawi	2000, 2004, 2010, 2015	12,759	1991–2015	94
Mali	1995–1996, 2001, 2006, 2012–2013, 2018	2,451	1991–2015	100
Mozambique	2011	4,327	1991–2011	52
Niger	1992, 1998, 2012	387	1991–2012	61
Zambia	2007, 2013–2014, 2018–2019	9,433	1991–2019	71

Independent variable

Our main variable of interest is the volatility in food prices experienced by households with school-aged children. To measure this, we construct an original index of local food price volatility using WFP market-level data (World Food Programme 2022). The WFP reports monthly consumer prices in local currencies for a variety of staple foods at local markets. Across sub-Saharan Africa, data are available for an average of 53 market towns per country, offering the opportunity to track food prices at a local level.

The scope of the WFP price data varies widely across periods and between markets. Data are available for the period 1991–2022, although most countries only have data starting from 2003. Generally, food prices are available for two to three food products each year, usually for the most common staples like wheat or millet.[8] However, in some country-years, the WFP reports data on many more available food products, up to 27 within a single market-year.[9] Including more food products in our measure allows us to sketch a more nuanced picture of the evolution of food prices by countering potential substitution effects between food products.[10] Further, focusing solely on a single food product might overestimate the impact of price changes (Dimova and Gbakou 2013).

To compare food prices across markets and time, we create a market-year indicator of local food prices, shown in Equation (1). Since the WFP collects monthly food price data, we first aggregate data to the annual level by averaging prices for each food product (k) within years (t) and markets (m). We then average the prices (V) of all available food products in each market-year and divide this by the number of food products (G) from which information is available in that market-year. We explicitly keep food prices in domestic currency and do not adjust for inflation as we want to measure any change in food prices including those caused by inflation and are not concerned with comparing the raw food prices between countries or across time.

$$P_{m,\,t} = \sum_{k=1}^{k} \left(\frac{V_{k,\,t}}{G_t} \right). \tag{1}$$

As we are interested in changes in food prices, we take the percentage change in the average food price between the previous year $t-1$ and the present year t. As a result, our first year of observation is 1992. This approach also helps to minimize any inherent autocorrelation in food prices. In line with other work on food price volatility (Smith 2014), this measure is then standardized to help address potential autocorrelation.[11]

We then geocode each market town and match DHS respondents to the nearest market in their country of residence[12] by straight-line distance from their survey cluster. We exclude DHS respondents who live more than 50 km from a market town to ensure that we match individuals to food prices that are plausibly local. In choosing this buffer, we follow the conventional standard in the literature that examines the impact of local spatial relationships (e.g., Østby et al. 2018). Again, we exclude respondents who indicate that they have moved location at any point in their life. This restriction offers us reasonable certainty that the food prices measured at each market town are analogous to the local food prices that the respondent experienced during their school-age years. As DHS respondents are not asked to report the location of their residence prior to moving, it is impossible to match "movers" to local food prices. However, this restriction requires that we exclude migrant households from our analysis, which may systematically differ from nonmigrant households. We examine this further via a series of robustness checks and find that the nonmover restriction is unlikely to bias our results.

Estimations, covariates, and fixed effects

To test the relationship between food price volatility and school dropout, we estimate a linear probability model. This model is an optimal choice given our binary dependent variable as it generates less bias than other nonlinear models (Horrace and Oaxaca 2006) and eases the interpretation of coefficients. This specification also allows us to include multiple fixed effects without suffering from the incidental parameter problem that would arise in a logistic regression.[13]

We regress food price volatility in each market-year, $\textit{Food Price}_{m,t}$, on the indicator for $\textit{Dropout}_{i,t}$ for each DHS respondent i in year t (see Equation 2).

$$\textit{Dropout}_{i,t} = \textit{Food Price}_{m,t}\beta_1 + \mathrm{X}\beta + \gamma_c + \theta_t + \varepsilon_{i,t}. \quad (2)$$

We include a vector of control variables ($\mathrm{X}\beta$) in our empirical analysis to address potential confounding between changes in consumer food prices and school dropout. However, because we back-date DHS responses, we have limited individual- or household-level controls relevant to a respondent's school-age years. First, armed conflict is likely to drive up food prices (Rezaeedaryakenari et al. 2020) and limit access to education, both by destroying education infrastructure and reducing teaching resources and staff (Justino 2016). To control for this, we add a variable *Conflict*, measuring the number of conflict events that occurred within a 50-km radius of the respondent each year using data from the Uppsala Conflict Data Program Georeferenced Event Data (Sundberg and Melander 2013).[14] Next, we include a measure of the individual's *Age* in years and whether the respondent is a *Boy* or not as reported in the DHS survey. These controls account for the fact that the cost of education and income-earning capabilities might change with age and gender.

Beyond these covariates, omitted variable bias remains a concern, particularly as the lack of data prevents us from measuring the supply of education or respondents' household resources during childhood. To account to some extent for this, we include DHS cluster fixed effects (γ_c) to control for a variety of community-level unobservable factors that could drive our results. For example, labor market conditions are likely to vary between communities, especially in rural areas, and so differences in returns to education may result in differences in how households invest in education (Brown and Park 2002). DHS cluster fixed effects also control for differences in school quality and availability and household social and economic networks between communities. We also include year fixed effects (θ_t) to help control for time-varying characteristics, like agricultural production technology and school availability, and to address serial correlation. This is especially important given that food prices display strong time trends that may bias standard errors if not addressed (Smith 2014). We choose to cluster the heteroskedasicity-robust standard errors at the level of treatment, the market, but also present models in the online Appendix with standard errors clustered at the DHS cluster level.

Results

The results of our analysis can be found in Table 2. In the first column, we examine the effect of food prices on school dropout without including any control variables. We find a positive and statistically significant effect; increases in food prices substantially increase the likelihood that children drop out of primary and secondary schools. To examine the substantive effect, we compare the change in the probability that a child will drop out of school when there is a one-unit increase in food price (i.e., an increase of 100%), with the average annual probability of dropping out of school (0.087) if there was no change in food price.[15] Although this increase sounds considerable, food prices are highly volatile and such an increase is not unreasonable. Throughout the study period, for example, local food prices increased by an average of 28 percent each year, with spikes of 46 percent in 2002 during the famine in Southern Africa and 76 percent in 2008 following the global food price crisis. The coefficient of our food price variable in Model 1 (0.0042) corresponds with a 4.82 percent increase in the likelihood that a child drops out of school (shown in the *percentage change* panel of Table 2). That is, when food prices increase by 100 percent, it increases the likelihood of dropout by 4.82 percent. In Models 2–4, we include control variables and different sets of fixed effects. Across all models, we find that increases in food prices have a positive and statistically significant influence on the likelihood of dropout across all four specifications. When controlling for age, gender, and local conflict, the coefficient of *Food Price* corresponds to a 4.23 percent increase in the likelihood of dropout (Model 2). As expected, age and

TABLE 2 The effect of food prices on school dropout

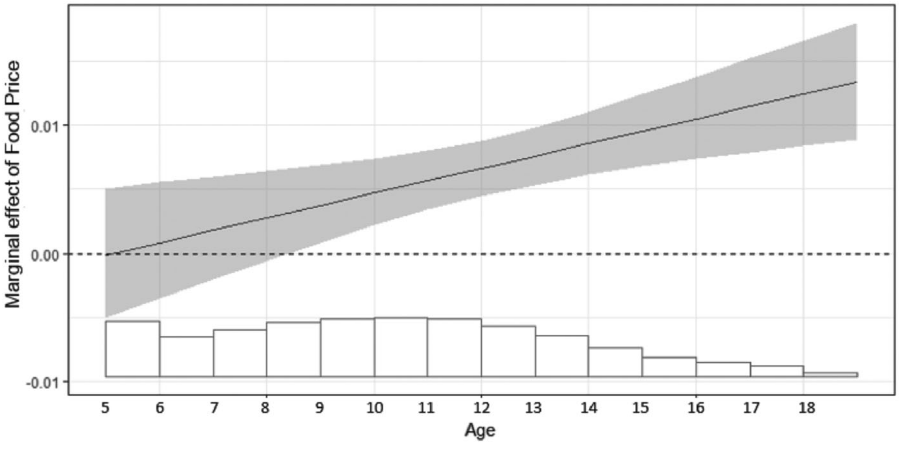
	Model (1)	Model (2)	Model (3)	Model (4)
Food price	0.0042**	0.0037*	0.0034*	0.0069***
	(0.0021)	(0.0020)	(0.0019)	(0.0020)
Age		0.0186***	0.0248***	0.0209***
		(0.0018)	(0.0026)	(0.0021)
Boy		0.0053***	0.0049***	0.0057***
		(0.0016)	(0.0016)	(0.0016)
Conflict		0.0014	0.0013	0.0013
		(0.0017)	(0.0016)	(0.0016)
Observations	140,820	140,820	140,820	140,820
Substantive effect:				
Food price (% change)	4.82%	4.23%	3.89%	7.90%
Fixed effects:				
DHS cluster	x	x	x	x
Year	x	x		
Cohort			x	
Survey wave				x

NOTE: The table shows the results of LPM regressions estimated using OLS with *Dropout* as the dependent variable. Since the *Food Price* variable is standardized, we present the percentage change in the annual likelihood of dropout for each *Food Price* coefficient. The unit of analysis is respondent-year. HC2 standard errors are in parentheses.
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

conflict events are positively associated with dropout.[16] Table 2 also shows that boys have significantly higher dropout rates than girls (irrespective of food prices), an effect that may seem counterintuitive given the large literature that demonstrates girls have more limited access to education (e.g., Psaki, McCarthy, and Mensch 2018; UNICEF 2020). However, this positive effect may reflect the fact that bias against girls especially occurs at the time of first enrollment, but once in school, boys may be more vulnerable to dropping out. We explore this possibility in more depth in the robustness section.

A potential threat to inference is the respondent's birth cohort, as individuals born around the same time will experience major events at similar ages, which may affect food prices or education outcomes. For example, it might be that older children drop out of school because of increasing opportunity costs but this might also be motivated because they lived through a war or drought that altered their incentives to attend school. Controlling for both year and birth-cohort effects when estimating the effect of age on school dropout is not possible due to a perfect correlation (Yang and Land 2013). While we cannot completely dismiss potential cohort effects, we re-estimate our models using birth-year instead of year fixed effects (see Model 3 in Table 2) and include both year and DHS survey wave fixed effects. The latter is a coarser measure of birth cohort, as respondents of a

FIGURE 1 The marginal effect of the food price index across age.



NOTES: Grey shaded area indicates a 95% percent confidence interval. The rug plot shows the distribution of observations across age. N = 140,820.

certain age were captured in each wave (see Model 4 in Table 2). The two models demonstrate that the effect of food prices on school dropout persists when using alternative strategies to address time trends. The substantial effect is around 4 percent in Models 2 and 3 and 8 percent for Model 4. It is important to note that the size of the food price effect is particularly noteworthy considering that food insecurity across sub-Saharan Africa is highly volatile: it occurs often and in extreme forms.

If school dropout is driven by household resources, we would expect the effect of food prices to change as children grow older for several reasons. First, school fees increase sharply between primary and secondary school, making it more expensive to educate older children (Moshoeshoe, Ardington, and Piraino 2019). Second, sending younger children to school may allow older household members to spend more time working. This effect likely decreases as children grow older and no longer require full-time supervision. Lastly, keeping older children in school prevents their employment in other income-generating activities. Older children will receive a higher wage than younger children (ILO 1996), thereby raising the opportunity costs for education. Dropout from secondary school thus offers greater savings and earning potential for household budgets.

To test this conditional relationship, we estimate our main model with the inclusion of an interaction term between age and the local food price index in year *t*. The results of this analysis can be found in Model 1 in Table 3. To ease interpretation and assess the statistical significance across years, we plot the marginal effect of food prices in Figure 1. The figure shows that the conditional relationship is statistically significant and that the effect of food prices varies across ages. Rising food prices have a stronger effect on

TABLE 3 The conditional effect of age and gender on school dropout

	Model (1)	Model (2)	Model (3)
	Full sample	Girls	Boys
Food prices × Age	0.0010*	−0.0000	0.0029***
	(0.0005)	(0.0006)	(0.0007)
Food prices	−0.0082	0.0053	−0.0324***
	(0.0058)	(0.0076)	(0.0067)
Age	0.0186***	0.0208***	0.0162***
	(0.0020)	(0.0020)	(0.0018)
Boy	0.0053***		
	(0.0016)		
Conflict	0.0019	0.0029	−0.0002
	(0.0020)	(0.0019)	(0.0025)
Observations	140,820	89,300	51,520
Substantive effect:			
Food price (% change)	−4.23%	−7.78%	22.9%
Food price × Age (% change)	0.49%	0.40%	1.91%
Fixed effects:			
DHS Cluster	x	x	x
Year	x	x	x

NOTE: The table shows the results of LPM regressions estimated using OLS with *Dropout* as the dependent variable. The unit of analysis is respondent-year. HC2 standard errors are in parentheses.
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

older children, increasing their likelihood of dropout more than for younger children, a finding that is consistent with our expectations.

While we do not have information on respondents' school fees to further examine the effect of higher schooling costs for older children, we do examine the role of opportunity costs by comparing the effect of food prices between boys and girls. We argued that boys are more likely than girls to participate in paid child labor and earn higher wages than girls (UNICEF and ILO 2020). As rising food prices constrain household budgets, we expect older boys to be most vulnerable to dropping out of school as they offer the highest earning potential. To investigate this, we estimate the effect of food price volatility on school dropout in two separate samples of girls and boys. The results can be found in Model 2 (girls) and Model 3 (boys) of Table 3.

While age has a strong conditional effect in the male subsample, the effect is statistically insignificant in the female subsample. This means that older boys are significantly more likely than younger boys to drop out of school following a rise in food prices, while girls' likelihood of dropping out does not depend on their age. This is further evidence that food prices affect education through substitution: as households respond to rising prices by pulling the most "expensive" students out of school.

Household analysis

One important limitation of our analysis is that we are unable to precisely measure household income at the time of dropout. The effect of food prices may vary across household wealth as price shocks might especially affect the most economically vulnerable households. To investigate the effect of a household's wealth on dropout rates, we replicate our analysis using responses to DHS household-level surveys instead of the individual surveys that we have used for the main analysis. In these household surveys, adult respondents are asked about household characteristics, such as their living conditions, and the educational level of their children. Unlike in the individual surveys, here our unit of observation is children in each household, rather than the adult respondent. Because we observe children during their education years, we are only able to back-date the household response by an average of five years. Important to note is that the use of this household-level data has two main advantages: we cannot only incorporate household characteristics, such as different measures of wealth, but migration might also be less of an issue since households are less likely to migrate in the average five-year window of backdating in the household sample than in the full sample (in which we backdate for a much longer period, and are forced to exclude respondents who indicate they have moved at some point in their life).

Notwithstanding, relying on these household surveys has a few important limitations.[17] Due to the survey structure, we skew our observation of dropout to younger respondents. This makes the household less suited to test the conditional relationship between age and food prices as there is no constant support for the interaction across age (Hainmueller, Mummolo, and Xu 2019). Most importantly, by including household characteristics at the time of the survey, we assume that these characteristics have stayed the same throughout a child's school years. Practically, for the upcoming analysis on the influence of wealth, we assume that household wealth (measured as an index of household asset ownership) has not changed dramatically between the year a child entered school and the year their household was surveyed.[18]

For this additional analysis, we use 14 household surveys of four countries: Burkina Faso, Malawi, Mozambique, and Niger. These four countries have the longest-run food price data. As in our previous analysis, we create a *Dropout* indicator that equals 1 in the year that a child leaves school, and 0 otherwise. Moreover, we follow the same approach as in the main analysis to match respondents to the food price data at their nearest market. In addition to the above controls (age, gender, and conflict), we also include in the analysis below a measure of household wealth, measured as an index that is the sum of seven indicators for the household's physical assets.

Table 4 shows the ' result when using this alternative DHS sample. Model 1 shows the results without any control variables. The statistically

TABLE 4 Household analysis

	Model (1)	Model (2)	Model (3)
Food price	0.0050**	0.006**	0.017***
	(0.002)	(0.003)	(0.004)
Age		0.038***	0.039***
		(0.001)	(0.001)
Boy		0.014***	0.014***
		(0.002)	(0.002)
Conflict		0.012	0.012
		(0.037)	(0.037)
Wealth index		−0.044***	−0.044***
		(0.001)	(0.001)
Food price × Wealth index			−0.003***
			(0.001)
Observations	313,508	293,240	293,240
Substantive effect:			
Food price (% change)	2.85%	3.42%	9.69%
Food price × Wealth index (% change)			–1.71%
Fixed effects:			
DHS cluster	x	x	x
Year	x	x	x

NOTE: The table shows the results of LPM regressions estimated using OLS with *Dropout* as the dependent variable. The unit of analysis is respondent-year. HC2 standard errors are in parentheses.
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

significant coefficient (0.005) shows that when food prices increase, it increases children's dropout by around 2.85 percent. In Model 2, we introduce the *wealth index*. The statistically significant wealth index coefficient (−0.044) confirms our expectation: wealthier households have lower average dropout rates. Importantly, the food price coefficient remains significant even when controlling for the wealth index. To examine the conditional effect of wealth on the relationship between food prices and dropout rate, we include an interaction term in Model 3. The significant, negative interaction term demonstrates that rising food prices are most likely to lead to school dropout among the poorest households (with a low wealth index score), providing further evidence that households sacrifice education to cover rising food costs.

Additional analysis and robustness checks

To further probe the validity of our results we carry out several robustness checks, of which the results can be found in the online Appendix. We highlight some important tests.

First, we added several control variables that capture changes across schooling systems. For example, we added an indicator for the provision of free primary education at the national level, the level of government spending on education (as a share of GDP in each country-year), and the number of primary school teachers per 1,000 citizens in each country-year. In addition, we use information from the UNESCO Institute for Statistics and control for the proportion of enrolled students who repeated each primary school grade level (from grades 1 to 7) in each country-year. Analysis of all these factors shows that our results remain robust when including these factors: there is still a positive, statistically significant relationship between food prices and dropout.

Second, limited WFP data availability—especially before 2003—means that our measure of food price incorporates a larger basket of goods in later study periods. Although year-fixed effects should largely control for this possible time trend, changes in the basket of goods may still affect our results. To address this, we use the annual percentage change in the price of a single food product with the longest period of consistently measured prices. In addition to this change, we also substitute our initial measure with an unstandardized measure as well as with one measuring the total percent change in food prices at each market (not weighted by the number of food products available). Our central findings remain unchanged regardless of the food price measure.

Third, the relationship between food prices and dropout might be affected by a host of confounding factors. To examine this in more detail, we add several variables besides local armed conflict. Not only do we include a measure of whether a household is located in a rural (coded 1) or urban area, but we also include measures of local rainfall and temperature, as well as indicators of natural disasters such as droughts and floods. Furthermore, in the household analysis, we add additional indicators of household wealth beyond the wealth index, including ownership of land, livestock, or a bank account, as well as a proxy measure of the educational attainment of household members. Even when including these factors, food prices still have a positive and statical significant effect on the likelihood of school dropout.

Fourth, our sample includes respondents matched to the nearest market within a 50-km radius and excludes respondents who indicated that they have ever moved location. However, we do not expect that household members travel 50 km to purchase food, but assume that prices at the nearest market (with WFP data coverage) are highly correlated with those at the household's local point of purchase. To test this assumption, we limit our analysis to DHS respondents living within 25 km and 12.5 km of their nearest market. We also estimate our model using the sample of respondents within 50 km, but in controlling for the distance (in kilometers) between their location and the market. The effect of food price volatility on school dropout remains positive and significant across all three specifications. We further test the mobility restriction by comparing respondents who have never moved to those who have moved prior to being surveyed and find that the samples do not differ significantly along key demographics. We also relax the mobility restriction by including "early-movers" in our sample, that is respondents who moved location prior to their school enrollment, which allows us to capture some migrant families while maintaining the precision of the local food price index. While this sample is limited due to inconsistent DHS questions about the timing of household relocation, our results remain robust, indicating that the effect of food prices on school dropout holds across migrant and nonmigrant households.

Fifth, we consider whether school enrollment causes changes in local food prices. While we do not expect food prices to be endogenous in the short term, school dropout (especially among older children) might affect local agricultural labor supply and wages, which may, in turn, alter food prices. To investigate this, we estimate the effect of the local dropout rate, measured as the proportion of DHS respondents at each market that left school in the previous year, on local food prices. The local dropout rate does not have a significant effect on food prices, suggesting that reverse causality is not a serious concern.

Lastly, in our main analysis we showed that boys are significantly more likely to drop out than girls, suggesting that bias against girls especially occurs at the time of first enrollment, but once in school, boys may be more vulnerable to dropping out (Sawada and Lokshin 2009). We explore this possibility in more depth by changing our dependent variable to enrollment. Our analysis supports our idea: girls are 3.52 percent less likely to be enrolled than boys, even controlling for other household characteristics. Most importantly, our analysis suggests that girls are more likely to enroll in school when their households have access to more resources. This suggests that the girls in our main analyses are those who are most resilient to changing economic conditions.

Conclusion

Given that school dropout rates are associated with a range of negative outcomes, such as poverty, lower use of health services, child marriage, and child labor, it is no surprise that much work has been conducted on explaining what causes children to drop out of school. Several factors are mentioned within the academic literature, most prominently income volatility. Negative changes in income might force parents to withdraw children from school to save money and smooth consumption in the short run. Earlier studies examining the role of income on education have tended to rely on aggregate measures, such as commodity price shocks and changes in agricultural conditions, and are usually restricted to single countries and limited time periods.

In contrast, our study is the first attempt to explore the influence of *local* food price volatility on individual school dropout in sub-Saharan African countries. We not only argue that there is a positive relationship between food price volatility and dropout risk but also that this effect is moderated by age and gender. Older children—and especially boys—are more likely to drop out with increases in food prices. Not only are the educational costs of older children higher than those of young children, but older (male) children are also more likely to find other income-generating activities that can help the household to smooth their food consumption.

Empirically, we use individual education attainment between 1991 and 2020 from more than 40 DHS surveys conducted in 14 sub-Saharan African countries. The interviewed men and women from these surveys are geolocated, which allows us to connect them to the location of local food markets. Using local consumer price data from the WFP we create a measure of annual food price volatility at 401 market towns across the region. We estimate the effect of changes in local food prices on the probability that a child drops out of school with a linear probability model. In doing so, we focus on only those DHS respondents that ever enrolled in school, thereby excluding those who did not go to school due to limited economic resources. The results show that a 100 percent increase in local food prices leads to a 4–8 percent increase in the likelihood of dropout. Moreover, this relationship is stronger for older children for whom education is more expensive and especially among boys who must sacrifice the most earnings from remaining in school. Additionally, we show that increases in food prices are especially detrimental for poorer households; children from these households are more likely to drop out in the face of rising food prices in comparison to households that have an economic buffer. These results hold for a range of robustness tests. Our findings lend support to our theory that rising prices put a strain on household budgets and force the substitution of children's education in exchange for food. Our results are in line with existing research on how income and economic shocks influence educational outcomes (e.g., Filmer and Pritchett 1999; García and Saavdra 2017) and those who examine the link between household income and schooling (e.g., Björkman-Nyqvist 2013; Brueckner and Gradstein 2016). Our contribution is a broader, cross-national test of this relationship through the novel use of changes in local food prices.

Our study is a first attempt to empirically analyze the food price–educational disruption relationship on a large scale, and we see several avenues for future research. Our use of DHS surveys to create a back-dated panel of respondents limits the number of control variables that we could include in our analysis, as the survey asks for little information about respondents' childhood circumstances. We addressed this in part by using several household-level surveys (including information on children's schooling), confirming our results. An important drawback of using back-dated surveys is that we had to assume that respondents started their education at the official age of school enrollment and that their education was continuous, while in reality children may have started school early or late, or temporarily dropped out only to rejoin at a later year. This potential issue might affect the precision of our estimates, but this also suggests that our results are a lower-bound estimate of the true effect of economic conditions on food prices.

Future work would benefit by using more complete data that can measure household income and educational attainment over time with more certainty. This would likely require substantial data collection with repeated surveys. Further, although our paper is primarily focused on exploring the economic conditions of underlying parents' decisions to withdraw their children from school, it is likely that several other noneconomic characteristics play a role, which might be explored in future work. For instance, the role of parents' education, birth order, and engagement in child labor likely influence the school dropout decision. Another possible avenue for future research is examining how specific education policies protect students or make them more vulnerable to the education effects of economic volatility. For instance, humanitarian aid in times of crisis may insulate households from income shocks as may more general educational policies like free primary school education or changes in eligibility for education subsidies.

From a policy perspective, we showed a clear wealth effect on the demand for education. This implies that well-designed and targeted policies that support a household's income directly or indirectly, for instance through investments in agricultural productivity or policies that reduce the direct or indirect costs of schooling (subsidies or study loans), must complement supply-side policies. For example, evidence from South Africa shows that unconditional social support, such as income grants for children, is likely to empower households in their decision-making toward children's schooling and help reduce dropout rates (Case, Hosegood, and Lund 2005). These retention policies should be accompanied by remediation policies, which require reliable and long-term funding for alternative programs, such as those that focus on labor market integration. Only with the development and implementation of these policies can we enhance long-run social mobility (Glewwe and Jacoby 2004).

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Data Availability Statement

Demographic and Health Survey data must be requested from the DHS program, after registration (https://dhsprogram.com/). The remaining data required for replication, including food price data, will be made available upon request to Kathleen J. Brown (k.j.brown@fsw.leidenuniv.nl).

Notes

1 Morduch (1999) notes that while informal insurance mechanisms may be efficient in coping with risks under the right circumstances, they are often weak and costly in the long run.

2 Changes in food prices can be a symptom of a local economic downturn, but other economic factors might move at the same time in the same direction as changes in food prices.

3 In a study on the impact of the rise in food prices on the education of children in poor households in Bangladesh, Raihan (2009) found that rural and urban households could save around 9 and 7 percent of their monthly household expenses, respectively, by not sending their children to school. Further, by withdrawing their children from schools and engaging them in any work, rural and urban households could earn around 10 and 11 percent of their monthly household expenses. Hence, the "net gain" (savings plus income) amounted to around 25 percent of the households' monthly expenses. Similar results are reported for Africa (ActionAid 2017).

4 The earliest survey that we have included with GPS data is that of Niger in 1992. 1991 is our first year of observation because of the availability of data on local food prices. These data are available for the years 1991–2022. Since our independent variable looks at the change in the average food price between the previous year $t-1$ and the present year t, our first year of observation is 1992.

5 We used variable V133, which is constructed by the DHS based on information coming from answers to the questions that probe into the highest educational level attended and the highest year of education gives the years of education completed at this level.

6 This information is gathered by UNESCO Institution for Statistics (2022). In our analysis, we take these different starting ages across years into account.

7 In creating this measure, two important assumptions are made: we assume that respondents began at the legal age of school attendance and that their education was continuous. In the online Appendix, we examine in more detail the effect of repetition.

8 Most of these food products are staple goods that can be easily stored, such as grains and rice.

9 Figure 1(A) in the online Appendix shows an overview of the distribution of food data across countries and years.

10 In the online Appendix, we show our results when focusing on a single (most common) food product, rather than on a basket of food products. The results mirror those presented in the main paper.

11 *Food Prices* is mean-centered by subtracting the group-mean from the percent change of average food prices.

12 For simplicity, we only match individuals to domestic markets. Individuals living near an international border may be closer to a market in another country.

13 See the online Appendix for alternative specifications.

14 In the online Appendix. we have added in addition to armed conflict the following confounding variables: rural/urban division, precipitation and temperature, and natural disasters. Our results remain robust.

15 Substantive effects are calculated by dividing the coefficient on *Food Price* by the average annual probability of dropout across the entire sample (0.087) if there was no change in food prices and multiplying this by 100.

16 Without including food prices, the relationship between conflict and dropout is statistically significant. Since food prices are very much correlated with conflict, including this variable diminishes the significance of conflict.

17 In the online Appendix, we discuss these limitations in more detail.

18 In the online Appendix, we have an additional analysis with the educational level of the household as a proxy for wealth (Table 15A).

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