Aggregate Risk, Saving and Malnutrition in Agricultural Households: Empirical Evidence from India

Anjini Kochar | C. Nagabhushana | N. Raghunathan

July 2016

Stanford
Center for International
Development

Aggregate Risk, Saving and Malnutrition in Agricultural Households:

Empirical Evidence from India

By

Anjini Kochar[+], C. Nagabhushana[++] and N. Raghunathan[++]

July 2016

[+]Stanford University. Corresponding author (anjini@stanford.edu)
[++]Catalyst Management Services, Bangalore, India

1.   Introduction

This paper explores the hypothesis that the large stocks of cereals maintained by agricultural households in developing economies is a precautionary response to price uncertainty and that this portfolio choice adversely affects household nutrition and child health, providing one explanation for poor nutrition even amongst relatively wealthy land-owning households. This may be surprising, only because prices of wheat and rice are far less volatile than other crops, because of government intervention in grain markets, both on the consumption side (through welfare programs such as India's Public Distribution System that distribute food grains at highly subsidized prices) and on the production side (through minimum support prices). Relatively low and stable prices compared to other food crops reduces the likelihood that households will sell stocks of wheat to purchase more expensive food items, thereby lowering their value as an inflation hedge. Their value to households lies, instead, in their substitutability for other foods. Though such substitution would occur, even if households did not maintain grain stocks, these savings allow households to transfer consumption across seasons allowing more consumption in seasons characterized by poor rainfall and low incomes than would otherwise be possible. Substitution of wheat for other foods, such as pulses, does, however, come at a cost: It is likely to reduce the nutritional content of households' diets.

Persistently high levels of malnutrition in developing economies such as India, despite significant income growth, have long been a matter of policy concern. In the state of Madhya Pradesh, for example, data from the latest round of the National Family Health Survey (2015-16) estimate that 44% of children in the state under the age of 5 are stunted, and 45% are underweight. Though detailed data from this report are not yet available, a troubling finding from the earlier 2005-06 (round 3) report is that, in this state, the percentage of malnourished children remains relatively stable over the wealth distribution, falling off only for the richest quintile of households. The percentage of stunted children in the lowest four quintiles of the wealth distribution was found to be 53%, 54%, 54% and 52%, respectively, falling to 42% for the richest quintile of households.[1] Similarly, the percentage of under-weight children was 67%, 67%, 62% and 63% amongst the bottom four quintiles and 50% for children in the richest quintile. Survey data that we collected on households in rural Madhya Pradesh in January 2016, that forms the basis for this study, confirms this similarity in malnutrition levels across different measures of households' socio-economic status.

Matching the limited variation in nutritional outcomes across the wealth distribution, data from the 2011 National Sample Survey (round 68) reveal that diets in Madhya Pradesh and

---

[1] A child is considered stunted or underweight if his or her height for age or weight for age, respectively, is less than 2 standard deviations below that of children of the same gender and age in the reference population. The NFHS surveys calculate a household asset index that is the basis for comparisons of malnutrition levels across the wealth distribution.

in other neighboring states in which malnutrition is also high such as Uttar Pradesh, Bihar, Chattisgarh and Jharkhand, heavily favor cereals, primarily wheat and rice, with little variation in this dependence across households distinguished by wealth or occupation. Expenditure on cereals amounts to 26% of total food expenditure in the state and 28% of expenditure in the neighboring states of Uttar Pradesh, Bihar, Chattisgarh and Jharkhand. In Madhya Pradesh, as in neighboring states, this percentage shows almost no variation across households distinguished by principal occupation; it is as high (26%) amongst agricultural households who derive their income primarily from the cultivation of their own land as it is amongst households who are primarily dependent on causal wage work in unskilled labor markets (28%).[2]

While the dominant role of cereals in the diet of Indian households has often been noted, less attention has been paid to the striking importance of consumption out of home stocks for households who derive their income primarily from cultivation. In Madhya Pradesh, a predominantly wheat growing state, data from the NSS (2011, round 68) reveal that consumption out of home stocks of wheat amounts to 42% of total wheat consumption of all households, but as much as 81% of the consumption of agricultural (farming) households. Similarly 62% of the wheat consumption and 67% of the rice consumption of agricultural households in neighboring states is also from home stocks.[3]

We examine the relationship between nutritional status and savings in wheat stocks using rich household data from a sample of approximately 2800 households from rural areas of Madhya Pradesh, collected in January 2016. In addition to standard household data, we collected detailed information on wheat stocks, consumption out of wheat stocks, and village level rainfall shocks. We match the household data with monthly data on prices for wheat and the main pulse consumed in this area, *tur* or red gram, at the level of block-level markets, for the 2010-2015 period. Using this data, we test three hypotheses. First, we assess whether stocks of wheat are held as a precautionary response against variability in the price not just of wheat, but also of red gram. Second, we examine whether households' stocks of wheat affect wheat consumption in the household, even in regressions that control for the effect of total savings. That is, we examine whether the composition of a household's portfolio of assets has implications for household nutrition. In a final set of regressions, we test whether the share of wheat in household diets affects child health, as measured by height-for-age and weight-for-age Z scores.

Our empirical strategy exploits a central implication of inter-temporal additive separability, that lagged prices and income shocks affect current consumption only through their

---

[2] In neighboring states, this percentage varies from 27% amongst agricultural households to 30% amongst casual wage households.

[3] In contrast, in the southern states of Maharashtra, Tamil Nadu, Andhra Pradesh and Karnataka, characterized by lower levels of child malnutrition, while the share of expenditure on cereals (23%) is also high, only 6% of wheat consumption and 11% of rice consumption is from home stocks. Amongst agricultural households in these states, these percentages are 16% and 29%, respectively.

effect on savings. Correspondingly, we use historical price data and lagged rainfall shocks to identify the effect of savings on expenditure, and mean (lagged) food prices to estimate the effect of current food expenditures on health outcomes.

Our findings support all three hypotheses stated above. This has important implications. First, it links poor nutritional outcomes to the methods utilized by households to save against price and income uncertainty. Previous research notes that while savings help insure households against risk, the form in which they save may adversely affect production efficiency and future income (Rosenzweig and Wolpin 1993). Our research suggests that portfolio choices affect not just income but also household nutrition and health. Second, the insurance value of wheat stocks suggests that improved access to financial institutions will increase financial savings only if they offer a significant risk premium. This helps explain why the significant improvement in financial sector access in countries such as India have not generated commensurate increases in financial savings (Kochar 2016). Finally, our research also helps reconcile two conflicting literatures. The first examines seasonality in consumption expenditures and generally finds that households are able to smooth consumption relative to income (Paxson 1993; Jacoby and Skoufias 1998)[4]. In contrast, a second set of studies finds that children born in the monsoon months, and particularly those born in periods of low rainfall, have poorer health outcomes (Mancini and Yang 2009; Lokshin and Radyakin 2012).[5] We suggest that households are able to protect total food intake in the face of poor rainfall and other income shocks, but that this is achieved by increasing the share of stored grains of lower nutritional value. Thus, while they are able to maintain consumption levels and stave off hunger when incomes are low, nutrition suffers.

The findings of this paper suggest the importance of policies that help reduce price volatility, including the integration of agricultural markets. It also suggests that policies that increase the relative return to financial savings, such as flexible delivery options, lower transaction costs and financial literacy programs may also help improve nutrition. Finally, since the insurance value of wheat comes from its substitution for other crops, educating households on the value of a balanced diet may also affect household's willingness to save in the form of stocks of wheat.

Our research relates to the extensive literature on the mechanisms by which households smooth consumption in the face of variable incomes, and the costs of smoothing mechanisms.

---

[4] Jacoby and Skoufias find that households are able to protect consumption from the idiosyncratic component of rainfall shocks, identified by interactions of rainfall shocks with predetermined farm characteristics. The evidence on aggregate shocks is more mixed, with households in two villages estimated as vulnerable to such shocks, but not households in the third sample village.

[5] This does not necessarily imply that households are unable to protect consumption from income shocks. Seasonal variation in consumption may also stem from seasonal variation in preferences or prices. For example, Behrman (1988) examines nutrient intake, and finds that it does vary seasonally, but does not investigate whether seasonal variation is a consequence of price variation from exposure to risk.

4

Section 2 of this paper discusses this research. Section 3 discusses the survey area and the data. The theoretical and empirical frameworks that underlie our analysis are specified in sections 4 and 5 respectively. Results are in section 6, and the last section concludes.

2. Household Responses to Aggregate Shocks

The question of how households maintain consumption in the face of income shocks has long absorbed research, particularly on developing economies where the agricultural sector provides the basis of employment for the majority of the population. The dependence of agricultural output on weather, such as monsoon rainfall, generates income profiles that are volatile and highly sensitive to weather risk. Despite this, studies by Paxson (1993) and Chaudhuri and Paxson (2002) reveal that the seasonality in food consumption is far less pronounced than income seasonality, even given the large aggregate component to seasonal income fluctuations in rural areas.

Research by Deaton (1990; 1991), Carroll (1992) and others suggests that a significant degree of consumption smoothing can be achieved, even in the absence of credit and insurance markets, by using assets as a buffer between consumption and income, accumulating assets in periods of high income and selling them to maintain consumption when incomes are low. The value of different types of assets in serving this insurance function will depend on the covariance between their returns and the risks that households face.

In developing economies, researchers most commonly distinguish between productive assets, such as livestock, and more liquid assets including stocks of food grains, cash holdings and formal savings accounts. Research on the use of livestock for consumption smoothing purposes in African economies (Fafchamps, Udry and Czukas 1998; Kazianga and Udry 2006) suggests that their insurance value may be limited, perhaps because their returns are positively correlated with income shocks (Zimmerman and Carter 2003).[6] In India, Rosenzweig and Wolpin (1993) find that stocks of bullocks do help households smooth consumption. However, their research also suggests a negative effect on production efficiency and hence on incomes: The use of productive assets as an insurance substitute may result in holdings that are less than optimal from the viewpoint of production efficiency (Rosenzweig 2001).

In many economies, including India, households hold large stocks of food grains. If grain prices rise with general food inflation, then these stocks can serve as an inflation hedge, and will have a higher return than holdings of cash or savings in bank accounts. While research by Park

---

[6] Zimmerman and Carter (2003) make this point in explaining the lack of use of livestock for consumption smoothing purposes found by Fafchamps et al (1998). They opine that a bad year for crop yields also typically results in low livestock prices, so that livestock prices are low particularly when the need for insurance is highest.

(2006), Saha and Stroud (1994) and others find that grain stocks do serve as an insurance substitute, this same research mentions two factors that reduce their effectiveness in this regard. First, the prices of food grains such as wheat, in many countries including India, are relatively stable, reflecting significant government intervention in the wheat market, both on the production side (through minimum support prices) and on the demand side (in India, because of the provision of subsidized wheat through the Government's Public Distribution System). This stability reduces the effectiveness of wheat stocks as an inflation hedge.

Second, researchers have generally found that sales out of home stocks are limited (Park 2006; Saha and Stroud 1994), shedding doubt on the buffer stock model that suggests that households will sell assets to maintain consumption in periods of low income. In Park's survey region of northwest China, though households store an average of 64% of annual grain production, sales amount to only 3% of production. Low sales are generally attributed to positive correlations between prices and yields (Park 2006). Within a theoretical framework that assumes just one season per year and one crop that the household both produces and consumes, it is conventionally assumed that random weather shocks occur at the end of the period and determine the availability of grain at the start of the next period. Bad weather implies that households will run down existing stocks (from the previous year's harvest), but also implies low output and hence low starting stocks and high prices for the next period, limiting the ability of households to use stocks as a buffer should next period's rainfall also be poor.

Features of the agrarian household economy suggest, however, that food stocks may provide effective insurance against aggregate rainfall shocks despite these two factors. One feature is that agricultural production encompasses several seasons within a year, with production in just one of these seasons being particularly subject to the vagaries of monsoon rainfall. In India, for example, the calendar year includes two main agricultural seasons, the Kharif or monsoon season, that extends from June to October or November, and the winter or Rabi season (with sowing occurring in November/December and harvest in April). Variation in both the overall level of monsoon rain but particularly in the timeliness of rainfall frequently wreaks havoc with the Kharif crop, so that farmers may earn zero or even negative income in this season. In contrast, Rabi cultivation is primarily undertaken under irrigated conditions and Rabi incomes are significantly higher than Kharif incomes. Though rainfall levels in the previous monsoon do affect groundwater retention and hence the availability of irrigation water, exposure to aggregate risk in this season is far less than it is in the Kharif season.[7]

This suggests that crops differ in the covariance of their returns with aggregate rainfall shocks and, in the Indian context, that Rabi crops are likely to be far more effective as insurance substitutes against aggregate monsoon related risks. An additional implication is that

---

[7] Idiosyncratic sources of risk are widely prevalent in the Rabi season, but village level markets, including credit and labor markets, provide effective insurance against idiosyncratic shocks (Kochar 1999, 1995).

precautionary motives are likely weaker in the Kharif season because it is followed by the Rabi crop that provides higher and less uncertain income. The fact that different grains differ in their insurance value, because of differences in the timing of harvests relative to the incidence of rainfall shocks, has not been emphasized in the research on consumption smoothing.

A second feature of household economies explains the value of grain stocks as an inflation hedge even when their price is relatively stable. This is the fact that, unlike stocks of other assets such as livestock or jewelry, grain stocks do not need to be sold to realize their insurance value. Instead, households can simply increase their consumption from home stocks when the price of other food crops increases, substituting wheat for more expensive food items. In India, prices of pulses, grown in the Kharif season, have been extremely volatile in recent years. Our interviews of households in the survey region and in other parts of India support the hypothesis of this paper. Faced with high prices of pulses, households have responded by shifting their diets towards wheat, using home stocks to enable increased consumption of "rotis" and accompanying this with a considerably watered down dish of pulses or vegetables.

This, however, implies a significant cost to this form of insurance in terms of the composition of household diets and, correspondingly, nutritional levels. While poor health and high levels of malnutrition, particularly amongst children, have frequently been attributed to poor diets and their high caloric content, our research helps explain the low nutritional content of household diets. It suggests that unbalanced diets are a consequence of the use of wheat stocks for consumption smoothing, in turn a consequence of the lack of better sources of insurance.

The link between financial choices and nutrition has received scant attention in the existing literature. Much of the research on this topic adopts a framework in which households transact in grain markets, either as sellers or as purchases, at market prices that are exogenous to the household. While Park (2006) and others allow for transaction costs, that drive a wedge between the sale and purchase price of food grains, suggesting the possibility of corner solutions, their empirical analysis does not incorporate such solutions or explore their implications. Renkow (1990)[8] adopts a model that allows the rate of return on stocks to be endogenous, assuming that stocks of wheat yield a "convenience" return, similar to a liquidity value that is a function of the level of current stocks. Renkow examines the implications of this endogeneity for income and price elasticities, but does not explore its implications for the costs of using buffer stocks of wheat for insurance purposes.

The results of this paper particularly apply to landowning households, the methods they use to smooth consumption, and the costs of such methods in terms of nutrition. While all households, including the landless, can accumulate wheat stocks for consumption smoothing

---

[8] Saha and Stroud (1994) also adopt Renkow's concept of convenience returns.

purposes, in India it is generally only landowning households that do. One explanation for this is the number of government programs, such as the Public Distribution System and the work-fare program, the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA), that ensure an insurance floor for the poor, reducing households' need for any form of precautionary savings.[9] Because the PDS and other programs, such as the government's maternal and child care programs (ICDS), that provide food to poor households are also very intensive in wheat, they may play a role in explaining the poor nutritional intake of the landless. Exploring this hypothesis is beyond the scope of this paper.

3. Risk, prices and survey area

The survey area for this research is the central state of Madhya Pradesh. We surveyed households across 8 blocks, 2 each in four districts of the state (Hoshangabad, Panna, Sehore and Vidisha). The state is amongst India's poorest, with high levels of malnutrition. The calendar year in this state, as in much of India, is divided into two main seasons, the Kharif or monsoon season, and the Rabi or winter season.[10]

Wheat is the principal crop of this region, grown in the winter or Rabi season, with sowing occurring between November and December, and harvesting between April and May. Area under wheat has increased over time, from 3.7 million hectares in 2001-02 to 6.0 million hectares in 2014-15. The major crop cultivated in the Kharif or monsoon season is soybean, with 5.6 million hectares being devoted to its production in 2014-15. In contrast, area under the other major crop of this season, paddy, was 2.2 million hectares in the same year.

Wheat is also the major item of food expenditure, for all households. Data from the 2011 National Sample Survey (round 68) for rural areas of the state reveal that expenditure on wheat, including expenditure out of own stocks and from the PDS, accounts for 17% of total food expenditure. Total cereal consumption (including wheat) is 26% of food expenditure. The next most important item of food expenditure is milk and milk products (19% of expenditure), followed by pulses (10%). Vegetables account for 9% of food expenditure.

Dividing households in the NSS survey by primary occupation reveals that the percentage share of wheat in total food expenditure is approximately the same across families who are primarily engaged in agricultural self-employment (17%), those engaged in non-agricultural self-employment (18%), and regular (16%) and casual wage earners (18%).[11] However, not surprisingly, the percentage importance of wheat from own-stocks varies considerably across

---

[9]Hubbard, Skinner and Zeldes (1995) make this point while explaining low savings of U.S. households.

[10] A small percentage of farmers also grow crops in a third summer season.

[11] The item for which expenditure shares varies the most across occupational groups is milk and milk products. Households engaged in agricultural self-employment report that these products accounts for 24% of food expenditures. The corresponding percentage for those engaged in non-agricultural self employment, regular wage work and casual wage work is 18%, 19% and 13% respectively.

these occupational groups. Households who are self-employed in agriculture report that as much as 81% of their total consumption of wheat is from home stocks. This percentage falls to 18% for households engaged in non-agricultural self-employment, 35% for regular (salary) wage earners, and 14% for casual wage earners.

Crop production in the Kharif season is risky, primarily because of its dependence on monsoon rainfall. The state suffered from both deficient as well as untimely rains in 2014-15 and 2015-16, with total rainfall in the state in these years amounting to 733.4 and 804.3, relative to an average of 1132 over the years 2002-03 to 2015-16. Untimeliness of rainfall in these years devastated the soybean crop, with many farmers reporting negative profits in the Kharif seasons of the past few years. Poor rainfall in the Kharif season also reduces soil moisture for Rabi crops, affecting the quality of irrigation and raising costs. However, as previously noted, the uncertainty in Rabi production, conducted under irrigation, is far less than it is in Kharif. Rabi incomes have higher means and lower variance than incomes earned during the Kharif season.

Crops are sold and purchased in block-level "mandis" or markets. Most households travel to these markets once a week, taking a day off from work to do so. This implies a considerable time and money cost to market transactions. The same markets are the venues where farmers sell most of their harvest. Data on food prices in the mandis that serve the 8 blocks in our survey are in figures 1 through 4. Figures 1 and 2 graph mean prices of wheat and red gram, respectively, across the 8 mandis for the years 2010 through 2014. The scale of these graphs differ because of differing degrees of price variation. The data reveal the greater variation in red gram prices, relative to wheat. The coefficient of variation in red gram prices over this 5 year period was 133.7, compared to the coefficient of variation in wheat prices of 26.4.

The greater degree of uncertainty faced by households in the Kharif season as regards the price of red grams, and pulses more generally, is reflected in the greater variance of its price in this season (June to October). The coefficient of variation in red gram prices over the Kharif season, averaged over the past 5 years, is 176.2, significantly higher than the coefficient of variation for the full year (133.69). And, the relative stability in wheat prices over the course of the calendar year is apparent in the lack of difference in the coefficient of variation in wheat prices over the Kharif season (25.0) relative to that calculated over all 12 months (26.4).

There is also considerable variation in prices across markets. To show this, we restrict our attention to monthly price data for 2014, and to mandis that are relatively close to each other. Figures 3 and 4 graph monthly average prices for wheat and red gram, respectively, for each of the two mandis in the neighboring districts of Hoshangabad and Sehore. Despite their geographic proximity, these figures reveal considerable variation in prices, suggesting low levels of market integration. This is particularly true for red gram.

4. Survey and Summary Statistics

4.1   The Survey

We surveyed approximately 3000 households over 108 villages in 8 blocks of our 4 survey districts. These districts are characterized by higher levels of poverty relative to other districts in the state.[12] The survey was conducted in January 2016, a "slack" period that comes after the Kharif harvest in October/November. The timing of the survey facilitates research on the methods used by households to smooth consumption over peak and lean agricultural seasons. In each village, we surveyed 15 households, randomly selected from amongst those with children under the age of 3. Dropping households with missing observations and trimming the top 1% of observations, our sample size is approximately 2800 households.

Data on household demographics, income and consumption were collected through standard modules. Households were asked about the consumption of food items and other items of recurring expenditure in the past 30 days (that is, approximately for the month of December). For all major items of food expenditure, including milk, pulses, eggs, vegetables and, of course, wheat and rice, we allowed for consumption out of own production and from home stocks, as well as for the availability of items from the government's PDS system. Data on income from agricultural and non-agricultural enterprises as well as wage income was collected by season for the Rabi and Kharif seasons of 2015 (that is, covering the period December 2014-November 2015)[13] This was supplemented by annual data on salaries, pensions and other government payments, remittances received and transfers made. The collection of income data by season allows us to calculate savings, measured as the difference between income and consumption, over the course of the Kharif season, as well as annual savings.[14] This calculation utilizes monthly expenditure on food and (regularly purchased) non-food items in the month before the survey (December), combined with monthly averages of expenditure on durable goods, education, health and other infrequently purchased items.

While total savings is measured as the difference between income and expenditure, we also separately collected information on household stocks of wheat,[15] including data on additions

---

[12] The districts reflect operational areas of a local NGO that promotes the development of farmer producer societies. This survey will be used to help the NGO develop agricultural interventions going forward. The NGO focuses on regions with relatively high levels of poverty.

[13] Details for a third summer season were also collected for those farmers reporting cultivation in this period.

[14] However, data on remittances is reported on an annual basis, since remittances are not regularly received. Their average monthly amount is used to calculate Kharif savings.

[15] The numbers of households holding stocks of crops other than wheat are minimal. While 1,582 households reported stocks of wheat, the numbers reporting stocks of rice and red gram, respectively, are 203 and 15.

to wheat stocks out of the Rabi harvest, as well as the amount of stocks just prior to the Kharif harvest and at the survey date. [16]

The household module also collected height and weight data of all children under the age of 6, as well as for their mothers. We discuss summary statistics in the next section. Here, we merely note that there was far greater variance in the height data, suggesting the need for greater caution in interpreting the determinants of height.

In addition to the household module, we also interviewed village leaders, asking them for information on the level (average, more than average, below average) and timeliness of monsoon rains (on time, early or late) for the 2013-2015 seasons. Their responses were coded into a binary indicator of rainfall shocks that takes the value 1 if the village reported that rains in the given year were either too early or too late. By this measure, the percentage of villages reporting rainfall shocks was 49% in 2013, 51% in 2014 and 50% in 2015. There is also variation in the reported incidence of rainfall shocks for any given village over time. Thus, of the villages that reported until rains in 2013, 39% reported the same in 2014, and 27% did so for 2015.

The data set is merged with detailed (block) market-level price data available from the Government of India (https://agmarknet.dac.gov.in). Data is available on prices for all crops that arrive in the market, with observations for multiple days in each month of each year. From this data set, we obtained prices for wheat and red gram, the two major food consumption items in the state, by month, from 2010 to 2015. Using this, we calculate the variance in prices over the survey period, but also over Kharif months (June to October). A longer time series was not collected because of lack of red gram arrivals, and hence prices, for many months of earlier years. Additionally, the volatility in the price of pulses has been particularly acute in the last 5 years, suggesting that it is this relatively short-term measure of variance that conditions farmers' expectations.

4.2   Summary statistics for households

Table 1 provides data on basic indicators of the socio-economic status of households, as well as health indicators for children under age 5. Amongst landowners, average land size is small, 6.9 acres. Family sizes are above the Indian average, at 7.2 for landowning households and 6 for landless households, with the difference primarily reflecting numbers of adult household members. 78% of all fathers and 63% of mothers have some formal schooling, with average years of education for those with some schooling varying from 8.7 years for fathers to 7.7 years for mothers. There are, however, significant differences in both male and female education across landowning and landless households.

---

[16] Collecting data with reference to the major harvest periods significantly aids recall.

The table also documents a high degree of malnutrition amongst children under age 5, as reflected in height and weight measures. We report height and weight for age Z scores (HAZ, WAZ) relative to WHO standards, with children with heights and weights 2 standard deviations below these standards classified as stunted and under-weight, respectively. As previously noted, data on child height are characterized by much greater variance, reflecting difficulties in accurately measuring height of young children.

The data reveal a high proportion of stunting and underweight children. 67% of children in our sample are stunted, and 53% are underweight. These percentages are higher than those reported in the recent Rapid Survey on Children (RSOC) conducted by UNICEF and the Government of India because the released data from that survey does not separately report data for rural children and because our survey area has a higher degree of poverty than the rest of the state. The data in this table also reveal only marginal differences in the percentages of children who are stunted or under-weight across landowning and landless households. 70% of landless children are stunted, relative to 65% of land-owning households, while the percentages of under-weight children are 55% and 52% across these two types of households respectively.

Table 2 provides information on household income, consumption, as well as stocks of wheat and use of financial assets. The average area sown in the Rabi season exceeds that in Kharif. Farmers reported large losses of their main Kharif crop, soya bean, in the past year, as a consequence of late rainfall. Average reported farm profits for the Kharif season are, in fact negative (-Rs. 3,672), with farmers' income for the year coming primarily from the previous Rabi season in which average incomes were Rs. 37,115. With the poor rains of the Kharif season, both landowning and landless households rely on the casual labor market for income in this season, suggesting that wage income does help even cultivator households protect consumption from shortfalls in income in the Kharif season. On average, annual consumption over the year is close to average income, with savings (measured as the difference between income and consumption) being close to zero. Savings are lower in the Kharif season, averaging –Rs 18,000 for the sample as a whole, primarily because of the lower savings of landowning households in this season (-Rs 28,000).

The table reveals the wheat-intensive nature of diets in the region: total expenditure on wheat, the sum of the value of consumption from home stocks, market purchases and from the Government's Public Distribution System amounts to 25% of expenditure on food. Supporting the NSS data reported earlier, the share of wheat in total consumption is approximately the same across landowners and landless households: it is 0.22 for landless households and marginally higher for landowners (0.25). For landowning households, wheat stocks provide 72% of the household's intake of wheat (in kgs). Market purchases for landowning households represent only 7% of total intake, with the residual coming from the PDS. Not surprisingly, landless households primarily depend on market purchases (47% of intake) and the PDS (37% of intake), with home stocks accounting for the remaining 17%. Though PDS wheat is important for all

households, it represents a much lower share of household expenditure because of its highly subsidized price. For the sample as a whole, PDS wheat accounts for 8% of total expenditure on wheat, with this percentage varying from 5% to 11% across landowning and landless households, respectively.

The table only reports the importance of consumption from home stocks for wheat, because "home" consumption is less important for other food items. For sample, consumption out of home stocks of rice amounts to only 14% of total rice consumption. This percentage is even lower, (7%) for red gram, the pulse that is predominantly eaten in this area. The only other food item for which "home" consumption is important is milk, with 60% of total household milk consumption coming from their own livestock.

The next panel of data in table 2 provides information on wheat output and wheat stocks. Landowning households store approximately 21% of their total wheat output, with 82% of landowners reporting that they store wheat for future consumption. Despite the fact that an insignificant number of landless households report wheat cultivation (on leased land), 12% of landless households also maintain wheat stocks at the end of the Rabi season. Though not reported in the table, market transactions in wheat stocks in the period between harvests, either in the form of purchases to add to stocks or sales of existing stocks, are few. Only 15% of households reported wheat purchases, while 9.6% reported wheat sales.

Comparing the proportion holding wheat stocks to those with active savings accounts, 72% of landowners and 54% of landless households maintain savings accounts. However, in most cases, these accounts are maintained primarily to receive government loans, such as the seasonal loans provided for agricultural operations (under the "Kisan credit card" or KCC scheme), as well as loans from cooperative societies and government subsidies from other programs. Savings passbooks maintained by households are thus primarily a record of government loans and payments, with as many negative entries (for loans received) as positive.

Amongst loans, the formal sector is the most important source for landowners, with 43% of families who own land reporting such loans. Dependence on relatives and friends is much lower (only 12% of landowning households), but as many as 24% of such households also report loans from moneylenders. In contrast, few landless households (10%) report loans from the formal sector. More landless households report loans from moneylenders (29%) and from relatives and friends (16%). Data on the purpose of loans (not reported in the table) reveal that formal sector loans are primarily for income-generating purposes such as working capital for agricultural operations. Loans from moneylenders are primarily used for food expenditures (28% of loans from moneylenders), and for expenditures on health or education (20% of moneylender loans). Households appear to turn to relatives and friends primarily to meet health and expenditure requirements (26% of loans from this source), and for ceremonial expenditures (20% of loans). Loans for food expenditure represent 16% of all loans from relatives and friends.

We confirm the lack of market purchases amongst households who consume from stocks of food through two-way frequency tables based on indicator variables that take the value 1 if the household reports consumption from food stocks or consumption from market sales(table 3), for the sample as a whole and then separately for landowning and landless households. For the sample as a whole, 61% report consumption out of stocks of wheat, but only 37% report any market purchases. For landowning households, the percentage reporting wheat consumption out of home stocks increases to 86%, with only 12% of landowners reporting any consumption from market purchases. For those who report some consumption out of home stocks, only 3% also report market purchases. Not surprisingly, landless households rely primarily on market purchases (72% of households).

One reason why market purchases are so low is the availability of wheat from the PDS. PDS foodgrains are available at below market prices for all households, though highly subsidized rates apply only to below-poverty-line households. A two-way frequency table between indicators for market consumption and PDS consumption (table 4) reveals that of the sample of landowners who report consumption out of home stocks, as many as 53% also report using PDS wheat. This percentage is larger for the 14% of landowners who do not report any consumption from their own stocks of wheat in the past month; 71% of this sample use PDS wheat. For landless households, 81% of those who report no consumption from home stocks report some consumption from the PDS.

3.   Theoretical Framework

The theoretical framework underlying the empirical analysis of this paper is a standard model of dynamic optimization with uncertainty and portfolio choice (MaCurdy 1999), adapted to allow for income seasonality and for the option of saving in the form of stocks of food grains (wheat). It thus closely follows the analysis in Park (2006), Fafchamps, Udry and Czukas (1996); Saha (1994), and others. Though the framework we utilize also captures the savings decisions of landless households, the discussion of this section is in terms of landowning households, given that their production decisions significantly affect the returns on stocks of wheat.

3.1   Framework

Following the Indian agricultural cycle, we distinguish between the Rabi and Kharif seasons. Production in the monsoon or Kharif season is subject to aggregate rainfall shocks against which insurance is unavailable, either from formal insurance markets or through informal village mechanisms.[17] The principal storage crop, wheat, is grown in the Rabi season under

---

[17] The ineffectiveness of village insurance mechanisms against aggregate shocks has been shown by Binswanger and Rosenzweig (1986), Fafchamps (1994), and Udry (1994), amongst others. Though the government runs several

irrigated conditions, and consequently its production is relatively immune to the aggregate shocks that affect Kharif production. While Rabi production is still subject to idiosyncratic shocks, such as damage from pests, to focus on the effects of aggregate shocks I assume that village credit and labor markets provide effective insurance against idiosyncratic shocks. Though the analysis can be modified to allow for aggregate risk in the Rabi season too, I instead make the simplifying assumption that Rabi production is unaffected by risk.

Households can store wheat at low cost. To highlight the role of prices, I ignore storage costs.[18] Consumption, sales and storage decisions for wheat are made at the time of the Rabi harvest, before the realization of the aggregate shocks that affect Kharif production. Food purchases and sales involve a transaction cost, τ, that reflects the time and money costs incurred in travelling to block-level markets. Denoting the price of wheat as P_c, the effective purchase price for households is $(P_c + \tau)$ while the effective sales price is $(P_c - \tau)$.

In addition to saving in the form of wheat stocks (s), households can also hold an alternative liquid asset (such as a savings account), denoted by b. The amount of this asset held at the end of period t earns a nominal rate of return r(t+1) at the beginning of period (t+1).

Period t encompasses both the Rabi (t_r) and Kharif (t_k) seasons. Households' lifetime preference functions are assumed to be strongly separable across seasons and time periods. Utility in any season derives from consumption of wheat (c), other (non-produced) market crops (m) and leisure (l), U(.)=U(c(.), m(.), l(.), ζ(,)), where ζ represents a set of "taste shifters." For notational simplicity, we drop ζ for the rest of this section, but include taste shifters in the empirical analysis that follows. We assume that the market crops purchased by households (for example, pulses) are grown in the Kharif season in neighboring regions that experience the same aggregate weather conditions. Their price, P_m is therefore subject to the random weather shocks θ that affect agricultural production in the region. Utility is assumed to be concave in c(.), m(.) and l(.), with a positive third derivative allowing a precautionary motive for savings; households save against future aggregate shocks.

Households earn income from farm production. Without loss of generality, I assume that the only inputs in farm production are land (A), provided inelastically, and family labor (L), with input decisions made at the start of the season yielding output at the end of the season. The household's time endowment, Ω, in any season, is divided between leisure and time spent on farm production. Farmers grow wheat (c) in the Rabi season and a cash crop (z) in the Kharif season, with production functions for these two crops being $F_c(A, L)$ and $F_z(A, L, \theta)$ respectively.

---

welfare programs, such as the distribution of subsidized food through the Public Distribution System and the workfare program MNREGA, these are targeted towards below-poverty-line households and do not protect landowners from aggregate income shocks.

[18] This reflects the change in storage facilities for households. Households currently use plastic bins for storage purposes, and state very minimal storage losses as a consequence. Bins require a onetime fixed cost that I ignore in the analysis. Allowing for storage costs does not affect the main theoretical results.

The household's maximization problem is to choose current and planned consumption, leisure and savings to maximize the expected value of the discounted stock of total utility over the remaining life cycle. Let β be the discount factor for next season's utility, so that lifetime expected utility in period t is:

(1) $\sum_{j=0}^{\infty} E_{t_r} \left\{ \beta^{2j} U(t_r + j) + \beta^{2j+1} U(t_k + j) \right\}$

Where E_{t_r} implies that the household takes into account all information available at the start of the current Rabi period. Household maximization is subject to season-specific budget, grain and time constraints, as well as non-negativity constraints on wheat stocks and financial assets.

I start by describing the constraint set faced by households at the start of the Rabi season. In this season, the grain constraint requires total output (q) and stocks remaining from the previous Kharif season (s(t_k-1)) to be divided between consumption (c), sales (q^s) and stocks (s). I assume that all households sell wheat in this season, and that sales are sufficiently high that they do not purchase wheat from the market.[19] In addition to the non-negativity constraints, $b(t_r) \geq 0, s(t_r) \geq 0$, the set of constraints facing households in this season are:

(2) $P_m(t_r)m(t_r) + b(t_r) = b(t_k - 1)(1 + r(t_r)) + (P_c(t_r) - \tau)q^s(t_r)$

(3) $F_c(A, L(t_r)) + s(t_k - 1) = c(t_r) + q^s(t_r) + s(t_r)$

(4) $l(t_r) + L(t_r) = \Omega$

Because grain sales in this period occur at the market price, the budget and grain constraints can be combined to yield:

(5) $b(t_r) + (P_c(t_r) - \tau)s(t_r) = b(t_k - 1)(1 + r(t_r)) + (P_c(t_r) - \tau)s(t_k - 1) +$

$(P_c(t_r) - \tau)F_c(t_r) - (P_c(t_r) - \tau)c(t_r) - P_m(t_r)m(t_r)$

---

[19] The critical point is that the household transacts in the market in this season, so that the relevant price is a market price. Since all agricultural households *do* sell wheat in the Rabi season, the restriction that they do not purchase wheat is a simplifying assumption that does not affect the analysis.

In the Kharif season, in addition to decisions regarding the production of the cash crop z, households choose between three options for wheat transactions: net market purchases, net market sales, or no market transactions. This decision is based on the reservation price of wheat, $\tilde{P}_c(t_k)$, defined as the marginal rate of substitution between wheat and the market food item, evaluated at the corner where consumption equals available stocks:

$$(6) \qquad \tilde{P}_c(t_k) = \frac{\frac{\partial u}{\partial c}}{\frac{\partial u}{\partial m}} \left(s(t_r), F_z(t_k) - \big(B(t_k) - B(t_r)\big) - B(t_r)r(t_k), l(t_k)\right)$$

Households will not transact in wheat markets if $P_c(t_k) + \tau \geq \tilde{P}_c(t_k) \geq P_c(t_k) - \tau$.

If the household does transact in the market, decisions in the Kharif season are similar to those made in the Rabi season, with prices replaced by Kharif season prices. If, instead, the household chooses not to sell or purchase wheat, outcomes are significantly different. Our survey data suggests that the "no-market transaction" option dominates for the vast majority of households, perhaps as a consequence of low (market) sales prices for wheat. Since the focus of this paper is not on explaining the lack of market participation but, instead, its consequences, we assume no market participation in the Kharif season (for landowning households), and consider the implications of this choice below.

A first implication is that the budget and grain constraint cannot be collapsed into one. Instead, the two separate constraints imply that households utilize different forms of savings to smooth consumption of different food items over time. Wheat stocks are used to smooth wheat consumption, while savings in financial assets (b) help the household smooth consumption of m. The budget and grain constraints that condition Kharif outcomes, allowing with time and non-negativity constraints, are the following:

$$(7) \qquad P_m(t_k)m(t_k) + b(t_k) = b(t_r)\big(1 + r(t_r)\big) + P_z F_z(A, L_k, \theta)$$

$$(8) \qquad s(t_r) = c(t_k) + s(t_k)$$

To analyze the household's decisions, we utilize a dynamic programming formulation based on the value function corresponding to period t_s as a function of the set of state variables:

$$(9) \qquad V(t_k) = V(s(t_k), B(t_k), \theta, t_k)$$

$$= \max U(t_k) + \beta E_{t_k}\left\{\sum_{j=0}^{\infty}\big\{\beta^{2j}U(t_r + j + 1) + \beta^{2j+1}U(t_k + j + 1)\big\}\right\}$$

With this, the household's objective function can be rewritten as:

(10) $U(c(t_r), m(t_r), l(t_r), \xi(t_r)) + \beta E_{t_r} \{V(s(t_k), b(t_k), \theta; t_k)\}$

Maximization of (10) generates the following first order conditions for Rabi outcomes:

(11) $\frac{\partial U}{\partial c}(t_r) = \lambda(t_r)(P_c(t_r) - \tau)$

(12) $\frac{\partial U}{\partial m}(t_r) = \lambda(t_r)P_m(t_r)$

(13) $\frac{\partial U}{\partial l}(t_r) = \lambda(t_r)\frac{\partial F_c}{\partial L}(t_r)$

(14) $\lambda(t_r)(P_c(t_r) - \tau) = \beta E_{t_r}\left\{\frac{\partial V(t_k)}{\partial s(t_r)}\right\}$

(15) $\lambda(t_r) = \beta E_{t_r}\left\{\frac{\partial V(t_k)}{\partial b(t_k)}\right\} = \beta E_{t_r}\{\lambda(t_k)(1 + r(t_k))\}$

In these equation, and the ones that follow, λ(t) is the Lagrange multiplier on the period t budget constraint. As is well known, equations (11) through (13) imply that optimizing agents set λ(t) multiplied by the price of consumption equal to the marginal utility of consumption.

Decisions made in the Rabi season regarding optimal wheat stocks and savings in financial assets reflect (14) and (15). Households set their savings policy so that the expectation of next period's marginal utility of wealth follows a martingale, with expectations incorporating any current period income shocks. From (14), the growth rate of consumption, or equivalently savings, reflects the current rate of return on wheat stocks, current prices and preferences, and expectations of future changes in income and prices. With non-quadratic preferences, this expectation incorporates the variance in prices, not just of wheat but also of other non-separable food items (m). It is worth noting that wheat price variation affects savings decisions, even if households do not consume market wheat or make market sales in the current year's sowing period, because market transactions will occur in future Rabi seasons and, possibly Kharif, seasons.

Before considering the implications of equations (14) and (15) for portfolio choices, we first specify the first order conditions that determine consumption in the Kharif season. These

18

result from the maximization of the one-period-ahead value function, with respect to wheat (c) and market food items (m), subject to the budget and grain constraints (7) and (8). The two first order conditions can be collapsed to yield the marginal rate of substitution between wheat and market crops as follows:

$$(16) \qquad \frac{\frac{\partial u(t_r)}{\partial c}}{\frac{\partial u(t_r)}{\partial m}} = \frac{\left(\frac{\mu(t_r)}{\lambda(t_r)}\right)}{P_m(t_r)}$$

In equation (16), μ is the Lagrange multiplier on the grain constraint (8) and represents the value to the household of an additional unit of wheat. Let $\hat{\mu} = \frac{\mu}{\lambda}$. $\hat{\mu}$ thus represents the household's endogenous marginal valuation of wheat stocks, in money terms, and can be interpreted as the shadow price of wheat in the absence of market transactions. This formulation helps to understand portfolio choices in the Rabi season. Let $\hat{P}_c = P_c(1-\tau)$. Equations (14) and (15) can then be rewritten as (17) and (18) respectively, following MaCurdy (1999):

$$(17) \qquad \lambda(t_r) = \beta E_{t_r}\{\frac{\lambda(t_k)\,\hat{\mu}\,(t_k)}{\hat{P}_c}\}$$

$$= \beta\, E_{t_r}\{\lambda(t_k)\}\left[E_{t_r}\{\frac{\hat{\mu}\,(t_k)}{\hat{P}_c}\} + cov\left(\frac{\lambda(t_k)}{E_{t_r}\{\lambda(t_k)\}}, \frac{\hat{\mu}(t_k)}{\hat{P}_c(t_r)}\right)\right]$$

$$= \beta\, E_{t_r}\{\lambda(t_k)\}\left[E_{t_r}\left\{\frac{\hat{\mu}(t_k)}{P_c(t_r)}\right\} - \sigma_{cp}\right]$$

$$(18) \qquad \lambda(t_r) = \beta\, E_{t_r}\{\lambda(t_k)\}[\,1 + E_{t_r}\{r(t_k\} - \sigma_{cr}\,]$$

In (17) and (18), σ_{cp} and σ_{cr} are the covariances of prices ($\hat{\mu}$) and interest rates, respectively, with consumption. These equations imply that portfolio choices are made taking insurance considerations into account. Specifically, households will choose not to hold financial savings if:

$$(19) \qquad [E_{t_r}\left\{\frac{\hat{\mu}\,(t_k)}{\hat{P}_c}\right\} - \sigma_{cp}] > [\,1 + E_{t_r}\{r(t_k\} - \sigma_{cr}]$$

Even though decisions regarding wheat consumption reflect available stocks, not money income, the non-separability of wheat and market goods in the utility function implies that an increase in the price of market goods such as pulses, that decreases consumption of pulses, will increase the demand for wheat, thus increasing the household's valuation of wheat (μ). Thus, the

covariance between µ and consumption of pulses is negative, providing an insurance value to wheat stocks. Consequently, even if the variation in wheat prices across seasons is small, households will still choose to hold wheat stocks if their insurance value is large enough to exceed the rate of return on financial savings. Relatively low interest rates and a low covariance between interest rates and consumption therefore explain households' preference to save in the form of wheat stocks.

The analysis of this section has two primary implications that we subsequently take to the data. First, precautionary motives explain households' decisions to hold stocks of wheat, with wheat stocks reflecting the variance not just in wheat prices, but also in the prices of other significant food crops such as red gram. Second, the household's relative consumption of wheat, and hence nutrition, will be affected by the household's portfolio choices, independent of the effect of total household savings on consumption. This can be seen from the first order condition for wheat consumption in the Kharif season:

$$(20) \qquad \frac{\partial U}{\partial c}\big(c(t_k), m\big(P_m(t_k), \lambda(t_k)\big), t_k\big) = \mu(s(t_r), t_k)$$

Equation (20) makes clear that the response of wheat consumption to prices and current income shocks reflects the non-separability in preferences between wheat and the market crop. If this were not the case, then wheat consumption would be determined solely by the grain constraint, with decisions regarding market purchases reflecting the budget constraint. Non-separable preferences imply that income shocks in the Kharif season that reduce consumption of the market crop, can also cause off-setting changes in wheat consumption through reductions in wheat stocks. This in turn allows households to minimize the consequences on overall food intake. From (20), the demand function for wheat consumption in the Kharif season reflects not just total savings, but also savings in stocks of wheat:

$$(21) \qquad c(t_k) = c(s(t_r), P_m(t_r), \lambda(t_r))$$

Since consumption during Rabi is given by market prices, the magnitude of portfolio effects on household nutrition varies with the length of time of the two seasons. Though we have assumed that the year is divided into two seasons, in practice, each season can be further sub-divided into a peak harvest period and a slack season in which households earn little income but undertake sowing and other pre-harvest operations. Household stocks of foodgrains therefore sustain consumption not just during the Kharif season, but also through the Rabi sowing season, and hence for a large part of the calendar year. As a consequence, the choice to save in the form of wheat stocks is likely to have a substantial effect on household nutrition.

3.2   Sensitivity of predictions to PDS and market transactions in the slack season:

The fact that the consumption of landowning households is affected by portfolio choices, not just total household wealth, results because they do not engage in market transactions for wheat in the Kharif season, limiting wheat consumption to their stocks. However, as previously noted, one reason for the lack of market purchases is the availability of subsidized wheat from the public distribution system. Do these implications change if households also consume wheat provided by the government through is public distribution system or if they report market purchases or sales of wheat at exogenous prices?

The availability of a (monthly) fixed amount of foodgrains through the PDS at subsidized prices is equivalent to a model of rationing in which households are provided with a ration at a below-market price. As long as household demand exceeds the rationed quantity, such purchases correspond to income effects, leaving unchanged the marginal valuation of the crop in question. However, the availability of PDS wheat implies that the household's demand for wheat is now an "excess demand," over and above what is available through the PDS. As noted above, this is one factor explaining the lack of market purchases of wheat in the Kharif season.

If, however, market purchases are reported within the reference period, this may still be consistent with an endogenous price for wheat if monthly transactions are an aggregate of weekly transactions, and household utility is assumed to be non-separable across weeks, but separable across seasons. If households report market purchases in one week of the month, then the price of the monthly aggregate of consumption will reflect a quantity-weighted average of market and shadow prices, and will therefore still reflect start-of-period wheat stocks. The significance of wheat stocks in determining consumption is thus an empirical issue; it will reflect the relative importance of consumption out of home stocks, relative to market purchases.

4. Empirical Framework

The empirical analysis of this paper has three objectives. First, it examines whether households' savings in food grains reflect the variance in the prices of wheat and red gram. Second, it assesses whether households' portfolio choices regarding the type of assets to save in affect household consumption, even when controlling for the household's overall savings. Finally, we evaluate the effect of food choices on child health, as reflected in WAZ and HAZ scores.

Despite the focus of the theoretical framework on landowning households, our empirical analysis is based on a sample of households that includes landless as well as landowning households. Doing so allows us to identify the effects of block level variables such as prices through their interactions with landownership, even in regressions that include block level fixed effects. This does, however, imply that we identify the effect of prices only on the savings

decisions of landowning households. Since wheat stocks are primarily held by landowning households, this is not a concern in assessing determinants of wheat stocks. However, it does mean that variation in prices cannot be used to also estimate total savings. We address this and other empirical issues below, separately for each of the three objectives of our analysis.

4.1 Determinants of wheat stocks

The equation underlying our empirical analysis of the determinants of savings derives from equation (14). As noted by Campbell (1987), this equation suggests that savings embody expectations of the change in income and prices in future periods, conditional on the household's current information set ($I(t_r)$), discounted by the return to savings. With non-quadratic preferences, expectations of any given variable will reflect its variance, providing a precautionary motive whereby greater uncertainty increases savings. This same equation determines savings in any specific asset, with the rate of return being that of the asset in question. Given this, our estimating equation for savings in wheat stocks at the end of the Rabi season of year t is:

$$(22) \qquad sav\_wht(t_r) = \alpha_0 + \alpha_1' \left(var\_pr_{k,2010-2014} * agland\right) + \\ \alpha_2'(mean\_pr_{k,2010-14} * agland) + \alpha_3' \ X(t_r) + \mu_b + \ u(t_r)$$

The dependent variable in this equation is additions to wheat stocks at the end of the Rabi harvest. The regression includes the mean and variance of the price of wheat and red gram, with the subscript "k,2010-14" denoting that the relevant moment is for Kharif (June to October) prices of the 5 previous years, 2010-2014. Focusing on lagged prices for the Kharif season allows for the fact that decisions regarding wheat stocks are made at the end of the Rabi harvest, and so primarily reflect household expectations of prices in the upcoming Kharif season. Price variables are interacted with the household's land ownership, reflecting the effect of landownership on the rate of return to wheat stocks, in turn a consequence of the fact that landowners are sellers of wheat in the Rabi season and so are able to acquire stocks at lower cost. Because the regression includes a set of block level variables, the effect of the mean and variance in prices is identified only through their interaction with land size. This reiterates the point made in previous sections, that our analysis explains the savings behavior of land-owning households, not of the landless.

In equation (22), X reflects variables that determine returns as well as expected income changes. This includes a full set of household demographic variables[20], an indicator variable for whether the mother has any formal schooling, number of years of education for the father, amount of agricultural land owned by the household, the size of the household plot, indicator variables for

---

[20] Family size, the number of adult males and, separately, females in three age groups (20-40, 40-60 and over 60), and an indicator variable for whether the grandfather is still alive.

whether the household is a "below-poverty-line household and whether it belongs to a scheduled caste or tribe. We also include variables that reflect socio-economic variables of the extended household, that likely affect savings decisions through informal means. These are the amount of land owned by the grandfather, an indicator for whether he had any formal schooling, and the number of his sons. The vector μ_b represents a set of block fixed effects.

In extensions to (22), we include the effect of rainfall surprises in the 2014 monsoon season, and its interaction with the father's education years, agricultural land, and the indicator variable for below-poverty-line status. Rainfall shocks are at the village level, and we allow for their heterogeneous impact on households, due to variation in informal sources of insurance, by interacting them with the father's years of education as well as the indicator variable signifying whether the household is a "below-poverty-line" household as per the government's classifications. BPL status enables the household to access subsidized wheat from the Government's public distribution network, and also enables participation in other welfare programs.

4.2   Determinants of household expenditures on wheat

Our test of the hypothesis that the composition of a household's portfolio affects wheat consumption is based on equation (21) that suggests that wheat expenditure will reflect (lagged) savings in wheat, even in regressions that control for the marginal utility of wealth. To estimate an inter-temporally consistent consumption equation, we follow MaCurdy (1983) and Blundell and Walker (1986), replacing the marginal utility of wealth by savings, and regressing current wheat expenditure on total savings and lagged savings in wheat at the end of the Rabi season. Household wheat expenditure in the month prior to the survey date is calculated as the sum of market expenditure, the value of home stocks consumed in the previous month, and the value of any PDS wheat consumed.

Identification of total savings and wheat savings stems from the assumption of inter-temporal additive separability of life-cycle utility, as in Blundell and Walker (1986). With separability, lagged values of prices, income shocks and other exogenous determinants of behavior affect current expenditures only through their effect on savings. Conditional on savings, current expenditures are a function only of current prices, preferences and shocks. Accordingly we use interactions of the household's land ownership with the (lagged) mean and variance of wheat and red gram prices, over the 2010-14 period as instruments, including current prices of wheat and red gram amongst the regressors.   Equation (22), of the previous sub-section, therefore serves as a first stage regression for wheat savings.

The interaction of the mean and variance of lagged prices with agricultural land suggests that our instruments identify the savings of land-owning, but not landless, households. While wheat savings are primarily held by landholding households, landless households do save in other

forms. Thus, to identify the effect of total savings, we need instruments that predict the variation in savings across our entire sample of households. For this purpose, we include our indicator of the lagged rainfall shock (from the 2014 monsoon), and its interaction with father's education, agricultural land, and BPL status. As with lagged prices, under the assumption of intertemporal additive separability of preferences, lagged income shocks will affect current consumption only through their effect on savings.

Our estimating equation is:

(23) $\log(wheat\_\exp(t_k)) = \beta_0 + \beta_1\, save\_tot(t_k) + \beta_2\, sav\_wht(t_r) +$
$$\beta_3 agland * price(t_k) + \beta_4' X(t_k) + \mu_b + u(t_r)$$

The set of conditioning variables (X) is the same as previously described, while the vector of current prices includes those of both wheat and red gram.

4.3   Effects of food consumption and diets on child WAZ and HAZ scores

In a final set of regressions, we consider the effect of the household's consumption level, and the share of wheat in food consumption on child malnutrition, as reflected in weight-for-age (WAZ) and height-for-age (HAZ) Z scores. The scores are calculated relative to WHO standards. Using a health production framework, WAZ and HAZ will reflect food intake. We allow the composition of the household's diet to affect nutrition by separately including wheat consumption amongst the set of regressors.

To interpret the results of this section, we use the framework of a dynamic health function, following the seminal work of Grossman (1972). Utilizing this framework, current health is a function of health in the previous period and of current inputs into the health production function, including food expenditure (and its composition). In regressions that do *not* condition on lagged health outcomes, substituting for lagged health delivers a reduced form specification in which current health reflects the history of food intake since birth. To generate an empirically tractable formulation, we assume that, as in life cycle models of consumption, food intake in each month has a permanent and a transitory component, with the transitory component constituting changes in food intake due to time-varying factors including income and preference shocks. One measure of this permanent component is monthly food expenditures averaged over the child's lifespan. Alternatively, instrumental variable estimates of the effect of current monthly food expenditure on anthropometric outcomes, utilizing determinants of permanent expenditure as instruments, also generate estimates of the effect of the permanent component of food expenditure. That is, the coefficients in this regression estimate the effect on anthropometric outcomes of having a regular monthly food expenditure at a level predicted on the basis of these permanent components.

Accordingly, we identify the effect of wheat expenditure using the mean of lagged wheat prices over the 2010-2014 period, rather than current prices. Given seasonal variation in prices, and inter-household differences in the ability to protect consumption against such variation, we separately calculate the mean of wheat prices in the Kharif and Rabi seasons of 2010 to 2014. With block fixed effects included in all regressions, mean prices are interacted with the same variables used previously that likely reflect differences in households responsiveness to prices (father's education years, BPL status and agricultural holdings.

Mirroring our concern over the identification of total savings as distinct from savings in wheat, we need to ensure that our instruments deliver estimates of total expenditure as distinct from just expenditure on wheat; instruments based on wheat prices may not well identify the effect of total food expenditure. Prices of other food items, including red gram prices, are invalid under our null hypothesis. Since we test the hypothesis that the composition of a household's diet matters for nutrition and health, this suggests that other foods, such as pulses, also have separate effects on health. Thus, the price of red gram would be correlated with omitted expenditure on pulses. Including expenditure on pulses and instrumenting it with prices does not help address the hypothesis we are testing: that an unbalanced diet, in terms of excessive wheat consumption, adversely affects health. This requires us to examine the effect of the share of wheat expenditures on health, in regressions that control for other food expenditures.

To identify the effect of total food expenditures, we apply the insights of two-stage budgeting (Gorman 1968), whereby households first allocate expenditures to broad groups, and then to the items that constitute such groups. This suggests that expenditures on other groups will determine total food expenditure. Identification, however, requires that the expenditure group we choose as an instrument cannot directly affect health. This suggests the unsuitability of groups such as clothing, education, or consumer durables that may directly affect health. Instead, we use (monthly) expenditures on consumer services and (annual) ceremonial expenditures. Expenditure on consumer services primarily reflects grinding charges for grains, but also expenditures on haircuts, tailoring and other services. 98% of households report such expenditures. Fewer households (32%) report ceremonial expenditures, but such expenditures are unlikely to affect health other than through their effect on household food expenditures. Because we have two expenditure groups included in our set of instruments, we can test their validity by utilizing standard over-identification tests.

Ideally, we would have liked to have mean expenditure on consumer services and ceremonies over the child's lifetime, so as to ensure that we identify the effect of "permanent" food expenditures on child height and weight. The extent to which we are able to do so depends on how much these items of expenditure vary from year to year. Our assumption is that they are relatively stable, but, our inability to confirm this with the data on hand needs to be kept in mind when interpreting the results of this section.

In addition to other regressors included in the previous set of regressions on household savings and on wheat expenditures, we also include child-level determinants, specifically the child's age and gender, as well as the mother's height and BMI, that reflect the child's health endowment. The regressions are run on all children in the household who are less than 6 years of age.

5 Results

5.1 Effect of price variance on savings in wheat

Our first set of results examines the effect of price variation on savings in wheat, based on equation (22). The results are in table 5. The first regression reveals that, controlling for mean values of (lagged) prices, wheat savings increase with the variance in red gram prices, but not wheat prices; the coefficient on the variance in wheat prices is negative but not statistically significant. This substantiates the oft-cited opinion that the relative stability in wheat prices, in turn a function of government intervention in wheat markets, minimizes uncertainty over these prices so that wheat price variance cannot be a significant determinant of savings including savings in wheat stocks. Instead, supporting the hypothesis of this paper, a significant determinant of wheat stocks is the variability in red gram prices. Our analysis find that households save in the form of wheat stocks against price variability in crops *other* than wheat.

The second regression of this table includes the rainfall shock of the 2014 monsoon season. Untimely rainfall in the Kharif season reduces wheat savings at the end of the Rabi season. This may be because, as earlier suggested, poor rainfall reduces groundwater levels and hence the costs of Rabi cultivation, reducing Rabi profits. It may also be because low incomes in the Kharif harvest cause households to reduce expenditure on capital, thereby reducing Rabi profits. For simplicity, the theoretical framework of this paper ignored decisions regarding capital, but clearly such decisions may connect incomes in the Kharif season to that earned in the following Rabi season.

The regressions of the first two columns of table 5 are the basis for the first stage regressions that identify the effect of savings and wheat savings on expenditure. The last two regressions of this table are the actual first stage regressions we utilize for the IV regressions reported subsequently. They differ from the first two regressions only in the inclusion of interactions of the 2014 rainfall shock with the household's agricultural land holdings, indicator for BPL status and father's education. The theoretical framework does not deliver any clear predictions for the signs of these interaction effects on savings, given that they will affect savings both through their effects on income and on expenditure. Their value as instruments comes from their interaction with lagged rainfall. F tests, reported at the bottom of these columns, support the significance of the instruments in these regressions.

Are there other assets that could also help buffer consumption from price and income shocks? The asset that has received the most attention in the empirical literature is livestock holdings. Though a high percentage (69%) of households do report ownership of livestock, transactions in livestock over the course of the year are minimal, with only 2.55% of sample households reporting either sales or purchases of livestock over a one year period. Instead, it is likely that, contrary to existing research but consistent with the research of this paper, ownership of livestock helps protect consumption in the fact of price and income shocks by enabling households to substitute consumption out of home stock for market purchases. Section 3 of this paper, which discussed summary statistics, noted the importance of "home" milk consumption, suggesting a similar insurance value to livestock. Unlike wheat, however, milk production from livestock is likely to be adversely affected by poor rains, which will reduce the production of fodder and drive up prices. As previously mentioned, Zimmerman and Carter (2003) suggest that this negative effect of rainfall shocks on the returns to livestock are one explanation for insignificant buffer stock role of livestock found in much of the research. It is beyond the scope of this research to explore this hypothesis.

5.2   Effect of portfolio composition on wheat expenditure

Our analysis of the effect of portfolio composition on wheat expenditure starts with OLS regressions of monthly wheat expenditure on total savings and on savings in wheat stocks, reported in table 6. We also examine the effect of savings on the *share* of wheat in total food expenditures. While existing stocks of wheat may increase wheat intake, they might also increase consumption of other items, with no adverse effects on health. Thus, considering the effect of savings on the share of wheat expenditures on total expenditures is important, since it allows us to assess whether wheat stocks *shift* expenditure towards wheat.

The OLS regressions confirm a separate effect of savings in wheat, even in regressions that control for total savings, with savings in wheat increasing both wheat expenditure, but also its *share* in total food expenditures. Since savings are endogenously determined by the household, and are likely to be correlated with unobserved preference variables as well as unobserved current shocks that also affect expenditure, the estimates reported in this table are likely biased. We thus turn to the results from instrumental variable regressions, based on the first stage regressions of the previous table.

The results from IV regressions are reported in table 7. The different regressions of this table explore the sensitivity of results to different instrument sets. For each instrument set, we report results from regressions on both total wheat expenditure, and for its share in total food expenditure. The first instrument set is the one reported in the first stage regressions of table 5, and includes interactions of agricultural land with the lagged mean and variance (over the 2010-2014 period) of wheat and red gram, as well as the 2014 monsoon shock and its interactions with a set of household variables (agricultural land, BPL status, father's years of education). The second instrument set drops the mean and variance of wheat prices, utilizing only information on the price of red gram. The third set does not utilize prices at all, with the instrument set

including only the 2014 monsoon shock and interacted terms. Finally, the last set of regressions is similar to the third set, but also includes interactions of the rainfall shocks with the mean and variance of wheat and red gram prices. This instrument set differs from the first in that the interactions of moments of the price distribution are with the rainfall shock, not with land holdings.

The results are very similar across all regressions, suggesting that identification does not come from a particular combination of the independent instruments and that the results are robust across different interaction terms. All regressions suggest a negative effect of savings on total expenditure, as expected, but also reveal that, controlling for total savings, an increase in wheat stocks increases both the expenditure on wheat, but also the share of wheat in total expenditures. That is, the regressions suggest that the *composition* of household portfolios has significant implications for a household's diet, and that, in particular, the decision to save in the form of wheat stocks explains the high calorie content of diets in the survey area.

In interpreting the results of this section, we note that the results do not explain the factors underlying portfolio effects. Our theoretical analysis suggests that this is due to the lack of market transactions in wheat, which in turn endogenizes the price at which households value food stocks. However, such effects could also arise from other market imperfections, for example in the market for labor, with an absent market for family labor similarly generating an endogenous wage rate. If labor use in one season had implications for labor use in other seasons, we would also get portfolio effects, even if households did transact in wheat markets, attributable to labor market imperfections. The fact that transactions in wheat markets are so limited suggests that it is this market that drives our results. However, alternative explanations are also possible. Our finding, then, is that portfolio effects matter, but we cannot confirm that these reflect the lack of market transactions in the wheat market.

5.3   Effect of food and wheat expenditure on child health

The last set of results in this paper evaluate whether the composition of a household's diet, in particular the share of expenditure on wheat, has implications for child health as measured by WAZ and HAZ scores. The regressions consider the effect on child height and weight of total household expenditure, and, separately expenditure on wheat. The coefficient on the latter variable estimates the effect of an increase in wheat expenditure, holding constant total food expenditure, and hence the effect on health of increasing the share of wheat in a household's diet. As earlier explained, the set of instruments is based on mean wheat price in the Kharif and Rabi seasons of the 2010-2014 period, as well as expenditure on consumer services.

OLS regressions on WAZ and HAZ scores, and the first stage regressions of food and wheat expenditures on the set of instruments are reported in Appendix table B. The OLS regressions reveal a positive effect of food expenditures on both WAZ and HAZ scores, and a negative effect of wheat expenditure, but the magnitudes are small and the coefficients on these variables are statistically insignificant. We therefore turn to the results from IV regressions, reported in table

8. F tests on the instruments (in Appendix table B) confirm the explanatory power of these variables.

The IV regressions (table 8) generate much larger coefficients than those in OLS regressions. The large difference in magnitude between the OLS and IV regressions is explained by our choice of instruments, motivated by our attempt to measure the effect of the permanent component of food expenditures on health in IV regressions. OLS estimates recover the effect of a marginal increase in the current month's expenditure on anthropometrics outcome, with current expenditures likely having a large transitory component. In contrast, the IV regressions recover the effects of an increase in the permanent component of food expenditure, and yield estimates of how current expenditure levels affect height and weight, should the child have consumed at this level throughout her lifetime.

For weight, increases in food expenditure improve weight-for-age Z scores, with the coefficient being statistically significant at the 10% level. The regression estimates also confirm the hypothesis that the composition of household diets is important: increases in the share of wheat have a negative effect that is statistically significant at the 10% level. The regressions on height have similar implications – height-for-age improves with total food expenditure but falls with an increase in the share of wheat – but are measured imprecisely, so that the coefficients are not significant at the 10% level.

As noted in the previous section, the fact that we have two expenditure groups that identify the effects of total food expenditure on WAZ and HAZ scores allows us to test their validity as instruments through standard over-identification tests. The second set of results in table 8 therefore includes expenditure on consumer services amongst the regressors, identifying the effect of total food expenditures only using ceremonial expenditures as an instrument. Similarly, the third set of results includes ceremonial expenditures amongst the regressors, identifying the effects of total food expenditure through the use of expenditure on consumer services as an instrument. Both sets of regressions validate our identification strategy. Neither expenditure on consumer services nor ceremonial expenditures has a direct effect on WAZ or HAZ scores.

The large standard errors of estimates in the first regression suggest possible heterogeneity in coefficient estimates. Since these regressions include all children under the age of 6, it is likely that there are important age effects that are ignored in the previous results. To assess this, we include interactions of total expenditure on food and expenditure on wheat with age, using age interactions with instruments for identification.[21] The results suggest that allowing for heterogeneity by age is important in that it significantly improves the efficiency of the results (without significantly changing magnitudes). Increases in total expenditure now has a statistically significant effect at th3 5% level on both WAZ and HAZ scores. Increases in wheat share similarly

---

[21] In practice, we generate predicted values of total food expenditure and wheat expenditure based on the first stage regressions, and then use these predicted values, as well as their interaction with age, for instruments.

reduce both measures, with the results being statistically significant at the 5% level for WAZ scores, and at the 10% level for HAZ scores. These effects taper off with age; older children's health is less sensitive to improvements in overall food expenditures and to the composition of household diets. Though the coefficients on the age interactions are not statistically significant at a 10% level, they still have considerable explanatory power; the probability associated with the null hypothesis of estimate values being zero is 0.11 for interactions of age with both total food expenditure and wheat expenditure for WAZ regressions, and 0.12 and 0.20, respectively, for HAZ regressions.

This last set of estimates suggest that access to both adequate amounts of food as well as a balanced diet on a regular basis have large health benefits for children. Estimating the effect for a 3 year old child, a one standard deviation improvement in (log) monthly food expenditures would have resulted in a 0.79 standard deviation improvement in her weight-for-age score and a 0.92 standard deviation improvement in height-for-age. Conversely, a one standard deviation increase in wheat expenditure, holding total food expenditure constant, reduces the weight-for-age of a 3 year old child by 0.8 standard deviations, and height by 1.2 standard deviations. [22]

6   Conclusion

This paper provides empirical evidence on the effect of savings decisions, specifically the decision to save in the form of stocks of wheat, on household nutrition. It addresses a long-standing challenge to policy makers and those working in the area of nutrition in poverty belts of countries such as India: the low correlation between incomes and malnutrition rates reflected in high rates of malnutrition even amongst large landowners. Our analysis suggests that the use of home stocks as a means of insurance against price volatility in important food crops such as pulses is an important explanation for this paradox. Available wheat stocks allow households to substitute wheat for pulses in periods of low income and high prices for pulses, lowering the nutritional value of household diets. We show that this imbalance in diets affects child health, as reflected in weight-for-age and height-for-age Z scores. Our research thus ties high rates of malnutrition to the lack of financial sector development, particularly in the field of insurance but also in the availability of other financial products that could help households smooth consumption over seasons.

---

[22] Though few comparable estimates are available in the literature, Thomas, Strauss and Henriques (1990) estimate the instrumented effect of (log) household expenditures on the height of Brazilian children, separately for children of different ages, with child height standardized by the median height of a child of the same sex and age in the U.S. They estimate significant effects of total expenditure that are statistically significant only for very young children (ages 0-5 months) in north-east urban Brazil. For this sample, the coefficient on log household expenditure is 1.67. Our analysis differs both in that we use food expenditures, rather than total expenditures, and in our instruments (prices, rather than the income variables used by Thomas et al).

References

Behrman, Jere R. 1988. "Nutrition, birth order and seasonality: Intrahousehold allocation among children in rural India." *Journal of Development Economics* 28(1): 43-63.

Blundell, Richard and Ian Walker. 1986. "A life-cycle consistent empirical model of family labor supply using cross-section data." *The Review of Economic Studies* 53(4):539-558.

Campbell, John Y., 1987. "Does Savings Anticipate Declining Labor Income? An Alternative Test of the Permanent Income Hypothesis." *Econometrica 55(6):* 603-640.

Chaudhuri, Shubham and Christina Paxson. 2002. "Smoothing Consumption Under Income Seasonality: Buffer Stocks vs. Credit Markets." Columbia University, Department of Economics, Discussion Paper #0102-54.

Deaton, Angus. 1991. "Saving and Liquidity Constraints." *Econometrica* 59(5):1221-1248.

Deaton, Angus and Guy Laroque. 1992. "On the behavior of commodity prices." *The Review of Economic Studies* 59(1): 1-23.

Deaton, Angus and Guy Laroque. 1996. "Competitive Storage and Commodity Price Dynamics." *Journal of Political Economy* 104(5): 896-923.

Fafchamps, Marcel; Christopher Udry and Katherine Czukas. 1998. "Drought and saving in West Africa: are livestock a buffer stock?" *Journal of Development Economics* 55:273-305.

Grossman, Michael. 1972. "On the concept of Health Capital and the Demand for Health." *Journal of Political Economy* 80(2):223-55.

Heckman, James. 1974. "Shadow Prices, Market Wages, and Labor Supply." *Econometrica* 42(4): 679-694.

Hubbard, R. Glenn, Jonathan Skinner, Stephen P. Zeldes. 1995. "Precautionary Saving and Social Insurance." *The Journal of Political Economy* 103(2):360-399.

Jacoby, Hanan G. and Emmanuel Skoufias. 1998. "Testing Theories of Consumption Behavior Using Information on Aggregate Shocks: Income Seasonality and Rainfall in Rural India." *American Journal of Agricultural Economics* (80):1-14.

Kochar, Anjini. 1999. "Smoothing Consumption by Smoothing Income: Hours of Work Responses to Idiosyncratic Agricultural Shocks in Rural India," *The Review of Economics and Statistics*, 81(1):50-61.

Kochar, Anjini. 1995. "Explaining Household Vulnerability to Idiosyncratic Income Shocks," *American Economic Review, Papers and Proceedings*, 85(2):159-164.

Lokshin, M. and S. Radyakin. 2012. "Month of birth and Children's Health in India." *Journal of Human Resources* 47:147-203.

Maccini, S. and D. Yang. 2009. "Under the Weather: Health, Schooling and Economic Consequences of Early-life Rainfall." *American Economic Review* 99:1006-26.

MaCurdy, Thomas E. 1983. "A simple scheme for estimating an intertemporal model of labor supply and consumption in the presence of taxes and uncertainty." *International Economic Review* 24, 265-289.

MaCurdy, Thomas E. 1999. "An essay on the life cycle: characterizing intertemporal behavior with uncertainty, human capital, taxes, durables, imperfect capital markets, and non-separable preferences." *Research in Economics* 53:5-46.

Park, Albert. 2006. "Risk and Household Grain management in Developing Countries." 116:1088-1115.

Paxson, Christina H. 1993. "Consumption and Income Seasonality in Thailand." *Journal of Political Economy* 101(1):39-72.

Pistaferri, Luigi. 2001. "Superior Information, Income Shocks, and the Permanent Income Hypothesis." *The Review of Economics and Statistics* 83(3): 465-476.

Renkow, Mitch. 1990. "Household Inventories and Marketed Surplus in Semisubsistence Agriculture." *American Journal of Agricultural Economics.* August: 664-675.

Rosenzweig, Mark R. 2001. "Savings Behavior in Low-income Countries." *Oxford Review of Economic Policy* 17(1):40-54.

Rosenzweig, Mark R. and Kenneth I. Wolpin. 1993. "Credit Market Constraints, Consumption Smoothing, and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India." *Journal of Political Economy* 101(2):223-244.

Saha, Atanu. 1994. "A two-season agricultural household model of output and price uncertainty." *Journal of Development Economics* 45: 245-269.

Singh, Geeta. 1998. "The Impact of India's Employment Guarantee Scheme on Rural Earnings." Stanford University.

Thomas, Duncan, John Strauss and Maria-Helena Henriques. 1990. "Child Survival, Height for Age and Household Characteristics in Brazil." *Journal of Development Economics:* 197-234.

Zimmerman, Frederick J. and Michael R. Carter. 2003. "Asset smoothing, consumption smoothing and the reproduction of inequality under risk and subsistence constraints." *Journal of Development Economics* 71:223-260.

Table 1: Household socio-economic characteristics

Variable	Total sample	Landowners	Landless
Proportion owning land	0.58	100%	--
	(0.49)		
Amount of land owned, if positive (acres)	6.93	6.93	--
	(16.03)	(16.06)	
Prop. Scheduled castes or tribes	0.37	0.30	0.47
	(0.48)	(0.46)	(0.50)
Family size	6.67	7.15	5.99
	(2.49)	(2.65)	(2.07)
Number of children <5 years	1.58	1.62	1.52
	(0.77)	(0.81)	(0.70)
Proportion of fathers with formal schooling	0.78	0.82	0.72
	(0.42)	(0.39)	(0.45)
Fathers' mean years of schooling if >0	8.73	9.24	7.93
	(3.25)	(3.40)	(2.82)
Proportion of mothers with formal schooling	0.63	0.68	0.56
	(0.48)	(0.47)	(0.50)
Mothers' mean years of schooling, if >0	7.69	8.06	7.06
	(3.03)	(3.07)	(2.86)
Mean HAZ for children <6 yrs	-2.84	-2.76	-2.95
	(3.08)	(3.12)	(3.00)
Proportion stunted, children <6 yrs	0.67	0.65	0.70
	(0.47)	(0.48)	(0.46)
Mean WAZ for children <6 yrs	-2.08	-2.05	-2.12
	(1.92)	(1.97)	(1.84)
Proportion underweight for children <6 years	0.53	0.52	0.55
	(0.50)	(0.50)	(0.50)
Sample size	2908	1699	1209

Table 2: Summary statistics on consumption, income and saving by landownership

Variable	Full sample	Landowners	Landless
Area sown, Income and savings			
Net area sown Kharif 2015	2.56	4.31	0.13
	(4.63)	(5.35)	(1.18)
Net area sown Rabi 2015	3.11	5.20	0.20
	(5.04)	(5.65)	(1.37)
Farm profits, Kharif 2015	-3,610.44	-3672.26	--
	(36,255.26)	(35,932.18)	
Farm profits, Rabi 2015	36,499.34	37,115.31	--
	(57,598.32)	(58,017.76)	
Wage income, Kharif 2015	10,559.79	8147.80	13,925.78
	(14,950.69)	(14,389.54)	(15,074.0)
Wage Income, Rabi 2015	4,124.87	2701.92	6126.22
	(5300.67)	(4340.57)	(5872.65)
Annual income 2015	61,699.08	71,177.75	48,836.3
	(63,784.76)	(75,399.62)	(39,874.74)
Savings 2015 (Rs. '000)	-8.75	-11.64	-4.75
	(75.94)	(91.20)	(47.15)
Kharif savings, 2015 (Rs.'000)	-17.82	-27.57	-4.44
	(49.91)	(58.44)	(30.20)
Household food expenditure	3252.91	3651.33	2693.00
(Rs/month)	(1466.96)	(1566.82)	(1091.26)
Share in total expenditure on			
Wheat	0.24	0.25	0.22
	(0.14)	(0.13)	(0.14)
Rice	0.07	0.08	0.06
	(0.08)	(0.08)	(0.07)
Pulses	0.15	0.16	0.14
	(0.09)	(0.09)	(0.09)
Red Gram (pulses)	0.11	0.11	0.10
	(0.08)	(0.08)	(0.07)
Milk, milk products, eggs	0.11	0.10	0.11
	(0.10)	(0.09)	(0.10)
Vegetables	0.18	0.18	0.19
	(0.09)	(0.09)	(0.09)

Table 2 (cont.)

Variable	Full sample	Landowners	Landless
Share of total wheat consumption (in kgs) from:			
Home stocks	0.49	0.72	0.17
	(0.42)	(0.33)	(0.32)
Market purchases	0.23	0.07	0.46
	(0.34)	(0.22)	(0.35)
PDS	0.27	0.21	0.37
	(0.26)	(0.24)	(0.27)
Wheat output and stocks			
Proportion with wheat stocks,	0.53	0.82	0.12
at Rabi end	(0.50)	(0.39)	(0.32)
Total wheat harvest output	60.99	61.44	--
for cultivators (qtls)	(79.52)	(80.03)	
Additions to stocks from Rabi	12.18	12.33	--
harvest, cultivators (qtl)	(17.38)	(17.54)	
Amount of wheat stocks, rabi	9.46	15.25	1.35
end (all hholds) (qtls)	(17.77)	(21.23)	(3.84)
Amount of wheat stocks,	3.25	5.25	0.43
survey date (all hholds, qtls)	(8.66)	(10.80)	(1.78)
Financial assets			
Proportion with active	0.64	0.72	0.54
savings account	(0.48)	(0.45)	(0.50)
Proportion with loan from	0.30	0.43	0.10
formal sector	(0.46)	(0.50)	(0.31)
Proportion with loan from	0.14	0.12	0.16
relatives / friends	(0.34)	(0.32)	(0.37)
Proportion with loan from	0.26	0.24	0.29
money lender	(0.44)	(0.43)	(0.45)
Sample size	2908	1699	1209

Note: standard deviations in parentheses. Wage income and net area sown is over the full sample (by landownership), with zero values for households not reporting any income / sown area. Data for farm profits are over the sample of households who report cultivation in that season. Data for farm profits for landless households are not reported since only 20 landless households reported cultivation in the Kharif season and 35 in the Rabi season. Savings is calculated as the difference between income and expenditure. Top 1% of observations are trimmed

Table 3: market and home consumption of wheat, by landownership

Consumption out of home stocks	Market purchases		
	None	Positive	Total
All households			
None	168	976	1,144
	(14.69)	(85.31)	(100.00)
	(9.14)	(90.54)	(39.22)
Positive	1671	102	1,773
	(94.25)	(5.75)	(100.00)
	(90.86)	(9.46)	(60.78)
Total	1,839	1,078	2,917
	(63.04)	(36.96)	(100.00)
	(100.00)	(100.00)	(100.00)
Landowners			
None	85	153	238
	(35.71)	(64.29)	(100.00)
	(5.67)	(75.74)	(13.98)
Positive	1,415	49	1,464
	(96.65)	(3.35)	(100.00)
	(94.33)	(24.26)	(86.02)
Total	1,500	202	1,702
	(88.13)	(11.87)	(100.00)
	(100.00)	(100.00)	(100.00)
Landless			
None	83	823	906
	(9.16)	(90.84)	(100.00)
	(24.48)	(93.95)	(74.57)
Positive	256	53	309
	(82.85)	(17.15)	(100.00)
	(75.52)	(6.05)	(25.43)
Total	339	876	1,215
	(27.50)	(72.10)	(100.00)
	(100.00)	(100.00)	(100.00)

Table 4: Home and PDS consumption of wheat, by landownership

Consumption out of home stocks	Consumption of PDS wheat		
	None	Positive	Total
All households			
None	244	900	1,144
	(21.33)	(78.67)	(100.00)
	(24.35)	(47.00)	(39.22)
Positive	758	1,015	1,773
	(42.75)	(57.25)	(100.00)
	(75.65)	(53.00)	(60.78)
Total	1,002	1,915	2,917
	(34.35)	(65.65)	(100.00)
	(100.00)	(100.00)	(100.00)
Landowners			
None	70	168	238
	(29.41)	(70.59)	(100.00)
	(9.20)	(17.84)	(13.98)
Positive	691	773	1,464
	(47.20)	(52.80)	(100.00)
	(90.80)	(82.15)	(86.02)
Total	761	941	1,702
	(44.71)	(55.29)	(100.00)
	(100.00)	(100.00)	(100.00)
Landless			
None	174	732	906
	(19.21)	(80.79)	(100.00)
	(72.20)	(75.15)	(74.57)
Positive	7	242	309
	(21.68)	(78.32)	(100.00)
	(27.80)	(24.85)	(25.43)
Total	241	974	1,215
	(19.84)	(80.16)	(100.00)
	(100.00)	(100.00)	(100.00)

Table 5: OLS Regressions of wheat savings on variance in prices

Variable	Wheat savings	Wheat savings	First stage regressions	
			Wheat savings	Total savings
Interactions of ag. land with:				
Var wheat price	-0.01	-0.01	-0.01	-0.09
	(0.02)	(0.02)	(0.02)	(0.09)
Var red gram price	0.002*	0.002*	0.002*	0.01*
	(0.001)	(0.001)	(0.001)	(0.003)
Mean wheat price	0.005*	0.005*	0.005*	-0.002
	(0.002)	(0.002)	(0.002)	(0.01)
mean gram price	0.005*	0.005*	0.005*	-0.01*
	(0.002)	(0.002)	(0.002)	(0.004)
Additional instruments				
Rainfall shock 2014	--	-2.04*	-2.54+	-5.02
		(0.93)	(1.52)	(4.39)
Rainfall shock*ag land	--		0.43*	2.51*
			(0.20)	(0.38)
Rainfall shock*BPL	--		1.47	-5.22
			(1.23)	(4.64)
Rainfall shock*father's educ	--		-0.32*	0.94*
			(0.17)	(0.44)
Additional regressors				
Wheat price, dec	0.001	0.001	0.001	-0.02*
	(0.002)	(0.002)	(0.002)	(0.01)
Red gram, dec	-0.0004	-0.0004	-0.0004	0.004*
	(0.0003)	(0.0003)	(0.0003)	(0.001)
Block fixed effects	Yes	Yes	Yes	Yes
Regression F	16.40	18.74	15.01	20.70
	(0.00)	(0.00)	(0.00)	(0.00)
F test on instruments	--	--	5.81	11.02
			(0.00)	(0.00)
Sample size	2792	2792	2792	2792

Note: Clustered standard errors (at the level of the village) in parentheses. Additional regressors are: indicator for BPL household, family size, number of adult males and females in 3 age groups (20-40, 40-60, above 60), indicator for grandfather alive, indicator for mother and grandfather having some formal education, father's education years, number of grandfather's sons, grandfather's agricultural land holding, house plot size, indicator for scheduled caste or tribe. *Significant at 5% level +Significant at 10% level

Table 6: OLS regressions of monthly expenditure on wheat and wheat share on savings

Variable	(log) wheat exp (Rs/month)		wheat share in exp
	Regression 1	Regression 2	Regression 3
Total savings	--	-0.002*	-0.001*
		(0.0003)	(0.0003)
Additions to wheat stock	0.01*	0.007*	0.003*
at end of Rabi	(0.002)	(0.002)	(0.001)
Ag. Land * price wheat	-0.005*	-0.007*	-0.003*
(Rs/kg., dec 2015)	(0.002)	(0.002)	(0.001)
Ag land * price of red	0.0004*	0.0004*	0.0003*
gram (Rs. /kg., dec 2015)	(0.0001)	(0.0001)	(0.0001)
Ag. Land	0.06*	0.08*	0.03+
	(0.02)	(0.03)	(0.019)
BPL	-0.21*	-0.20*	-0.11*
	(0.04)	(0.04)	(0.03)
SC/ST	-0.13*	-0.11*	-0.07+
	(0.05)	(0.05)	(0.04)
Father's education years	0.01*	0.01*	0.01+
	(0.004)	(0.004)	(0.004)
Mother formal schooling	0.03	0.02	0.002
	(0.04)	(0.04)	(0.04)
Family size	0.08*	0.08*	0.05*
	(0.01)	(0.01)	(0.01)
Block fixed effects	Yes	Yes	Yes
Regression F	26.96	28.75	10.84
	(0.00)	(0.00)	(0.00)
Sample size	2792	2792	2792

Note: Clustered standard errors (at the level of the village) in parentheses. Additional regressors are listed in the note to Table 5.

*Significant at 5% level   +Significant at 10% level

Table 7: IV regressions of monthly expenditure on wheat and wheat share on savings

Variable	(1) Full instrument set		(2) Full minus variance and mean of wheat price		(3) Only rain shocks (with interacted terms)		(4) Set (3) + interactions of rain shocks with prices	
	(log) wheat exp.	(log) wheat share	(log) wheat exp.	(log) wheat share	(log) wheat exp.	(log) wheat share	(log) wheat exp.	(log) wheat share
Total savings	-0.004*	-0.003*	-0.003*	-0.003*	-0.004	-0.004+	-0.01+	-0.005*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)
Additions to wheat stock at end of Rabi	0.02*	0.01*	0.02*	0.01*	0.03*	0.02*	0.03*	0.019+
	(0.005)	(0.004)	(0.01)	(0.004)	(0.01)	(0.01)	(0.01)	(0.012)
Ag. Land * price wheat (dec 2015)	-0.01*	-0.01*	-0.01*	-0.006*	-0.016*	-0.01*	-0.02*	-0.01*
	(0.004)	(0.003)	(0.004)	(0.003)	(0.007)	(0.005)	(0.01)	(0.006)
Ag land * price of red gram (dec 2015)	0.0004*	0.0003*	0.0004*	0.0003*	0.0004+	0.0003	0.0004+	0.0003+
	(0.0002)	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.00018)
Ag. Land	0.14*	0.08*	0.14*	0.07*	0.21*	0.16*	0.21*	0.14+
	(0.06)	(0.04)	(0.06)	(0.04)	(0.09)	(0.08)	(0.10)	(0.08)
BPL	-0.15*	-0.08*	-0.16*	-0.08*	-0.11*	-0.02	-0.11*	-0.03
	(0.04)	(0.03)	(0.04)	(0.03)	(0.05)	(0.04)	(0.06)	(0.05)
Father's education years	0.01*	0.01+	0.01*	0.01+	0.01*	0.01	0.01	0.007+
	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.01)	(0.004)
Wald χ^2	664.59	249.83	664.64	246.00	474.16	162.43	528.25	171.82
(Prob > χ^2)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Note: Clustered standard errors (at the level of the village) in parentheses. Additional regressors are listed in the note to table 5:.

*Significant at 5% level   +Significant at 10% level

Table 8: IV regressions of total food and wheat expenditure on child anthropometrics (all children < 6 years)

Variable	IV		Over-id test		Over-id test		With age interactions	
	WAZ	HAZ	WAZ	HAZ	WAZ	HAZ	WAZ	HAZ
(log) hhold food exp	3.16[+]	4.78	3.51[+]	5.19	3.18[*]	4.81	2.82[*]	3.61[*]
	(1.76)	(3.77)	(2.19)	(4.03)	(1.64)	(3.82)	(1.04)	(1.56)
(log) hhold wheat exp	-1.83[+]	-3.16	-1.84[+]	-3.13	-1.79[+]	-3.16	-1.57[*]	-2.02[+]
	(1.14)	(2.77)	(1.13)	(2.73)	(1.05)	(2.78)	(0.62)	(1.09)
(log) Hhold food exp *age	--	--	--	--	--	--	-0.34	-0.50
							(0.21)	(0.33)
(log) Wheat exp * age	--	--	--	--	--	--	0.21[+]	0.24
							(0.13)	(0.19)
(log) exp on services	--		-0.05	-0.07	--	--	--	--
			(0.18)	(0.31)				
Exp on ceremonies	--	--	--	--	-0.001	-0.0003	--	--
					(0.001)	(0.002)		
Age	0.05[*]	-0.03	0.05[*]	-0.02	0.05[*]	-0.03	1.41	2.43
	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.93)	(1.56)
Male	0.01	0.10	0.01	0.10	0.01	0.10	0.03	0.14
	(0.08)	(0.14)	(0.09)	(0.14)	(0.08)	(0.14)	(0.06)	(0.09)
Mother's height (cms)	0.015[+]	0.02	0.014[+]	0.02	0.015[+]	0.02	0.02[*]	0.03[*]
	(0.009)	(0.02)	(0.01)	(0.02)	(0.009)	(0.02)	(0.01)	(0.01)
Mother's BMI	0.07[*]	0.02	0.07[*]	0.03	0.07[*]	0.02	0.07[*]	0.02
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.015)
Family size	-0.02	0.04	-0.03	0.03	-0.02	0.04	-0.03	-0.005
	(0.05)	(0.11)	(0.06)	(0.12)	(0.05)	(0.11)	(0.04)	(0.06)
Wald χ^2	164.71	119.68	161.15	101.13	167.71	118.90	255.94	161.98
(Prob > χ^2)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Note: Clustered standard errors (at the level of the village) in parentheses. Additional regressors are listed in the note to table 5. [*]Significant at 5% level   [+]Significant at 10% level

Appendix Table A: First stage regressions of total and wheat savings on variance in prices, using price data for all months

Variable	Wheat savings	Total savings
Interactions of ag. land with:		
Var wheat price	-56.86[+]	-46.59
	(33.71)	(122.89)
Var red gram price	6.14[*]	18.77[*]
	(2.8)	(7.79)
Mean wheat price	0.006[*]	-0.005
	(0.002)	(0.01)
mean gram price	0.003[+]	-0.01[*]
	(0.0015)	(0.004)
Additional instruments		
Rainfall shock 2014	-2.47	-4.26
	(1.54)	(4.51)
Rainfall shock*ag land	0.41[*]	2.32[*]
	(0.20)	(0.45)
Rainfall shock*BPL	1.53	-4.85
	(1.25)	(4.63)
Rainfall shock*father's educ	-0.32[*]	0.95[*]
	(0.17)	(0.44)
Additional regressors		
Wheat price, dec	-0.001	-0.02[*]
	(0.002)	(0.01)
Red gram, dec	0.0002	0.004[*]
	(0.0004)	(0.001)
Block fixed effects	Yes	Yes
Regression F	15.56	17.85
	(0.00)	(0.00)
F test on instruments	6.13	8.61
	(0.00)	(0.00)
Sample size	2792	2792

Note: Clustered standard errors (at the level of the village) in parentheses. . Additional regressors are: indicator for BPL household, family size, number of adult males and females in 3 age groups (20-40, 40-60, above 60), indicator for grandfather alive, indicator for mother and grandfather having some formal education, father's education years, number of grandfather's sons, grandfather's agricultural land holding, house plot size, indicator for scheduled caste or tribe [*]Significant at 5% level   [+]Significant at 10% level

Appendix Table B: OLS and First stage regressions for HAZ and WHZ regressions

Variable	OLS regressions		First stage regressions	
	WAZ	HAZ	(log) food expenditure	(log) wheat expenditure
(log) food expenditure	0.16	-0.13	--	--
	(0.10)	(0.20)		
(log) wheat expenditure	-0.003	-0.04	--	--
	(0.04)	(0.09)		
(log) expenditure on services	--	--	0.13*	0.20*
			(0.02)	(0.04)
Exp. on ceremonies (Rs. '000)	--	--	0.001*	0.001*
			(0.0002)	(0.0004)
Ag land x mean wheat prices, rabi 2010-15	--	--	-0.01*	-0.01*
			(0.002)	(0.003)
Ag land x Mean wheat prices, Kharif 2010-15	--	--	0.01*	0.01*
			(0.002)	(0.004)
BPL x mean wheat prices, rabi 2010-15	--	--	-0.03	0.01
			(0.04)	(0.07)
BPL x mean wheat prices, Kharif 2010-15	--	--	0.04	0.03
			(0.05)	(0.10)
Father's ed yrs x mean wheat prices, rabi 2010-15	--	--	0.004	0.02*
			(0.004)	(0.008)
Father's ed yrs x mean wheat prices, kharif 2010-15	--	--	-0.003	-0.02*
			(0.004)	(0.01)
Block fixed effects	Yes	Yes	Yes	Yes
Regression F	10.3	3.84	40.64	27.12
	(0.00)	(0.00)	(0.00)	(0.00)
F test on instruments	--	--	12.84	5.39
			(0.00)	(0.00)
Sample size	3997	3753	3997	3997

Note: Clustered standard errors (at the level of the village) in parentheses. Additional regressors are: Mother's height and BMI, SC/ST, BPL household, family size, number of adult males and females in 3 age groups (20-40, 40-60, above 60), indicator for grandfather alive, mother and grandfather having some formal education, father's education years, number of grandfather's sons, grandfather's agricultural land holding, house plot size. Agricultural land is measured in '00 hectares. *Significant at 5% level   +Significant at 10% level
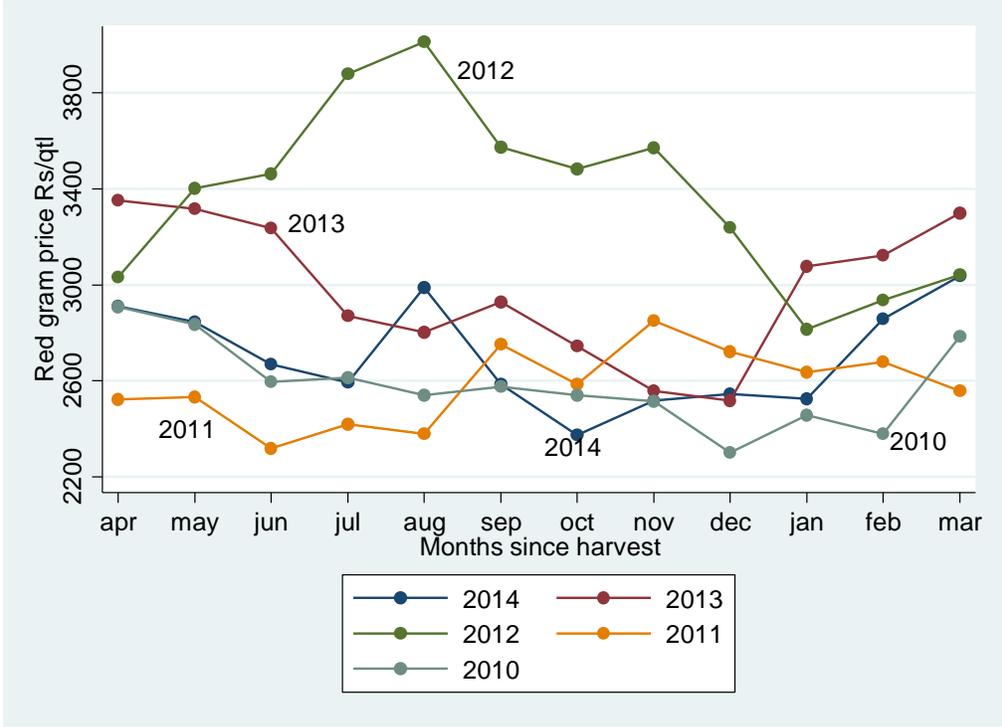
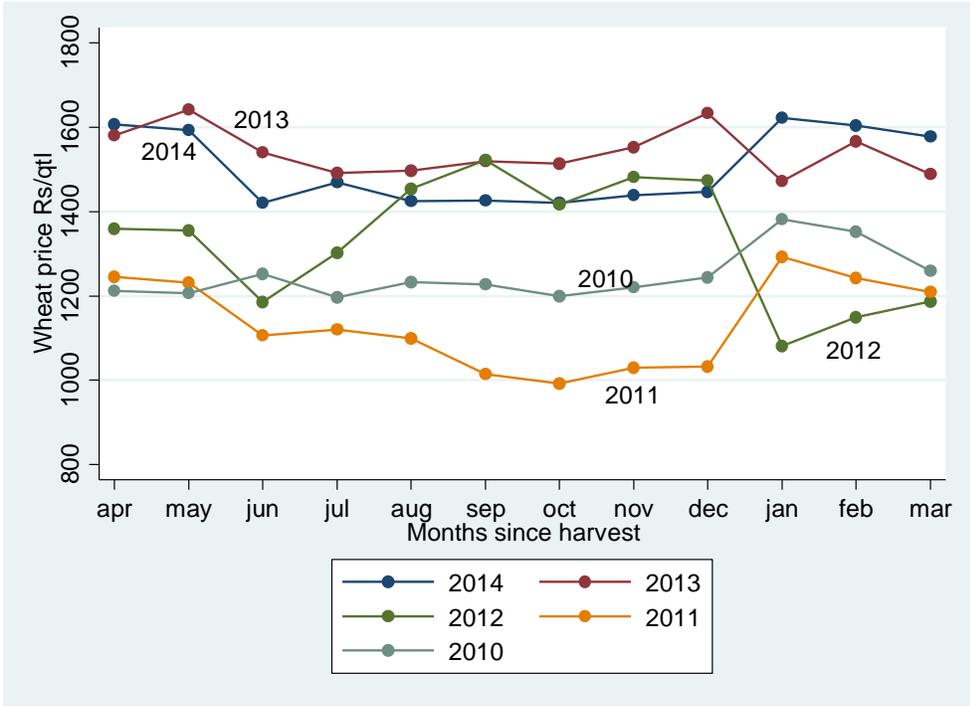Figure 1: Average Red Gram prices, survey region, by month and year (Rs./qtl)

Figure 2: Average wheat prices, survey region, by month and year (Rs./qtl)
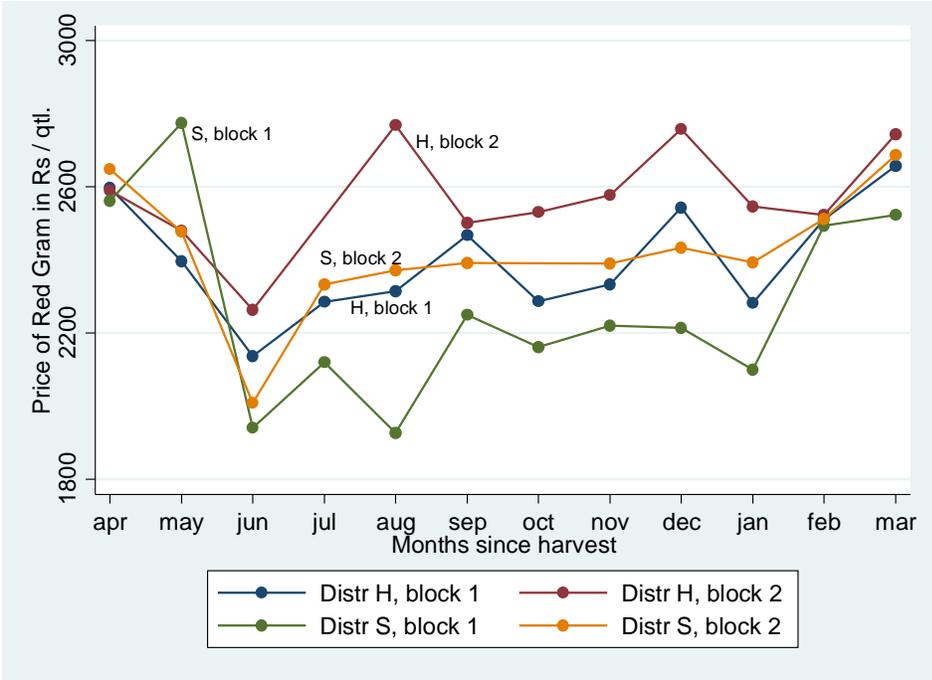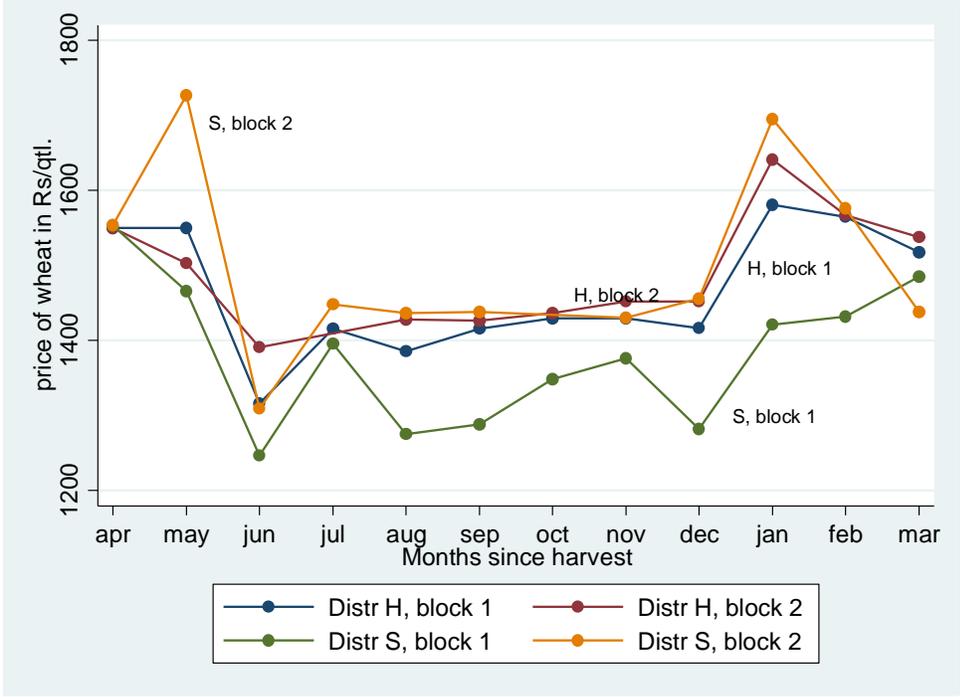
Figure 3: Monthly red gram prices, 2014, neighboring markets

Figure 4: Monthly wheat prices, 2014, neighboring markets