MEASURING THE EFFECTS OF FOOD PRICE INCREASES AND AGRICULTURAL COMMERCIALIZATION ON POVERTY AND NUTRITION

BY

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DISSERTATION

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ABSTRACT

My three paper dissertation evaluates the economic welfare effects of food price increases and agricultural commercialization on households in Malawi and Mexico. Issues of poverty measurement and poverty alleviation are examined in the context of recent increases in commodity prices. By analyzing these concepts together, my research helps to more accurately address poverty in this volatile time in food price history, with a specific eye toward future policy interventions.

My first paper focuses on the impact of food price increases on welfare in the Mexico. My second paper expands the theme of food price increases to incorporate agricultural commercialization during this time period. Due to somewhat surprising results concerning the negative relationship between agricultural commercialization and children's nutrition, my final paper explores this topic in more detail by examining some of the correlations between commercialized households and nutritional outcomes. Taken as a whole, the findings support continued research into the influence of food price variability and agricultural risk management on children in the developing world.

The incorporation of geographic diversity, with research in both Mexico and Malawi, provides some acknowledgment of the global nature of recent food price increases. Examining the two very different kinds of poverty present in these countries broadens the scope of my work. Food price spikes have occurred around the globe, and policymakers have responded through different means. These two countries have approached poverty alleviation from different directions, with Mexico focusing on conditional cash transfer programs and Malawi spending more on agricultural encouragement through fertilizer subsidies. My research examines the affects of food price increases on welfare, and provides insights into future policy decision for the next price spike.

In addition to their geographic diversity, these two countries are in different stages of the development process. The income diversity of these countries further strengthens the poverty-

related findings, as results will incorporate large variations in the relative wealth of the populations being studied. As countries proceed through the structural transformation process, they may respond differently to food price shocks.

The Mexico paper looks at how Mexican households responded to significant food price shocks. Recent food price increases reportedly caused significant numbers of households to fall into poverty, particularly in the developing world. Most research into the welfare effects of these food price changes assumes constant demand or approximates second order substitution effects. Poverty forecasts with these assumptions may overestimate or underestimate the effect of food price increases in a nation where most households consume diverse food baskets. I account for full substitution by calculating a theoretically consistent food demand system, accounting for household responses to food price changes by decreasing some food purchases and increasing other food purchases. I use Mexican data to confirm the mitigation of adverse welfare effects from food price increases after accounting for country-specific dietary preferences in modeling demand. In comparison to previous literature, my welfare measures predict theoretically consistent numbers of Mexican households entering poverty due to recent food price changes.

My Malawian paper refines the food price increase discussion to look specifically at agriculturally commercialized households. 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.

My second Malawi paper examines the somewhat surprising negative relationship agricultural commercialization and children's nutritional outcomes. Building on previous research that identified a causal negative relationship between nutritional health and agricultural commercialization in Malawi, this paper explores differences in the tobacco-producing households. By analyzing the characteristics of agriculturally commercialized households in Malawi, I identify some of the factors that influence the negative correlation between tobacco crop adoption and nutritional deficiencies in the children of smallholders. Nationally representative 2010-2011 data allow for a more preliminary assessment of programs designed to promote better childhood nutritional outcomes. In that context, Malawi's push toward formal market integration and road infrastructure projects is contextualized in terms of its benefits to children's nutritional health.

In the end, the non-random observational nature of the data make causality claims difficult to support. I contend that the characteristics of households and communities associated with formal market participation tend to also positively influence the health of children. Future research may allow for a causality argument to be developed, with current positive correlation results from this research supporting general development contentions that higher education, improved family planning and reductions in transportation costs tend to benefit children's nutritional health.

Increases in commodity prices have influenced each of these countries differently. I use nationally representation household surveys to determine more wide-scale effects of food price increases. The Mexican paper calculates a food demand system in an attempt to more accurately measure the number of impoverished households due to increasing food prices. The first Malawian paper analyzes smallholder cash crop adoption in the face of recent staple food price spikes. The second Malawian paper examines some of the correlations behind the negative nutritional outcomes discovered in the first paper and individual, household and community level variables. Both of Malawi papers are specifically focused on smallholder agricultural households, with commercialization defined as being a producer of tobacco, Malawi largest export. Each of these situations presents a unique set of circumstances that, when taken together, should provide a greater appreciation for the effect of recent food price volatility on the poor and vulnerable.

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Contents

Chapter 1

Poverty Effects of Food Price Escalation: The Importance of Substitution Effects in Mexican Households

1.1 Introduction

Two food price spikes in the last four years have raised concerns about declines in the economic welfare of low income households who spend a large percentage of their budget on food. While the price spikes of 2008 and 2010 are likely caused by temporary shocks, such as drought in Russia and Argentina, the changing patterns of demand and supply make food price spikes more likely in the future (Piesse and Thirtle, 2009). Such household shocks are a significant policy concern because they may increase poverty rates and inflict greatest harm on the poorest members of society.

Several studies calculated the household income loss from the food price changes that spiked in 2008 (De Hoyos and Medvedev, 2009; Ivanic and Martin, 2008). These studies analyzed data from a number of countries. México is one country included in both studies. Several recent articles have specifically studied the economic welfare losses of Mexican households (Chávez Martín del Campo et al., 2008; Valero-Gil and Valero, 2008; Porto, 2010). We contribute new insight to this literature

by calculating income changes that account for substitution in response to food price increases for urban and rural households in México.

Mellor (1978) proposed measuring the income losses from food price increases by assuming zero price elasticity of consumer demand for food commodities. This is likely a valid assumption for staple goods in low income countries, but not for food commodities in middle income countries with more varied diets. The importance of distinguishing between staples and more varied diets is reinforced by recent work of Jensen and Miller (2011) who argue staple calorie share is a better measure of food insecurity than recommended caloric thresholds. Even if the diet is varied, Deaton (2000) argued that the welfare effects of small food price changes can be calculated with a first-order approximation that multiplies the price change by the original quantity demanded. Additionally, he observed that the magnitude of the welfare effects of finite price changes also depends on second-order effects which account for substitution responses to price changes. The substitution effect of food price increases may be particularly important in middle income countries with diverse diets, such as México.

While Mexican food prices have been increasing since 2001 (see figure 1.1), there was a significant food price spike in 2008. After a similar spike in 2010 Parker (2011) reported that the spike resulted in "...export bans, food riots, panic buying and emergency price controls". The recent food price spikes in México are representative of general price increases experienced around the world.

After the Mexican food price increases from 2006 to 2009, studies like Valero-Gil and Valero (2008) reported the income losses of Mexican households using the first-order approximation proposed by Mellor (1978) and Deaton (2000). In a recent study of the economic welfare effects of

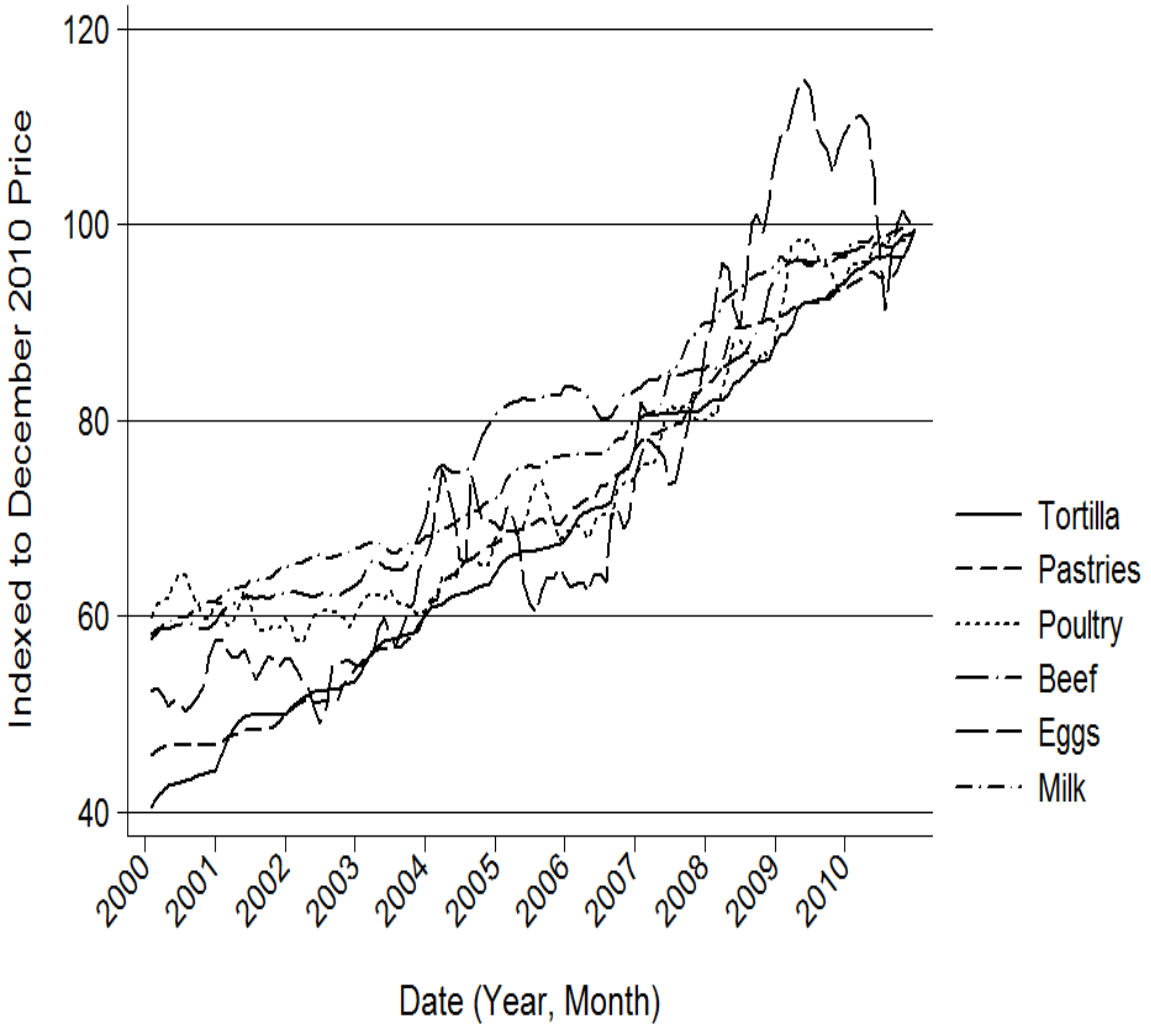


Figure 1.1: Average Monthly Prices for Selected Staple Foods in México (2000-2010). (Source: Banco de Mexico (various years))

food price changes for rural Mexican households, Porto (2010) approximated the income losses from consumption by adding a second-order term to account for substitution. Chávez Martín del Campo et al. (2008) estimate the distributional welfare effects of food price increases using a similar second-order term to approximate theoretically consistent welfare effects. We calculate Mexican household income loss from food price increases using theoretical welfare measures derived from a parametric household expenditure function recovered from econometric parameter estimates. We demonstrate that our theoretical welfare measures are significantly less than first-order approximations and greater than second-order approximations.

Our study extends the new understanding to help inform policymakers about the effects of the recent food price crisis. By providing a more complete understanding of consumer responses to food price increases, we hope to assist the targeting of poverty reduction strategies like México's conditional cash transfer program Oportunidades. Chávez Martín del Campo et al. (2008) showed that increasing Oportunidades payments is a relatively efficient response to the income loss from food price increases. Furthermore, by using the food poverty line designed by the Mexican National Council for the Evaluation of Social Development Policy (CONEVAL) we accurately identify the income losses from food price increases that drive households into food poverty.

1.2 Global and Local Food Prices

The food price spike of 2008 generated a considerable amount of recent literature, including the comprehensive analysis of its effect on poor consumers of De Hoyos and Medvedev (2009). They provided one of the few formal assessments of direct and indirect welfare effects, using the first-order approximation, on poor households around the world. They also calculated income gains for

households in the rural economy. Their findings, based on changes in the domestic food consumer price index from January 2005 to December 2007, suggested a 1.7 percent increase in global extreme poverty, taking into account both the direct and indirect effect of food price increases. The authors emphasized the significant regional variation, with poverty in Latin America remaining roughly unchanged in comparison to a 6 percent increase in East Asia. These results highlighted the importance of country specific poverty analysis. We refine their welfare analysis by using the prices of food items, aggregated into six main categories, to specifically examine the substitution effects of Mexican household food consumption to increases in specific food commodities.

Studies of Mexican household responses to income shocks include a study of the 1995 Mexican peso crisis, where Mckenzie (2006) investigated the effects of economic shocks on low-income consumers. He used Encuesta Nacional de Ingreso-Gasto de los Hogares (ENIGH) data to identify household consumption adjustments in the face of a general price shock. The study compared changes in durable and non-durable consumption patterns after the peso crisis. Mckenzie (2006) demonstrated that mean expenditure shares on these goods reacted more than expected under Engel's law, after accounting for household size and the age of the household head. Engel curve analysis of these variables illustrated how Mexican consumers protect their basic food consumption by reducing their durable goods purchases during this time of general price increases.

Valero-Gil and Valero (2008) combined ENIGH data from 2006 with 2006-2008 international commodity prices to estimate how increasing prices affected consumer poverty status, assuming demand remained unchanged after the price increases. They identified the basic components of the Mexican diet as: maize tortillas, poultry, soft drinks, milk, eggs, tomatoes, beans, beef, pastries (or sweet bread), sugar and vegetable oil. By applying the after-survey international prices to the survey

quantities and subtracting the differences in expenditure from household income they documented increases in expected poverty and extreme poverty within México. They found the number of poor Mexican households increased by almost 3 percent (800000) and a little more than an additional 1.5 percent (400000) of households became extremely poor.

Chávez Martín del Campo et al. (2008) concluded that even though poverty is highly sensitive to food price increases, poor Mexican families were able to substitute food products and reduce wealth loss. The authors analyzed the effect of the food price increase on poverty in México, focusing on cereals. In addition, they evaluated different policy instruments to alleviate the food price spike effect. They described the methods that México uses to define their food, capabilities, and family resources poverty lines, which differ substantially from the World Bank $1 and $2 a day poverty measures. The food poverty line refers to a basic basket of food; the capabilities poverty line adds health services and education, and the family resources poverty line further adds housing and transportation. Chávez Martín del Campo et al. (2008) found that the food price increases in the last years affected the food poor more intensely than the rest of the population. Following, and extending their work, we also use the income based poverty lines in rural (population less than 2500) and urban (population greater than or equal to 2500) communities.

Porto (2010) tried to account for food consumption substitution in response to food price increases by developing an identification strategy to estimate elasticities of demand from equations expressing the expenditure on individual food goods as linear functions of total food expenditure, demographic variables, and a quality adjustment. He then used his estimated elasticities to calculate approximations to compensating valuation, the amount of income households would have to receive to return them to the utility level that they were at before food price increases. His estimates add a

second-order term that is a function of the own-price elasticity of demand to the first-order term used in other studies. His second-order approximation which expresses compensating variation (cv) income loss as a percentage of total food expenditure is:

$$cv \approx s_i d\ln p_i + (1/2)\eta_{ii} s_i (d\ln p_i)^2$$

Porto (2010) approximated economic welfare measures and analyzed rural households in México. He carefully calculated increases in rural incomes from increased prices of agricultural commodities. We complement Porto's contribution and provide new insights into consumption responses by calculating price and income elasticities and a theoretically consistent welfare measure of the change in income needed to return Mexican households to their utility levels before the food price increases. Lewbel and Pendakur (2009) argued that a parametric demand system is required to correctly measure consumer welfare measures from price changes. Our study obtains such measures by estimating a complete food demand system for Mexican households. We confirm Porto's observation that the first-order approximation significantly overestimates household welfare loss from food price increases in middle income countries, but we also show that his second-order approximation underestimates the welfare loss.

1.3 The ENIGH Data

Our research utilizes the 2006 ENIGH Mexican household survey. This nationally representative survey covers all areas in México and includes extremely detailed information on the expenditure, income, and demographics of the households. The survey began in 1984, became biennial in 1992, and added an additional year in 2005. The Mexican government conducts this survey for 10 weeks

in the third quarter of the year. Expenditure data includes the quantities and expenditures for a multitude of individual goods. Income is broken into quarterly and monthly observations, denoting the source of the money.

To estimate an empirical demand system, household consumption data are aggregated into expenditure categories. Figure 1.2 displays the budget shares of non-poor and poor households along general expenditure categories. Leverage and dfbeta statistics of simple Engel curve specifications revealed that extremely small values of food budget shares had very large leverage, and extremely large values of food budget shares had very large dfbetas. Leverage and dfbeta statistics are diagnostic statistics that identify, possibly outlying, observations that have large influence on estimated coefficients and the predicted value of the response variable (Rousseeuw and van Zomeren, 1990; Bollen and Jackman, 1985). Therefore the data was trimmed at both extremes.[1]

The disaggregated food commodities are aggregated into maize tortilla, cereals, meats, dairy, fruits and vegetables, and other.[2] Budget shares of the aggregate commodities are calculated by dividing the expenditure on each sub-group by the overall food expenditure. Prices are calculated by adding expenditures in each sub-group then dividing by the sum of the quantities to obtain a price for the aggregate commodity. The number of individual food items in the budget shares differ greatly; in total the food budget shares represent nearly 250 individual commodities.

Summary statistics of budget shares and prices of the aggregate commodities are presented in table 1.1. The summary statistics justify tortilla's inclusion as a single food commodity because its budget share is similar to those of the other aggregate commodities. The mean total food budget of

[1] Valero-Gil and Valero (2008) discuss removing large and small observations to lessen the impact of outliers, but they do not report their final sample size.

[2] The other category includes a variety of individual goods including beans, cooking oil, prepared foods, and food away from home.

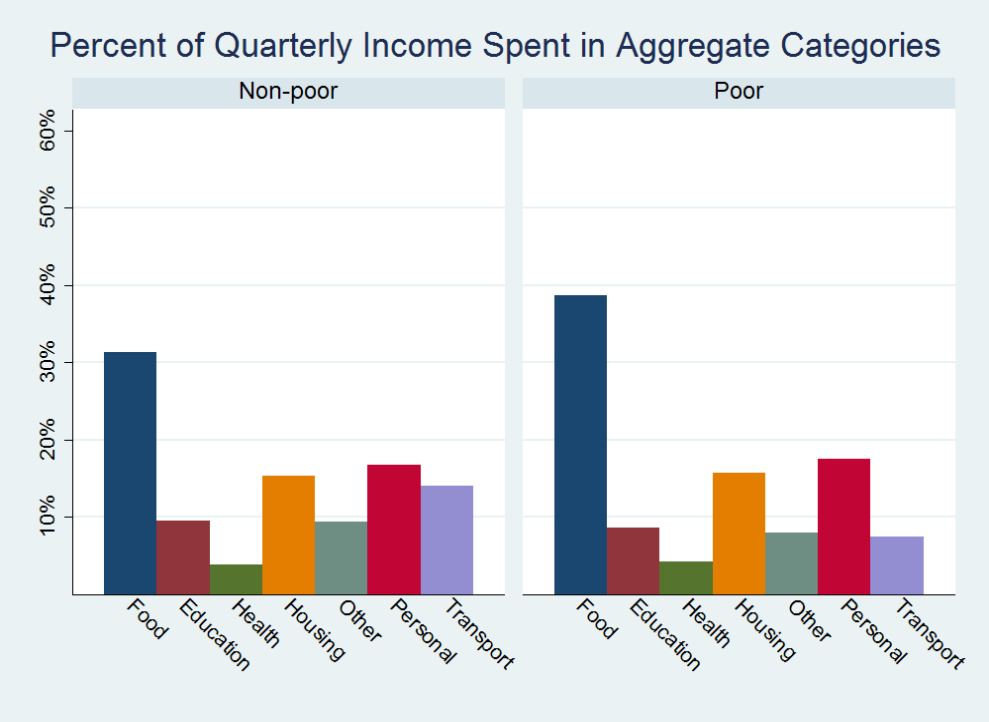


Figure 1.2: First Stage Budgeting, Quarterly Mean Expenditure Shares

poor households is 80 percent of the mean total food budget of non-poor households measured by weekly food expenditure in Mexican pesos.

The specification and analysis of the food demand system begins with evaluation of the Engel curves for each food category based on nonparametric regressions of the shares of food categories against the log of total food expenditure. The nonparametric regressions for the six food categories are presented in figure 1.3. These nonparametric regressions help identify the rank (number of income terms) of the demand specification by differentiating between linear and quadratic functional structure (Banks et al., 1997). While there is slight curvature to some of the regression lines, there does not appear to be significant deviation from linearity toward quadratic behavior.

Table 1.1: Sample Summary Statistics

	Urban		Rural	
	$non-poor$ $mean/(sd)$	$poor$ $mean/(sd)$	$non-poor$ $mean/(sd)$	$poor$ $mean/(sd)$
Shares				
tortilla	0.08	0.14	0.11	0.15
	(0.056)	(0.077)	(0.067)	(0.089)
cereal	0.09	0.09	0.09	0.12
	(0.057)	(0.063)	(0.060)	(0.079)
meat	0.27	0.25	0.24	0.20
	(0.121)	(0.116)	(0.115)	(0.115)
dairy	0.12	0.12	0.12	0.12
	(0.076)	(0.084)	(0.082)	(0.092)
fruit/veg	0.14	0.13	0.15	0.14
	(0.083)	(0.079)	(0.084)	(0.076)
other	0.30	0.26	0.30	0.28
	(0.165)	(0.136)	(0.150)	(0.133)
Prices				
tortilla	7.81	7.64	7.76	7.43
	(1.319)	(1.304)	(1.363)	(1.237)
cereal	23.26	18.79	20.56	18.14
	(12.435)	(10.898)	(11.962)	(12.386)
meat	36.78	29.19	33.70	28.95
	(12.962)	(11.058)	(12.806)	(12.070)
dairy	19.92	23.29	21.48	21.68
	(18.142)	(22.213)	(20.026)	(19.859)
fruit/veg	12.73	12.59	12.97	13.216
	(5.169)	(5.510)	(5.216)	(5.603)
other	12.11	10.03	11.00	10.03
	(10.388)	(8.0829)	(8.6326)	(5.371)
food expend.	639.98	428.20	525.78	409.09
	(353.557)	(204.509)	(288.823)	(193.520)
Observations	6535	540	1425	150

prices – pesos, food expenditures – pesos per week

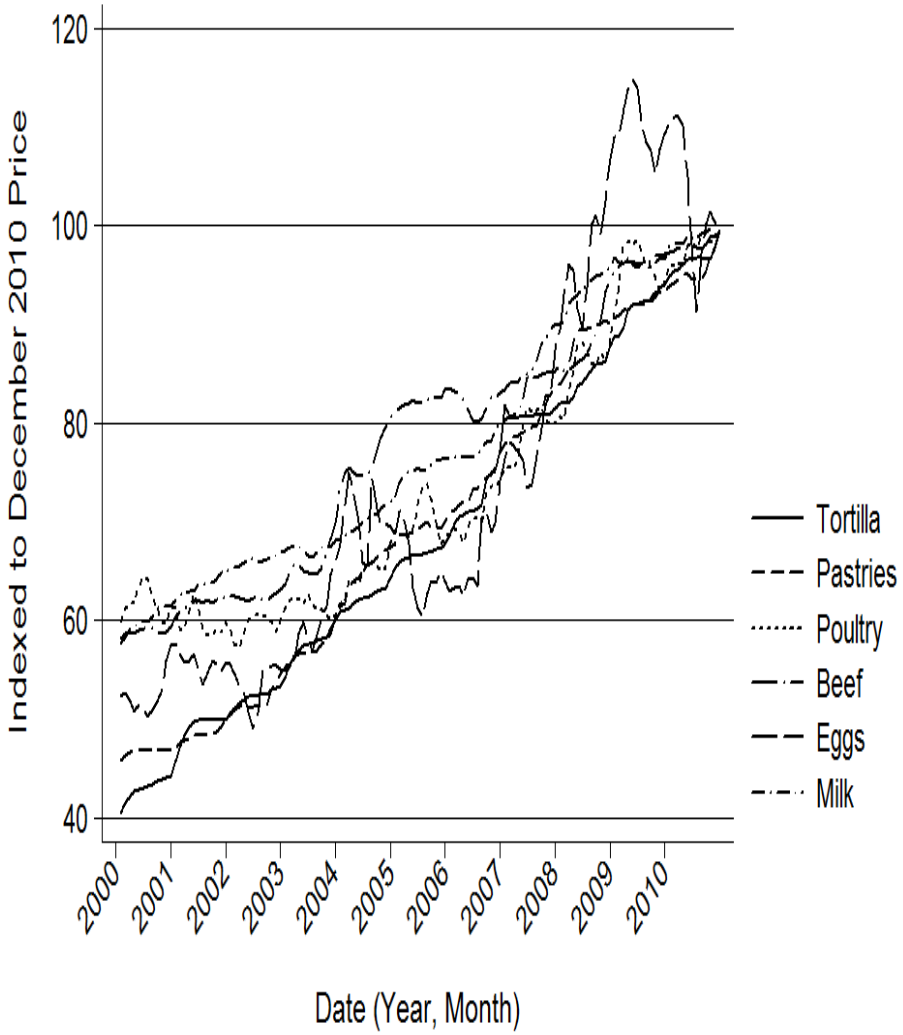


Figure 1.3: Engel Curves of Food Budget Shares on Log Food Expenditure

1.4 Empirical Model

Engel curve analysis identifies rank two demand (budget shares are linear in log total expenditure) as appropriate for estimating Mexican household food demand. Rank two demand systems, originally studied by Gorman (1953), are composed of two independent functions of prices interacting with functions of total expenditure. Muellbauer (1976) generalized Gorman's results on consistent aggregation of demand functions. As part of that research, Muellbauer defined the rank two demand functional form that generates equations expressing the share of the food budget spent on individual food commodities that are of the form:

$$s_i(p, w) = a_i(p) + b_i(p) \ln w$$

where $s_i(p, w)$ is the budget share of the i_{th} food commodity, p represents prices and w represents total food expenditure. That is, budget shares are a linear function of the natural log of total food expenditure with an intercept and a slope that are independent functions of prices. Muellbauer also showed that the expenditure function has the generic form:

$$\ln e(p, u) = a(p)\,(1 - u) + b(p)u \tag{1.1}$$

where p is prices of food commodities, and u is the utility of the household. We follow Deaton and Muellbauer (1980) by specifying:

$$a(p) = \alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \tag{1.2}$$

$$b(p) = a(p) + \beta_0 \prod_i p_i^{\beta_i} \tag{1.3}$$

where i and j range over the food commodities in the demand system. Substituting (2) and (3) into (1) produces the log expenditure function:

$$\ln e(p,u) = \alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j + u\beta_0 \prod_i p_i^{\beta_i} \tag{1.4}$$

and the indirect utility function:

$$V(p,w) = \frac{\left(\ln w - \left(\alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j\right)\right)}{\beta_0 \prod_i p_i^{\beta_i}} \tag{1.5}$$

To account for differences in household size we implement the specification of returns to scale in consumption discussed by Deaton (2000), with children converted to adults using equivalency scales. If there are constant returns to scale in consumption, and n represents adult equivalent household size, indirect utility would satisfy:

$$V(p,w) = n\frac{\left(\ln(w/n) - \left(\alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j\right)\right)}{\beta_0 \prod_i p_i^{\beta_i}} \tag{1.6}$$

meaning that the utility of a household with n equivalent adults who share consumption equally is the sum of individual utilities where each individual is allocated $1/n$th of consumption resources. There are economies of scale in consumption if the need for goods does not grow as fast as the household size. A simple way to model this is to assume that the need for goods to achieve a given

utility level grows more slowly than the number of individuals, say at a rate n^{θ}, where $0 < \theta < 1$. If $\theta < 1$ there are economies of scale in consumption. Deaton (2000) argues that this is a plausible way to capture the idea that two can live together more cheaply than they can live separately.

Using the economies of scale specification to account for household size, the following budget share equations form the system of estimating equations:

$$\begin{aligned} s_i(p, w) &= \alpha_i + \sum_j \gamma_{ij} \ln p_j \\ &+ \beta_i \left(\ln w - \theta \ln n - \left(\alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \right) \right) \end{aligned} \tag{1.7}$$

The parameters must satisfy the following restrictions in order for the demand system to exhibit Slutsky symmetry and satisfy the adding up constraint:

$$\sum_i \alpha_i = 1 \qquad \sum_i \beta_i = 0 \qquad \sum_j \gamma_{ij} = 0$$

$$\gamma_{ij} = \gamma_{ji}$$

These restrictions are used to recover the parameters for the share equation that is dropped to avoid a singular covariance matrix for the errors.

The parameters of the demand system are estimated by applying nonlinear seemingly unrelated regression to the system of five share equations (with the share of other food being dropped). Parameter estimates provide a clearer understanding of household food consumption behavior in 2006, summarized through income and price elasticities. And the parameter estimates provide a theoretically consistent model of household food demand that can be used to evaluate the welfare implications of food price increases.

1.5 Estimation Results

Parameter estimates of the demand system for urban non-poor and poor households are presented in table 1.2. A limited set of parameters are reported because they do not have a direct interpretation, but they do provide evidence about model fit. The extremely small p-values for most of the reported coefficients indicates a good fit of the demand system.

The one parameter in the demand system with direct interpretation is θ, the economy of scale in consumption. This parameter is 0.576 for non-poor households and 0.570 for poor households. These estimates suggest substantial economies of scale in food consumption. This means that if household size and household resources double, non-poor households experience a 42 percent increase in per capita resources and poor households experience a 43 percent increase in per capita resources. These calculations applied an adult equivalence scale of 0.75 on children under eighteen. The increasing returns to scale in food consumption might be due to additional household members making smaller demands on food resources, as well as benefits from larger scale food preparation.

A full set of elasticity estimates, income elasticities and compensated price elasticities, were calculated at the medians of the urban and rural non-poor and poor households. The elasticity estimates were bootstrapped 370 times to obtain reliable estimates of standard errors. Using a formula derived by Andrews and Buchinsky (2000), this implies that the relative difference between the bootstrap standard errors and standard errors based on infinite bootstraps is less than 10 percent with probability greater than 0.95, if the coefficient of excess kurtosis of the bootstrap estimates is conservatively assumed to be two.

Estimates of income elasticities of demand for urban and rural non-poor and poor households

Table 1.2: Parameter Estimates (Urban Households)

	non-poor	poor		non-poor	poor
α_1	-0.0566^{***}	-0.0854^{***}	γ_{13}	-0.0279^{***}	-0.0270^{***}
	(0.00479)	(0.0189)		(0.00164)	(0.00526)
α_2	0.0692^{***}	0.0955^{***}	γ_{14}	-0.00172	-0.00451
	(0.00274)	(0.00944)		(0.000893)	(0.00311)
α_3	0.105^{***}	0.137^{***}	γ_{15}	-0.00135	-0.0123^{*}
	(0.0108)	(0.0273)		(0.00136)	(0.00489)
α_4	0.0760^{***}	0.0830^{***}	γ_{22}	0.0186^{***}	0.000861
	(0.00654)	(0.0175)		(0.00126)	(0.00379)
α_5	0.136^{***}	0.181^{***}	γ_{23}	-0.0143^{***}	-0.0110^{**}
	(0.00733)	(0.0201)		(0.00136)	(0.00389)
β_1	-0.0642^{***}	-0.0825^{***}	γ_{24}	-0.000235	0.00121
	(0.00135)	(0.00495)		(0.000777)	(0.00202)
β_2	-0.0146^{***}	-0.00542	γ_{25}	0.000222	0.0104^{***}
	(0.00149)	(0.00443)		(0.00114)	(0.00310)
β_3	-0.0179^{***}	-0.00321	γ_{33}	0.0885^{***}	0.0762^{***}
	(0.00305)	(0.00723)		(0.00317)	(0.00795)
β_4	-0.0144^{***}	-0.00837	γ_{34}	-0.00168	-0.00537
	(0.00196)	(0.00531)		(0.00145)	(0.00325)
β_5	-0.000838	0.0119^{*}	γ_{35}	-0.00471^{**}	-0.0119^{*}
	(0.00214)	(0.00572)		(0.00180)	(0.00463)
θ	0.576^{***}	0.570^{***}	γ_{44}	0.000698	0.00346
	(0.0189)	(0.0601)		(0.00140)	(0.00366)
γ_{11}	0.0738^{***}	0.0895^{***}	γ_{45}	0.0132^{***}	0.00717^{**}
	(0.00223)	(0.00876)		(0.00109)	(0.00270)
γ_{12}	-0.00447^{***}	-0.00328	γ_{55}	-0.00340	-0.00869
	(0.000956)	(0.00332)		(0.00193)	(0.00483)
Observations	65355	540		6535	540

standard errors in parentheses

$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

are presented in table 3. It is important to note that the income elasticity of demand for tortilla by non-poor and poor households is not significantly different from 0 except for the urban non-poor who have a very small income elasticity, indicating that changes in income are unlikely to change tortilla demand. This is most likely a reflection of the status of tortilla as a staple that these households consume in the desired quantity. The income elasticities reveal that none of the goods

are inferior, while the other commodity is a luxury for non-poor and poor households, and fruits and vegetables are a luxury for poor households.

The income elasticities of cereal, meat, dairy, and fruits and vegetables are all close to one, demonstrating that welfare analysis of price changes need to account for shifts in demand caused by the income effect of the changes. The elasticities indicate that the income effect could be large for these commodity groups. In contrast, the small tortilla income elasticities suggest that first-order expenditure differences might be appropriate welfare measures for tortilla price changes. Further evidence about these effects will be provided by the compensated price elasticities.

Table 1.3: Income Elasticities

	urban non-poor	urban poor	rural non-poor	rural poor
tortilla	0.148^{***}	0.0926	0.0510	-0.0299
	(0.0218)	(0.0581)	(0.0448)	(0.182)
cereal	0.845^{***}	0.885^{***}	0.815^{***}	0.725^{***}
	(0.0220)	(0.0830)	(0.0421)	(0.164)
meat	0.914^{***}	0.935^{***}	0.990^{***}	0.916^{***}
	(0.0123)	(0.0535)	(0.0273)	(0.0958)
dairy	0.867^{***}	0.870^{***}	0.900^{***}	0.981^{***}
	(0.0189)	(0.0806)	(0.0489)	(0.166)
fruits and vegetables	0.997^{***}	1.131^{***}	0.999^{***}	1.023^{***}
	(0.0197)	(0.0700)	(0.0340)	(0.131)
other	1.405^{***}	1.327^{***}	1.356^{***}	1.430^{***}
	(0.0156)	(0.0540)	(0.0309)	(0.112)
Observations	6535	540	1425	150

standard errors in parentheses, 370 bootstrap replications

$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

Compensated own price elasticities, which measure pure substitution effects, are reported in table 1.4. The elasticity of demand for fruits and vegetables is large for all households (only urban non-poor have a slightly greater elasticity for dairy). And the elasticity of demand for meat is small

for all households. These results indicate that households reduce fruit and vegetable consumption significantly more than meat consumption in response to price increases.

Table 1.4: Compensated Own Price Elasticities

	urban non-poor	urban poor	rural non-poor	rural poor
tortilla	-0.0418	0.0327	-0.100	0.0368
	(0.0332)	(0.0868)	(0.0700)	(0.249)
cereal	-0.689^{***}	-0.674^{***}	-0.855^{***}	-0.992^{***}
	(0.0174)	(0.0578)	(0.0378)	(0.105)
meat	-0.393^{***}	-0.418^{***}	-0.457^{***}	-0.412^{***}
	(0.0128)	(0.0532)	(0.0301)	(0.114)
dairy	-0.923^{***}	-0.809^{***}	-0.820^{***}	-0.687^{***}
	(0.0132)	(0.0476)	(0.0341)	(0.117)
fruit and vegetable	-0.902^{***}	-0.949^{***}	-0.915^{***}	-1.016^{***}
	(0.0161)	(0.0487)	(0.0406)	(0.122)
other	-0.516^{***}	-0.535^{***}	-0.536^{***}	-0.613^{***}
	(0.0117)	(0.0525)	(0.0278)	(0.116)
Observations	6535	540	1425	150

standard errors in parentheses, 370 bootstrap replications

$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

The own price elasticity of tortilla demand is not significantly different from 0 for all households. This is important information because tortilla is a disaggregate commodity, while all of the other commodities are aggregated. Economic reasoning suggests that disaggregate commodities should have larger own price elasticities than aggregate commodities due to a larger array of substitutes for these goods. Thus, from this standpoint the small own price elasticity for tortilla is surprising , but the small elasticity is consistent with tortilla's status as a staple good in the Mexican diet.

Examination of the income and compensated price elasticities for tortilla for non-poor households provides an interesting picture of demand. Using the Slutsky equation in elasticities:

$$\eta_{ij} = \eta^*_{ij} - \eta_i s_j$$

where η^*_{ij} is compensated demand elasticity of good i with respect to price j, η_i is income elasticity of good i, and s_j is the budget share of good j, we find that the own price elasticity of Marshallian demand, η_{ii}, for tortilla is not significantly different from 0 for all households. Thus, Marshallian demand for tortilla is perfectly inelastic. This implies that compensating and equivalent variation for tortilla price changes are rectangles defined by the change in price along vertical lines that are virtually identical. This is equivalent to the first-order approximation of food price increases used by Valero-Gil and Valero (2008).

1.6 Welfare Analysis

As depicted in figure 1.1, the prices of many items in Mexican household food budgets increased significantly between the third quarter of 2006 and the first quarter of 2009. These increases have the effect of lowering the income of Mexican households who are net food buyers as most of the urban households are, resulting in a loss of economic welfare and moving some households into poverty. Defining efficient policy responses to the welfare loss of Mexican households requires quantification of the losses derived from estimates of household food demand. First-order approximations assuming fixed quantities and second-order approximations that adjust based on the own-price elasticity of demand only approximate the welfare loss, but compensating variation provides a more precise measure of the loss of household economic welfare. To measure this change in economic welfare we estimated parameters of the demand system and simulated price changes to calculate compensating variation (cv):

$$cv(p^0, p^1, w) = e(p^0, u^0) - e(p^1, u^0) = w - e(p^1, u^0)$$

Compensating variation represents the net income the household must be given to restore them to the utility level they were at before the price change. It is negative after a price increase because it is expressed as a central authority's expenditure to restore the household to the pre-price change utility level.

The economic welfare changes of food price increases are presented in table 1.5. First, consider the effect of a 25 percent increase in tortilla prices. By the first-order and second-order approximations the median income loss is 9.86 pesos per week for urban non-poor households, 11.48 pesos per week for urban poor households, 9.75 pesos per week for rural non-poor households, and 10.74 pesos per week for rural poor households. These income losses are identical because the own-price elasticity of demand for tortilla is zero. The approximate measures are within one standard error of the compensating variation measure, so there is no statistically significant difference between the theoretically consistent measure and the approximations, as expected.

Moving beyond staple goods, we examine a price increase in many of the goods affected by grain prices. When maize prices dramatically increase, cereals, meats and dairy should all follow a similar path. Maize plays a prominent role in feed and is the main ingredient in many cereal products. But these items are not staple goods, thus making imprecise the first-order and second-order welfare approximations. A 25 percent increase in cereals, meats and dairy products, for urban non-poor households, causes a median weekly income loss of 46.17 pesos by compensating variation, 62.38

pesos by the first-order welfare approximation, and 35.51 pesos by the second-order approximation. The first-order approximation overestimates the welfare loss because it allows for no substitution. The second-order approximation underestimates the welfare loss because it adjusts for the reduction in consumption of more expensive food products but it does not adjust for increases in relatively less expensive food products. Given the standard error of compensating variation all differences are statistically significant. Our results demonstrate that estimates of full substitution behavior are needed to produce accurate economic welfare measures. The differences for other sub-populations, presented in table 1.5, follow a similar pattern.

Next, consider a 50 percent increase in the more limited cereal and meat categories. This scenario emphasizes the approximation error of first and second-order approximations because the price change is larger than marginal, creating greater substitution effects. This price change causes a median weekly income loss of 68.91 for urban non-poor households by compensating variation. In contrast, urban non-poor households experience a median weekly income loss of 96.85 by the first-order approximation and 45.40 by the second-order approximation. Thus the first-order approximation overestimates the income loss by 41 percent and the second-order approximation underestimates the income loss by 34 percent. The results in table 1.5 demonstrate that the first-order approximation consistently overestimates the income loss, ranging from 16 percent to 42 percent, and the second-order approximation consistently underestimates the income loss, ranging from 24 percent to 52 percent. These results provide the important insight that the bias of the second-order approximation can be greater than the bias of the first-order approximation for large price changes because it fails to account for the increase in expenditure on relatively less expensive foods.

The consequences of the upward bias in the first-order welfare approximation and downward bias

Table 1.5: Welfare Effects of Food Price Increases

	urban non-poor	urban poor	rural non-poor	rural poor
	(25 % increase in tortilla)			
compensating variation	-10.06^{***}	-11.02^{***}	-7.76^{**}	-9.76^{**}
	(2.548)	(2.435)	(2.548)	(3.247)
first-order approximation	-9.86	-11.48	-9.75	-10.74
second-order approximation	-9.86	-11.48	-9.75	-10.74
	(25 % increase in cereal, meat, and diary)			
compensating variation	-46.17^{***}	-32.84^{***}	-42.49^{***}	-28.56^{***}
	(1.409)	(4.179)	(2.294)	(6.740)
first-order approximation	-62.38	-39.63	-45.51	-32.91
second-order approximation	-35.51	-20.84	-23.24	-15.36
	(50 % increase in cereal, and meat)			
compensating variation	-68.91^{***}	-49.84^{***}	-62.81^{***}	-35.73^{***}
	(2.437)	(7.253)	(3.740)	(9.468)
first-order approximation	-96.85	-64.04	-72.86	-50.77
second-order approximation	-45.40	-28.14	-30.27	-27.24

standard errors in parentheses, 370 bootstrap replications; expenditure – pesos per week

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

in the second-order approximation can be further illustrated by considering the implied increases in poverty. Table 1.6 presents calculations of the number of households that would be driven below each of the three Mexican poverty levels by a 50 percent increase in the price of cereal and meat. To make the prediction we converted the weekly welfare losses to monthly welfare losses and subtracted these losses from the sum of monthly household income.[3] The new income levels are then compared to the previously mentioned food, capabilities, and family resources poverty lines, with population measures of poverty changes being calculated by multiplying sample observations by expansion factors that are the inverse of the probability of being sampled. These factors provide nationally representative statistics (De Hoyos, 2005).

Table 1.6: Poverty Effects of Food Price Increase

	food	capabilities	family resources
first-order approximation	36297	100792	304423
compensating variation	22696	62129	209504
second-order approximation	17544	27691	129648

Number of urban households where food price increases move income below poverty line.

The food price change drives 36297 urban households below the food poverty line, a 5.7 percent increase in the number of urban households in poverty, according to the first-order approximation, and 22696 urban households move below the food poverty line, a 3.6 percent increase, according to compensating variation. Thus the first-order welfare approximation overestimates the increase in urban food poverty by 60 percent. The second-order approximation predicts 17544 urban households will be pushed below the food poverty line, a 2.8 percent increase. The second-order approximation underestimates the food poverty increase by 23 percent. Moving to the capabilities

[3]Household income is measured by a variable whose label translates to current monetary household income.

poverty line the first-order approximation identifies 100792 households moving into poverty, an 8.3 percent increase, compensating variation identifies 62129 households, a 5.1 percent increase, and the second-order approximation identifies 27691 households, a 2.3 percent increase. The first-order welfare approximation overestimates this poverty increase by 67 percent, and the second-order approximation underestimates the increase by 55 percent. Finally by the family resources poverty line 304423 households are driven into poverty, an 8.7 percent increase according to the first-order approximation, 209504 households move into poverty, a 6.0 increase according to compensating variation, and the second-order approximation predicts a 3.7 percent increase of 129648 urban households. The first-order bias overestimate is 45 percent, and the second-order bias underestimate is 38 percent.

Thus the first-order welfare approximation consistently overestimates the number of households that food price escalation drives into poverty by 50 percent or more, and the second-order welfare approximation underestimates the poverty increase by 40 percent or more. Failure to account for full substitution in food consumption in response to specific food price increases causes the first-order welfare approximation to significantly overestimate the increase in poverty caused by food price increases. The second-order approximation consistently underestimates the income loss because it only accounts for the reduced consumption of more expensive foods but does not account for the increased consumption of relatively less expensive foods. We have demonstrated that this bias is significant for Mexican urban (population greater than 2500) households.

1.7 Conclusion

This article focuses on quantifying the consumption welfare losses and poverty predictions for Mexican households due to the world food price increases from 2006 to 2009. Specifically, we measure the income losses from tortilla, cereal, meat and dairy price increases, differentiating by household status, non-poor and poor, and urban and rural. Our study makes several contributions to the literature: we use a country-specific food poverty level to measure poverty status; we focus on the main foods consumed by Mexicans to accurately represent the Mexican diet; and we estimate a complete food demand system that allows for substitution effects to better capture consumer behavior through the estimation of compensating variation. Consequently, our results provide a welfare analysis of consumption income losses that fully accounts for substitution to inform specific recommendations for Mexican policymakers.

We find evidence of the need to account for the income effect when performing welfare analysis of food price increases through the income elasticities of cereal, meat, dairy and fruit and vegetable (all close to one), but not for tortillas. We confirm tortillas as a staple food for both non-poor and poor households, while none of the goods studied are inferior goods. By determining that the cross price elasticities relative to tortillas are not significant for poor households, we conclude that tortilla's staple status makes first-order welfare approximations accurate.

To perform an appropriate welfare analysis of income losses from consumption, we calculate compensating variation for the representative commodities, differentiated by urban and rural and household poverty status. We find that the first-order approximation consistently overestimated poverty increases by 45 to 65 percent. And the second-order approximation underestimates income

losses by 24 to 52 percent. We demonstrate that information about household substitution in response to price increases is needed to predict the household's income losses, and who will fall below the poverty line. A 50 increase in the price of cereal and meat causes household poverty increases from 3.6 percent to 6.0 percent depending on the particular measure used to define poverty. The income losses of rural households will be diminished by income increases from higher agricultural prices as shown by Porto (2010). Thus our welfare losses for rural households should be considered an upper bound, but the losses for urban households should be an accurate measure of their full loss.

Furthermore, this study represents a first step toward designing policies targeted at alleviating poverty in the developing world through theoretically consistent measurement of income losses that food price increases have on the different socioeconomic groups within a middle income developing country. First-order approximations are easy to calculate as a first cut measure of welfare changes, and second-order approximations can adjust for reduced consumption using an estimate of own-price elasticity of demand, but we have demonstrated that measurement of income loss accounting for substitution is required to obtain accurate estimates of poverty increases from large food price increases in middle income developing countries.

Mexican policymakers should refocus their price alleviation efforts on the poorest portions of their population. Ineffective tortilla price ceilings, proven to be to expensive due to leakage and the inability to enforce these price restrictions, failed to assist the neediest consumers in 2007. However, expanding conditional cash transfer payments to poor households, such as Oportunidades, during periods of food price shocks would direct aid toward the people most harmed by the price spikes. By weighting Oportunidades payments according to Mexican food prices, the government

has already begun the process of efficiently disbursing food assistance (Arias-Vazquez et al., 2008). Another challenge for the Mexican government is to extend the coverage of social programs like Oportunidades, because an important percentage of the population below the food poverty line is not covered by any social program (Chávez Martín del Campo et al., 2008).

Chapter 2

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

2.1 Introduction

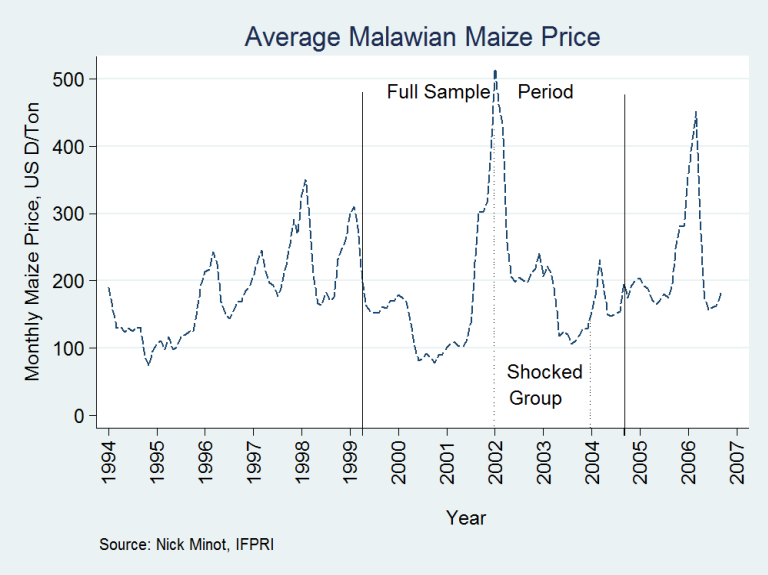
While widespread international encouragement exists for cash crop production, the impact of this commercialization on health remains undetermined (Harrigan, 2008). In the case of Malawi, where agricultural commercialization mainly centers on tobacco, recent governmental policies have promoted domestic food production in the face of longterm aid dependence and national food deficits (Ecker, Breisinger, and Pauw, 2011; Levy, Barahona, and 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). Arguments within Malawi remain contentious over focusing on maize self-sufficiency versus expanding 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 and 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, and 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 2.1: 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 2.1, a significant maize price spike accompanied that drought, with prices remaining high for an extended time period. By building on the covariate shock literature, I 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.

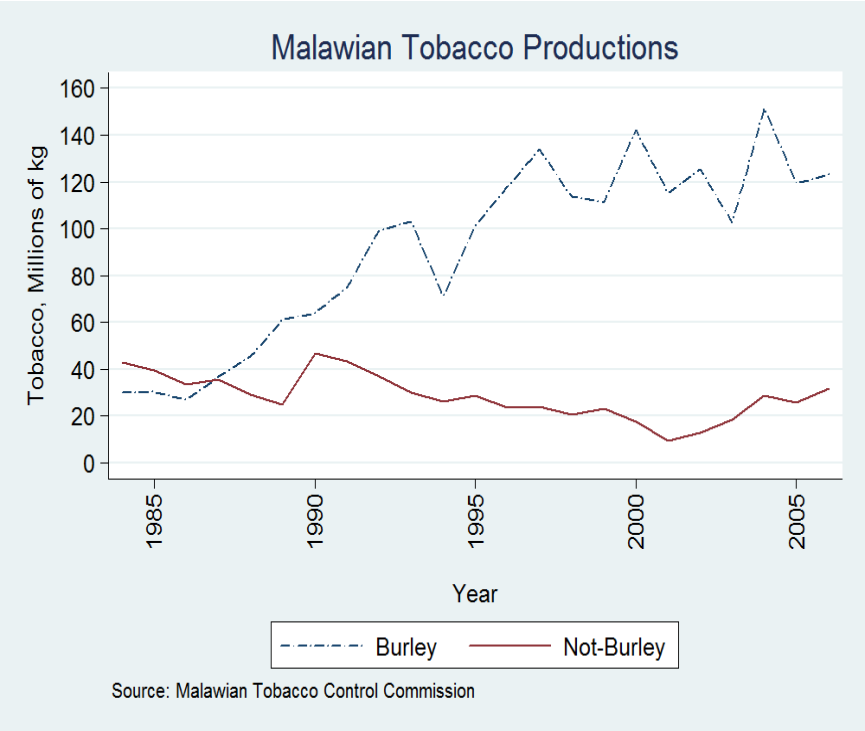
2.2 Malawian Agricultural Commercialization

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 of burley tobacco (World Bank, 1989; Peters, 1996; Tobin and Knausenberger, 1998).

Tobacco has played a prominent role in Malawi's historical economic development. Although production levels have fluctuated over time, figure 2.2 demonstrates how burley 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).

Malawi is well-suited for growing burley tobacco, much of which is used as a low-cost filler supplied to international cigarette producers. Burley production, with its delicate cultivation and particular harvesting requirements, exhibits few economies of scale (Jaffee, 2003). Additionally, burley tobacco's air-curing process is not capital intensive, further lending itself to small scale

Figure 2.2: Malawi Tobacco Production



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 and 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, produced tobacco (Kadzandira, Phiri, and 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 and Hanmer, 2009).

All legally sold tobacco in Malawi goes through the regional auction floors identified in figure

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

2.4.[2] While tobacco production originally concentrated itself in the South, growth quickly spread throughout the country. Most smallholders continue to sell their crop through burley 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 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.

[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.

[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).

2.3 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 and 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 and Cogill, 1987, Foreward).

Kennedy and Cogill field test Mellor's concept by measuring the effects of commercialization on income and nutrition in Kenya (Kennedy and 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.

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 and 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 and 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, and Bundervoet, 2007). And Hoddinott (2006) finds a Zimbabwean drought to have long term stunting effects only on children under the age of two.

My 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). The use of nationally representative data updates the agricultural commercialization literature to estimate the nationwide effects of recent food price shocks.

2.4 Data and Definitions

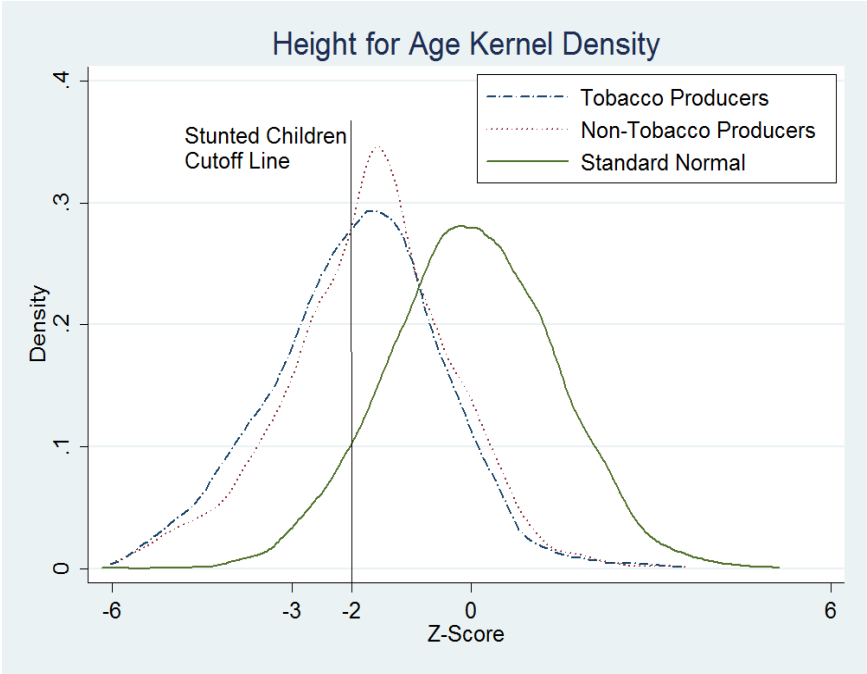
My work determines the effect of cash crop production on childhood undernutrition by examining crop choice in relation to stunting after controlling for a number of external factors. Stunting, a robust long-term measurement of childhood undernutrition, compares a child's height and age to a globally 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 and Thomas, 1998).

Stunting has been shown to accurately measure longterm childhood nutrition levels (Beaton et al., 1990a; 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).

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. I apply Barker's idea to Malawi by testing the effect of fetal undernutrition through stunting level comparisons by farmer type and time period.

Figure 2.3 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

Figure 2.3: Distribution of Children's Z-Scores



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 2.3.

My 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. I 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. I classify cash crop producers as those who grew tobacco in the 2001-2002 or 2002-2003 crop seasons in order to analyze the effects of adoption decisions during the time of food price increases.[5] While I am only able to identify

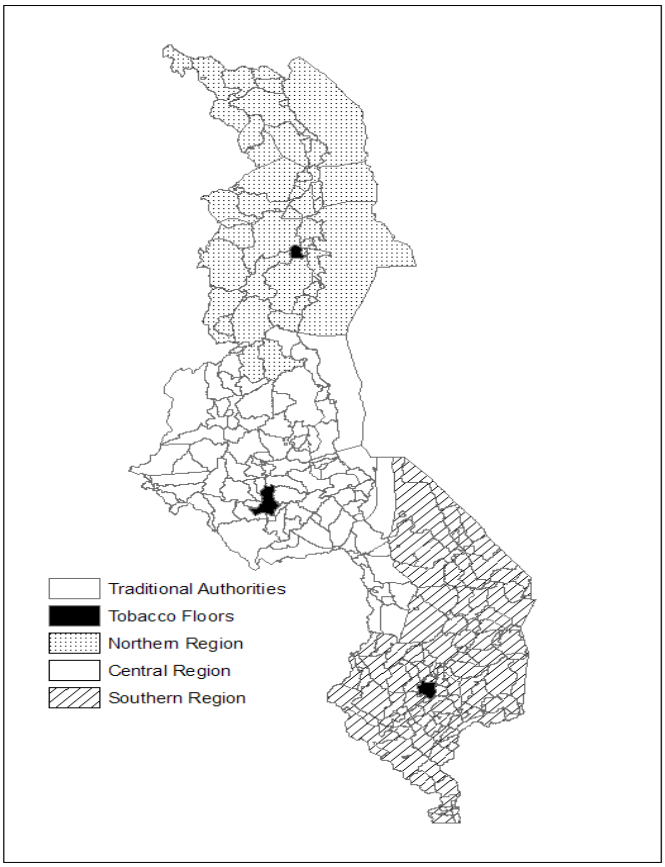
[4]Box-plot graphics of my cutoff decision are available by request. Significance levels decreased with one or two acre smallholder definitions due to high standard errors, although the signs and magnitudes of the coefficients of interest remained consistent.

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

tobacco growers in general during this period, as previously shown in figure 2.2, burley represents the majority of all production.

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.[6] 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.

Figure 2.4: Malawi by Region, Traditional Authorities and Tobacco Floors



[6]Unfortunately, I am 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.

Differentiating the sample by adoption decision, as seen in table 2.1, allows for household-level comparisons of tobacco and non-tobacco producers.[7] 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. On average, tobacco producers are significantly more likely to own a bicycle. They also have a greater percentage of stunted children.[8]

Table 2.1: Smallholder Summary Statistics

	Non-Burley median/sd	Burley median/sd	Difference median/Pearson χ^2
Household Size	5	6	1
	[4, 7]	[4, 7]	16.23***
Household Head Age	35	35	0
	[29, 46]	[29, 44]	1.87
Aggregate Income	130	187	57
	[55, 274]	[90, 327]	76.00***
Acreage	2	3	1
	[1, 3]	[2, 4]	345.48***
Children Stunted (%)	43	49	
Food Price Shock (%)	78	89	
Bicycle owner (%)	41	60	
Observations	4623	1091	

[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. See Wilcoxon (1945) for additional information on this nonparametric k-sample test.

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

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

[8] To check the accuracy of the nutritional observations, Mei and 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%.

outcomes. Figure 2.4 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, and Saiti-Chitsonga, 2009; Pelletier and 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.

2.5 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.[9] 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 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.[10]

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 2.2 to account for potentially significant variables at the child, household, community, district and regional levels.[11] Previous work on health outcomes in relation to household characteristics provides a wealth of information on significant contributing factors to reducing nutritional deficiencies.[12]

Expanding on the covariate shock literature, tests are performed to determine if households

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

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

[11]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. I elected to use the total income RIGA number that calculates the value of own consumption from the household questionnaire.

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

Table 2.2: Variables by Type

Individual	Gender
Household	Tobacco Producer, Household Head Age, Number of Children in the Household, Household has a Permanent Floor, Child lives in a Permanent House, Acreage Controlled by the Household, Size of the Household, Household Income Quintile, Mother's Education Level, Child Always Sleeps Under a Bed Net, Former Tobacco Tenant Farmers, Household Grows Non-Burley Tobacco, Agricultural Shock Dummy
Community	Clinic
District	1998 maize price, Number of tobacco producing households in 1998
Regional	Southern Dummy, Central Dummy

that devoted part of their limited acreage to cash crops experienced differing nutritional outcomes compared to solely food producing farmers. Ideally, if the burley adoption decision could be independently varied an estimate of the effect of burley 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 burley adoption dummy, and X_i is a vector of observable household attributes.

As seen in table 2.3, the OLS estimates show that tobacco adoption insignificantly decreases the height of the children of tobacco producers regardless of time period. 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.

This paper's empirical strategy exploits variations in Malawian agricultural commercialization patterns and previous maize prices. To avoid endogeneity concerns between tobacco adoption and children's health, I develop two district level instruments from the 1998 Integrated Household Survey (IHS-1) to predict adoption decisions.[13] These instruments are built on the premise that farmers

[13]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.

Table 2.3: In Utero During Stable or Shocked Prices OLS Results, Select Variables

	Stable	Shocked		Stable	Shocked
Tobacco	-0.042	-0.168	2^{nd} income quintile	0.011	0.011
	(0.071)	(0.087)		(0.079)	(0.097)
Male	0.151^{**}	0.278^{***}	3^{rd} income quintile	0.060	0.083
	(0.051)	(0.060)		(0.080)	(0.097)
Permanent floor	0.253^{**}	0.167	4^{th} income quintile	0.046	0.029
	(0.081)	(0.100)		(0.082)	(0.097)
Child bed nets	0.189^{***}	0.208^{**}	Highest income quintile	0.112	0.158
	(0.091)	(0.065)		(0.079)	(0.102)
Southern	-0.034	0.256^{**}	Mother high education	0.082	0.177
	(0.079)	(0.091)		(0.091)	(0.108)
Central	-0.245^{**}	0.045	Constant	-2.322^{***}	-2.578^{***}
	(0.078)	(0.091)		(0.213)	(0.248)
Observations	3163	2551			

[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.

are likely to grow commercialized crops after seeing others in their neighborhood previously adopt and opportunities to grow tobacco due to fluctuations in the price of maize. 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 first instrument counts the number of farmers growing tobacco in the 1998 survey at the district level. The second instrument calculates the average maize price by district to capture variation in prices that may alter the production decisions of farmers but not affect the current health of household members.[14]

Theoretically, my instruments are based on a model of crop adoption decisions built upon predicted prices. Following Eckstein (1984), recent prices influence crop production planting decisions dynamically, with past prices diminishing in importance over time. Farmers form rational expectations for expected prices and profits from cash crop versus food crop plantings based on

[14] Annual tobacco price data comes from the Malawian Tobacco Control Commission, as the IHS-1 data does not contain detailed tobacco sales information.

the outcomes from previous adopters, the money required to buy the maize they would forgo if choosing to switch to tobacco production and other specific factors like land quality and access to inputs. Price shocks prove very important in this context, as they are unpredictable and they may alter the health outcomes of household members as the cost of food increases or the purchase price of tobacco declines.

There are two common concerns raised about the validity of my estimation strategy. The first relates to geographic specific biases that may favor tobacco production in certain sections of Malawi, possibly because of technology diffusion, climatological factors or historical growth patterns. Alternatively, stunting itself, due to its widespread nature or inconsistencies in measurement, may not accurately capture the health situation. The area-specific attributes are addressed with district level fixed effects. Additionally, two separate robustness checks are presented in the next section, the first of which only uses the commodity price instrument while the second focuses on an alternative measure of children's health. Statistical evidence is shown to further demonstrate the legitimacy of the instruments.

I account for the binary nature of my commercialization variable by employing a first stage probit estimation to recover the predicted probabilities of adoption. This efficient prediction, which Wooldridge identifies as the optimal instrument in this binary regression situation, then instruments for burley production when estimating the second stage concerning children's health (Wooldridge, 2010, p.231). The burley adoption dummy is expressed as:

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

where D_i^* is a latent variable underlying burley 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. Along with omitted variable bias, this framework further accents the need for instrumentation of the adoption decision due to the correlation of

v_i, the error term of the indicator variable equation, with u_i due to common unobserved attributes influencing burley adoption and health outcomes. The initial probit is run to obtain predicted probabilities of tobacco adoption, with z_1 being the included exogenous variables and z_2 the excluded exogenous variables: $P(D_i|z) = \Phi(\delta_1 z_1 + \delta_2 z_2)$.[15] The strength of the first stage estimation is initially demonstrated by its ability to correctly predict almost 90% of the adoption decisions. Afterwards, I recover the predicted probabilities for use as the optimal instrument in estimation of tobacco adoption's influence on children's health.

To circumvent omitted variable bias and account for heterogeneity across households, I estimate an instrumental variable two-step generalized method of moments (GMM) model with robust clustered standard errors. By utilizing the aforementioned adoption predictions, the model efficiently estimates agricultural commercialization's effect on children's health via their z-score. My preferred estimation model follows the standard GMM criterion function:

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

The results are consistent throughout table 2.4. 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 -2.05 means that tobacco crop adoption during the food price crisis was a highly significant factor for stunting. In a globalizing world, figure 2.5 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.[16] 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%.

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

[15]The first stage probit includes control variables not directly related to production decisions to remain consistent in the stunting estimation.

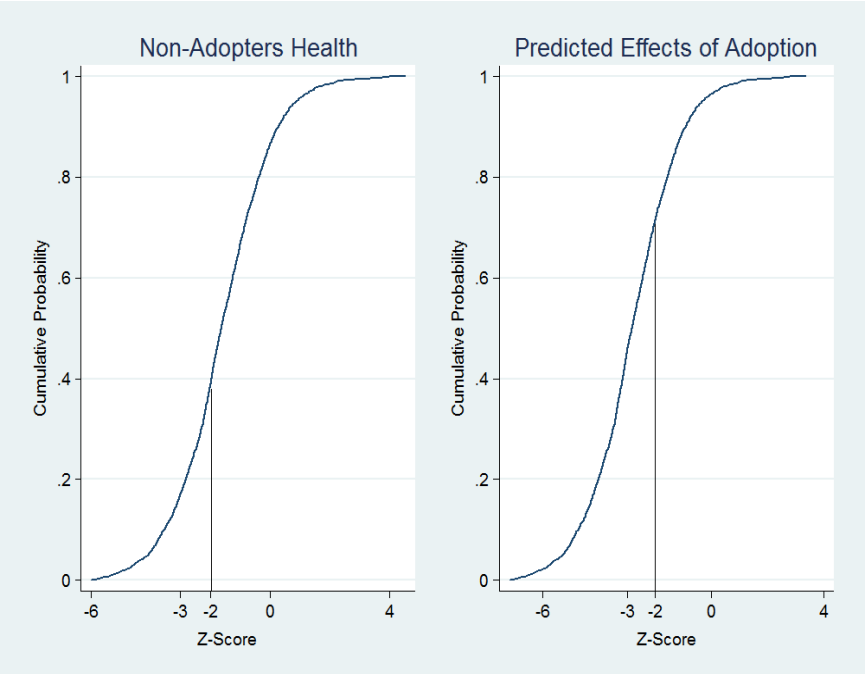
[16]This analysis admittedly does not account for heterogeneity within the sample, which may alter the adoption effects.

Table 2.4: In Utero During Stable or Shocked Prices Two Step GMM Results, Full Model

	Stable	Shocked		Stable	Shocked
Tobacco	−0.984	−2.053*	Household size	−0.025	0.033
	(0.514)	(0.811)		(0.023)	(0.029)
Male	0.147**	0.321***	Mother medium education	0.058	0.137
	(0.052)	(0.073)		(0.094)	(0.136)
Household Head Age	−0.002	−0.003	Mother high education	0.110	0.220*
	(0.002)	(0.003)		(0.108)	(0.088)
Children	0.037	−0.021	2^{nd} income quintile	0.034	0.098
	(0.023)	(0.038)		(0.074)	(0.092)
Permanent house	0.062	0.125	3^{rd} income quintile	0.101	0.146
	(0.074)	(0.090)		(0.071)	(0.128)
Permanent floor	0.222	0.079	4^{th} income quintile	0.112	0.228
	(0.123)	(0.110)		(0.085)	(0.115)
Protected water	−0.003	−0.008	Highest income quintile	0.154	0.301**
	(0.089)	(0.133)		(0.101)	(0.128)
Child bed nets	0.195**	0.203**	Tobacco tenant	0.234	0.682
	(0.072)	(0.066)		(0.255)	(0.352)
Presence of Clinic	−0.098	−0.119	Other tobacco	0.813**	1.349*
	(0.070)	(0.096)		(0.293)	(0.528)
Acreage	0.064	0.104	Agricultural shock	0.106	0.040
	(0.033)	(0.056)		(0.141)	(0.217)
Southern	−0.077	0.195	Central	−0.152	0.270
	(0.196)	(0.146)		(0.192)	(0.156)
Constant	−2.311***	−2.607***	Observations	3163	2551
	(0.241)	(0.325)			

[1] Robust standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05, clustered at the district 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.
[9] Other tobacco farmers refers to households that grew non-burley tobacco.

Figure 2.5: Non-Tobacco Household CDFs



spike, having been born in 2002 or 2003, most likely suffered from severe fetal undernutrition.[17] As previously discussed, recent literature has shown that in utero undernutrition may greatly influence long term health and educational attainment in children (Field, Robles, and Torero, 2009). These tobacco adoption findings highlight some of the conditions that constrain children from reaching their full mental and physical capabilities.

The ability to demand higher prices and the skills associated with advanced tobacco production proved important in increasing the likelihood of positive children nutritional health outcomes. The significance of tobacco related variables demonstrates the importance of accounting for land and different tobacco production types when examining adoption effects. The significant other tobacco production variables probably reflect non-burley tobacco producers, who are not directly measurable at the time of the price spike.[18]

The tobacco adoption findings accompany a number of control variables that display mostly expected results. Male children and higher income households faired better on average than their

[17] See Almond and Currie (2011) for an overview of the long term health consequences of fetal undernutrition.

[18] As seen in figure 2.2, while non-burley tobacco production has declined over time, it still represents a small percentage of Malawian tobacco growers.

counterparts during the food price spike.[19]. 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. A host of household and geographic level control variables, relating to farming decisions, household make-up and health all proved insignificant.

The incorporation of district level clustering of the standard errors, to remain consistent with the district-level instruments used in the estimation, strengthens the robustness of the results. This clustering helps to account for variation within the sample due to geographic location or land quality. Future research may be able to provide even greater accuracy through examinations at the sub-district level.

These results depend on the soundness of the instruments. To support arguments for the 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 burley adoption. The highly significant coefficients on the excluded instruments in the first stage probit provides additional evidence of this property.

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 0.347 and a p-value of 0.556 for the group born outside of the shock, and a J-statistic of 0.001 with an accompanying p-value of 0.974 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.[20]

Additional 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 164.55 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.[21] These standard tests expand the statistical support for the instrumental estimation.

[19] See Zere and McIntyre (2003) for further inquiry into the effects of income distribution on nutritional outcomes

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

[21] See Stock and Yogo (2005) for additional information on these tests.

2.6 Robustness Checks

The tobacco adoption findings are robust to numerous alterations, all reporting similar results. Concerns over adoption decision 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.

I 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. The tobacco adoption coefficient estimate rejects the endogeneity test that treats it as exogenous for both populations. It reports values of 2.31 in the out-of-shock group and 4.19 for the in-shock sample, with the p-value for the shocked group being significant at the 5% level. These results indicates a presence of endogeneity in the adoption decision during the food price spike, requiring the use of alternative variables to instrument for tobacco adoption.

To verify the overall robustness of the results I varied the estimations in numerous ways, the first of which focuses on the instrumental variables. I reduce the estimation to a single-instrument by only using the district level 1998 maize price variable to determine tobacco adoption's effect on children's health. As seen in the second and third columns of table 2.5, the signs are consistent across all three estimations. The tobacco adoption effect is still significantly negative when only using one instrument, with the greater than one standard deviation drop in stunting z-score remaining between comparisons of the tobacco adoption coefficients of children in utero during and outside the food price spike.

To further test the results, I 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., 1990a). 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 2.5, produce very similar results to the original stunting estimation. Children born into tobacco producing households during

the food price spike were significantly more likely to be wasted than those born into non-adopting households. These findings provide additional evidence of the uneven effects escalating food prices have on the nutritional outcomes of children in cash crop producing households.

Table 2.5: In Utero During Stable or Shocked Prices Robustness Results, Select Variables

	Maize Stable	Maize Shocked	WAZ Stable	WAZ Shocked
Tobacco	-0.495	-1.528	-0.244	-1.191
	(0.466)	$(0.810$	(0.364)	(0.740)
Male	0.149^{**}	0.309^{***}	0.055	0.242^{***}
	(0.053)	(0.071)	(0.031)	(0.047)
Permanent floor	0.238	0.103	0.097	0.069
	(0.123)	(0.109)	(0.075)	(0.101)
Child bed nets	0.192^{**}	0.204^{**}	0.147^{**}	0.153^{**}
	(0.069)	(0.064)	(0.049)	(0.057)
Mother high	0.096	0.208^{*}	0.088	0.347^{***}
	(0.103)	(0.085)	(0.080)	(0.082)
2^{nd} income quintile	0.022	0.074	0.021	0.086
	(0.074)	(0.087)	(0.056)	(0.071)
3^{rd} income quintile	0.080	0.128	0.072	0.120
	(0.075)	(0.117)	(0.070)	(0.091)
4^{th} income quintile	0.078	0.173	0.112	0.275^{**}
	(0.064)	(0.116)	(0.056)	(0.107)
Highest quintile	0.132	0.261^{*}	0.096	0.184^{*}
	(0.094)	(0.127)	(0.068)	(0.083)
Southern	-0.055	0.212	0.001	0.014
	(0.174)	(0.127)	(0.127)	(0.107)
Central	-0.200	0.207	-0.010	0.043
	(0.187)	(0.125)	(0.144)	(0.150)
Constant	-2.316^{***}	-2.599^{***}	-1.035^{***}	-1.318^{***}
	(0.225)	(0.308)	(0.207)	(0.163)
Observations	3163	2551	3056	2425

[1] Robust standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05, clustered at the district 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 maize columns only use the maize price 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] Mother high education is mothers who studied beyond primary school.
[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.

Finally, I 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, I 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.

2.7 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). My results expand on previous literature that explored theoretical reasons for negative health outcomes associated with smallholder agricultural commercialization (von Braun, Kennedy, and 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, and 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.

Chapter 3

Unpacking Malawian Agricultural Commercialization: Understanding the Factors Behind Undernutrition

3.1 Introduction

Recent research showing negative nutritional effects of cash crop adoption in Malawi contradict previous findings concerning the benefits of agricultural commercialization (Wood and Nelson, 2012). This paper uses updated data to explore what individual, household and community factors, including direct access to the formal tobacco auctions, influences the nutritional health of commercialized farmers' children. An increased understanding of the attributes associated with nutrition in Malawi may allow for better targeting of future program towards those most in need.

Assessments of vulnerable individuals within Malawi identify the promotion of value added agriculture and building infrastructure as two major paths to improving livelihoods (Devereux et al., 2006). Malawi's recent focus on road construction and maintenance is hoped to have improved market access (Foster and Shkaratan, 2011). Devereux et al. (2006) determine remoteness, measured by the distance to the nearest paved road or primary school, to be a significant contributer to lower asset wealth. Improving transportation has the potential to decrease chronic poverty and malnutrition in Malawi by providing better access to household wealth-generating activities.

Roads represent a major priority in the Malawi's Poverty Reduction Strategy Paper (Government

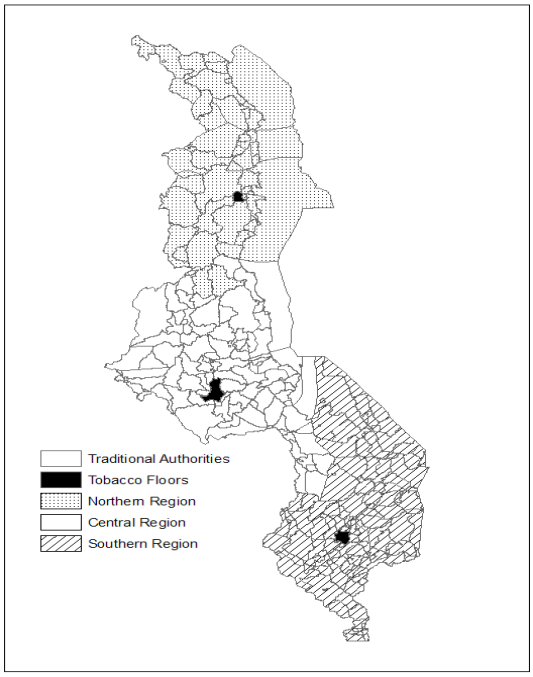


Figure 3.1: Malawi by Region, Traditional Authorities and Tobacco Floors

of Malawi, 2007). They are the main priority listed among important infrastructure improvement needs. Additionally, expansion of the transportation network, agriculture and integrated rural development are half of the broad themes discussed in the document.[1] Specifically, the government looks to add value to tobacco, with accessing formal tobacco auction markets being one of the first steps down this development path.

Tobacco production represents the majority of all Malawian exports and is unique in that international sales must occur at governmentally regulated auctions. An auction floor is located in the largest city in each of Malawi's southern, central and northern regions. As shown in figure 3.1, the distance to the closest tobacco floor varies throughout the country. Although previously required to sell directly to the floors, the Malawian government legalized intermediary sales in the 1990s.

Intermediaries operate throughout the country. Oftentimes they are private traders, who offset auction risk uncertainty by purchasing at below market level prices. The Malawian government, through their Agricultural Marketing and Development Corporation (ADMARC), provides some

[1]Researchers have also highlighted the importance of expanding Malawi's road network in rural poverty reduction efforts (Ellis et al., 2003).

rural trading stations. ADMARC's role in Malawian agriculture has decreased over time but it continues to produce and even purchase small amounts of tobacco in more rural areas.[2]

There are many factors and consequences of selling tobacco on the informal market. On the one hand, smallholders reduce the transportation costs associated with bringing the crop to the market. On the other hand, intermediary buyers' purchasing prices are oftentimes below market levels. Burley tobacco clubs have formed to help reduce the reliance of smallholder farmers on the tobacco intermediaries, and to help circumvent the one bale minimum sales requirement for the tobacco floors (Takane, 2008).

Greater understanding of the factors that influence nutritional outcomes is the first step toward addressing the negative relationship between agricultural commercialization and children's health in Malawi. After testing a number of assistance programs, from tobacco extension services to reducing transportation costs, I do not discover the mythical magic bullet that may not exist. General trends show that increasing access to formal tobacco markets and reducing rural to urban transportation rates has beneficial effects on children's health. But there is not one single policy to change the situation, which accurately reflects my personal experience on-the-ground in Malawi.

3.2 Literature Review

A number of policies have been floated to improve Malawian health outcomes. The development field has previously identified a number of methods to improving children's nutritional health, from encouraging more education for mothers to increasing agricultural outputs through extension services. Improving market access through infrastructure improvements is one of the stronger recent arguments, with supporters claiming wide-reaching benefits to commercialized (and commercializing) households.

A wide variety of development literature focuses on nutritional health and infrastructure improvement. Individual, household and community level factors may alter children's nutritional

[2]See The World Bank (2003) for more information on AMDARC's influence on rural producers.

levels. Infrastructure, with the health care access and wealth-generating activities that typically accompany its construction, has also been shown in past studies as beneficial to children's health. By merging the literature surrounding these general topics, this research extends and supports previous development findings.

Stunting is primarily a measure of a child's height for age, thus major characteristics of the children must be taken into account when using stunting as the dependent variable. Most health and nutrition studies account for the gender of the child. Pongou et al. (2006) find the change in malnutrition rates between 1991 to 1998 in Cameroon to differ between males and females, with the males' difference being highly significant. Other variables like age of the child and number of siblings may also influence nutritional outcomes and are therefore included in the estimations.

Many more household level factors affect stunting, including age of the household head, household size, and income of the household. Age of the household head may reflect a shift in values or simply more accumulated knowledge. Rahman and Chowdhury (2007) split household heads into older and younger categories and conclude that children living in households with older household heads are significantly less likely to be stunted. Children who live in larger households might be shorter than children who live in smaller households because of the quantity of food required to feed the additional household members, so this variable is included in the regressions (Wolfe and Behrman, 1982). Masanjala (2006) determines that increasing asset and off-farm income to be more important than farm income in reducing stunting. Babatunde and Qaim (2010) support this result by showing significantly lower levels of stunting in households with higher levels of off-farm income.

A number of publications focus on the relationship between mother's education or mother's bargaining power and child's health. The notable study by Lundberg et al. (1997) on the pooling of household resources is an early example of research examining changes in childhood welfare in relation to altering the gender of the adult income recipient. Recent work continue to find mother's education highly significant in relation to stunting (Boyle et al., 2006; Frost et al., 2005). Glewwe (1999) determines that mother's education to be a proxy for health education, possibly through literacy, while Kabuno-Mariara et al. (2008) find mother's education specifically more important

than parents' education in predicting stunting.

Household geographic location has also been important in the literature. Sastry (1996) and Thomas and Strauss (1992) determine urban status important in assessing stunting. And Orr et al. (2009) argue that Malawian regions differ in general household characteristics, thus providing additional covariates in the estimations.

Barriers to trade entry represent a major strain in the development literature. Questions over market failures and rural infrastructure have produced estimates of a 15% ad valorum tax on fixed transactions costs for rural Kenya agricultural producers (Renkow et al., 2004). Smallholder trade impediments, in the forms of a general inability to access markets, inefficient agricultural credit allocation or a lack of technology/knowledge dispersion, have been identified as a significant cause of rural underdevelopment (Barrett, 2008). Many developing countries have focused on rural infrastructure projects as a means of improving smallholder market participation.

A number of studies have looked at the effects of road building in the developing world. Although traditionally thought to provide many benefits to rural households, the studies examining the effects of expanding road networks discover mixed results. Previous research has measured the effects of additional road access through changes in labor income, households' consumption and poverty levels.

Gachassin et al. (2010) explore the perceived benefits of rural road construction in Cameroon. They use time to the nearest tarred road to proxy for road construction in a nationally representative cross-sectional household survey. Contrary to common belief, they find rural road access does not provide significant poverty reduction benefits, with the real gains coming from increased labor income. Their findings suggest that rural road expansion is not a panacea for general underdevelopment, and that policymakers should focus on specific goals to maximize effectiveness.

Road expansion has been shown to positively influence household per capita consumption and income. In a carefully designed experiment specifically testing the impacts of Peruvian road rehabilitation, Escobal and Ponce (2002) use a smoothed propensity score matching technique to evaluate consumption and income changes. They find road maintenance to improve household

income, mostly through increasing non-agricultural income. Consumption patterns did not vary as much, with evidence of investment in livestock as a possible savings mechanism.

Many researchers have focused on the role roads play in poverty reduction. Gibson and Rozelle (2003) show significant reductions in poverty when increasing rural infrastructure access in Papua New Guinea. They determine that poverty disproportionately affects rural populations in their cross-sectional sample, with distance to road and size of household being key contributers to household poverty status. They conclude that road expansion brings with it a wide range of advantages, from increased economic opportunities to greater medical and educational access.

This paper extends previous research on the effects of agriculturally commercialization and specifically focuses on the factors that influence children's nutritional health outcomes. Benefits from higher tobacco prices through increased market access may partially offset the negative correlation between stunting z-score and agricultural commercialization. Having a greater understanding of the attributes that influence nutrition in agriculturally commercialized households should help evaluate the benefits of continued investment in certain rural development projects.

3.3 Data, Motivation

This research uses the World Bank and the Malawian National Statistics Office's recently completed 2010-2011 Integrated Household Survey (IHS-3) dataset. These data are nationally representative and provide larger sample sizes than previous Malawian projects. The IHS-3 data are particularly extensive, allowing for a better understanding of the household decision-making process.

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

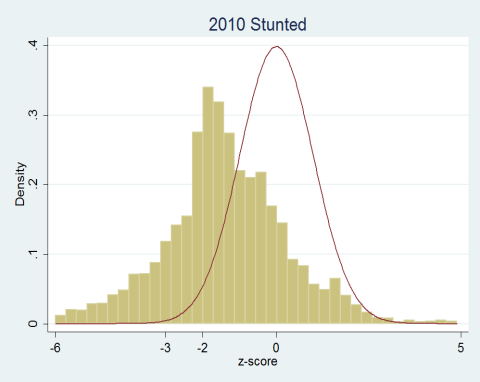


Figure 3.2: General Z-score Distribution

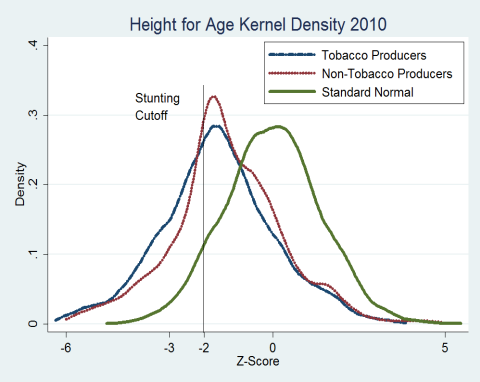


Figure 3.3: Specific Z-score Distribution

experience greater probabilities of early mortality, decreased physical capabilities and diminished mental capacity (Grantham-McGregor et al., 2007; Fawzi et al., 1997).[3]

Malawi has traditionally struggled with low height for age z-scores (World Health Organization, 2009). As seen in figure 3.2, these data continue to show negatively skewed z-scores. In comparison to the representative group, a disproportionate number of Malawian children between the ages of 6 months and 5 years fall to the left of the two standard deviations below zero stunting cut-off line.

Crop specific stunting trends also follow previous patterns. Figure 3.3 shows tobacco producing households continuing to demonstrate a greater likelihood of having stunted children. This correlation questions traditional agricultural development assumptions and needs to be further analyzed to greater understand the relationship between tobacco production and low nutritional outcomes.

I use a number of individual, household and community level variables to understand the relationship between tobacco producing households and children's nutritional status. The significantly different mean values for a number of the covariates seen in table 3.1 reflects a certain set of characteristics related to children's nutritional health.[4] Due to the general differences in the distributions between tobacco and not-tobacco producing households, I compare the normalized difference in their mean values using an unpaired, unequal variance t-test. P-values are not reported, as the

[3]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).

[4]Wooldridge (2010) suggests normalized mean differences to generally be significant if the values is above 0.25.

Table 3.1: General Summary Statistics according to Tobacco Production Status

	Non-Tobacco	Tobacco	Normalized Difference
Gender (male)	0.50	0.51	−0.48
Age (months)	32.71	32.64	0.11
Mother's educ (high)	0.15	0.13	1.41
Father's educ (high)	0.25	0.28	−1.75
Household head age	36.43	35.30	2.73
Children under 15	3.23	3.34	−1.81
Cell phone access	0.35	0.35	−0.18
Permanent floor	0.16	0.08	6.15
Rainy acres (kms)	1.56	2.67	−20.16
Ag income	4.26	10.44	−76.15
Enterprise income	2.07	1.58	3.08
Wealth index	−0.66	−0.95	4.66
Tobacco extension	0.10	0.41	−15.38
Child hosp exp	0.83	0.93	−0.96
Child trad med	0.04	0.03	0.31
Dist main road	9.42	10.77	−3.09
Central region	0.34	0.64	−15.15
Northern region	0.18	0.22	−2.41
Urban trans. cost	5.93	6.12	−2.22
Observations	5943	617	

[1] An unpaired t-test with unequal distributions is performed to recover the normalized differences in the mean values.

[2] Chi hosp exp represents children's formal hospital expenses, while Chi trad med represents children's traditional medicine expenses, both of which are also entered in the log form. Children's traditional and formal health expenses, agricultural income, business income, and urban transportation cost are in log form. Urban transportation cost is a subjective measurements of recent changes in these services. High education is defined as above eighth grade.

unequal nature of the comparison does not lend itself to traditional comparisons of the mean values.

The normalized mean value comparisons between the two groups indicate that tobacco producers were generally led by younger household heads, were less likely to have a permanent floor, controlled more land, received more income from agriculture and less from enterprises, and had less wealth than non-tobacco growing households. Additionally, there appears to be some geographic patterns to the growing decision. Tobacco producing households were farther from the main roads, with greater cost to reach the urban areas. My simple ordinary least squares identification does not account for possible endogeneity within the variables. Additionally, the absence of certain highly important agricultural-related observations, like agro-climatic condition of the land or access to

rainfall, may lead to unobserved variable bias. Due to these limitations, my paper is not a casual explanation but more of an exploratory correlation study looking at the attributes and characteristics associated with children's nutritional outcomes.

Table 3.2: OLS Results, Full Children's Sample with z-score as the Dependent Variable

Burley grower	-0.349^{*}	Male child	-0.196^{***}
	(0.148)		(0.047)
Age in months	-0.010^{***}	Mother's educ, high	0.027
	(0.002)		(0.067)
Father's educ, high	-0.086	House head age	0.000
	(0.056)		(0.003)
Rainy acreage	0.028	Children under 15	-0.023
	(0.028)		(0.023)
Ag Income	-0.003	Enterprise Income	-0.004
	(0.008)		(0.007)
Cell phone	0.125^{*}	Chi hosp exp	0.021
	(0.058)		(0.016)
Chi trad med exp	-0.044	Asset wealth index	-0.006
	(0.036)		(0.021)
Permanent floor	0.225^{*}	Central region	-0.133
	(0.086)		(0.197)
Southern region	0.720^{***}	Distance main road	-0.002
	(0.190)		(0.003)
Urban trans cost	-0.032	Constant	-0.828^{**}
	(0.041)		(0.281)
Observations	6560		

[1] Robust clustered standard errors *** p<0.001, ** p<0.01, * p<0.05, with population weights

[2] Chi hosp exp represents children's formal hospital expenses, while Chi trad med represents children's traditional medicine expenses, both of which are also entered in the log form. Children's traditional and formal health expenses, agricultural income, business income, and urban transportation cost are in log form. Urban transportation cost is a subjective measurements of recent changes in these services.

The previously discovered negative relationship between tobacco adoption and children's stunting levels in the 2004-2005 (IHS-2) data remains in this new dataset. After controlling for a number of important nutritional factors, and clustering the robust standard errors at the district level, table 3.2 demonstrates that the significantly negative correlation continues to exist between tobacco

producers and low stunting z-scores. These results show the importance of accounting for gender and age. Some household and locational attributes, like living in a household with a permanent floor, also significantly influence children's stunting z-score.

In order to better understand the influence burley tobacco growing has on children's health, I limit the sample to smallholder burley-producing households that reported the sales mechanism they chose for their tobacco. The narrow scope of the paper allows for a deeper analysis of the factors that influence health outcomes, with a specific focus on formal market access. Unpacking the factors behind the significantly negative influence burley tobacco production continues to exert on children's nutritional health will help policymakers accurately target future assistance.

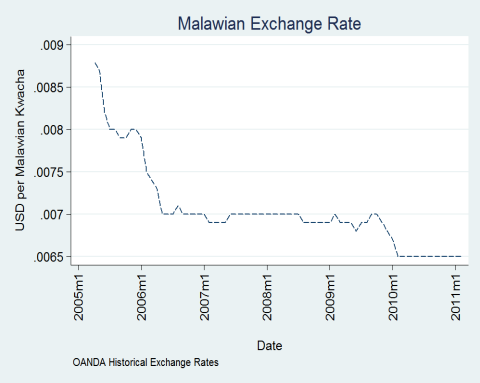


Figure 3.4: Malawian Exchange Rate

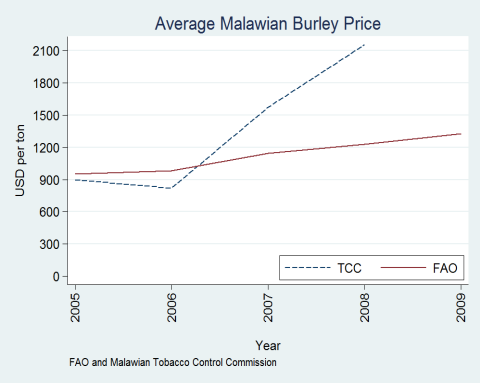


Figure 3.5: Malawian Burley Price

The negative relationship between tobacco and nutritional health is unexpected, as Malawi's currency has not fluctuated greatly over the last five years and the price of burley tobacco has increased significantly. Figure 3.4 shows Malawi's Kwacha has lost about a quarter of its value, which undoubtedly affects tobacco producers who are reliant upon the market to buy food. But Malawian burley tobacco prices, as shown in figure 3.5, have consistently climbed over the same timespan. The official Malawian Tobacco Control Commission shows a more than doubling of prices, while the United Nations' Food and Agriculture Association reports a more modest price rise.

In light of these initial findings, this paper examines how access to the characteristics attributed to formal tobacco market households have influenced children's stunting. Malawi has focused

recent infrastructure investments on road building, thus theoretically increasing access to higher formal tobacco market prices while simultaneously decreasing transportation costs.

Table 3.3: Burley Only Summary Statistics according to Tobacco Sales Channel

	Informal	Formal	Normalized Difference
Gender (male)	0.53	0.49	0.88
Age (months)	32.56	32.61	−0.02
Mother's educ (high)	0.12	0.15	−0.89
Father's educ (high)	0.22	0.32	−2.42
Household head age	34.68	35.74	−1.29
Children under 15	3.20	3.41	−1.74
Cell phone access	0.29	0.39	−2.41
Permanent floor	0.03	0.12	−4.24
Rainy acres (kms)	2.36	2.84	−4.60
Ag income	9.90	10.74	−7.73
Enterprise income	1.53	1.66	−0.41
Wealth index	−1.44	−0.66	−7.91
Tobacco extension	0.36	0.44	−1.85
Child hosp exp	1.11	0.86	1.15
Child trad med	0.03	0.03	0.02
Dist main road	10.21	11.04	−1.02
Central region	0.70	0.60	0.09
Northern region	0.11	0.28	−5.34
Urban trans. cost	6.25	6.06	1.23
Observations	217	400	

[1] An unpaired t-test with unequal distributions is performed to recover the normalized differences in the mean values.

[2] Chi hosp exp represents children's formal hospital expenses, while Chi trad med represents children's traditional medicine expenses. Children's traditional and formal health expenses, agricultural income, business income, and urban transportation cost are entered in log form. Urban transportation cost is a subjective community level measurements of average cost to the nearest urban center. High education is defined as above eighth grade.

A number of differences present themselves in table 3.3 when examining summary statistic comparisons between burley tobacco households choosing to sell through informal and formal channels. The normalized mean value comparisons demonstrates some significant differences between formal and informal market sales channel participants. Formal market participants are more likely to have higher educated men, additional children under the age of 15, greater access to cell phones and higher quality flooring in their homes. From an agricultural perspective, they

generally control more land, receive more agricultural income (although are not generally wealthier), and show some regional growing patterns.

Similar to the previous summary statistics, the lack of a common distribution requires examination of normalized mean values of unequal variances. As explained previously, my ordinary least squares identification strategy at this point will only establish correlations between certain attributes and children's nutritional outcomes. But by gaining a better understanding of the factors that are closely related to children's health, this research is a first step to disentangling the negative relationship between tobacco production and low height for age stunting z-scores.

Table 3.4 examines some of the factors that influence children's nutritional outcomes, with child's z-score being the dependent variable in this ordinary least squares regression and clustering the robust standard errors at the district level. Some of the traditional development measures, like households led by more knowledgeable older household heads and having fewer children to feed under the age of 15 were more likely to reduce stunting. Surprisingly, increasing agricultural income and being a male child were actually more likely to decrease children's health. Spending more money on children's formal medical treatment was also likely to lead to a higher stunting z-score.

These results offer some support for the argument that infrastructure improvements may prove beneficial for children's nutritional health. Larger tobacco harvests were significantly more likely to decrease children's health. And greater urban transportation costs were highly significant in the negative direction, meaning they were more likely to lead to lower nutritional outcomes. But formal market access showed a positive correlation with higher nutritional outcomes.

These formal market and urban transportation cost findings help justify continued policy focus on infrastructure improvement. Interpreting table 3.4 in a policy context, reducing transportation costs and increasing formal market access is, in general, correlated with healthier children. Concentrating on infrastructure improvement is supported by these encouraging positive correlations.

Table 3.4: OLS Results, Burley Only Producers with z-score as the Dependent Variable

Formal market	0.388^{*}	Male child	-0.498^{***}
	(0.181)		(0.099)
Age in months	-0.004	Mother's educ, high	0.352
	(0.004)		(0.255)
Father's educ, high	-0.128	House head age	0.018^{*}
	(0.127)		(0.008)
Tobacco Harv $<$	-0.000^{*}	Rainy acreage	0.021
	(0.000)		(0.071)
Children under 15	-0.157^{*}	Ag inc	-0.095^{**}
	(0.076)		(0.029)
Business Inc	0.025	Tobacco extension	0.120
	(0.022)		(0.161)
Cell phone	-0.069	Chi hosp exp	0.055^{**}
	(0.299)		(0.017)
Chi trad med exp	0.183	Asset wealth index	0.027
	(0.169)		(0.131)
Permanent floor	-0.040	Central region	-0.543^{*}
	(0.253)		(0.233)
Southern region	0.812^{**}	Distance main road	-0.009
	(0.266)		(0.005)
Urban Trans Cost	-0.096^{***}	Constant	0.080
	(0.020)		(0.518)
Observations	617		

[1] Robust clustered standard errors, *** p<0.001, ** p<0.01, * p<0.05, with population weights

[2] Chi hosp exp represents children's formal hospital expenses, while Chi trad med represents children's traditional medicine expenses. Children's traditional and formal health expenses, agricultural income, business income, and urban transportation cost are entered in log form. Urban transportation cost is a subjective community level measurements of average cost to the nearest urban center.

3.4 Exploring Heterogeneous Effects

Trying to understand the factors that influence nutritional outcomes is fairly complex. Questions over possible heterogeneous outcome measures led to some additional simultaneous quantile regressions presented below. Examining the households in different sections of the distribution allows for a more robust understanding of the attributes that affect the stunting z-scores.

The results in table 3.5 are difficult to interpret, as no individual variable is shown to uniformly

influence all quantiles of children. The quantile regression, with child's z-score continuing to be used as the dependent variable, shows results for the first, twenty-fifth, fiftieth and seventy-fifth slices of the distribution.[5] Although the results fail to advocate for one individual policy, they do shed some additional light on the factors correlated with nutritional income that differ among different sections of the population.

In general, the findings present mixed results. Children in households with more children under the age of 15 are more likely to be stunted. Spending more money on formal children's health services shows generally positive results, expect for in the lowest group. The regional dummies exert a strong influence, demonstrating the importance of accounting for geographic location when attempting to understand nutrition health outcomes.

The formal market and urban transportation costs are of particular interest. Participating in the formal markets is unambiguously positive, with a significant result at the fiftieth and seventy-fifth groupings. Urban transportation cost is a bit trickier to interpret, as the sign switches after the first group. In general, higher transportation costs appear to be more likely to be correlated with lower nutritional outcomes for healthier children, which brings into question the infrastructure focus as a means of combating poor nutritional outcomes. Future studies that more specifically measure this subsection of the population may produce more accurate results, which may decrease the standard errors and allow for a clearer understanding of the influence of infrastructure improvements and formal market access on children's nutritional health.

3.5 Conclusion

This research confirms the correlation between agricultural commercialization and negative children's health outcomes. Future studies may tease out the causation behind this relationship further, possibly by incorporating the previous Integrated Household Survey from 2004-2005. Future researchers will need to further unpack the relationship differences between formal and informal

[5]Limitations within the quantile regression estimation disallow the use of weights and robust standard errors.

Table 3.5: Quantile Results, Burley Only Producers with z-score as the Dependent Variable

	q01	q25	q50	q75
Formal market	0.778	0.252	0.396*	0.439*
	(0.422)	(0.186)	(0.190)	(0.206)
Male child	0.208	−0.378*	−0.278	−0.374*
	(0.364)	(0.173)	(0.171)	(0.178)
Mother's educ, high	0.644	0.398	0.479	0.195
	(0.586)	(0.273)	(0.284)	(0.254)
House head age	0.033	0.012	0.014	0.016
	(0.024)	(0.012)	(0.009)	(0.009)
Children under 15	−0.177	−0.180**	−0.208**	−0.110
	(0.148)	(0.062)	(0.067)	(0.063)
Ag income	−0.339**	−0.156**	−0.095	−0.070
	(0.120)	(0.057)	(0.056)	(0.055)
Tobacco extension	−0.369	0.101	0.330	0.323
	(0.368)	(0.186)	(0.176)	(0.190)
Cell phone	0.670	0.067	0.069	−0.068
	(0.542)	(0.230)	(0.220)	(0.275)
Chi trad med exp	−0.013	0.041	0.080*	0.049
	(0.076)	(0.035)	(0.037)	(0.038)
Asset wealth index	−0.007	−0.000	−0.082	−0.070
	(0.180)	(0.082)	(0.094)	(0.130)
Central region	−0.926	−0.571	−0.861**	−0.446
	(0.598)	(0.331)	(0.284)	(0.350)
Southern region	1.135	0.918*	0.488	0.994*
	(0.608)	(0.417)	(0.320)	(0.387)
Distance main road	−0.020	−0.008	−0.006	0.002
	(0.021)	(0.011)	(0.009)	(0.011)
Urban Trans Cost	0.070	−0.030	−0.102	−0.133*
	(0.098)	(0.050)	(0.054)	(0.054)
Constant	−3.108	−0.381	0.351	0.513
	(1.764)	(0.843)	(0.763)	(0.901)
Observations	617	617	617	617

[1] *** p<0.001, ** p<0.01, * p<0.05 with 400 bootstrap replications

[2] All of the variables from table 3.4 are also used here, with the same variable entered in log form. Agricultural and business income, father's education, tobacco harvested, rainy acreage, traditional medicine expenditure and permanent floor results are insignificant and are available by request to the author. Urban transportation cost is a subjective measurements of recent changes in these services. High education is defined as above eighth grade.

market participants, as demonstrated by the differences in the simple summary statistic normalized mean values. At this point, I am able to determine that formal market participation and reducing urban transportation costs are significantly likely to increase children's health in general. Other traditional development investments, like increasing tobacco extension services or agricultural income fail to demonstrate similar positive correlations, suggesting future policymakers should possibly focus their efforts in alternative directions.

The quantile regressions, although difficult to interpret, generally supported a positive relationship between formal market participation and children's nutritional health. My current results are limited to correlation, due to the difficulties with identifying a causal mechanism and limited sub-sample sizes. Future research may be better able to account for unobserved variables including more refined geographic location, agro-climatic land conditions, and an ability to account for risk preferences, which would prove helpful in more accurately identifying the causal chain. These results should help motivate researchers to continue exploring the relationship between infrastructure and health.

Concerns remain over the interaction between infrastructure improvement and increasing formal market participation. Road investment, while important, does not necessarily translate into lower transportation cost. Recent research has found sticky transportation prices, even after the significant expansion to Malawi's road network (Lall et al., 2009). Encouraging competition and developing regional markets more would allow for more efficient trucking. Current one-way trade into the major cities limits the economic benefits of utilizing the new roads, as truckers oftentimes are only paid for their trips into the cities.

In addition to transportation costs, questions have also been raised over the Malawian public sector. Inefficient decentralized local government issues may further distort rural prices and blunt the benefits derived from the expanded road network (Ellis et al., 2003). Further research into price differences or local government restrictions might demonstrate even greater possible gains from increasing market access.

While further refinements will increase the strength of this analysis, formal market access

appears to relate to better nutritional outcomes after burley tobacco crop adoption. For agricultural commercialization to fulfill Malawi's development aspirations, a greater understand of the means to reverse negative stunting patterns is required. This study, taken in conjunction with others like Fafchamps and Hill (2005) that outline the importance of formal market participation, is another step down the path of encouraging rural development and nutritional health.

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