AAEA Selected Paper: 469192

Food Calorie Intake under Grain Price Uncertainty: Evidence from Rural Nepal

Suwen Pan*
Department of Agricultural and Applied Economics
Texas Tech University, P.O. Box 2132, Lubbock, TX 79409-2132.
Tel: (806)742-0261
Fax: (806)742-1099
s.pan@ttu.edu

Cheng Fang
Food and Agriculture Organization (FAO), Rome, Italy

Roderick M. Rejesus
Department of Agricultural and Resource Economics
North Carolina State University
NCSU Box 8109, Raleigh, NC 27695-8109.

Paper Prepared for The American Agricultural Economics Association 2008 Annual Meeting, July 27-29, Orlando, FL, USA.

**Corresponding author.* *The views expressed in this paper are those of the authors and do not necessarily reflect the views of FAO, Texas Tech University, and North Carolina State University.*

Abstract

This study evaluates the effects of grain output price uncertainty on the farm income of rural households and, consequently, how this uncertainty influences caloric intake through changes in farm income. Using a rural household data set, augmented with output price uncertainty measures calculated from historical time-series data, we find that grain output price uncertainty tends to decrease crop production income of rural households. In addition, we find that higher crop income from production increases calorie intake of rural households. Taken together, these results suggests that output price uncertainty during the production process may tend to reduce caloric intake of rural Nepalese households since the price uncertainty negatively affects the crop income households need to buy calorie-rich staple foods.

Keywords: Food Calorie Intake, Price Uncertainty, Nepal

JEL Codes: D12; O13; Q11; Q12

Introduction

Nepal is one of the poorest countries in the world with 31 percent of its population living in poverty and Gross Domestic Product (GDP) per capita at only $260 in 2006 (DFID, 2007). The country's overall human development index value of 0.49 ranks Nepal at 138th among 177 countries worldwide. Nutritional indicators for Nepal are also among the lowest in the world. Almost half of the children are either underweight or stunted, and 50 percent of women aged 15-59 are anemic. The incidence of undernourishment as measured by insufficient caloric intake is also very high at 40.7 percent (FAO, 2004). Over 9 million people in Nepal were identified as vulnerable to food insecurity (FAO/UNDP 2003).

Given the severe nutritional deficiencies of households in Nepal, there is interest in further understanding the effects of food price uncertainties on caloric intake. This is especially important in light of the drastic increases in grain prices observed in the global marketplace, which is currently being driven by historically low food stocks, droughts and floods linked to climate change, high oil prices, and growing demand for bio-fuels. In the case of Nepal, there is special interest in how grain output price uncertainties affect the income of rural farm households (who typically produce these grains) and, consequently, how the changes in income caused by the grain price uncertainties ultimately affect caloric intake of these rural farm households (who also purchase/consume these grains).[1]

The primary purpose of this paper, therefore, is to assess the effects of grain output price uncertainties on income and, consequently, on the food calorie intake of rural farm households in Nepal. A household level cross-sectional data set, augmented with price uncertainty measures based on historical time-series data, is used to achieve this objective. The price uncertainty

[1] Note that grain crops (e.g. rice and wheat) are the major food staples in the country.

measures are calculated using time-series models and the effects of uncertainty on farm incomes and caloric intake are analyzed using a two-stage (instrumental variables) approach.

Note that there have been a number of studies that have investigated factors affecting food calorie intake around the world, especially in Africa (Aromolaran 2004; Akinleye and Rahji 2007). But to the best of our knowledge, no study has yet investigated the caloric intake decision of Nepalese farm households in the presence of output price uncertainty during the production process. As one of the poorest developing countries in the world, an investigation of Nepalese farm households' food calorie intake decisions in the presence of grain price uncertainty during production would provide insights that have not been observed in previous studies. These insights may have important implications for the design of nutritional/public health policies and/or economic development policies that can assist in the alleviation of food insecurity and malnutrition in Nepal (as well as other less-developed countries).

Conceptual Framework

As in other developing countries, agricultural households in Nepal are typically classified as semi-commercial, with part of their production being used for their own consumption. Rural farm households in Nepal are typically both producers and consumers of the same agricultural products (i.e. rice, wheat). Following the arguments of Singh, Squire and Strauss (1986), Strauss and Thomas (1995), and Carter and Zhong (1999), it is common to assume that semi-commercial farmers in this case make recursive decisions. That is, production is dependent on market prices but independent of consumption decisions, and consumption and labor supply decisions are dependent on income derived from production. This means that consumption (and calorie intake) depends on production but production does not depend on consumption, under certain conditions. The conditions for the assumption of a recursive decision model to hold are the following:

existence and access to local input/output markets, a fixed land base, the practice of farmers marketing surplus products, and a situation where farmers are prices takes. All these conditions hold in the rural agricultural sector of Nepal

Following the approach of Carter and Zhong (1999), let the farm household's utility function for a given season be:

(1) $$U = f(X_S, X_O, X_L),$$

where X_S are calorie-generating staple foods, X_O are non-calorie generating "other goods", and X_L is amount of leisure time.[2] The household's utility function can then be maximized subject to the following simple cash income constraint:

(2) $$P_s X_s + P_O X_O + P_L L = P_L T + \pi,$$

where P_s is the price of the staple foods, P_O is the price of "other goods", P_L is the wage rate, L is the labor input used on the farm, T is the total stock of household time, and π is farm household income. Maximization of equation (1) subject to equation (2) leads to a system of equations where the household's production and consumption decisions can be shown to be made recursively (Singh, Squire and Strauss 1986).

The recursive nature of the model is attractive because it means that all prices are exogenous. According to Carter and Zhong (1999), the model's recursive nature allows one to specify the demand equation for the food staple as a function of food prices, household income, and other socio-demographic variables that determine demand. Since caloric intake is a direct function of the amount of staple food consumed (or demanded), caloric intake can also be assumed to be a function of food prices, household income, and other socio-demographic

[2] In this specification, we implicitly assume that most of the calories consumed by farm households are from staple foods. This makes sense in our case given that most of the calories consumed by rural farm households in Nepal are from the staple food crops. One can easily change this to reflect calories from all food products and have the same qualitative insights.

variables that determine caloric intake. In these types of recursive household models, it is typically assumed that prices at the time of consumption are known/fixed and, therefore, the uncertainty in grain prices affects consumption and calorie intake decisions only indirectly through the income from staple food production.[3] Therefore, caloric intake can be represented as:

$$C = f(P_s, \pi(\sigma), \gamma) \quad (3)$$

where C is caloric intake, π is the farm income from production that is assumed to be affected by grain price uncertainty (σ), and γ is a vector of socio-demographic variables that determine calorie intake. Empirically estimating equation (3) is important in order to determine how grain price uncertainty affects rural farm household income and caloric intake in Nepal.

Empirical Methodology

Measuring Grain Price Uncertainty

To be able to empirically estimate (3) we first need to explicitly obtain measures of grain price uncertainties and determine how it affects income. To obtain a good estimate of grain price uncertainty in Nepal, it is important to note that the domestic price of grains (i.e. rice and wheat) in Nepal is heavily influenced by the grain prices of neighboring India, due to the trade treaty between the two countries. This treaty allows trade of primary agricultural products between the two countries to be free of any customs duties and quantitative restrictions. Hence, any measurement of grain price uncertainty in Nepal must take the relationship between Nepalese grain prices and Indian grain prices into account.

The statistical properties of the price time series are investigated using the Augmented Dickey-Fuller test and autocorrelation function (ACF) plots. Based on these approaches, we find

[3] This implicitly assumes that grain price uncertainty do not have a direct effect at the time of the consumption/caloric intake decision. At the time of consumption, grain price uncertainty only “indirectly” affects caloric intake through its effect on the income from grain production.

that monthly rice and wheat prices in Nepal are stationary and the relationship between the Nepalese and Indian grain prices can be modeled using the following specification by Slade (1986), Asche, Gordon, and R. Hannesson (2004):

(4) $$P_t^N = a + \sum_{j=1}^{m} b_j P_{t-j}^N + \sum_{i=0}^{n} c_i P_{t-i}^I + \varepsilon_t \quad ,$$

where P_t^N is the price of grains in Nepal at time t, P_t^I is the price of grains in Nepal at time t, *i* and *j* are the number of lags of the Indian and Nepalese grain prices (respectively), *a*, *b*, and *c* are unknown parameters to be estimated, and ε_t is a random error term. The lag structure specification is chosen so that ε_t is white noise. If a joint hypothesis test suggest that all *c*'s in (4) are statistically not zero (i.e. the null hypothesis that $c_i = 0$ is rejected), the data supports the hypothesis that P^I causes P^N. Interchanging price variables in equation (7) allows a test of whether P^N causes P^I. If one price causes the other with no evidence of causality in the opposite direction, it indicates price leadership. If $\sum b_j + \sum c_i = 1$, there exists a long-run "law of one price" (LOP). If $c_0 = 1$, c_i=0 and $b_j = 0$ then the LOP holds in a static sense. From equation (4), 12-month ahead forecast variances are calculated for each region in Nepal and we use these forecast variances as our measure of grain output price uncertainty that affects production decisions and income.

Effects of Grain Price Uncertainty on Income and Caloric Intake

Once the grain output price uncertainty measures are determined, its relationship with the farm household's income from crop production needs to be examined. Following Sarris (2002), Rapsomanikis and Sarris (2005), Sarris and Karfakis (2006), the gross crop income (Y_h) of household *h* can be defined as:

(5) $$Y_h = \sum_{i=1}^{n} P_{h,i} Q_{h,i} \ ,$$

where Q is the quantities of each product i produced (i = 1,…n) by the household and P is the price of each product produced by the household. Equation (5) implies that household crop income is a function of price and quantities.

It can be argued, therefore, that household crop income is not only affected by price uncertainty, it is also affected by quantity (or yield) uncertainty as well. In this regard, yield uncertainty is estimated using the following ARIMA (p, q, d) model:

(6) $$(1 - \sum_{i=1}^{p} \phi_i L^i)(1 - L)^d P_t = (1 + \sum_{i=1}^{q} \theta_i L^i)\xi_t \ ,$$

where d is a positive integer that controls the level of differencing, L is the lag operator, ϕ and θ are the parameters of the autoregressive and the moving average part of the model, and the ξ's are error terms and are assumed to be independent, identically distributed variables sampled from a normal distribution with mean zero. As with the price uncertainty measure, we use the 12-month ahead forecast variance from equation (6) as a measure of yield uncertainty. The relationship between crop income and grain price uncertainty is then examined by estimating an equation where the farm household's crop income is a function of grain price uncertainty, yield uncertainty, and other observable control covariates that affect income, such as input amounts (e.g. fertilizer and seeds) and household/farm characteristics (i.e. educational levels of the household head, household size, etc.).

The ultimate decision variable of interest is caloric intake and how this variable is affected by income from agricultural production during which grain output price uncertainty was present in the production process. As suggested earlier, we could have simply estimated a caloric intake variable that is a function of food prices, household income, and other socio-demographic variables. However, note that household income generated during the production process (before consumption) may be endogenous to caloric intake due to unobserved variables that affect both dependent variables. For example, the proportion of household grain production set aside for home consumption is unobserved in our data set, which in turn affects both income and caloric intake. Unobserved health conditions of the household members are also possible variables that can cause endogeneity in the caloric intake equation.

In light of this potential endogeneity problem, we use a two-stage (instrumental variables) approach to more accurately estimate the effect of household income on caloric intake and indirectly infer the grain price uncertainty effect on caloric intake. The first-stage is implemented by estimating the crop income equation described above (i.e. as a function of grain price uncertainty, yield uncertainty, and other observable control covariates that affect income), but we include "time to get to major market" as an additional instrumental variable.[4] The distance to major market also serves to identify the crop income equation relative to the caloric intake equation. The first-stage crop income equation can then be defined as:

$$\ln Y_{ht} = P_{ht}^{U}\beta + Q_{ht}^{U}\gamma + X_{ht}^{Y}\alpha + v_{ht}\,, \tag{7}$$

where P_{ht}^{U} is a vector of price uncertainty variables, Q_{ht}^{U} is a vector of yield uncertainty variables, X_{ht}^{Y} is a vector of observable control covariates, β, γ, and α are parameters to be estimated, and v_{ht} is the random error term.

The second-stage caloric intake equation can then be estimated by using the predicted income variable ($\ln \hat{Y}_{ht}$) as an explanatory variable:

$$\ln C_{ht} = \ln \hat{Y}_{ht}\delta + P_{ht}\lambda + X_{ht}^{C}\rho + \varepsilon_{ht}\,, \tag{8}$$

[4] Time to get to major market seems to be a valid instrument since it tends to be correlated with crop income but it does not typically affect the hypothesized unobserved variables described above.

where C_{ht} is the caloric intake of the household, P_{ht} are the staple food prices, X_{ht}^{C} are a vector of observable control covariates, and δ, λ, and ρ are parameters to be estimated, and ε_{ht} is the random error term. Based on previous literature, estimation using household survey data typically exhibit heteroskedasticity. Thus, we test for heteroskedasticity in (8) and apply Heteroskedasticity-robust standard error procedures to correct for this problem.

Data and Empirical Specification

There are two types of data used in the analysis. The time series data used includes historical monthly data for prices (May 1989 – April 2004) and yearly data for yields (1989-2004). It contains monthly New Delhi (India) wheat and rice prices, as well as wheat and rice prices for different regions in Nepal. The cross-sectional data set used in the study is the 2003/04 Nepal Living Standards Survey (NLSS), which was designed as a multi-topic survey collecting a comprehensive set of data on different aspects of household welfare (consumption, income, housing, labor markets, education, health etc.). The purpose of these data is to allow the Government to monitor progress in improving national living standards and to evaluate the impact of various government policies and programs on the living conditions of the population. The survey was conducted under the responsibility of the Household Survey Division of the Central Bureau of Statistics (CBS).[5]

A two-stage stratified sampling procedure was used to select the sample for the first stage of the survey (NLSS I). The smallest administrative unit in the 1991 Population Census was the ward, and this was selected as the primary sampling unit (PSU) for the survey. In the first stage, 275 wards were selected with probability proportional to size (PPS) from each of the four ecological strata, using the number of households in the ward as the measure of size. The sample

[5] For more details about the survey, see Kinnon and Prennushi (2002).

frame considered all the 75 districts in the country, and indeed 73 of them were represented in the sample. In the second stage (NLSS II), a fixed number of households – twelve – were selected from each PSU. Eventually, the sample size of the household data set after NLSS II is 4,008 households. Thirteen households were dropped from the original 4,008 due to data issues (i.e. missing data).Of the remaining 3,995 household, we only use the 2,751 households in the rural areas since these rural households are the ones that are typically involved in crop production.

The major variables used in the study and summary statistics are presented in Table 1. As explained in the previous section, the dependent variables of interest in this study are crop income (*Income*) and total food calorie intake (*Calorie*). The rural households in Nepal have an average intake of about 2540 calories/day which is slightly above the 2250 calories/day minimum food calorie requirement for an adult male advocated by FAO (Waterlow and Payne,1990). Note that the average daily caloric intake in Nepal tends to be lower than the average of 2,800 calories/day for an adult male in India (Logan 2007).

As mentioned in the previous section, we are interested in accurately estimating the effect of grain output price uncertainty on production income, and then how this uncertainty (working through income) affects caloric intake decisions. Hence, the first equation that needs to be specified is the crop income equation where the independent variables include price uncertainty variables, yield uncertainty variables, and observable control covariates (see equation (7)). The output price uncertainty variables used in the crop income equation are estimated rice and wheat price uncertainty from equation (4). The yield price uncertainty variables in the crop income equation are estimated rice, wheat, and maize uncertainty measures from equation (6). The observable control covariates in the crop income equation include: age (*Age*), household size

(*HSize*), female dummy (*Female*), high school dummy (*HighSchool*), land ownership dummy (*Own*), number of cows produced (*Cows*), number of sheep produced (*Sheep*), number of chickens produced (*Chicken*), seed cost (*Seeds*), fertilizer cost (*Fertilizers*), drought dummy (*Drought*), flood dummy (*Flood*), fruit dummy (*Fruit*), and rural region dummies (*Mountain* and *Hill*, with *Terrai* omitted). Note that time to major market (*Time*) is also included in the specification as an instrument.

In the food calorie intake equation (see equation 8), the main independent variables in the specification are the predicted crop income from the first-stage equation, the price (rice and wheat) and yield (rice, wheat, and maize) uncertainties, the price of staple foods, and observable control covariates. The prices included in the food calorie intake equation are rice price (*Rice price*), wheat price (*Wheat price*), and maize price (*Maize price*). The control covariates included in the food calorie intake specification are: age (*Age*), female dummy (*Female*), high school dummy (*HighSchool*), land ownership dummy (*Own*), number of cows produced (*Cows*), number of sheep produced (*Sheep*), number of chickens produced (*Chicken*), fruit dummy (*Fruit*), value of durables (*Durables*), value of remittances (*Remittances*), value of housing (*Housing*), cost of illness (*Ill*), and rural region dummies (*Mountain* and *Hill*, with *Terrai* omitted).

Results and Discussions

Grain Price Uncertainty Estimates

Tables 2 and 3 present the parameter estimates from the time series models used to calculate the rice and wheat price uncertainty measures. The Granger causality tests indicate that Nepal prices are caused by India prices, but not vice versa. Most of the Nepal regional prices are positively related with their own lagged one-period prices, as well as the lagged one-period India prices. Given that India prices tend to be positively related with world prices, it can be argued that most

Nepal prices will increase if world prices increase. The results indicate that the LOP does not exist in the Nepal and India grain market (rice and wheat), but instead it seems that India has the price leadership in this market. Using the parameter estimates from Tables 2 and 3, the price uncertainty measures can be calculated and the summary statistics of these price uncertainty measures are presented in Table 4.

Parameter Estimates of the Crop Income Equation

The parameter estimates of the rural crop income equation for Nepal are presented in Table 5. Our results indicate that the following variables have statistically significant positive effects on Nepalese rural crop income: age, ownership, number of cows raised, number of chicken raised, fertilizer costs, drought dummy, and fruit dummy. The positive and significant age variable indicates that more experienced farmers tend to have higher incomes. Nepalese farmers that own their land also tend to have higher incomes. The positive and significant effects of the number of cows and chicken raised, as well as the fruit dummy, indicate that Nepalese farmers who have more diversified operations tend to have higher income.

On the other hand, the variables that have a statistically significant negative effect on crop income are: household size, female dummy, seed costs, rice price uncertainty, wheat yield uncertainty, and the mountain dummy. The negative household size effect suggests that bigger families may tend to consume more of their production such that income from the crops sold tends to be lower. The important result here is the strongly negative effect of rice price uncertainty and wheat yield uncertainty. This suggests that uncertainty about the prices that farmers will receive at harvest tend to depress incomes (which may be due to reduced efforts or underinvestment during the production process).

Parameter Estimates of the Caloric Intake Equation

Following the crop income estimation, the predicted crop income is calculated and included in the second stage calorie intake equation. The parameter estimates from the calorie intake equation are presented in Table 6. The variables that have statistically significant positive effects on caloric intake are: income, age, female dummy, number of cows produced, number of sheep produced, number of chicken produced, the value of durables, the value of remittances, the value of housing, and the yield uncertainties (include rice, wheat, and maize). The negative regional dummy coefficients indicate that caloric intake in the mountain and hill areas of Nepal tend to be lower than the caloric intake in the Terrai region. The significance of the crop income variable is expected since higher incomes make it possible to purchase more food items and increase caloric intake. Similarly, the cows, sheep, and chicken produced are mostly animals that the household typically sell or consume. Hence, similar with the crop income effect, if more of these animals are sold then the family has more funds to purchase food and increase caloric intake. If the household consume the meat from these animals, the calories from meat products also tend to be high (which may also explain the positive effect). Hence, the animals raised by rural households can also be thought of as a "calorie smoothing" mechanism to maintain household consumption and caloric intake, in case the crop income generated by the household is not sufficient. Interestingly, all the yield uncertainties are negative and significant. The results are related with the nature of semi-commercial characteristics as we discussed earlier.

Note that the calculated income elasticity from this study (0.133) is consistent with the existing estimates in the literature. Reutlinger and Selowsky (1976) have estimated income elasticities of calorie intake at around 0.17 (evaluated at the mean) using cross-sectional, cross-country data. Behrman and Deolalikar (1987) for India, Bouis and Haddad (1992) for the Philippines, and Ravallion (1983) for Indonesia also have estimated calorie-income elasticities that are close to the estimate in this study (Dawson and Tiffin 1998). With the strongly positive income elasticity and negative yield uncertainities, one can argue that the price and yield uncertainty in the crop production process causes lower caloric intake. That is, the presence of yield and price uncertainty in production reduces the crop income of rural households at harvest (based on the parameter estimates from the first equation); and then the lower income causes a reduction in the caloric intake equation (due to the positive income elasticity of calorie demand).

Another important result to take note of in Table 6 is the insignificant effect of rice, wheat, and maize price variables as well as the price uncertainties (both rice and wheat).[6] This indicates that caloric intake decisions are not statically directly affected by changes in the price of staple foods (i.e. it is highly inelastic). With this result it can be argued that caloric intake of rural households in Nepal is not substantially affected by higher staple prices, but instead incomes are the major factor that drives food consumption and caloric intake decisions. This may be due to the semi-commercial nature of rural farm households in Nepal (i.e. if prices are high, they just consume more of their production).

Conclusion and Policy Implications

Since most rural farm households in Nepal are semi-commercial farms, there is interest in uncovering the effect of output price uncertainty (prior to harvest) on crop income. Consequently, with Nepalese households' nutritional deficiencies, there is also significant interest on how the price uncertainty in production ultimately influences caloric intake decisions of farm households -- since the price uncertainty affects the household income needed to purchase staple foods with high calorie content. Hence, this study investigates the effects of grain output price uncertainties on income and, consequently, on the food calorie intake of rural farm households in Nepal.

[6] The highly price inelastic demand for calories in this study is consistent with the findings of Beatty and LaFrance (2005).

Using time-series approaches to provide measures of uncertainty, together with a two-stage regression approach, we find that output price uncertainty (especially for rice) significantly reduces the expected crop income of rural Nepalese households. We also find that calorie intake has a significant positive relationship with the crop income of the household, but food prices tend to not substantially affect calorie intake (i.e. highly price inelastic). Therefore, given these results, one can argue that output price uncertainty during the production process may tend to reduce caloric intake of rural Nepalese households since the price uncertainty negatively reduces the income households need to buy calorie-rich staple foods.

The results above have important implications for the government wishing to alleviate the nutritional status of rural farm households in Nepal. First, the insignificant price-calorie elasticities, relative to the significant calorie-income elasticity, suggests that policies aimed at enhancing rural incomes rather than policies that manipulate *retail* prices of staple foods may have more of an impact on the nutritional status of rural Nepalese farm households. Note, however, that policies that help stabilize *farm gate* prices received by producers would probably help improve farm incomes and improve the nutritional status of farm households. Price floors at the farm gate, for example, would lessen uncertainty and may help increase farmer efforts and investments throughout the season to increase incomes. These income-enhancing policies may in turn allow the rural households to purchase more nutritious foods that improve caloric intake.

References

Aromolaran, A. B. “Intra-Household Redistribution in south-Western Nigeria.” Economic Growth Center discussion paper No. 890, 2004, Yale University.

Akinleye1, S. and Rahji M. “Nutrient elasticities among Nigerian households differentiated by income.**”** *Agrekon, 46(2007): 274-288.*

Asche, F., D. V. Gordon, and R. Hannesson. “Tests for Market Integration and the Law of One Price: the Market for Whitefish in France.” *Marine Resource Economics*, 19(2004): 195-210.

Behrman, J.R., and A. B. Deolalikar. “Will Developing Country Nutrition Improve with Income? A Case Study for Rural India.” *Journal of Political Economy,* 95 (1997): 492-507.

Beatty, Timothy and J.T. LaFrance. “United States Demand for Food and Nutrition in the 20th Century.” *American Journal of Agricultural Economics* (Papers & Proceedings), 87 (2005): 1159-1166.

Bouis H. E. and L. J. Haddad. “Are Estimates of Calorie-income Elasticties too High?” *Journal of Development Economics*, 39(1992): 333-64.

Carter, Colin A. and Funing Zhong. “Rural Wheat Consumption in China.” *American Journal of Agricultural Economics*, 81(1999): 582-592.

Dawson, Philp J. and Richard Tiffin. “Estimating the Demand for calories in India.” *American Journal of Agricultural Economics,* 80(1998):474-481.

Department for International Development, UK, (DFID). Country Profile: Nepal, 2007. Available at http://www.dfid.gov.uk/countries/asia/nepal.asp.

Dickey D. and Fuller W. “Distribution of the Estimators for Autoregressive Time Series with a Unit Root.” *Journal of the American Statistical Association*, 74(1979): 427-431.

Food and Agriculture Organization (FAO). “Food Insecurity and Vulnerability in Nepal: Profiles of Seven Vulnerable Groups.” Agricultural and Development Economics Division, the Food and Agriculture Organization of the United Nations ESA Working Paper No. 04-10, 2004.

FAO/UNDP. “Nepal Agricultural Policy and Strategies for Poverty Alleviation and Food Security.” NEP/99/023: SPPD Report, 2003. Kathmandu, Nepal.

Kinnon Scott and Giovanna Prennushi. “Nepal Living Standards Survey I (1995/96) Survey Design and Implication.” World Bank working paper, 2002. Available at **http://www.worldbank.org/html/prdph/lsms/country/nepal/docs/nep96bidr.pdf.**

Logan, Trevon D. “The Transformation of Hunger: the Demand for Calories past and Present.” The Ohio State University and NBER 2007 working paper.

Rapsomanikis G and A. Sarris. "The impact of domestic and international commodity price volatility on agricultural income instability in Ghana, Vietnam and Peru." FAO Commodities and Trade Policy Research Working Paper No. 15, 2005.

Ravallion, M. "Income Effects on Undernutrition." *Economic Development and Culture Change*, 38 (1983): 489-515.

Reutlinger, S. and M. Selowlky. *Malnutrition and Poverty: Magnitude and Policy Options.* Beltimore MD: World Bank/Johns Hopkins University Press, 1976.

Sarris, A. "The Demand for Commodity Insurance by Developing Country Agricultural Producers: Theory and Application to Cocoa in Ghana." Policy Research Working Paper 2887, 2002, World Bank, Development Research Group.

Sarris, A. and P. Karfakis. "Household Vulnerability in Rural Tanzania." FAO 2006 working paper.

Singh, I., L. Squire, and J. Strauss (1986). "A Survey of Agricultural Household Models: Recent Findings and Policy Implications." *World Bank Economic Review*, 1(1986): 149-79.

Slade, M.E. "Exogeneity Test of Market Boundaries Applied to Petroleum Products." *Journal of Industrial Economics* 34(1986):291–304.

Strauss, J., and D. Thomas. *Human Resources: Empirical Modeling of Household and Family Decisions.* Handbook of Development Economics, vol 3A. Jere Behrman and T. N. Srinivasan, eds., chap 34 pp 1185-2023. Amsterdam, New York and Oxford: Elsevier Science, North Holland, 1995.

Waterlow, J.C. and P.R. Payne (1990). "Interrelationships between Protein and Energy Requirements." FAO 1990 workign paper. Available at http://www.fao.org/docrep/meeting/009/ae906e/ae906e11.htm.

Table 1. Summary Statistics and Variable Definitions for Rural Household Data (n = 2751)

Variable	Variable Definition	Mean	St. Dev.
Income	Total crop income per capita (Rs)	3895.88	9888.52
Calorie	Food calorie intake per day	2539.50	888.12
Area	Total land area (acres)	0.33	0.33
Rice	Total rice production (kg)	1067.77	1868.97
Wheat	Total wheat production (kg)	214.63	517.80
Maize	Total maize production (kg)	254.76	428.89
Age	Age of household head	45.68	14.26
HSize	Household size	5.34	2.58
Female	=1 if female head of household, 0 otherwise	0.20	0.40
HighSchool	=1 if head with high school degree, 0 otherwise	0.01	0.09
Own	=1 if own land, 0 otherwise	0.15	-0.64
Cows	No. of cows raised	17.33	86.84
Sheep	No. of sheeps raised	27.07	111.52
Chicken	No. of chickens raised	3.76	11.94
Time	Time to major market (hours)	0.09	0.48
Seeds	Seed cost for all crops (Rs)	0.25	1.00
Fertilizer	Fertilizer cost for all crops (Rs)	1.08	2.95
Drought	=1 if experienced drought, 0 otherwise	0.14	0.35
Flood	=1 if experienced flood, 0 otherwise	0.74	0.44
Fruit	=1 if have income from fruits, 0 otherwise	0.28	0.45
Durables	Total value of durable goods per capita (Rs)	63788.85	381136.18
Remittances	Total value of remittances per capita (Rs)	33287.33	615348.65
Housing	Housing value per capita (Rs)	64307.03	377669.24
Ill	Illness cost per capita	2192.41	39331.40
Rice Price	Rice price (Rs/kg)	7.73	0.11
Wheat Price	Wheat price (Rs/kg)	13.63	4.93
Maize Price	Maize price (Rs/kg)	13.46	2.26
Mountain	=1 if rural mountain area, 0 otherwise	0.14	0.34
Hill	=1 if rural hill area, 0 otherwise	0.45	0.50
Terrai	=1 if rural terrain area	0.41	0.44

Table 2. Effects of Indian Rice Price on Nepal Rice Price and Granger Causality Tests

Variables	----- Regions in Nepal -----										
	Bhojpur	Chitwang	Dhankuta	Doti	Ilam	Jhapa	Kailali	Kathmandu	Morang	Palpa	Parsa
Constant	0.325 (1.142)	0.655 (0.556)	0.101 (0.544)	0.123 (0.515)	0.1004 (0.544)	0.105 (0.720)	0.339 (0.351)	-1.120 (0.990)	2.813 (1.775)	0.738 (0.461)	0.588 (0.354)
P_{t-1}^{N}	0.731* (0.130)	0.794* (0.058)	0.610* (0.060)	0.846* (0.042)	0.610* (0.062)	0.687* (0.059)	0.837 (0.049)	0.720* (0.078)	0.103 (0.078)	0.848* (0.462)	0.935* (0.078)
P_{t-2}^{N}	0.131 (0.102)							0.051 (0.081)			-0.019 (0.107)
P_{t-3}^{N}											-0.122 (0.075)
P_{t-1}^{I}	-1.95* (0.55)	0.209* (0.07)	0.515* (0.097)	0.201* (0.072)	0.515* (0.097)	0.395* (0.097)	0.169* (0.067)	1.352* (0.435)	0.879* (0.181)	0.139* (0.067)	0.343* (0.176)
P_{t-2}^{I}	2.262* (0.55)							-0.874* (0.441)			-0.454* (0.214)
P_{t-3}^{I}											0.309* (0.169)
Granger Causality test(χ square) for India	17.827	8.872	27.957	7.807	27.957	16.917	6.46	20.695	23.449	4.32	18.469

Table 3. Effects of India Wheat Price on Nepal Wheat Price and Granger Causality Tests

Variables	----- Regions in Nepal -----										
	Achham	Banke	Chitwang	Dhankuta	Dhanusha	Doti	Ilam	Jhapa	Jumla	Kailali	Kaski
Constant	-0.657	-0.907	0.127	0.323	-0.949	1.795*	0.932	-0.141	-0.686	-0.342	0.534
	(1.544)	(0.509)	(0.873)	(2.469)	(0.889)	(0.903)	(0.643)	(0.522)	(4.044)	(0.478)	(0.804)
P_{t-1}^{N}	0.849*	0.757*	0.444*	0.277*	0.539*	0.504*	0.822*	0.702*	0.753*	0.801*	0.612*
	(0.051)	(0.061)	(0.074)	(0.083)	(0.072)	(0.073)	(0.051)	(0.061)	(0.061)	(0.051)	(0.079)
P_{t-2}^{N}											
P_{t-1}^{I}	0.518*	0.576*	1.118*	1.714*	1.037*	0.867*	0.304*	0.612*	1.401*	0.407*	0.792*
	(0.262)	(0.139)	(0.177)	(0.375)	(0.188)	(0.162)	(0.093)	(0.133)	(0.644)	(0.108)	(0.189)
P_{t-2}^{I}											
Granger Causality test(χ square) for India	3.894	17.201	39.667	20.919	30.503	28.471	10.616	21.293	4.735	14.24	17.476

Table 3. Effects of India Wheat Price on…. (Continued)

	----- Regions in Nepal -----							
Variables	Kathmandu	Morang	Nuwakot	Parsa	Ramechhap	Rolpa	Rupandehi	Surkhet
Constant	-0.274	-1.024	-0.734	-0.534	4.537	1.644	-3.299	2.613
	(0.564)	(0.565)	(0.804)	(0.818)	(1.788)	(0.889)	(4.773)	(1.03)
P^N_{t-1}	0.773*	0.572*	0.839*	0.623*	0.421*	0.634*	-0.045	0.761*
	(0.052)	(0.091)	(0.045)	(0.073)	(0.087)	(0.077)	(0.084)	(0.073)
P^N_{t-2}		0.109						
		(0.084)						
P^I_{t-1}	0.547*	1.318*	0.468*	0.819*	0.899*	0.681*	2.676*	0.463*
	(0.129)	(0.236)	(0.148)	(0.188)	(0.257)	(0.161)	(0.652)	(0.157)
P^I_{t-2}		-0.561*						
		(0.252)						
Granger Causality test(χ square) for India	18.092	36.614	9.947	18.894	12.263	17.911	16.831	23.525

Table 4. Summary Statistics of Uncertainty Measures (12-month ahead forecast variance)

Uncertainty Measures	Mean	Standard Deviation
Rice Price Uncertainty	2.40	0.91
Wheat Price Uncertainty	3.84	0.99
Rice Yield Uncertainty	0.26	0.09
Wheat Yield Uncertainty	0.18	0.04
Maize Yield Uncertainty	0.24	0.22

Table 5. Determinants of Rural Crop Income in Nepal (Dependent Var: ln(*Income*))

Variables	Parameter Estimate	St. Error
Intercept	-2.490*	0.332
ln(*Age*)	0.162*	0.065
ln(*HSize*)	-0.192*	0.049
Female	-0.113*	0.058
HighSchool	-0.021	0.224
Own	0.621*	0.065
ln(*Cow*)	0.068*	0.021
ln(*Sheep*)	0.014	0.018
ln(*Chicken*)	0.150*	0.034
Time	0.040	0.045
ln(*Seeds*)	-0.172*	0.024
ln(*Fertilizers*)	0.201*	0.021
Drought	0.199*	0.068
Flood	-0.042	0.058
Fruit	0.292*	0.049
Rice Price Uncertainty	-0.077*	0.027
Wheat Price Uncertainty	-0.029	0.023
Rice Yield Uncertainty	0.091	0.261
Wheat Yield Uncertainty	-0.819*	0.560
Maize Yield Uncertainty	-0.124	0.103
Mountain	-0.150*	0.078
Hill	-0.041	0.055
R-squared		0.233

Note: * denotes statistical significance at the 10% level.

Table 6. Determinants of Household Caloric Intake in Rural Nepal (Dep. Variable = log(*Food Calorie intake*))

Variables	Parameter Estimate	St. Error
Intercept	7.083*	0.969
ln(*Income*)	0.133*	0.017
ln(*Age*)	0.093*	0.026
Female	0.047*	0.022
HighSchool	0.019	0.082
Own	-0.026	0.025
ln(*Cow*)	0.020*	0.009
ln(*Sheep*)	0.014*	0.008
ln(*Chicken*)	0.057*	0.012
Fruit	-0.011	0.019
ln(*Durables*)	0.019*	0.005
ln(*Remittances*)	0.019*	0.003
ln(*Housing*)	0.016*	0.004
ln(*Ill*)	0.0006	0.003
ln(*Rice Price*)	0.052	0.442
Ln(*Wheat Price*)	-0.003	0.042
Ln(*Maize Price*)	0.026	0.124
Rice Price Uncertainty	0.004	0.007
Wheat Price Uncertainty	0.003	0.006
Rice Yield Uncertainty	-0.175*	0.072
Wheat Yield Uncertainty	-0.428*	0.155
Maize Yield Uncertainty	-0.056*	0.029
Mountain	-0.088*	0.021
Hill	-0.044*	0.015
R-squared		0.126

Note: * denotes statistical significance at the 10% level