Up in Smoke?: Agricultural Commercialization, Rising Food Prices and Stunting in Malawi

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Abstract

Agricultural commercialization, or the transition from food to cash crops, has gained increasing attention over the past few decades. Plans for developing world farmers to focus on labor-intensive cash crops, to exploit their natural comparative advantage, typically depend on stable food markets to supply these formerly subsistence households. The trade-off between cash and food crop production requires reevaluation in the context of numerous food price spikes and general food price increases experienced globally over the last decade.

Discovery of a correlation between Malawian cash crop production and low nutritional health outcomes creates questions of the traditional development path. This paper clarifies the causal effect behind that negative relationship. A nationally representative data set and the 2002-2003 Malawian domestic food crisis allow for time-specific comparisons between the health of children in utero during stable and increasing food price markets. Identifying children exposed to in utero food shocks is the first step to explaining the recent changes in the nutritional outcomes of cash crop producers.

Estimates of the effects of Malawian crop adoption on children's health are obtained using robust inference techniques. The causal effects of cash crop production are identified by instrumenting endogenous adoption decisions with predetermined variables. The findings show children of cash crop farmers experienced disproportionately negative effects if they were in utero during the food price shock. The results support the argument that food price shocks negatively influence those more reliant on the market for food purchases, suggesting the need for targeting small scale commercial farmers during times of staple food price spikes.

Keywords: Malawi, poverty, food prices, cash crops, tobacco
JEL Classifications: D13, I15, O13, Q16

1 Introduction

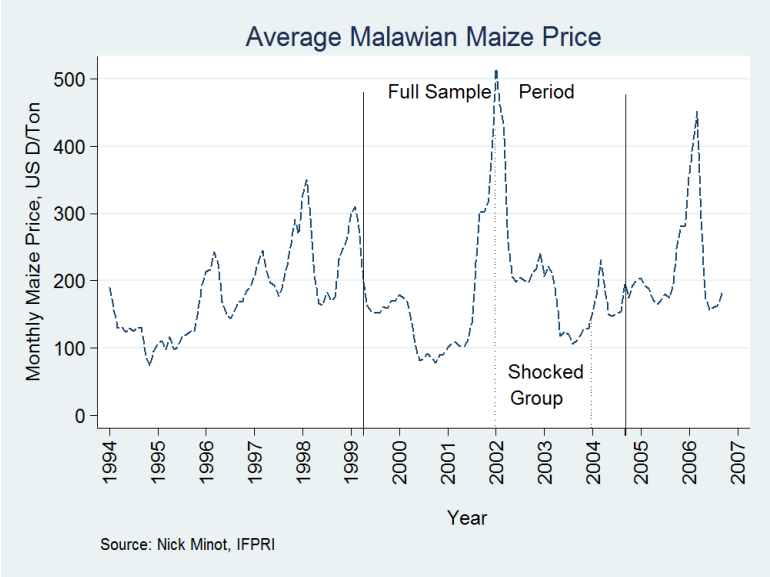
While widespread international encouragement exists for cash crop production, the impact of this commercialization on health remains undetermined (Harrigan, 2008). In the case of Malawi, where agricultural commercialization mainly centers on tobacco, recent governmental policies have promoted domestic food production in the face of longterm aid dependence and national food deficits (Ecker, Breisinger & Pauw, 2011; Levy, Barahona & Chinsinga, 2004). However, previous research has documented that greater food production or economic growth does not necessarily translate into improved nutritional health (Headey, 2011; Pelletier et al., 1995). A continuing debate exists within Malawi over encouraging agriculture to focus either on maize self-sufficiency or expanded cash crop production (Harrigan, 2003).

The gains for Malawi's smallholder farmers from structural reform through tobacco liberalization need to be reevaluated in light of recent food price spikes (Sahn & Arulpragasam, 1991). Tobacco production is an inherently risky venture in Malawi, as large increases in maize prices may leave cash crop producers unable to purchase the additional food required after foregoing subsistence farming. Previous research identified a negative correlation between Malawian tobacco production and children's nutritional health (World Bank, 2007). This result contradicts earlier Malawian studies that found an insignificant nutritional difference between commercialized and traditional farmers (von Braun, 1995; Kennedy, Bouis & von Braun, 1992). Spikes in Malawi's maize market may have adversely affected commercialized farmers.

Combining recent food price shocks with nationally representative survey data allows for a reevaluation of the commercialization literature. Most of the studies addressing agricultural commercialization use small samples and evaluate the effects of changing production during times of relative food price stability. The extensive data currently available on both health and

food prices makes Malawi a natural choice for a reassessment of commercialization.

Figure 1: Malawian Aggregated Monthly Maize Prices



Malawi experienced multiple recent unexpected food shocks, mainly because of droughts. A severe drought in 2001, combined with governmental policies and grain trading inefficiencies, caused a major domestic food crisis (Minot, 2010; Rubey, 2004). Multiple downward governmental revisions of national maize production estimates disguised the severity of the crisis to both consumers and assistance organizations (Devereux, 2002). As seen in table 1, a significant maize price spike accompanied that drought, with prices remaining high for an extended time period. By building on the covariate shock literature, we demonstrate that children of commercialized farmers who experienced in utero nutritional shocks faired significantly worse than their food crop producing counterparts.

Examination of Malawian production choices will provide a greater understanding of the effects of agricultural commercialization on household food security in times of high food prices. By exploring the effect of agricultural commercialization on childhood stunting, or

having a low height for age because of undernutrition, this research clarifies the impact of cash crop production on health in times of food price increases. Recent emphasis on alternative agricultural options in the developing world, be it herbs, hot peppers or tobacco, may leave uninsured smallholders exposed to food price spikes and lump-sum payment issues.

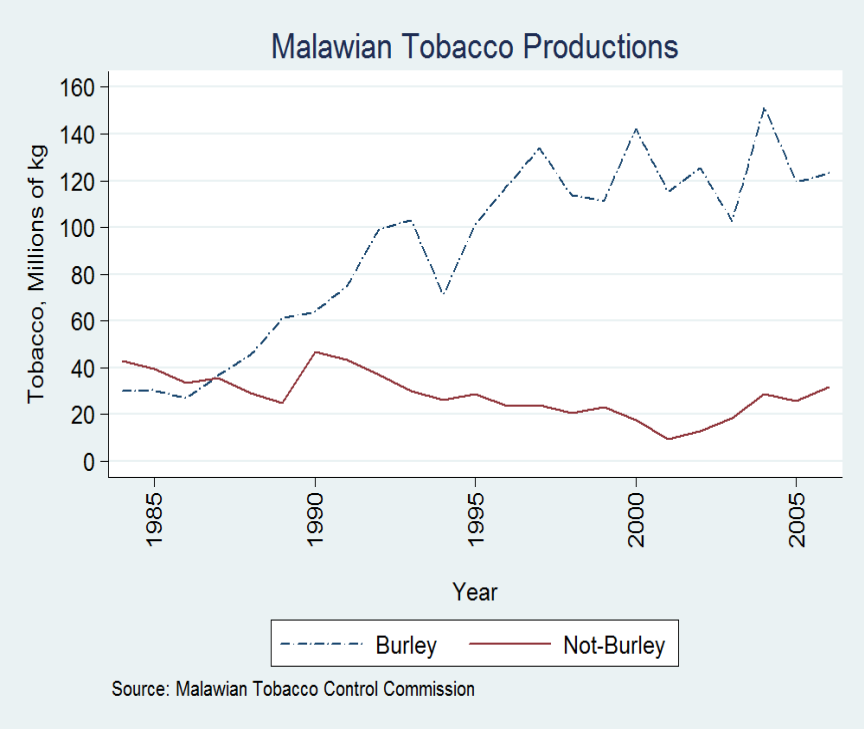
2 Malawian Agricultural Commercialization

Malawi is one of the poorest countries in the world. It ranks 160 of 182 on the UN's Human Development Index, with many deeming agricultural commercialization essential for Malawian growth (World Bank, 2009; United Nations Development Programme, 2009; Republic of Malawi, 2000). International development organizations have generally advocated for agricultural commercialization in Sub-Saharan Africa, with Malawi specific researchers mostly focusing on the potential tobacco cultivation (World Bank, 1989; Peters, 1996; Tobin & Knausenberger, 1998).

Tobacco has played a prominent role in Malawi's historical economic development. Although production levels have fluctuated over time, figure 2 demonstrates how the burley variety has represented the majority of all tobacco exports since the late 1980s and currently dominates the Malawian market. Burley reigns not only as Malawi's most important cash crop but also accounts for the majority of all Malawian exports (Orr, 2000; Jaffee, 2003). Due to data limitations, this paper groups all tobacco producers together, with the large majority of producers cultivating burley tobacco.

Malawi is well-suited for growing burley tobacco, much of which is used as a low-cost filler supplied to international cigarette producers. Tobacco production, with its delicate cultivation and particular harvesting requirements, exhibits few economies of scale (Jaffee,

Figure 2: Malawi Tobacco Production



2003). Additionally, burley tobacco's air-curing process is not capital intensive, further lending itself to small scale Malawian production (Takane, 2008).

Tobacco production initially centered on large scale estates but, with international encouragement, Malawi began liberalizing their tobacco industry in the early 1990s.[1] Smallholders first sold tobacco on the Malawian auction floor, under a quota, in 1991 (Tobin & Knausenberger, 1998). In 1994 Malawi repealed the Special Crops Acts that favored estates and smallholders quickly rushed into tobacco production (Tsonga, 2004). Eventually smallholder tobacco restrictions, in the forms of quota systems, control boards and grower's clubs, were abolished. By 1998 almost 20% of Malawian households, including over 400,000 smallholders,

[1]See Chirwa et al. (2008) for additional information on the history of tobacco in Malawi. Zeller, Diagne & Mataya (1998) provide insights into smallholder tobacco adoption decisions, but subsequent lifting of the governmental entry restrictions may have altered production choices.

produced tobacco (Kadzandira, Phiri & Zakeyo, 2004). Almost all of the new households who entered the market grew burley tobacco, with smallholders currently accounting for 70% of Malawi's total production (Lea & Hanmer, 2009).

All legally sold tobacco in Malawi goes through the regional auction floors identified in figure 4.[2] While tobacco production originally concentrated itself in the South, growth quickly spread throughout the country. Most smallholders continue to sell their crop through tobacco clubs, typically including 10 to 20 farmers, but recent legal changes allow them to sell directly to the floors if so desired. The Central region now houses the busiest tobacco auction floor with the most registered tobacco clubs, although thousands of clubs exist in each of Malawi's three geographic regions (Jaffee, 2003; Tsonga, 2004). All producers must sell at least one bale of tobacco to be eligible for the auctions, thus farmers on small plots may resort to selling to intermediary buyers at below market prices (Takane, 2008). Malawi's auction sales have somewhat plateaued over the last decade, with reports of illegal exporting to neighboring countries, lower auction prices due to plastic contamination and possible collusion amongst tobacco purchasers (Kadzandira et al., 2004).

Reasons for significantly different health outcomes between producers extend beyond food price shocks, providing numerous extension possibilities to this work. Lump-sum tobacco payments, problematic in themselves, are oftentimes significantly delayed. A recent small-scale study reports a significant amount of conspicuous consumption among tobacco producers when collecting their tobacco earnings, with many tobacco producers spending their profits on beer, clothes, or bicycles (Prowse, 2009). Summary statistics presented later support this anecdotal argument, with the majority of tobacco producing households owning a bicycle. Concerns also

[2]The original Limbe floor is in Southern Malawi, but a floor opened in the Central region in 1979 and in the Northern region in 1993.

exist over the tobacco transportation network, as all tobacco must travel to one of the three auction houses for sale.[3] While data constraints restrict the ability to delve deeper into possible behavioral causes of nutritional deficits, understanding the effects of commercialization is the first step in pinpointing the cause of disproportionately negative health outcomes for cash crop producers.

3 Agricultural Commercialization Literature

Although an extensive literature exists surrounding agricultural commercialization, much of it was undertaken during times of relative food price stability or food price controls. These articles generally support the concept of smallholder commercialization and find positive nutritional benefits for adopters (Sahn, 1990). Exploration of the comparative advantages of developing countries in labor-intensive cash crops has roots in the seminal development article by Johnston & Mellor (1961). They use Japanese silk worms as an example of increasing food security through cash crop production. Mellor later wrote that agricultural commercialization represented "the cornerstone of economic development for most developing countries" (Kennedy & Cogill, 1987, Foreward).

Kennedy and Cogill field test Mellor's concept by measuring the effects of commercialization on income and nutrition in Kenya (Kennedy & Cogill, 1987). Their results show Kenyan sugar farmers to have greater household income, which translated into higher levels of nonfood expenditures. They do not detect any significant differences in nutritional outcomes between children in cash crop and food crop producing households, even in the face of a drought at the beginning of their data collection.

[3] Some smallholders report paying 70% more than their large-scale competitors for tobacco transportation, while others complain of tobacco disappearing during transport (Jaffee, 2003).

A number of articles specifically examined Malawi's tobacco commercialization, but most rely on significantly limited data from the 1990s, when the Malawian government restricted smallholder production (Kees van Donge, 2002). Kennedy includes Malawi in reports comparing commercialization's effect on nutritional health in multiple countries. She finds insignificant differences in the nutritional levels of tobacco and non-tobacco producing households during times of food price stability (Kennedy, 1994; Kennedy et al., 1992).

Masanjala (2006) examines the effect of smallholder Malawian tobacco market liberalization on poverty alleviation. He concludes that tobacco adoption in the mid 1990s increased total household income but decreased nonfarm household income. His study determines that tobacco farming significantly decreased caloric-intake food security, with the majority of the children in the 85 tobacco producing households in his sample being stunted. Masanjala speculates that lump sum tobacco payments inhibit consumption smoothing, leaving these households particularly vulnerable to food price shocks. He suggests future poverty alleviation efforts focus on increasing nonfarm income, which he estimates to positively influence caloric intake.

Past investigations into the cash crop adoption decision rightfully focus on the ability of farmers to acquire food. Modeling the planting choice requires geographic price data to account for the variability in food prices within national borders. Fears of food inaccessibility oftentimes result in the desire for food self-sufficiency, and should be accounted for when accessing adoption effects (Jayne, 1994; Fafchamps, 1992). Dorward & Kydd (2004) show that Malawians encountered food access difficulties during the 2002-2003 food price crises, with agricultural households being negatively influenced by both the natural disaster and opportunistic individuals who inflated grain prices.

Droughts and food price shocks may change the relationship between small scale commercial agriculture and household nutritional health. Carter & Maluccio (2002) use South African

panel data to show an inability for communities to insure against covariate shocks resulting in increased levels of stunting after economic disasters. Crop failures in Rwanda have been demonstrated to disproportionately decrease the height of low-income girls (Akresh, Verwimp & Bundervoet, 2007). And Hoddinott (2006) finds a Zimbabwean drought to have long term stunting effects only on children under the age of two.

Our research combines the previous crop adoption literature with recent work on covariate shocks in developing economies to examine the effects of cash cropping in times of food price spikes. In answering the call for greater analysis of Malawian agricultural production trends, this paper estimates the food security implication of smallholder tobacco adoption (Harrigan, 2003).

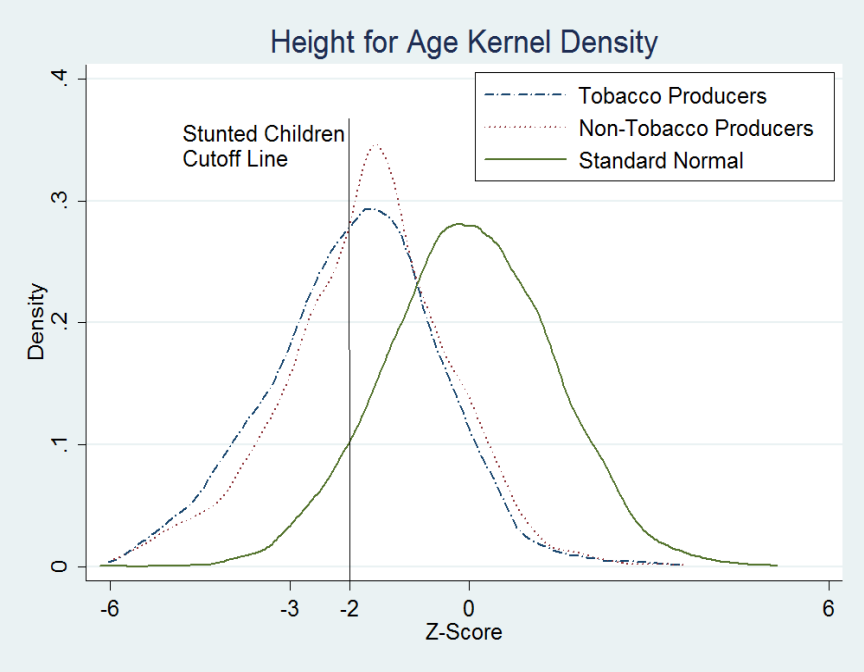
4 Data and Definitions

Our work determines the effect of cash crop production on childhood undernutrition by examining crop choice in relation to stunting after controlling for a number of external factors. Stunting, a robust long-term measurement of childhood undernutrition, compares a child's height and age to a globally representative World Health Organization (WHO) reference population (Habicht et al., 1974). Abnormally short children are defined as having a z-score of two standard deviations or more below the mean of the WHO population (Waterlow et al., 1977; Dibley et al., 1987). A wide range of literature has demonstrated that malnutrition in general, and height in particular, affects long term wage, health and education attainment opportunities (Belli, 1971; Strauss & Thomas, 1998).

Stunting has been shown to accurately measure longterm childhood nutrition levels (Beaton et al., 1990; Briend et al., 1989). In comparison to standard reference populations, stunted

children experience greater probabilities of early mortality, decreased physical capabilities and diminished mental capacity (Grantham-McGregor et al., 2007; Fawzi et al., 1997). Stunting is identifiable within the child's first year, with previous literature measuring children from six to sixty months of age (Duflo, 2003). Researchers attribute a large number of childhood deaths in Africa to undernutrition and have called for future Malawian health interventions to focus on stunting (Espo et al., 2007). Recent updates to the WHO's Child Growth Standards have further emphasized the importance of nutritional deficiencies in newborn rural Malawian children (Prost et al., 2008).

Figure 3: Distribution of Children's Z-Scores



Pregnant women and young infants are particularly influenced by undernutrition. Previous research demonstrates that in utero nutritional status permanently affects physical attributes like stature (Victora et al., 2008). Barker (1997) clarifies the link between in utero undernutrition

and negative health outcomes. He specifically focuses on undernutrition during pregnancy, suggesting that maternal health strongly influences the growth and development potential of children during the fetal stage. We apply Barker's idea to Malawi by testing the effect of fetal undernutrition through stunting level comparisons by farmer type and time period.

Figure 3 demonstrates that a significant number of children in Malawian tobacco and non-tobacco households fell below the two standard deviation stunting threshold. This finding is consistent with past surveys, which have consistently shown high percentages of stunted children in Malawi (World Health Organization, 2009). Tobacco producing smallholders within Malawi are more likely to have stunted children than their non-producing counterparts, as depicted by the larger percentage of these children falling below two standard deviations in figure 3.

Our definition of a Malawian smallholder farmer is based on analysis of the World Bank and Government of Malawi's 2004-2005 nationally representative Integrated Household Survey (IHS-2) data set. We limit smallholders to seven acres or less of cropped land, although the results are robust to differing designations. The seven acre cutoff contain 95% of Malawain households that control agraian land. [4]

Inedible cash crop production in Malawi centers on tobacco.[5] We classify cash crop producers as those who grew tobacco in the year of or the year after each child's birth in our sample, in order to analyze the effects of adoption decisions during the time of food price increases. This fairly broad definition attempts to encompass a large group of potential tobacco

[4]Box-plot graphics of our cutoff decision are available by request. Significance levels decreased with one or two acre smallholder definitions due to high standard errors, although the signs and magnitudes of the coefficients of interest remained consistent.

[5]Malawian production of other inedible cash crops like cotton or tea pale in comparison to tobacco (World Bank, 2007).

production beneficiaries.[6]

Few Malawian farmers monocrop tobacco. Due to food necessities and risk reduction through diversification, tobacco farming households oftentimes grow additional crops. Almost all of the tobacco producing households also reported growing non-tobacco crops in the current planting season.[7] Regardless, smallholders who planted and tended to labor intensive tobacco made a significant production decision. Malawian farm households typically experience inadequate food production, with a well defined hungry season before early green maize is edible for consumption. By directing a portion of their land away from food production, tobacco growers reduced the amount of on-farm food available for their families.

Differentiating the sample by adoption decision, as seen in table 1, allows for household-level comparisons of tobacco and non-tobacco producers.[8] The aggregate household income statistics show tobacco households to have more overall income than their only food producing counterparts, although the interquartile ranges greatly overlap. Additionally, tobacco producing households control more land and have larger families at the median, although the interquartile range of these variables also show a large degree of overlap. On average, tobacco producers are more likely to own a bicycle. They also have a greater percentage of stunted children.[9] These average summary statistics are provided for context, as a means of highlighting differences in resource allocation.

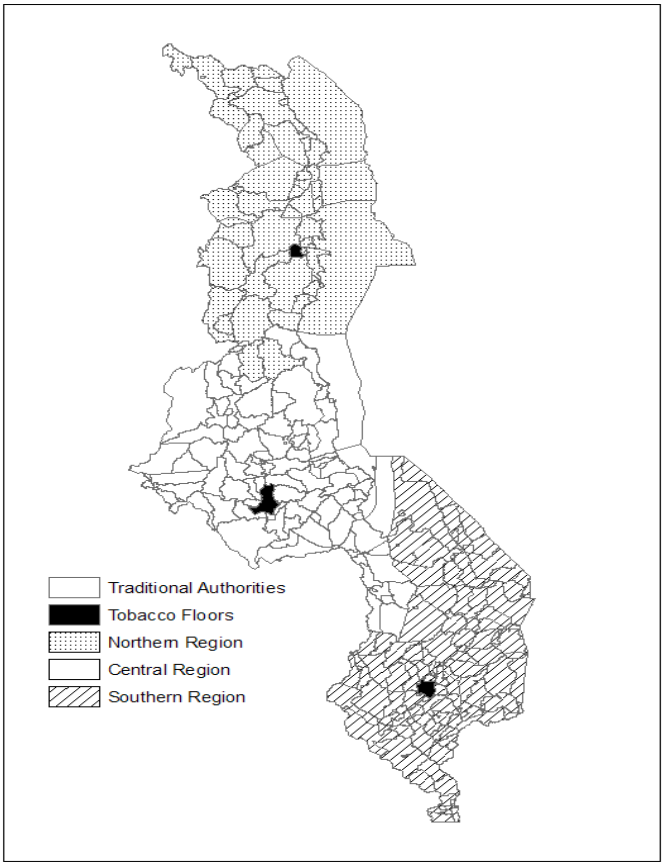
[6]All findings are robust to alternative tobacco producer definitions, including tobacco production the year of and year after birth, only the year of birth, only the year after birth, or only producers during the food price spike.

[7]Unfortunately, we are unable to observe the percentage of land devoted to tobacco production during the drought, as the recall questions ask for a binary response to which of the last five years did the household grow tobacco.

[8]The median statistics provide a more robust measure of location than means, while the interquartile ranges show a greater level of scale than standard deviation.

[9]To check the accuracy of the nutritional observations, Mei & Grummer-Strawn (2007) suggest checking for the number of unrealistic height for age measurements below six deviations or above five deviations from the mean. From this nutritional perspective, these data look very accurate with the number of unrealistic individual measurements around 1%.

Figure 4: Malawi by Region, Traditional Authorities and Tobacco Floors



Adoption decisions and nutritional health is also tied in with local food prices. These prices vary within Malawi, making it important to account for regions within any analysis of nutritional outcomes. Figure 4 breaks Malawi into its internationally recognized Northern, Central and Southern regions (United Nations, 2010). These areas are geographically and ethnically diverse, and may be thought of as distinct populations (Orr, Mwale & Saiti-Chitsonga, 2009; Pelletier & Msukwa, 1991). It is necessary to control for these regions when assessing the effects of agricultural commercialization. Taking all of these different factors into account allows for estimation of tobacco adoption's effect on the nutritional health of Malawian children.

Table 1: Smallholder Summary Statistics

	Non-Tobacco median/icr	Tobacco median/icr	Difference median/Pearson χ^2
Household Size	5	6	1
	[4, 7]	[4, 7]	11.53***
Household Head Age	35	34	−1
	[29, 46]	[29, 43]	5.92*
Aggregate Income	130	188	58
	[55, 274]	[90, 334]	69.36.00***
Acreage	2	3	1
	[1, 3]	[2, 4]	317.85***
Summary Statistic Averages			
Children Stunted (%)	43	51	
Food Price Shock (%)	78	89	
Bicycle owner (%)	40	61	
Observations	4673	1041	

[1] Aggregate household income are annual figures from the Food and Agricultural Organization's (FAO) Rural Income Generating Activities (RIGA) project converted into average United States Dollar value from the survey collection period.

[2] Stunted percentages exclude the 97 observations outside of the plausible WHO nutritional outcomes, 84 of which had a z-score below -6.

[3] The survey asked participants if they had experienced household shocks over the past five years, and if so, to recount the three most significant events. Shocks represents the percentage of household reporting a significant shock due to food price increases within the last five years.

[4] The interquartile range is in brackets.

[5] The Pearson χ^2 median difference tests the assumption that the households are drawn from the same distribution. Standard errors significance levels are of *** p<0.001, ** p<0.01, * p<0.05. See Wilcoxon (1945) for additional information on this nonparametric k-sample test.

5 Identification and Estimation

To determine the effects of the maize price spike and fetal undernutrition on children's health, the sample is split between children in utero outside and those in utero during the food price increase.[10] Although maize prices began increasing in September of 2001, only children born in 2002 and 2003 are designated as in utero during the food price shock to ensure exposure to

[10] While maize prices varied throughout Malawi, this specific food crisis has been characterized as one of the worst in recent Malawian history (Hartwig & Grimm, 2011).

the spike. As maize prices receded to more typical levels by 2004, children born before or after the spike are classified as being in utero outside of the shock.[11]

A number of reasons, independent of the cash crop adoption decision, exist for explaining negative child health outcomes. The analysis includes variables accounting for many of the previously identified casual factors for stunting. The effects of tobacco production on childhood stunting are evaluated using the variables listed in table 2 to account for potentially significant variables at the child, household, community, district and regional levels.[12] Previous work on health outcomes in relation to household characteristics provides a wealth of information on significant contributing factors to reducing nutritional deficiencies.[13]

Table 2: Variables by Type

Individual	Gender
Household	Tobacco Producer (dummy), Household Head Age, Number of Children in the Household, Household has a Permanent Floor (dummy), Child Lives in a Permanent House (dummy), Acreage Controlled by the Household, Size of the Household, Household Income Quintile, Mother's Education Level, Child Always Sleeps Under a Bed Net (dummy), Former Tobacco Tenant Farmers (dummy), Exposure to Agricultural Shock (dummy)
Community	Clinic, Tobacco Land Growing Suitability
District	Number of tobacco producing households in 1998
Regional	Southern Dummy, Central Dummy

Expanding on the covariate shock literature, tests are performed to determine if households that devoted part of their limited acreage to cash crops experienced differing nutritional outcomes compared to solely food producing farmers. Ideally, if the tobacco adoption decision

[11]The estimation results are robust to longer and shorter definitions of the price shock group.

[12]All of the variables originate from the IHS-2 data, except for the district level instruments taken from the first Integrated Household Survey and the income variables from the Food and Agricultural Organization's Rural Income Generating Activities (RIGA) project. we elected to use the total income RIGA number that calculates the value of own consumption from the household questionnaire.

[13]Recent literature questions past results in clarifying the links between health and development (Deaton, 2003).

could be independently varied an estimate of the effect of tobacco adoption would be measured by:

$$y_i = \alpha + D_i\theta + X_i\beta + \varepsilon_i$$

Where y_i is the z score of children 6-60 months old, D_i is the tobacco adoption dummy, and X_i is a vector of observable household attributes.

Table 3: In Utero During Stable or Shocked Prices OLS Results, Select Variables

	Stable	Shocked		Stable	Shocked
Tobacco	-0.008	-0.261^{**}	Male	-0.153^{**}	-0.283^{***}
	(0.070)	(0.089)		(0.051)	(0.060)
Protected water	0.067	0.141^{*}	Permanent floor	0.259^{***}	0.161
	(0.055)	(0.065)		(0.074)	(0.094)
Child bed nets	0.187^{***}	0.208^{**}	Mother high ed	0.079	0.178
	(0.055)	(0.064)		(0.086)	(0.100)
2^{nd} income quintile	0.013	0.014	3^{rd} income quintile	0.060	0.085
	(0.083)	(0.096)		(0.080)	(0.097)
4^{th} income quintile	0.049	0.037	Highest income quintile	0.113	0.168
	(0.081)	(0.096)		(0.083)	(0.098)
Southern	-0.042	0.243^{**}	Central	-0.252^{***}	0.049
	(0.077)	(0.088)		(0.075)	(0.090)
Constant	-2.009^{***}	-2.009^{***}	Observations	3163	2551
	(0.195)	(0.232)			

[1] Robust standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05
[2] All regressions were run on the entire variable set, with select variables being reported.
[3] Children in utero before or after the food price shock are classified in the stable group, while those in utero at the time of the shock are placed in the shock category.
[4] Child bed nets represents households who report that their children always sleep under a bed net.
[5] Mother high education is mothers who studied beyond primary school.
[6] Aggregate household income are annual figures from the FAO's RIGA project converted into average United States Dollar value from the survey collection period.

As seen in table 3, the OLS estimates show a insignificant difference between tobacco and non-tobacco producers for children born outside of the food price spike. Previewing

our preferred model results, tobacco adoption demonstrates a significantly negative effect on the height of children in utero during the food price spike and born into tobacco producing households. Omitted variable bias is almost certainly present in this initial regression, but the direction of that bias is difficult to predict. On the one hand, early technology adopters might be more likely to both adopt tobacco production and invest in children's resources. On the other hand, tobacco revenue is often controlled by male households heads who might spend less on their children.

Tobacco adoption is a household choice, therefore unobserved household, community and regional attributes that influence adoption decisions and child health outcomes are likely to be in the omitted variables. The identification strategy, to independently vary tobacco adoption, is based on a rational expectations crop adoption model developed by Eckstein (1984). Tobacco is a relatively new crop for smallholder producers in Malawi. They were not allowed to plant tobacco until the mid 1990s. Adoption of tobacco has grown swiftly since then. The Eckstein (1984) crop adoption model captures significant elements of the tobacco adoption decision in Malawi.

Maize is the traditional crop in Malawi, and tobacco is a new crop that smallholders consider for adoption. The adoption decision is forward looking because the benefit of tobacco is the revenue streams that it will generate. Smallholder expectations of future revenue streams are based on past values of observed variables that are likely to be correlated with crop revenues, but not necessarily in line with their production capabilities.

The data set contains a limited number of variables that smallholders use to predict tobacco revenues. But there are a couple of variables that are very likely to be in this information set, but not likely to be related to child health outcomes. Our instruments, from the 1998 Integrated Household Survey (IHS-1) and GAEZ, are developed to predict adoption decisions.

This paper's empirical strategy exploits variations in Malawian agricultural commercialization patterns and previous maize prices. We develop two instruments to avoid endogeneity concerns between tobacco adoption and children's health. The first come from the 1998 Integrated Household Survey (IHS-1).[14] The other is developed from the Global Agro-Ecological Zones (GAEZ) dataset to predict adoption decisions.[15]

These first instruments are built on the premise that farmers are likely to grow commercialized crops after seeing others in their neighborhood previously adopt. The IHS-1 information comes from before the births of the IHS-2 children, thus avoiding any direct links to children's current nutritional health. The IHS-1 instrument counts the number of farmers growing tobacco in the 1998 survey at the district level.

The other instrument accounts for the opportunity to grow tobacco due to the suitability of the land for tobacco cultivation. This instrument creates tobacco suitability index at the sub-district level, on a continuous scale from 0-10,000. For the purposes of this paper, medium input, rain-fed tobacco land suitability is used, but the results were robust to low-input tobacco also.[16].

The two instruments would suggest an overidentified linear instrumental variable estimator for the endogenous tobacco adoption variable. But, the adoption variable is a binary variable, so a linear first stage estimator could produce negative predicted values. Newey & McFadden (1984) show that in general estimation models that include generalized method of moments, given endogenous variables, x, and exogenous variables, $\mathbf{w}$, the asymptotically optimal instru-

[14]While the IHS-1 is less precise than its 2003 counterpart, district level matching between the IHS-1 and IHS-2 allows for direct comparisons. Future surveys should allow for even greater levels of accuracy in matching between surveys.

[15]For additional information on the United Nation's Food and Agricultural Organization and the International Institute for Applied Systems Analysis GAEZ dataset, see gaez.fao.org.

[16]The GAEZ dataset cautions that it is representative only at the national level, but we managed to extract suitability figures for each enumeration area.

ments are $Z = \mathrm{Var}(w)^{-1}\mathrm{E}(x|\mathbf{w})$. In a model with a single binary endogenous explanatory variable, x_2, $\mathrm{E}(x_2|\mathbf{w}) = P(x_2 = 1|\mathbf{w}) = F(\mathbf{w})$, where $F(\mathbf{w})$ is the predicted probability from a binary response model such as probit. In this context $\mathrm{Var}(w)^{-1}$ can be ignored because it is just a scaling factor.

Thus the two excluded instruments are used in a first stage probit model, together with the included exogenous variables. The predicted probabilities of tobacco adoption are generated from the first stage probit, and used as the instrument for tobacco adoption in an exactly identified linear generalized methods of moments second stage. Tobacco adoption is expressed as: ${D_i}^* = \Phi(z'\beta) + v_i$, and the recovered predicted probabilities are $\hat{\Phi}$. The strength of the first stage estimation is demonstrated by its ability to correctly predict around 90% of the adoption decisions.

$$ {D_i}^* = z_i\gamma + v_i $$

where D_i^* is a latent variable underlying tobacco adoption. Cash crop households are identified by the equation:

$$ D = 1(z_i\gamma + v_i \geq 0) $$

The indicator variable takes discrete values depending on the realized value of the latent variable, which signifies the crossing into tobacco production.

The two step exactly identified generalized method of moments (GMM) model accounts for heterogeneity of the variance across the sample. The estimates solve the exactly identified GMM criterion function:

$$ \min_\beta (\textstyle\sum_i z_i'u_i)'\hat{\sum}^{-1}(\sum_i z_i'u_i) $$

Table 4: In Utero During Stable or Shocked Prices Two Step GMM Results, Full Model

	Stable	Shocked		Stable	Shocked
Tobacco	−0.094	−0.709*	Male	−0.153**	−0.298***
	(0.387)	(0.324)		(0.047)	(0.051)
Head Age	−0.001	−0.002	Children	0.043	−0.027
	(0.003)	(0.003)		(0.029)	(0.039)
Permanent house	0.055	0.116	Permanent floor	0.258**	0.138
	(0.060)	(0.108)		(0.082)	(0.111)
Protected water	0.062	0.111	Child bed nets	0.187***	0.208**
	(0.082)	(0.082)		(0.054)	(0.065)
Household size	−0.031	0.044	Acreage	0.012	0.035
	(0.026)	(0.034)		(0.033)	(0.026)
Mother medium	0.030	0.104	Mother high ed	0.080	0.187*
	(0.090)	(0.094)		(0.082)	(0.076)
2^{nd} income quintile	0.016	0.034	3^{rd} income quintile	0.063	0.099
	(0.089)	(0.120)		(0.067)	(0.112)
4^{th} income quintile	0.055	0.082	Highest income quintile	0.117	0.208
	(0.092)	(0.122)		(0.085)	(0.119)
Tobacco tenant	−0.179	0.195	Agricultural shock	0.033	−0.068
	(0.231)	(0.245)		(0.143)	(0.158)
Southern	−0.046	0.216*	Central	−0.243*	0.090
	(0.091)	(0.092)		(0.124)	(0.105)
Presence of Clinic	−0.061	−0.097	Constant	−2.006***	−1.982***
	(0.066)	(0.087)		(0.259)	(0.246)
Observations	3163	2551			

[1] Robust standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05, clustered at the enumeration area level.

[2] Children in utero before or after the food price shock are classified in the stable group, while those in utero at the time of the shock are placed in the shock category.

[3] Children is the number of people under the age of 18 living in the household.

[4] Child bed nets represents households who report that their children always sleep under a bed net.

[5] AIDS refers to households with a diagnosed case or with a member who has sores that will not heal.

[6] Mother medium education is mothers who completed primary school, while high education indicates they studied beyond that point.

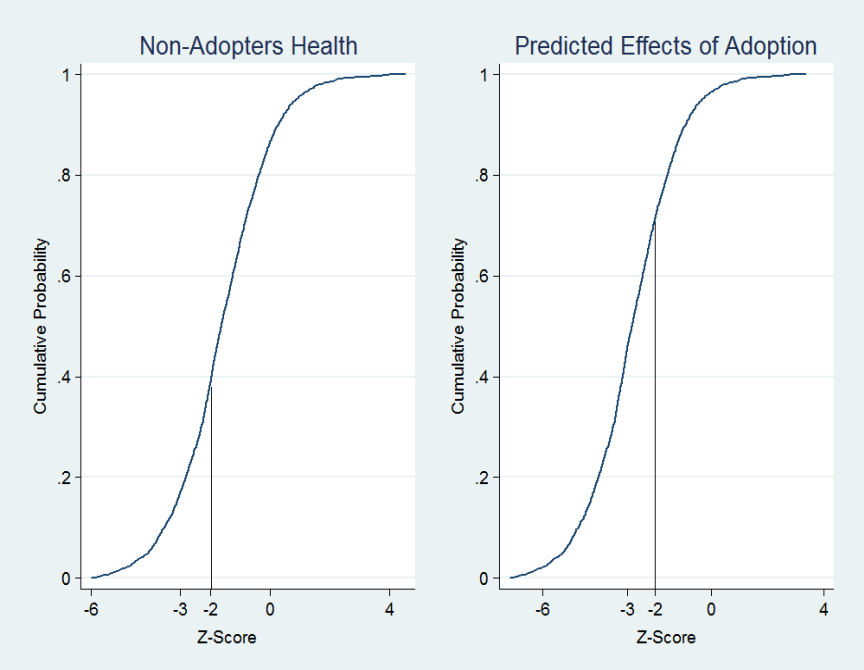
[7] Aggregate household income are annual figures from the FAO's RIGA project converted into average United States Dollar value from the survey collection period.

[8] Tobacco tenants are those households that previously grew tobacco in a tenancy arrangement.

The results are consistent throughout table 4. Z-score is used as the dependent variable for the estimation, thus the lower the score the worse the health outcome.

The tobacco adoption coefficients demonstrates that children in utero during the price shock are being disproportionately affected by the food crisis. The tobacco coefficient of -0.71 means that tobacco crop adoption during the food price crisis was a highly significant factor for stunting. In a globalizing world, figure 5 compares the previous findings to a hypothetical evaluation of adoption effects were all Malawian households growing tobacco at the time of the food price spike.[17] An average one standard deviation z-score decrease would increase severe stunting (zscores less than or equal to -3) by 81% while simultaneously increasing moderate stunting by another 16%.

Figure 5: Non-Tobacco Household CDFs



[17]This analysis admittedly does not account for heterogeneity within the sample, which may alter the adoption effects.

These findings support the contention that commercialized farmers face a distinct set of disadvantages during food price spikes. Children of cash crop producers identified as in utero during the spike, having been born in 2002 or 2003, most likely suffered from severe fetal undernutrition.[18] As previously discussed, recent literature has shown that in utero undernutrition may greatly influence long term health and educational attainment in children (Field, Robles & Torero, 2009). These tobacco adoption findings highlight some of the conditions that constrain children from reaching their full mental and physical capabilities.

The tobacco adoption findings accompany a number of control variables that display mostly expected results. Children born into higher income households showed a general positive trend in zscore coefficients, although the insignificant differences lend weight to the idea that household bargaining might be influencing purchasing decisions. [19]. Male children on average faired significantly worse than females in nutritional status. Encouragingly, bed nets and mothers with higher levels of education proved once again capable of providing health benefits for children, especially in times of need. The significance of permanent floor and general regional dummy variables demonstrated the importance of accounting for household location and status. A host of household and geographic level control variables, relating to farming decisions, household make-up and health all proved insignificant.

The incorporation of enumeration area level clustering of the standard errors strengthens the robustness of the results. This clustering helps to account for variation within the sample due to geographic location or land quality. Results were also generally robust to district level clustering, and to the inclusion of sampling weights.

These results depend on the soundness of the instruments. To support arguments for the

[18] See Almond & Currie (2011) for an overview of the long term health consequences of fetal undernutrition.
[19] See Zere & McIntyre (2003) for further inquiry into the effects of income distribution on nutritional outcomes

instruments, a number of specification tests are performed to provide further statistical evidence of instrument validity. One essential attribute of the instruments is verified by the robust pairwise correlation between each instrument and tobacco adoption. The highly significant coefficients on the excluded instruments in the first stage probit provides additional evidence of this property.

Examination of the estimates rule out weak instrument arguments. Weak instrument tests are performed for the excluded instruments, all of which report strong instrumental power. Test results indicate a Cragg-Donald Wald F statistic of 336.65 for the stable food price estimation and a value of 110.57 for the shocked group, thus rejecting weak instrument hypotheses with p-values of 0.00.[20] These standard tests expand the statistical support for the instrumental estimation. When moving from an optimal to a linear over-identified models, the F statistics fall to 42.44 for the stable group and 21.99 for the shocked population.

Exogeneity tests are used to evaluate the required orthogonality property of the instruments. The exogeneity tests are performed by estimating an over-identified model that uses the instruments linearly instead of optimally. The over-identified linear model produces a Hansen J statistic of 0.062 and a p-value of 0.804 for the group born outside of the shock, and a J-statistic of 1.261 with an accompanying p-value of 0.262 for those in utero during the price increase. The failure to reject either of the null hypotheses supports the instruments' orthogonality with the error term.[21]

[20] See Stock & Yogo (2005) for additional information on these tests.

[21] For details on this exogeneity test see Baum, Schaffer & Stillman (2003, 2007).

6 Robustness Checks

The tobacco adoption findings are robust to numerous alterations, all reporting similar results. Concerns over tobacco adoption endogeneity, instrumental variable choice and health outcome measures are explored. These additional results further support the food price shock's negative nutritional effect on cash cropping households.

We first examine the need to instrument the adoption decision by confirming the endogeneity between the tobacco adoption decision and children's health through a post-estimation endogeneity test of the linear model. The tobacco adoption coefficient estimate rejects the endogeneity test that treats it as exogenous for both populations. It reports values of 7.02 in the stable price group and 7.87 for the shocked sample, with the p-value for both groups being significant at the 1% level. These results indicates a presence of endogeneity in the adoption decision, requiring the use of alternative variables to instrument for tobacco production.

To verify the overall robustness of the results we varied the estimations in numerous ways, the first of which focuses on the instrumental variables. We reduce the estimation to a single-instrument by only using the district level 1998 number of tobacco producing households variable to determine tobacco adoption's effect on children's health. As seen in the second and third columns of table 5, the coefficients are consistent with our previous findings. The tobacco adoption effect is still significantly negative when only using one instrument, with a very similar magnitudes of tobacco adoption coefficients of children in utero during and outside the food price spike.

To further test the results, we replaced the stunting dependent variable with a weight based measure of undernutrition. Wasting, or being under-weight for your age, is typically considered more of a short term measurement of inadequate food consumption (Beaton et al., 1990).

Although wasting is less of a widespread Malawian problem than stunting, this still effects a significant number of individuals throughout the country (World Health Organization, 2009). The wasting dependent variable estimations, found in the the fourth and fifth columns of table 5, produce very consistent results with the original stunting estimation. Although children born into tobacco producing households during the food price spike were not significantly more likely to be wasted than those born into non-adopting households, the magnitude and direction of the signs is similar. These findings provide additional evidence of the uneven effects escalating food prices have on the nutritional outcomes of children in cash crop producing households.

Finally, we tried to incorporate interaction effects into the model to focus the discussion on smallholders of different income background, with the belief that low income farmers face a different set of stunting issues than their richer counterparts. Unfortunately, possibly due to limited variation within the instrumented tobacco variable, the coefficient estimates of tobacco and income quintiles are of the expected sign but statistically insignificant. To further support this idea, we separate the tobacco and non-tobacco producers and run a simple ordinary least squares estimation to see the general effect of income on stunting levels. Non-producers show the expected results, with higher income households more likely to have healthier stunting outcomes. While the tobacco producing households fail to demonstrate statistically significant nutritional differences, probably due to smaller sample sizes, the coefficients trend upward. Larger sample sizes, along with panel data, may afford future researchers the ability to better tease out this relationship.

Table 5: In Utero During Stable or Shocked Prices Robustness Results, Select Variables

	Tobacco Producers Instrument Only		Wasting as Dependent Variable	
	Stable	Shocked	Stable	Shocked
Tobacco	-0.114	-0.723^{*}	-0.009	-0.542
	(0.376)	(0.311)	(0.186)	(0.288)
Male	$-0.153**$	-0.299^{***}	-0.057	-0.235^{***}
	(0.047)	(0.051)	(0.039)	(0.046)
Permanent floor	0.257^{**}	0.137	0.108	0.093
	(0.081)	(0.112)	(0.040)	(0.070)
Child bed nets	0.187^{***}	0.208^{**}	0.147***	0.158^{***}
	(0.054)	(0.065)	(0.039)	(0.047)
Mother medium ed	0.031	0.105	0.040	0.155^{*}
	(0.090)	(0.094)	(0.064)	(0.078)
Mother high ed	0.080	0.188^{*}	0.078	0.329^{***}
	(0.082)	(0.076)	(0.067)	(0.074)
2^{nd} income quintile	0.017	0.035	0.013	0.063
	(0.089)	(0.120)	(0.052)	(0.083)
3^{rd} income quintile	0.064	0.100	0.061	0.099
	(0.067)	(0.112)	(0.054)	(0.073)
4^{th} income quintile	0.056	0.084	0.097	0.209^{*}
	(0.091)	(0.122)	(0.061)	(0.087)
Highest income quintile	0.118	0.209	0.086	0.149
	(0.085)	(0.119)	(0.059)	(0.083)
Southern	-0.047	0.215^{*}	0.008	0.032
	(0.091)	(0.092)	(0.062)	(0.070)
Central	-0.241	0.091	-0.034	-0.040
	(0.123)	(0.104)	(0.067)	(0.082)
Constant	-2.005^{***}	-1.981^{***}	-0.923***	-0.852^{***}
	(0.258)	(0.246)	(0.174)	(0.182)
Observations	3163	2551	3056	2425

[1] Robust standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05, clustered at the enumeration area level.
[2] All regressions run on the entire variable set, with select variables reported.
[3] Children in utero before or after the food price shock are classified in the stable group, while those in utero at the time of the shock are placed in the shock category.
[4] The second and third columns only use the number of tobacco producers in 1998 instrument, while the WAZ columns use both instruments with weight for age as their dependent variable.
[5] Bed nets represents households whose children always sleep under a bed net.
[6] Mothers medium ed is those who completed primary school, with higher being those who studied beyond that point.
[7] Aggregate household income are annual figures from the FAO's RIGA project converted into average United States Dollar value from the survey time period.
[8] There are slightly less weight for age observations due to less weight reporting.

7 Conclusion

The move from correlation to causation is an important step in identifying the reasons behind disparities in the effects of food price increases on the Malawian population. Recent work linking economic development and nutritional health has shown the importance of accounting for undernutrition when evaluating the effectiveness of growth plans (Ecker et al., 2011; Headey, 2011). Our results expand on previous literature that explored theoretical reasons for negative health outcomes associated with smallholder agricultural commercialization (von Braun, Kennedy & Bouis, 1990). Applying these ideas to an actual food price spike, the large negative tobacco coefficients show cash crop producing households to be disproportionately affected by the shock, with children significantly more likely to be stunted than their non-tobacco producing counterparts.

Future extensions of this work may examine behavioral or expenditure differences in households by production type. Uncovering possible intra-household allocation constraints hinted at through both this research and anecdotal evidence in the literature would help to explain why adoption decisions influence nutritional outcomes. Applying the work of Lundberg, Pollak & Wales (1997) and Thomas (1990) to the Malawian context may produce fruitful insights into the household expenditure decision making process. The next round of the Malawian Integrated Household Survey will provide additional information on production and expenditure decisions, allowing for better comprehension of cash cropping choices in the face of food price increases.

The cash crop adoption results demonstrate an important vulnerability in developing world agriculture, which is particularly pertinent with the increasing global commercialization of agriculture. Identifying the individuals most affected by the volatility in food prices is the

first step toward remedying their situation. As food markets continue to generally increase, acknowledgment of previous disparities in nutritional outcomes allows for increased effectiveness in targeting the neediest for food aid during times of future food price shocks.

Increasing international trade provides overwhelming benefits to many sectors of the global economy. Understanding and accounting for the potential pitfalls associated with agricultural commercialization will only strengthen the movement toward decreasing hunger. This paper helps to pinpoint the causes behind negative health outcomes for commercialization, and continues the research on the effects of food price shocks on the developing world. Future work, with panel datasets, international food price spikes and more specified price data will allow for an even greater understanding of how food price increases influence the health outcomes of children around the world.

References

Akresh, R., Verwimp, P., & Bundervoet, T. (2007). Civil war, crop failure, and child stunting in Rwanda. Technical Report 4208, World Bank Policy Research Working Paper. 10

Almond, D. & Currie, J. (2011). Killing me softly: The fetal origins hypothesis. *Journal of Economic Perspectives*, *25*(3), 153–172. 23

Barker, D. (1997). Maternal nutrition, fetal nutrition, and disease in later life. *Nutrition*, *13*(9), 807–813. 11

Baum, C., Schaffer, M., & Stillman, S. (2003). Instrumental variables and gmm: Estimation and testing. *Stata Journal*, *3*(1), 1–31. 24

Baum, C., Schaffer, M., & Stillman, S. (2007). Enhanced routines for instrumental varables/gmm estimation and testing. *Stata Journal*, *7*(4), 465–506. 24

Beaton, G., Kelly, A., Kevany, J., Martorell, R., & Mason, J. (1990). Appropriate uses of anthropometric indices in children. Nutrition policy discussion paper 7, United Nations Administrative Committee on Coordination- Subcommittee on Nutrition. 10, 25

Belli, P. (1971). The economic implications of malnutrition: The dismal science revisited. *Economic Development and Cultural Change*, *20*(1), 1–23. 10

Briend, A., Hasan, K., Aziz, K., Hoque, B., & Henry, F. (1989). Measuing change in nutritional status: A comparion of different anthropometric indicies and the samples sizes required. *European Journal of Clinical Nutrition*, *43*(11), 769–778. 10

Carter, M. & Maluccio, J. (2002). Social capital and coping with economic shocks: An analysis of stunting in South African children. Technical Report FCND discussion paper No. 142, International Food Policy Research Institute. 9

Chirwa, E., Kumwenda, I., Jumbe, C., Chilonda, P., & Minde, I. (2008). Agricultural growth and poverty reduction in Malawi: Past performance and recent trends. ReSAKSS Working Paper 8, Regional Strategic Analysis and Knowledge Support Group: Sourthern Africa. 6

Deaton, A. (2003). Health, inequality, and economic development. *Journal of Economic Literature*, *41*(1), 113–158. 16

Devereux, S. (2002). The Malawi famine of 2002. *IDS Bulletin*, *33*(4), 70–78. 4

Dibley, M., Goldsby, J., Staehling, N., & Trowbridge, F. (1987). Development of normalized curves for the international growth reference: Historical and technical considerations. *The American Journal of Clinical Nutrition*, *46*, 736–748. 10

Dorward, A. & Kydd, J. (2004). The Malawi 2002 food criss: The rural development challenge. *The Journal of Modern African Studies*, *42*(3), 343–361. 9

Duflo, E. (2003). Grandmothers and granddaughters: Old-age pensions and intrahousehold allocation in South Africa. *The World Bank Economic Review*, *17*, 1–25. 11

Ecker, O., Breisinger, C., & Pauw, K. (2011). Growth is good, but is not enough to improve nutrition. 2020 Conference Paper 7, International Food Policy Research Institute. 3, 28

Eckstein, Z. (1984). A rational expectations model of agricultural supply. *The Journal of Political Economy*, *92*(1), 1–19. 18

Espo, M., Kulmala, T., Maleta, K., Cullinan, T., Salin, M.-L., & Ashorn, P. (2007). Determinants of linear growth and predictors of severe stunting during infancy in rural Malawi. *Acta Paediatrica*, *91*(12), 1364–1370. 11

Fafchamps, M. (1992). Cash crop production, food price bolatility, and rural market integration in the Third World. *American Journal of Agricultural Economics*, *74*(1), 90–99. 9

Fawzi, W., Herrera, M. G., Spiegelman, D., Amin, A. E., Nestel, P., & Mohamed, K. (1997). A prospective study of malnutrition in relation to child mortality in Sudan. *American Journal of Clinical Nutrition*, *65*, 1065–9. 11

Field, E., Robles, O., & Torero, M. (2009). Iodine deficiency and schooling attainment in Tanzania. *American Economic Journal: Applied Economics*, *1*(4), 14069. 23

Grantham-McGregor, S., Cheung, Y. B., Cueto, S., Glewwe, P., Richter, L., Strupp, B., & The International Child Development Steering Group (2007). Developmental potential in the first 5 years for children in developing countries. *Lancet*, *369*(9555), 60–70. 11

Habicht, J.-P., Yarbrough, C., Martorell, R., Malina, R., & Klein, R. (1974). Height and weight standards for preschool children: How relevant are ethnic differences in growth potential? *Lancet*, *1*(7858), 611–614. 10

Harrigan, J. (2003). U-turns and full circles: Two decades of agriculture reform in Malawi 1981-2000. *World Development*, *31*(5), 847–863. 3, 10

Harrigan, J. (2008). Food insecurity, poverty and the Malawian starter pack: Fresh start or false start? *Food Policy*, *33*, 237–249. 3

Hartwig, R. & Grimm, M. (2011). An assessment of the effects of the 2002 food crisis on children's health in Malawi. forthcoming in Journal of African Economies. 15

Headey, D. (2011). Turning economic growth into nutrition-sensitive growth. 2020 Conference Paper 6, International Food Policy Research Institute. 3, 28

Hoddinott, J. (2006). Shocks and their consequences across and within households in rural Zimbabwe. *Journal of Development Studies*, *42*(2), 301–321. 10

Jaffee, S. (2003). Malawi's tobacco sector: Standing on one strong leg is better than on none. *Africa Region Working Paper*, *55*, 1–58. World Bank Working Paper Series. 5, 7, 8

Jayne, T. S. (1994). Do high food marketing costs constraing cash crop production? Evidence from Zimbabwe. *Economic Development and Cultural Change*, *42*(2), 387–402. 9

Johnston, B. & Mellor, J. (1961). The role of agriculture in economic development. *The American Economic Review*, *51*(4), 566–593. 8

Kadzandira, J., Phiri, H., & Zakeyo, B. (2004). Malawi tobacco sector performance audit: The perceptions and views of smallholder tobacco farmers on the state of play in the tobacco sector. Technical report, The World Bank. 7

Kees van Donge, J. (2002). Disordering the market: The liberalisation of burley tobacco in Malawi in the 1990s. *Journal of Southern African Studies*, *28*(1), 89–115. Special Issue: Malawi. 9

Kennedy, E. (1994). *Agricultural commercialization, economic development and nutrition*, chapter Health and Nutrition Effects of Commercialization of Agriculture, (pp. 79–99). International Food Policy Research Institute. 9

Kennedy, E., Bouis, H., & von Braun, J. (1992). Health and nutrition effects of cash crop production in developing countries: A comparative analysis. *Social Science & Medicine*, *35*(5), 689–697. 3, 9

Kennedy, E. & Cogill, B. (1987). Income and nutritional effects of the commercialization of agriculture in southwestern Kenya. Research Report 63, International Food Policy Research Institute. 8

Lea, N. & Hanmer, L. (2009). Constraints to growth in Malawi. World Bank Policy Research Working Paper 5097, World Bank. 7

Levy, S., Barahona, C., & Chinsinga, B. (2004). Food security, social protection, growth and poverty reduction synergies: The starter pack programme in Malawi. Technical report, The Overseas Development Institute Natural Resource Perspectives. Number 95. 3

Lundberg, S., Pollak, R., & Wales, T. (1997). Do husbands and wives pool their resources? Evidence from the United Kingdom child benefit. *The Journal of Human Resources*, *32*(3), 463–480. 28

Masanjala, W. H. (2006). Cash crop liberalization and poverty alleviation in Africa: Evidence from Malawi. *Agricultural Economics*, *35*, 231–240. 9

Mei, Z. & Grummer-Strawn, L. (2007). Standard deviation of anthropometric z-scores as a data quality assessment tool using the 2006 WHO growth standards: A cross country analysis. *Bulletin of the World Health Organization*, *85*(6), 441–448. 13

Minot, N. (2010). Staple food prices in Malawi. In *Food Security Collaborative Working Papers*, AAMP. 4

Newey, W. & McFadden, D. (1984). *Handbook of Econometrics*, chapter Large Sample Estimation and Hypothesis Testing, (pp. 2112–2245). Elsevier Science. 19

Orr, A. (2000). 'Green gold'?: Burley tobacco, smallholder agriculture, and poverty alleviation in Malawi. *World Development*, *28*(2), 347–363. 5

Orr, A., Mwale, B., & Saiti-Chitsonga, D. (2009). Exploring seasonal poverty traps: The 'six-week window' in southern Malawi. *Journal of Development Studies*, *45*, 227–255. 14

Pelletier, D., Deneke, K., Kidane, Y., Haile, B., & Negussie, F. (1995). The food-first nias and nutrition policy: Lessons from Ethiopia. *Food Policy*, *20*(4), 279–298. 3

Pelletier, D. & Msukwa, L. (1991). The use of national sample surveys for nutritional surveillance: Lessons from Malawi's national sample survey of agriculture. *Social Science Medicine*, *32*(8), 887–898. 14

Peters, P. E. (1996). Failed magic or social context? Market liberalisation and the rural poor in Malawi. Technical report, Harvard Institute for International Development. 5

Prost, M.-A., Jahn, A., Floyd, S., Mvula, H., Mwaiyeghele, E., Mwinuka, V., Mhango, T., Crampin, A., McGrath, N., Fine, P., & Glynn, J. (2008). Implication of new WHO growth standards on identification of risk factors and estimated prevalence of malnutrition in rural Malawian infants. *PLoS ONE*, *3*(7), e2684. 11

Prowse, M. (2009). Becoming a bwana and burley tobacco in the central region of Malawi. *The Journal of Modern African Studies*, *47*, 575–602. 7

Republic of Malawi (2000). Interim poverty reduction and growth strategy paper - A road map. Technical report, Republic of Malawi. 5

Rubey, L. (2004). Do no harm? How well intentioned (but misguided) government actions exacerbate food insecurity: Two case studies from Malawi. Technical report, USAID. 4

Sahn, D. (1990). The impact of export crop production on nutritional status in Côte d'Ivoire. *World Development*, *18*(12), 1635–1653. 8

Sahn, D. & Arulpragasam, J. (1991). The stagnation of smallholder agriculture in Malawi: A decade of structural adjustment. *Food Policy*, *16*(3), 219–234. 3

Stock, J. & Yogo, M. (2005). *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*, chapter Testing for Weak Instruments in Linear IV Regression, (pp. 80–108). Cambridge University Press. Editors Donald Andrews and James Stock. 24

Strauss, J. & Thomas, D. (1998). Health, nutrition, and economic development. *Journal of Economic Literature*, *36*, 766–817. 10

Takane, T. (2008). *African rural livelihoods under stress: Economic liberalization and smallholder farmers in Malawi*. Institute of Developing Economics, JETRO. 6, 7

Thomas, D. (1990). Intra-household resource allocation: An inferential approach. *The Journal of Human Resources*, *25*(4), 635–664. 28

Tobin, R. & Knausenberger, W. (1998). Dilemmas of development: Burley tobacco, the environment and economic growith in Malawi. *Journal of Southern African Studies*, *24*(2), 405–424. 5, 6

Tsonga, E. (2004). An analysis of the performance of Malawi's tobacco production and exports. Technical report, Malawian Ministry of Agriculture, Irrigation and Food Security. 6, 7

United Nations (2010). Regional map of Malawi. Technical report, United Nations. 14

United Nations Development Programme (2009). Human development report 2009. Technical report, United Nations. 5

Victora, C. G., Adair, L., Fall, C., Hallal, P. C., Martorell, R., Richter, L., Sachdev, H. S., & Maternal and Child Undernutrition Study Group (2008). Maternal and child undernutrition: Consequences for adult health and human capital. *Lancet*, *371*(9609), 340–357. 11

von Braun, J. (1995). Agricultural commercialization: Impacts on income and nutrition and implications for policy. *Food Policy*, *20*(3), 187–202. 3

von Braun, J., Kennedy, E., & Bouis, H. (1990). Commercialization of smallholder agriculture: Policy requirements for the malnourished poor. *Food Policy*, *15*(1), 82–85. 28

Waterlow, J. C., Buzina, R., Keller, W., Land, J. M., Nichaman, M. Z., & Tanner, J. M. (1977). The presentation and use of height and weight data for comparing the nutritional status of groups of children under the age of 10 years. *Bulletin of the World Health Organization*, *55*(4), 489–498. 10

Wilcoxon, F. (1945). Individual comparisons by ranking methods. *Biometrics Bulletin*, *1*(6), 80–83. 15

World Bank (1989). *Sub-Saharan Africa from crisis to sustainable growth: A long-term perspective study*. World Bank. 5

World Bank (2007). Malawi poverty and vulnerability assessment: Investing in our future. Full Report 36546-MW, World Bank. 3, 12

World Bank (2009). Gross national income per capita 2008, Atlas method and PPP. Technical report, World Bank. 5

World Health Organization (2009). WHO global database on child growth and malnutrition. Technical report, World Health Organization. Malawi. 12, 26

Zeller, M., Diagne, A., & Mataya, C. (1998). Market access by smallholder farmers in Malawi: implications for technology adoption, agricultural productivity and crop income. *Agricultural Economics*, *19*, 219–229. 6

Zere, E. & McIntyre, D. (2003). Inequities in under-five child malnutrition in South Africa. *International Journal for Equity in Health*, *2*(7), online. 23