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Consumption Smoothing and Labor Supply Allocation Decisions: Evidence from Tanzania

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Abstract

This paper tests the hypothesis that agricultural households engage in intermittent wage labor as a way to smooth consumption in the face of idiosyncratic shocks to agricultural income. Using data on agricultural households from the Tanzanian LSMS-ISA National Panel Survey and global commodity price data as a source of plausibly exogenous variation, the sensitivity of wage labor to farm income shocks is estimated. The idiosyncratic shock to post-harvest income is estimated by incorporating pre-harvest information, including local farm-gate prices as instrumented by global commodity prices. The results show that households are more likely to select into wage labor and work more hours in response to negative income shocks. Positive income shocks are shown to have a weakly negative effect on selection into wage work and hours worked. This response may help to explain the lack of an observed relationship between consumption and income shocks if wage labor can be thought of as an informal insurance mechanism which allows households to effectively smooth their consumption.

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1 Introduction

This paper attempts to estimate the labor allocation response of Tanzanian farm households to idiosyncratic shocks to crop income, following the previous work of Kochar (1999) who estimated a similar response by Indian farm households. As an extension of Kochar (1999), this study makes use of a much larger nationally representative dataset and provides a different identification strategy as described below. The motivation for this branch of literature comes as a response to the well established view in economics that labor markets in developing countries are characterized by market failures which prevent fluid movement in and out of market labor activities (Stiglitz, 1976; Dasgupta and Ray, 1986). Therefore, this paper seeks to add to the literature by testing the extent to which those conditions prevail in a different context. In addition, a secondary aim is to explore the degree to which global factors such as commodity prices influence the lives and decisions of households in developing countries, in a similar fashion as recent work by Adhvaryu, Kala and Nyshadham (2013).

While evidence that agricultural households adjust their labor supply in response to shocks to farm income exists, most of this literature shows that households behave in a theoretically predictably way by increasing labor supply after a shock in order to smooth consumption (Skoufias, 1993; Jacoby and Skoufias, 1997; Skoufias and Parker, 2002). In addition, there is evidence that the marginal propensity to consume out of wage income is greater than the marginal propensity to consume out of own-farm income, suggesting that wage labor can act as an intermittent supplement to farm income as a method to smooth consumption (Carriker et al., 1993). However, in comparison to the vast literature on precautionary savings or credit, the evidence on labor supply decisions in response to shocks is relatively limited, so the primary contribution of this work is to provide an additional case in which the degree of labor supply response to idiosyncratic shocks is estimated.

1.1 Literature Review

What follows is a loosely chronological review of the relevant theoretical and empirical literature which is influential to this work. There are at least five major branches of the literature which are identified as essential to understanding this type of analysis. Section 1.1.1 will present the basic theory of the agricultural household. Section 1.1.2 will expand on this basic view of the agricultural household by reviewing the theory regarding household saving and consumption smoothing mechanisms. Section 1.1.3 will explore the literature on labor markets in developing countries and examine theories on how households respond to income shocks. Finally, Section 1.1.4 will present literature dealing specifically with the relationship agricultural households have with commodity markets.

1.1.1 Agricultural Households

The primary unit of analysis in this study will be agricultural households in Tanzania, therefore it is essential to start with a theoretical framework of such households. The agricultural household model was developed as a way to understand the dynamics of farming households who act as both producers of agricultural goods and consumers of those good. One of the first attempts was by Kuroda and Yotopoulos (1978), who sought to explain the lack of observed correlation between staple price increases and market surplus in Japan. In a world with complete markets, households would decide between consuming own-produced goods or selling them on the market; likewise they would decide between using their own labor on the farm or hiring in labor and consuming more leisure.

However, in most rural areas of developing countries markets may not be complete or even exist at all. In these cases, the notion that household production and consumption decisions are made separately may not accurately describe agricultural households. According to Taylor and Adelman (2003), a more accurate model should explain the net-surplus production of farm households, subsistence and sub-subsistence household farms, small-scale renter and sharecropper farms, and small-scale industrial farms. The first model to explain all of these behaviors was presented by Singh, Squire and Strauss (1986). Others expanded the framework by allowing for endogenously determined shadow prices in the case of missing or incomplete markets (De Janvry, Fafchamps and Sadoulet, 1991). Rosenzweig (1980) added another important addition to the literature on agricultural households by extending the neoclassical model to allow for differing levels of land ownership between households, and derived testable hypotheses about labor supply and education relationships for households based on the level of land ownership.

Taylor and Adelman (2003) go on to suggest that market structure is the key characteristic when considering the response households will have to policies or shocks, or when deriving any comparative statics. Indeed, they suggest that one of the most important assumptions in many agricultural household models is that family and hired labor are perfect substitutes and that the household can sell labor at a market wage. This paper will attempt to test the latter part of that assumption.

1.1.2 Saving and Consumption Smoothing

This paper is primarily concerned with the extent to which agricultural households can smooth their consumption in the face of price shocks. As such, it is crucial to consult the relevant literature on savings and consumption smoothing in developing countries. Perhaps the best place to start with this branch of the literature is with Deaton et al. (1989), who developed a model of households which are credit constrained but which accumulate a buffer stock of assets in order to smooth consumption when faced with a negative income shock. This model of household savings and consumption smoothing was an innovation over the previously held notion that households smooth consumption out of permanent income, as suggested by Friedman (1957). The model diverges from the permanent income hypothesis in a few key ways, including by allowing for multi-generational households with intra-household transfers, by allowing for the declining absolute risk aversion characteristic of households dependent on uncertain agricultural income, by not permitting borrowing, and by defining saving as a high-frequency inter-temporal type of saving.

Any discussion on savings and consumption smoothing in an agricultural context invariably leads to a discussion on insurance and risk. Agricultural households in poor countries tend to be involved in income generating activities which are risky and intermittent, due to fluctuations in the weather or other external forces. Rosenzweig (1988) developed a model to explain the role of the household as a risk-mitigating institution that took into account the structure of the household and the degree to which the household engaged in consumption smoothing. He suggests that there are six important characteristics of agricultural households which must be taken into account in order to understand how risk is mitigated, including stochastic weather inputs, the stationary inter-temporal distribution of weather outcomes, positive correlations in weather outcomes which diminish over space, land as an immobile factor, stable or constant production technology, and the high cost of acquiring information.

Taking into account these characteristics of rural households, the theory of insurance that has developed suggests that risk-adverse agents are able to insure themselves locally out of the stock of accumulated village assets, so that household consumption can be expected to move along with average village consumption (Rosenzweig, 1988). In an empirical test of this theory, Townsend (1994) found that although formal insurance markets were non-existent in rural India, households were able to smooth consumption via asset transactions and that household consumption did in fact co-move with average village consumption.

In light of these findings, many economists have questioned the demand for formal insurance in developing countries. However, formal insurance schemes such as weather or index based insurance have grown in popularity among development agencies and NGOs as a tool to fight poverty. In an examination of demand for such products, Mobarak and Rosenzweig (2012) develop a theory of formal insurance demand that suggests informal networks lower demand for insurance if the network protects against aggregate village-level risk, but not if networks only insure against household-specific risks. Using data from India, they find that formal and informal network based insurance can in fact act as compliments under certain circumstances, allowing households to take on more risk and smooth consumption.

1.1.3 Labor Markets in LDCs

Given that the main focus of this paper is on extent to which labor markets in rural Tanzania can act as a buffer to shocks, it is imperative to review the literature on labor markets in developing countries. One of the most important contributions to this branch of the literature was by Stiglitz (1976) who formalized the efficiency wage hypothesis. This hypothesis sought to explain unemployment in developing countries by suggesting that employers would pay employees more than a market wage in order to increase efficiency or prevent shirking when monitoring is difficult. This could potentially lead to a pool of un- or underemployed people in urban markets especially when considering the type of rural to urban migration described by Lewis (1954), who suggested that surplus agricultural labor from rural areas would migrate to urban areas where a fixed wage was paid to manufacturing laborers.

An update to the Lewis (1954) model came from Harris and Todaro (1970) (H-T) who suggested that rural agricultural workers would migrate to urban areas based on the expected wage in the urban area, so that an equilibrium is reached when the expected wage in the urban area is equal to the marginal product of labor in the agricultural sector. Many updates and extensions to the H-T model have been suggested, including by Fields (1975), who extended the model by generalizing job-search behavior, allowing for different urban sectors, allowing for hiring based on observed educational level, and by considering labor turnover. The model developed by Fields (1975) predicted a much lower unemployment rate than predicted by the H-T model.

However, this paper is more concerned with labor market outcomes in the *rural* sector itself. To that effect, a slightly different but related branch of literature, dealing with own-farm and off-farm labor allocation decisions, is of primary relevance. Huffman (1980) found that increasing investment in human capital by farm households increased the amount of off-farm or market labor performed, and developed a theoretical model that assumed labor supply decisions of farm households would be made jointly between a wage earning job and own-farm employment. However, this model assumed that decisions on farm inputs were made simultaneously with labor market allocation decisions, an assumption that may seem dubious in the face of the seasonal nature of agricultural work. Skoufias (1993) addressed this issue by developing a model of labor utilization in agricultural households where decisions are made in a two-stage dynamic framework, corresponding to planting and harvesting periods. He found that households made planting decisions based on the perceived risk of the harvest yield; a shock could be realized if the actual harvest was less than or greater than the *ex ante* expected harvest. Furthermore, Mishra and Goodwin (1997) theorized that risk averse farmers with greater farm income variability would increase their off-farm labor supply as a way to mitigate the risk associated with higher income variability. They found that this is indeed the case with a sample of U.S. farm households.

It is clear from the literature that agricultural households sometimes use market labor as a way to mitigate risk and smooth consumption. Reardon (1997) proposed that rural non-farm labor was just one of several ways in which agricultural households could diversify their income sources. However, he also found that the markets for non-farm income in rural areas of Africa were not well developed and that most non-farm employment tended to be informal in nature, leading to an unequal distribution of non-farm earnings across rural areas. It light of these and other findings, it is a pertinent research question to understand more about how these rural non-farm labor markets function and the extent to which they benefit agricultural households.

While this paper will focus primarily on the effect on labor supply of commodity price shocks, there are many different types of income shocks agricultural households may be subject to, and there is a large body of literature examining how households respond to those shocks. For example, Jacoby and Skoufias (1997) find that agricultural households in India reduce their investments in education as a response to weather/season related income shocks. In this sense, certain types of consumption like educational expenditures can be seen as a form of self-insurance poor agricultural households use to mitigate income shocks. Skoufias and Parker (2002) find a similar result in Mexico, where exogenous shifts in the unemployment rate change the intra-household division of labor and also reduce the probability of school attendance.

1.1.4 Commodities

The final important branch of the literature regards the choice of instrument in this paper, commodity prices. It has long been observed that agricultural households in developing countries appear to be at great risk to the whims of global markets for various staple goods. Newbery and Stiglitz (1982) recognized this situation and developed a theory of optimal commodity storage to explain how farms could keep some of their harvest in storage as a form of insurance against both price shocks and production shocks such as weather in the next harvest period. This theory rests on the assumptions that agents are risk neutral, hold common objective beliefs about price distribution over different states of the world, and have access to perfect capital markets to finance their storage. All of these assumptions are likely violated in the context of rural agricultural households in developing countries, so some modifications to the theory were needed.

Deaton and Laroque (1992) apply the aforementioned theoretical framework to data on a series of typical commodities and find that, in general, the behavior of prices do conform to conditional expectations. However, due to nonlinearities induced by non-negative inventories and the price series themselves, there are abnormal events in the data that cannot be explained by the theory put forth by Newbery and Stiglitz (1982). They also find that the optimal storage theory does not explain the high degree of autocorrelation present in most commodity price series. Deaton (1999) goes on to suggest a theory of commodity price movement that is based in part on early work done by Lewis (1954), who suggested that the price of a given commodity could not rise above the costs of growing it in the lowest wage country where a significant amount of it is grown. This implies that, since wages have grown slowly in rural Africa where many commodities are grown and exported, there is no predictable trend in commodity prices, but rather a tendency for mean reversion that is continually buffeted by short-run innovations to the global price. However, Deaton (1999) provides a counterexample to this theory by examining the situation where industrialized countries can compete with poor countries in commodity production by substituting productivity for low wages. In this case, the result is essentially unchanged when accounting for factor prices, and trends in commodity prices remain as unpredictable as ever (Deaton, 1999).

1.2 Theoretical Framework

In setting up a theoretical framework that models the labor allocation decision of households in response to farm income shocks, this paper draws heavily from previous agricultural household literature including Taylor and Adelman (2003); Rosenzweig (1980). However, the model presented here is primarily a simplification of model developed by Kochar (1999) which is a dynamic model that divides agricultural production into two stages, pre- and post- harvest. In the pre-harvest stage, households make agricultural production decisions based on the best set of information available to them at that time. In this model, let h_1^o represent total household own-farm labor in the first stage, x_1 represent other pre-harvest inputs such as seeds and fertilizer, and θ_1 represent beginning period shocks to farm income. Therefore, the output in the first stage is:

$$\pi_1 = \pi(p_1, \theta_1, h_1^o, x_1) \tag{1}$$

In the first stage, farmers have yet to realize any revenues from harvest, so output will be negative.

In the second stage, farmers take into account the output (essentially fixed costs of harvesting) from the first stage, as well as harvest specific inputs, own-farm labor during harvest, and farm income shocks realized ex post:

$$\pi_2 = \pi(p_2, \theta_2, h_2^o, x_2, \pi_1(.)) \tag{2}$$

The next step in model formulation is to state the household maximization problem. Household preferences for consumption are given by $U(.)$, which is assumed to be differentiable and increasing in consumption. The household consumes $c(.)$ and produces income by either performing own-farm labor or market wage labor in time period t so that t is a stage in the agricultural production process so that:

$$U = U(c(t), h^o(t), h^w(t)) \tag{3}$$

Assuming that household utility functions are separable over time, the household maximizes utility subject to the inter temporal budget constraint:

$$M(t+1) = (1 + r(t+1)[M(t) + \pi_s(t) + \sum_i w_i(t)h_i(t) - c(t)] \tag{4}$$

$$s = 1, 2 \tag{5}$$

and a time allocation constraint, ignoring leisure for the sake of parsimony:

$$h^o + h^w = \Omega(t) \tag{6}$$

where

$$c(t), h^o, h^w \geq 0 \tag{7}$$

Where $M(t)$ is the household's total budget at the beginning of t and $\Omega(t)$ is the total labor time endowment of the household

Maximization leads to the following first order conditions:

$$U_c(c(t), h^o(t), h^w(t)) = \lambda(t) \tag{8}$$

$$U_{h^w}(c(t), h^o(t), h^w(t)) \geq \lambda(t)w(t) \tag{9}$$

$$U_{h^o}(c(t), h^o(t), h^w(t)) \geq \lambda(t)\frac{\partial \Pi}{\partial h^o}(t) \tag{10}$$

$$\lambda(t) = E_t[\lambda(t+1)(1 + r(t+1))] \tag{11}$$

$\lambda(t)$ is representative of the marginal utility of wealth for the household, and under uncertainty $\lambda(t)$ changes between stages as the household takes into account shocks to update expectations about future farm income (Kochar, 1999). This observation is critical to the empirical strategy to be described below, in which shocks to second-stage harvest income will be estimated using a model of the first-stage information set of the household and used as predictors of market wage employment.

The rest of the paper will proceed as follows: Section 2 will describe the data used in the empirical analysis and Section 3 will describe the three basic steps of the empirical analysis. Section 4 will present results and provide discussion and Section 5 will conclude.

2 Data

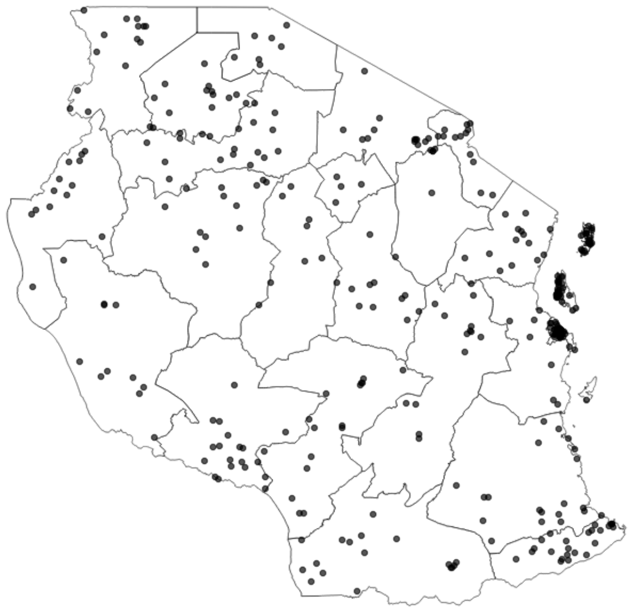
This study uses survey data from three rounds of the Tanzania National Panel Survey LSMS-ISA (NPS). This nationally representative survey collects information on a wide variety of topics including agriculture, labor, demographics, and consumption and expenditures. The first round of the survey was conducted over twelve months from October 2008 to September 2009, the second round was conducted from October 2010 to September 2011, and the third from October 2012 to September 2013. From each round, parts of two survey instruments are used: a household questionnaire conducted at the household and individual level, and an agriculture questionnaire conducted at the household plot and crop level.

2.1 Sampling Design

The NPS survey revisited all households interviewed during the first round of the panel and had a total sample size of 9,338 re-interviewed adults from 3,265 households. These households were sampled from 409 enumeration areas which are defined as either entire villages in rural areas or primary sampling units from the national census in urban areas. The survey was stratified into four different strata: Dar es Salaam, other mainland urban areas, mainland rural areas, and Zanzibar (National Bureau of Statistics United Republic of Tanzania, 2011). The second round of the panel included additional households and individuals to account for the formation of new households that had split off from the original sample, but for the purposes of this study only households which were sampled in both rounds and responded to the agricultural questionnaire are included in the analysis.

A multi-stage randomized stratified sampling procedure was employed with a cluster size of eight households per enumeration area. The selection of clusters was stratified along two dimensions; the first stage comprised of the eight administrative zones in Tanzania and the second dimension consisted of the four strata mentioned above. For Zanzibar, the sample was stratified between rural and urban areas in equal proportions, and for the mainland the sample was stratified between rural

Figure 1: NPS Sample Villages



and urban, and within urban between Dar es Salaam and other urban areas. The share of the sample in rural areas, Dar es Salaam, and other urban areas was arbitrarily fixed at 65%, 17.5%, and 17.5% respectively. In the second stage of sampling, the households within a given cluster were selected. Households that had been part of a previous randomized survey, the Household Budget Survey in 2007 (HBS), were randomly selected within HBS strata while households which were non-HBS were selected by drawing a simple random sample within cluster. Sampling weights were derived to adjust for the probability of being selected for a given cluster, household, or individual (Sandefur, 2009).

Each round of the NPS was enumerated over a span of ten months, which posed significant sequencing and seasonality issues, particularly with agricultural households whose recall after harvest would be dependent on the month in which they were interviewed. In order to combat these issues, the NPS randomized the ordering of interviews so that the time of interview was not correlated with any other important socio-economic factors (Sandefur, 2009). However, timing is still a nontrivial issue when attempting to compare responses to the agricultural questionnaire and the household questionnaire due household questions being asked relative to the time of interview and agriculture questions being asked relative to the time of harvest, which naturally varies depending on the region of Tanzania and the particular crops being harvested. This timing problem poses difficulties to the empirical analysis performed in this study, which shall be discussed in greater detail in Section 3.

Table 1: Descriptive Statistics

	Whole Panel Sample		Households with Wage Earner	
Number of Household-Year Observations	4,101		1,528	
Number of Households	1,815		969	
	Mean	SD	Mean	SD
Head of Household Characteristics				
Age	47.713	15.023	45.117	13.580
1(Female)	0.235	0.424	0.200	0.400
Household Characteristics				
1(Worked for Wages in Past Week)	0.373	0.484		
Total Household Acreage	2.467	3.450	2.491	3.454
Total Harvest Value	306.44	423.88	309.38	415.92
Total Expenditures	3,179.9	2,808.8	3,875.9	3,266.7
Food & Beverage Expenditures	2,140.5	1,560.5	2,491.9	1,735.3
Adult Equivalents in Household	4.255	2.221	4.524	2.289
Household Labor Activity (Past Week)				
Hours Worked for Wages in Past Week	18.402	30.738	49.388	31.709
Own Farm Hours in Past Week	37.456	45.433	27.115	41.120

Note: Harvest values and expenditures shown in thousands TSH, adjusted using a Fisher price index calculated by the NPS with 2008 as base year

As part of the main focus the NPS, annual consumption aggregates were calculated at the household level using household expenditure variables recorded in the survey. While these consumption aggregates were meant to be representative of all household consumption during the past year, due to data and practical issues they overweight food consumption and the consumption of other non-durable goods. Within each round of the NPS, prices were adjusted for cost-of-living differences using Fisher price indices based only on food items. These Fisher price indices adjusted prices by both stratum and quarter of fieldwork in order to account for spatial and temporal price differences in the sample. For the purposes of this study, other nominal monetary values of interest, including harvest values and local farm-gate prices, were adjusted using these same Fisher price indices. In order to adjust for price differences between rounds of the NPS, Fisher food price indices across rounds were estimated at 1.21 and 1.34, respectively. Stated differently, the rate of inflation of food prices between round one and round two was approximately 21% and between round two and round three approximately 34%. These inflation factors were used to express all prices and monetary values in terms of 2008 Tanzania Shillings (for comparison, \$1 USD = 1,151 TSH as of 01/01/2008).

2.2 Commodity Price Data

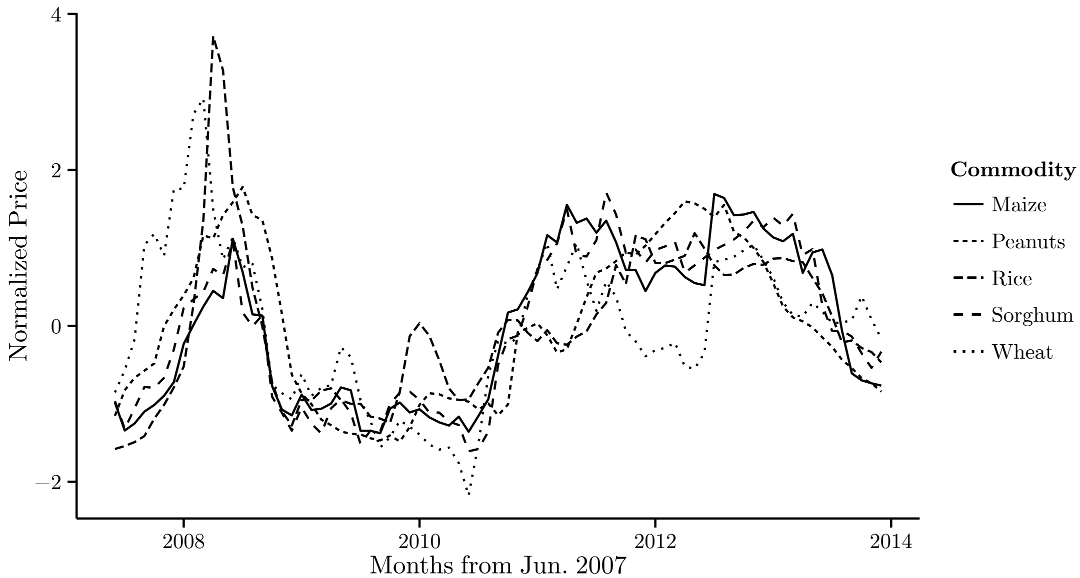
In addition to the primary NPS dataset, this study also incorporates data on global commodity prices gathered from the World Bank's Global Economic Monitor database. A monthly time series of global prices (adjusted to 2008 USD) from June of 2007, sixteen months before the beginning of NPS fieldwork, to December 2013 were pulled for a group of commodity crops. Five of these crops: maize, rice, sorghum, wheat, and peanuts, accounted for 99.7% of plots grown by households in the NPS sample.

The particular time frame for global commodity prices is fortuitous, at least for the purposes of this analysis. The global financial crisis and ensuing Great Recession of 2008/2009 provides an excellent source of dramatic variation in commodity prices, as shown in Figure 2. However, Tanzania was relatively untouched by financial turmoil of the developed world, with GDP growth averaging between 6-7% during the entire time frame (World Bank). This provides an interesting plausibly exogenous shock to agricultural prices which can be exploited for the purposes of identification. In addition, Figure 2 shows the strong co-movement of commodity prices which indicates that farmers may be unable to diversify their crop holdings to mitigate price shocks.

Most households in the NPS harvested multiple crops, so in order to compare prices across households a normalized local price index was created using unit values (harvest value divided by quantity in kilograms) weighted by the proportion each crop contributed to the household's total harvest by value. A similar index was created for global prices, again using the same proportions that each crop contributed to the total harvest value. Since the NPS contains data on the month in which harvest occurred for each household by crop, the normalized global price index was matched to the NPS data by the median harvest month for all crops by household. For example, a farm household which did most of its harvesting in June of 2008 would be matched with the normalized global price index based on its unique set of weights for June of 2008.

It is likely that global prices may take some time to manifest themselves into affecting local farm-gate prices in Tanzania. This could be due to a variety of factors which are applicable in the Tanzanian context, including incomplete markets, poor infrastructure, and low levels of liquidity for existing agricultural stocks (Deaton and Laroque, 1992). For this reason, the six-month lagged global price index was also calculated for each of the commodities and was matched to the NPS data in a similar fashion as the contemporaneous prices.

Figure 1: Commodity Price Co-Movement



3 Empirical Strategy

The empirical strategy employed proceeds in three basic stages. First, in order to test the validity of global commodity prices as an instrument, the extent to which global prices matter for the sample of agricultural households in the NPS is tested on several outcomes including local farm-gate prices, total expenditures, and food and beverage expenditures (Adhvaryu, Kala and Nyshadham, 2013). The following model is estimated for household i in village j at month of harvest t, for outcome O, contemporaneous and six-month lagged global price g, household fixed effects μ_i, and village-year fixed effects $\delta_t \eta_j$:

$$O_{ijt} = \alpha + \beta_1 g_{it} + \beta_2 g_{i,t-6} + \mu_i + \delta_t \eta_j + \epsilon_{ijt} \tag{12}$$

Since the prices vary at the monthly level and by commodity, households that harvest different crops in different months will have different values for the contemporaneous and lagged price.

3.1 Shocks to Agricultural Income

Second, following the example set forth in Kochar (1999), the shock to farm profit experienced by a household in a harvest season is estimated. Farm profit is measured as the total value of harvest for a given household for all crops in a given harvest season minus relevant input costs such as hired labor, seed and fertilizer, land rents, and repayment of inputs purchased on credit. Costs exclude the value of household labor due to the inherent difficulty in estimated such values. The shock to profit, θ_{it}, is defined as the deviation of ex post farm profit from ex ante expectations of farm profit based on the household ex ante information set $I(t-1)$ such that $\theta_{it} = y_{it} - E(y_{it}|I_{i,t-1})$. This can be viewed as an error in forecasting farm profit on the part of the household, and is estimated as the residual from regressing observed farm profit on variables which may plausibly determine household ex ante expectations of farm profit (Kochar, 1999).

The set of regressors used to measure expectations about farm profit include basic household demographic variables, such as the sex of the head of household, the size of the household, and the ratio of children to adults in the household. The local price index faced by the household before harvest is likely a strong indicator that households take into account when forming expectations about farm profits. However, the purpose of this analysis is to ultimately estimate the impact of price shocks on wage labor and local prices are likely endogenous with wage labor, especially if market frictions exist which affect households differentially in some systematic but unobservable way. An instrumental variables approach can help mitigate this endogeneity (Kochar, 1999), and plausibly exogenous global commodity prices might act as a valid instrument for local prices. As such, the following regression is estimated using both contemporaneous and lagged global price indices to instrument for the local price index in addition to household and village-year fixed effects:

$$y_{ijt} = \alpha + \gamma \mathbf{X}_{ijt} + \beta_1 p_{ijt} + \mu_i + \delta_t \eta_j + \epsilon_{ijt} \tag{13}$$

Where y_{ijt} is realized farm profit for household i in village j (village and enumeration area are used synonymously) in time t, with t being defined as a unique month-year group. The $\mathbf{X}_{ijt}$ is a vector of the demographic characteristics mentioned above, and p_{ijt} is the household's local price index as instrumented by the global price indices. The $\delta_t \eta_j$ is a village-year fixed effect and μ_i is a household fixed effect.

In this framework, the predicted residuals obtained from (13) act as estimates of θ_{it}, the shocks to farm profit realized by households (Kochar, 1999). The shock estimates are disaggregated into positive and negative shocks, θ_{it}^{+} and θ_{it}^{-}, respectively, in order to allow for differential impacts of positive and negative shocks to farm income.

3.2 Market Hours of Work and Consumption Effects

Third, the impact of shocks to farm profit on hours of wage labor are estimated in a market hours of work equation. However, it is pertinent to discuss the nature of the data with regards to hours of wage labor. In the NPS, wage labor was recorded as hours worked for wages during the past week. A large portion, around 63%, of the sample reports working no hours for wage labor, and thus the sample can be regarded as censored in terms of selection into wage work. Additionally, the wage labor questions were asked in relation to the time the NPS was administered, while the agricultural questions were asked in relation to the last long rainy season harvest conducted by the household. In order to control for this discrepancy (which was random as designed by the NPS), the number of days between the harvest and the survey administration is included as a control variable. As such, a simple model for estimating hours of wage work can be written as:

$$h_{it}^* = \alpha + \beta \mathbf{X}_{it} + \gamma_1 \theta_{it} + \gamma_2 \theta_{it}^+ + \gamma_3 \theta_{it} \times \theta_{it}^+ + \delta_t + \epsilon_{it} \quad (14)$$
$$h_{it} = h_{it}^* \text{ if } h_{it}^* > 0$$
$$h_{it} = 0 \text{ if } h_{it}^* < 0$$

Where h_{it}^* represents the unobserved latent variable describing demand for hours of wage labor. Possible endogeneity between wage labor hours and farm income shocks is controlled for by using the predicted residuals from (13). Equation (14) is estimated using a Tobit model to correct for the censoring of wage labor hours at zero. However, if different factors are determining selection into wage work than the number of hours worked, then the Tobit estimation will be biased (Puhani, 2000). This seems likely to be the case given that such a small portion of the sample actually perform any wage work and considering possible heterogeneity in labor markets in Tanzania. A possible solution to this problem is to use a Heckman selection estimation technique that allows for different variables to affect selection and behavior. As such, different specifications of the Tobit and Heckman are estimated in order to determine if shocks do impact wage work and if selection is determined by separate factors.

Finally, in order to confirm that households are indeed able to smooth consumption in the face of shocks to farm profits, the following consumption equation is estimated:

$$C_{ijt} = \alpha + \beta \mathbf{X}'_{it} + \gamma_1 \theta_{it} + \gamma_2 \theta_{it}^+ + \gamma_3 \theta_{it} \times \theta_{it}^+ + \mu_i + \delta_t \eta_j + \epsilon_{it} \quad (15)$$

Where the RHS variables are defined as in the previous estimation equations. Consumption is measured as the household's aggregate annual consumption expenditure as recorded by the NPS.

4 Results

The results from the estimations outlined above are presented in Tables 2-5. Specifically, Table 2 presents the estimated effects of global commodity prices on a set of household outcomes. Table 4 presents the results of the estimation of expected level of farm profits for the household using exogenous global prices as instruments. Table 4 presents the estimated effects of farm income shocks on wage labor hours using Tobit and Heckman estimation. Table 5 presents the estimated effects of farm profit shocks on consumption

From Table 2, the effect of the contemporaneous global price index on the local price index is shown to be significant and positive, which matches expectations. The six-month lagged price has no significant effect on farm-gate prices, suggesting that local prices adjust relatively quickly to global conditions and that providing some evidence for a lack of persistence in the global commodity prices across the time series. However, the effect of the global price on the local price is relatively small, suggesting that there are significant market frictions and/or a significant presence of intermediate markets which obscure the global price relative to the agricultural household.

Global prices do not seem to have an effect on total expenditures or food and beverage expenditures, which is consistent with the notion that agricultural households are able to smooth their consumption to mitigate commodity price changes. This of course poses the question of how households are able to smooth consumption, which is addressed by the market hours of work estimation. This simplified set of regressions provides evidence that, in general, agricultural households in Tanzania are marginally affected by global commodity prices via the effect they have on local prices, but are able to somehow avoid any significant effect on consumption.

Table 2: Effects of Global Commodity Price on Local Prices and Household Expenditures

	Local Price	Total Expenditures	Food Expenditures
Global Price	0.068**	25.352	−18.276
	(0.021)	(76.083)	(52.204)
L6.Global Price	0.015	−96.157	−88.205
	(0.025)	(93.110)	(63.887)
Fixed Effects		Household, Village-Year	
Obs.	4,101	4,101	4,101

Note: *p<0.1; **p<0.05; ***p<0.01

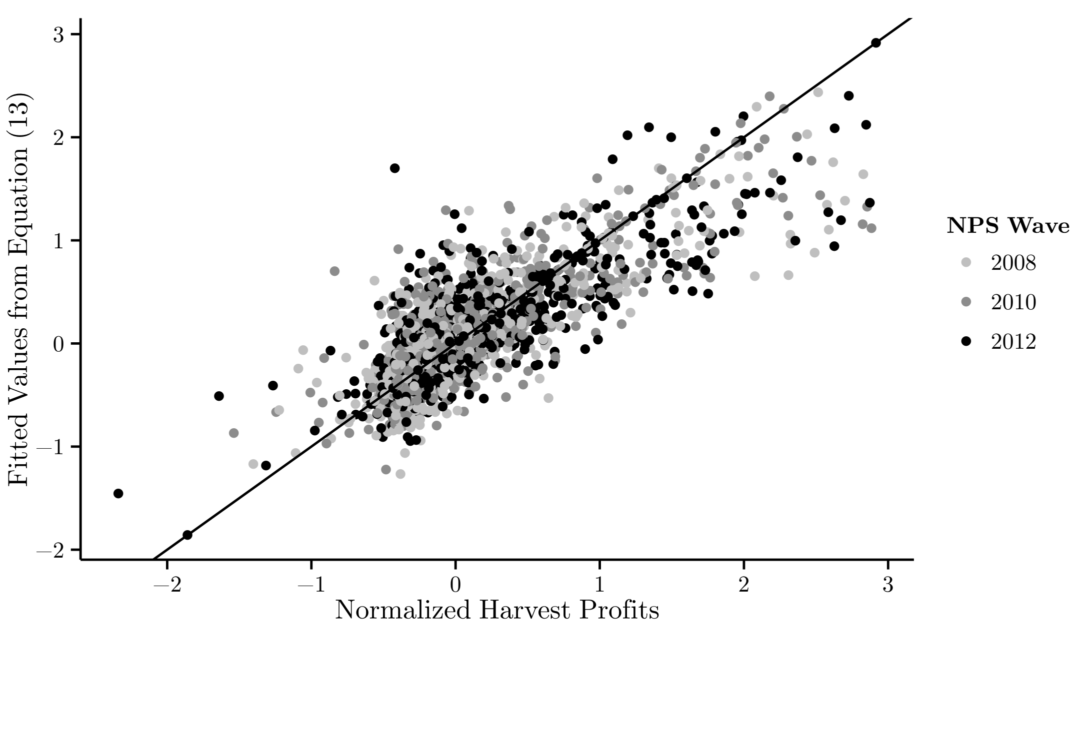
Table 3 provides and estimate of farm profits based on the set of household characteristics and local prices believed to be a part of the household's information set at the beginning of the harvest. Admittedly, the set of covariates included in the estimation shown in Table 3 pales in comparison to the true information set households possess before making decisions about agricultural production. Households possess superior knowledge about their own expected income, but even this private knowledge may be limited by uncertainty, especially in the context of risky agricultural production activities. Therefore, any variable included in the reduced form equation of the household ex ante information set is necessarily a rough proxy at best. However, as shown in Table 3 and more clearly in Figure 2, several household demographic characteristics and the set of household and village-year fixed effects do a decent job at predicting farm profits. Farm-gate prices do not have a significant effect on harvest profits, but this could be due to a lack of precision resulting from correcting standard errors for the estimation of instrumental variables. Most of the predictive power from Equation (13) comes from the fixed effects, suggesting that household farm profits are primarily explained by idiosyncratic factors specific the household and thus not easily explained by the limited data available on the household's information set. It is important to note that due to the timing issues mentioned previously, harvest profits were normalized so that different harvest months and crop indices could be compared side-by-side. The residuals from the estimation presented in Table 3 were predicted and used as a measure of farm profit shocks, or deviations from household expected level of farm income after harvest.

Table 3: Household Harvest Profit Prediction

	Normalized Harvest Profits	
Farm-Gate Price	0.499	(0.405)
1(Male)	0.077	(0.187)
Adult Equivalents in Household	−0.014	(0.014)
Age of Household Head	0.028	(0.025)
Age Squared	−0.000	(0.000)
Total Household Acreage	0.033**	(0.011)
Proportion of Commodity Crops	−0.449***	(0.098)
Distance to Market	0.000	(0.001)
Fixed Effects	Household, Village-Year	
Obs.	4,101	

Note: *p<0.1; **p<0.05; ***p<0.01

Figure 2: Household Harvest Profit Prediction



The aim of this paper is to estimate the labor allocation response of agricultural households to farm income shocks. To this end, equation (14) was estimated in Table 4 using a Tobit model. Negative income shocks seem to have a significant positive effect on the hours of wage work performed by the household. The sign on this effect seems consistent with theoretical expectations that households engage in wage labor as a way to mitigate the loss in income due to a farm profit shock. Positive income shocks are predicted to decrease the hours of wage work performed by a household. This is also consistent with the notion that agricultural households use wage work as an informal insurance mechanism to make up for losses to farm income, and may be able to consume more leisure in response to a positive income shock. The results also seem to rule out the alternative hypothesis that households respond to negative farm profit shocks by redoubling efforts on the farm, in which case opposite signs on the shock measures would be expected. This indicates that wage labor serves as a substitute to farm income and labor markets seem robust enough to absorb the additional supply of labor generated by income shocks. However, it may be likely that the Tobit estimation is inappropriate because different factors are influencing selection into wage labor than are influencing the choice of labor allocation once selected into wage labor.

The final step in estimating the effect of farm income shocks on labor allocation is estimating equation (14) using a Heckman selection estimation. The results of this estimation are also presented in Table 4. The Heckman estimation reveals that selection is not significantly determined by separate factors as confirmed by the insignificant inverse Mill's ratio, and the results are broadly consistent with the Tobit estimation. Once again, it appears that negative farm income shocks are associated with a increase in the number of hours of wage work performed, although the effect is not significant. However, there is evidence that negative profit shocks increase the probability of choosing to engage in wage labor at all, which is consistent with the explanation given above with regards to the Tobit estimation results. Likewise, positive income shocks are associated with a decreased probability of selecting into wage labor. This provides further evidence that the theoretically expected view of wage labor as a form of insurance is broadly accurate. It is also consistent with the notion that wage labor provides a substitute to variable farm income, and can be avoided more easily when times are good on the farm.

Finally, Table 5 provides evidence that households are able to smooth consumption in the face of farm profit shocks. All of the income shock parameters are insignificant, which is to be expected if households are indeed able to smooth their consumption. However, it must be cautioned that

Table 4: Effect of Profit Shocks on Wage Work

	Hours of Wage Work					
	Tobit		Heckman (Outcome)		Heckman (Selection)	
	(1)		(2)		(3)	
Profit Shock	27.907***	(9.329)	5.359	(6.619)	0.397***	(0.153)
1(Positive Shock)	−3.413	(3.222)	−0.129	(2.078)	−0.030	(0.053)
Profit Shock × 1(Positive Shock)	−37.158***	(12.304)	−11.766	(8.752)	−0.525***	(0.201)
1(Male)	6.236**	(3.083)				
Age	0.128	(0.544)	0.801**	(0.353)	−0.009	(0.009)
Age Squared	−0.008**	(0.005)	−0.008	(0.003)	−0.000	(0.000)
Total Household Acreage	0.158	(0.369)	−0.212	(0.243)	0.005	(0.006)
Distance to Market	0.090	(0.095)	0.018	(0.064)	0.002	(0.002)
Adult Equivalents	4.053***	(0.598)	1.474***	(0.544)	0.061***	(0.010)
Proportion Commodity Crops	−3.478	(4.402)	0.467	(2.859)	−0.053	(0.073)
Days from Harvest to Survey	0.011	(0.011)	−0.015**	(0.007)	0.000*	(0.000)
Inverse Mills Ratio					−2.702	(9.080)
Observations	4,101		1,494		2,607	

Note: *p<0.1; **p<0.05; ***p<0.01

this smoothing is not *necessarily* the result of labor supply allocation decisions. While it is entirely possible that households are able to smooth consumption via some other unobserved mechanism, the existence of evidence for both a labor supply response to shocks and a consumption non-response to those very shocks provides strongly plausible evidence that it is indeed the case that households are using wage labor as a form of informal insurance.

All of the results presented above seem to be at least pointing in a consistent direction. However, it is possible that something else altogether is occurring in the sample. Further robustness checks will be needed in order to rule out competing stories of how farm income shocks affect wage labor. In particular, issues remain with properly timing the effects of global prices and agricultural production, and with establishing a clear causal channel through which farm income shocks affect labor allocation. While global commodity prices are plausibly exogenous, there are likely other sources of bias present in the estimations above which will need to be addressed before a confident statement can be made about causality.

Table 5: Effect of Profit Shocks on Consumption

	Normalized Total Expenditures	
Profit Shock	0.090	(0.099)
1(Positive Shock)	0.016	(0.027)
Profit × 1(Positive Shock)	−0.273	(0.167)
1(Male)	−0.026	(0.272)
Age	0.018	(0.022)
Age Squared	−0.000	(0.000)
Adult Equivalents	0.173***	(0.013)
Total Household Acreage	−0.011**	(0.004)
Distance to Market	0.001	(0.000)
Proportion Commodity Crops	0.065	(0.056)
Days from Harvest to Survey	0.000	(0.000)
Fixed Effects	Household, Village-Year	
Observations	4,101	

Note: *p<0.1; **p<0.05; ***p<0.01

5 Conclusion

This paper tests the hypothesis that agricultural households engage in intermittent wage labor as a way to smooth consumption in the face of idiosyncratic shocks to agricultural income. Using panel data from a nationally representative sample of Tanzanian farm households, it is shown that households are more likely to select into wage labor and work more hours in response to negative income shocks. Positive income shocks are shown to have a weakly negative effect on selection into wage work and a negative effect on hours worked. This response helps explains the extent to which the observed relationship between consumption and income shocks is offset by wage labor as an informal insurance mechanism. These results suggest that wage labor is seen as a substitute to own-farm labor.

The empirical analysis proceeded in three steps. The first was to estimate the extent to which global prices matter for the sample of agricultural households in the NPS on a variety of outcomes including local farm-gate prices, total expenditures, and food and beverage expenditures. The second was to estimate the surprise or shock to farm income experienced by a household in a harvest season, using global commodity prices as a source of plausibly exogenous variation. Tobit and Heckman selection estimation was used to estimate the effect of farm income shocks on market wage work and the effect of income shocks on consumption expenditures was also estimated.

As mentioned above, the results are consistent with themselves, and are in general agreement with much of the literature in the sense that they seem to confirm the theoretical hypothesis that households engage in wage labor in order to smooth consumption. Further robustness checks will be required to rule out other explanations and the empirical strategy may need to be adjusted to better account for the nature of the data. However, the results presented here provide at least a preliminary overview of the labor supply allocation decisions households make in response to farm income shocks, and if confirmed in subsequent analysis would provide a valuable supporting example that agricultural households either are able to engage in wage labor intermittently in order to smooth consumption.

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