Food Calorie Intake under Grain Price Uncertainty in Rural Nepal

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Abstract This study evaluated the effects of grain output price uncertainty on the farm income of rural households and, consequently, how this uncertainty influenced caloric intake through changes in farm income. Using a national rural household survey data set in Nepal, augmented with output price uncertainty measures calculated from historical time-series data, we found that grain output price uncertainty (especially for rice and wheat) tends to decrease crop production income of rural households. In addition, we found that lower crop income from production decreases calorie intake of rural households. Taken together, these results suggest that output price uncertainty during the production process tends to reduce caloric intake of rural Nepalese households. The price uncertainty seemed to reduce the crop income households need to buy calorie-rich staple foods.

Keywords Food calorie intake · Price uncertainty · Nepal

Introduction

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

Given the severe nutritional deficiencies of households in Nepal (FAO/UNDP 2003), 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. Aside from uncertainty in the global marketplace, the unstable socio-political environment in Nepal (i.e., no government has survived from more than 2 years since 1990)¹ also contributes to the uncertainty in domestic grain

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¹ Governments in Nepal tend to be very unstable. Since 1990, governments collapsed either through internal political conflicts or through parliamentary dissolution by the monarch. Note that Nepal was a parliamentary monarchy from 1990 until 2008 (see, e.g., Ruff 2008).

prices. This socio-political instability makes it even more important to understand the effects of grain price uncertainty on poor rural households because this sector of the economy is typically the most negatively affected by the uncertainty caused by rapid socio-political transitions (e.g., Bronson et al. 2005; Lamdin 2008).

With these global and domestic forces affecting price uncertainty in Nepal, there is special interest in how grain output price uncertainties (in particular) 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. The primary purpose of this research, 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, was used to achieve this objective. The price uncertainty measures were calculated using time-series models and the effects of uncertainty on farm incomes and caloric intake were analyzed using a three-stage least squares (3SLS) regression 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 & Rahji 2007; Fan & Chern 1997; Murasko 2008; Simmons et al. 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 and politically unstable 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.

Conceptual Framework

As in other developing countries, agricultural households in Nepal are typically classified as subsistence agricultural households (Calkins 1982), with most of their production being used for their own consumption and a smaller proportion being sold. Rural farm households in Nepal are typically both producers and consumers of the same agricultural products (e.g., rice, wheat). Following the arguments of Carter and Zhong (1999), Singh et al. (1986), and Strauss and Thomas (1995), it is common to assume

that subsistence farmers in this case make recursive decisions for a given season. 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: (a) existence and access to local input/output markets, (b) a fixed land base, (c) the practice of farmers marketing surplus products, and (d) a situation where farmers are price takers. 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:

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

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:

$$PX_S + P_OX_O + P_LL = P_LT + \pi, \quad (2)$$

where P is the output price of the staple foods, P_O is the price of *other goods*, P_L is the market 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 Eq. 1 subject to Eq. 2 leads to a system of equations where the household's production and consumption decisions can be shown to be made recursively (Singh et al. 1986).

The recursive nature of the model is attractive because it means that all prices are exogenous. According to Carter & 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 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

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.

intake decisions only indirectly through the income from staple food production. Therefore, caloric intake can be represented as:

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

where C is caloric intake, π is the farm income from production that is assumed to be affected by grain price uncertainty (s), and γ is a vector of socio-demographic variables that determine calorie intake. Empirically estimating Eq. 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 Nepal–India Treaty of Trade negotiated in 1996 and renewed with changes in 2002 for a period of 5 years (Nath 2004). 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 (Dickey & Fuller 1979) and autocorrelation function (ACF) plots. Based on these approaches, we found 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 Asche et al. (2004) and Slade (1986):

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

where P_t^N is the price of grains in Nepal at time t , P_t^I is the price of grains in India 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 different from zero (i.e., the null hypothesis that $c_i = 0$ is rejected), the data supports the hypothesis that the lagged prices of grains in India (P^I) affects the price of grains in Nepal (P^N).

Interchanging price variables in Eq. 7 allows a test of whether the lagged prices of grains in Nepal (P^N) affects the price of grains in India (P^I). If one price significantly affects the other with no evidence of causality in the opposite direction, it indicates price leadership. If $\sum b_j + \sum c_i = 1$, a long-run Law of One Price holds. If $c_0 = 1$, $c_i = 0$ and $b_j = 0$ then the Law of One Price holds in a static sense. From Eq. 4, 12-month ahead forecast variances are calculated for each district in Nepal where data are available (i.e., 11 districts for rice and 19 districts for wheat). We then use these forecast variances as our measure of grain output price uncertainty that influences production decisions and the income from production.

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 Rapsomanikis and Sarris (2005); Sarris (2002), and Sarris and Karfakis (2006), the gross crop income (Y_h) of household h can be defined as:

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

where Q is the quantities of each product i produced ($i = 1, \dots, n$) by the household and P is the output price of each product produced by the household. Eq. 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. In this regard, yield uncertainty is estimated using the following ARIMA (p, q, d) model:

$$\left(1 - \sum_{i=1}^p \phi_i L^i\right) (1 - L)^d \text{Yield}_t = \left(1 + \sum_{i=1}^q \theta_i L^i\right) \xi_t, \quad (6)$$

where d is a positive integer that controls the level of differencing, L is the lag operator, j and q 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 used the 12-month-ahead forecast variance from Eq. 6 as a measure of yield uncertainty. The relationship between crop income and grain price uncertainty was then examined by estimating an equation where the farm household's crop income was a function of grain price uncertainty, yield uncertainty, and other observable control covariates that affect income: such

as, input quantities (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 was caloric intake and how this variable was 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 was 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 was 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 are endogenous in the caloric intake equation (Chen et al. 2007).

In light of this potential endogeneity problem, we used a 3SLS to more accurately estimate the effect of household income on caloric intake and indirectly infer the grain price uncertainty effect on caloric intake. We used 3SLS instead of 2SLS to account for the endogeneity of income in the caloric intake equation, as well as the potential correlation between the error terms in the crop income and calorie intake equations. The 3SLS approach is also typically justified on the ground of efficiency (i.e., it is more efficient than 2SLS estimates if there is correlation between error terms).

The first-stage of the 3SLS was 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). We also included *travel time* (i.e., the time it takes to get to the nearest major market) as an additional instrumental variable. The travel time variable also serves as an instrument to identify the crop income equation relative to the caloric intake equation. The first-stage crop income equation can then be defined as:

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

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:

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

where C_{ht} is the caloric intake of the household, P_{ht} are the staple food output prices, X_{ht}^C are a vector of observable

control covariates, and δ , λ , and ρ are vectors of parameters to be estimated, and ε_{ht} is the random error term. The third-stage was implemented by retrieving the residuals from both equations to estimate a covariance matrix and then a Feasible Generalized Least Square (FGLS) approach was used to re-estimate Eq. 8. In addition, based on previous literature, estimation using household survey data typically exhibits heteroskedasticity. Thus, we tested for heteroskedasticity in (8) and applied Heteroskedasticity-robust standard error procedures to correct for this problem.

Data and Empirical Specification

There are two types of data used in this analysis. The time series data used includes historical monthly data for rice and wheat prices (January 1995–April 2004) and yearly data for rice, wheat, and maize yields (1989–2004).³ The time-series data set contains monthly New Delhi (India) wheat and rice prices, as well as wheat and rice prices for different districts in Nepal. The cross-sectional data set used in the study is the 2003/04 Nepal Living Standards Survey, 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). For more details about the survey, see Kinnon and Prenzushi (2002).

A two-stage stratified sampling procedure was used to select the sample for the first stage of the survey (Nepal Living Standards Survey 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 frame considered all the 75 districts in the country, and indeed 73 of them were represented in the sample. In the second stage (Nepal Living Standards Survey II), a fixed number of twelve households were selected from each PSU. Eventually, the sample size of the household data set after Nepal Living Standards Survey II was 4,008 households. Thirteen

³ We were not able to find reliable time-series data for maize prices. Thus, maize price uncertainty was not calculated and not included in the income and caloric intake equations (See Table 5).

Table 1 Summary statistics and variable definitions for the 2003/2004 rural household data ($n = 2751$)

Variable	Variable definition	Mean	SD
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
Age	Age of household head	45.68	14.26
H Size	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
OwnLand	= 1 if own land, 0 otherwise	0.85	0.36
NumCows	No. of cows raised	17.33	86.84
NumSheep	No. of sheep raised	27.07	111.52
NumChicken	No. of chickens raised	3.76	11.94
Travel time	Travel time to major market (h)	0.09	0.48
SeedCost	Seed cost for all crops (Rs)	0.25	1.00
FertilizerCost	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 person (Rs)	76723.35	287116.50
Remittances	Total value of remittances per person (Rs)	45221.50	604408.70
Housing	Housing value per person (Rs)	24750.82	71476.03
HealthCost	Health care cost per person	2044.11	22021.47
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 region, 0 otherwise	0.14	0.34
Hill	= 1 if rural hill region, 0 otherwise	0.45	0.50
Tarai	= 1 if rural Tarai region, 0 otherwise (omitted)	0.41	0.44
Chetri	= 1 if part of Chetri ethnic group, 0 otherwise	0.17	0.38
Brahmin	= 1 if part of Brahmin ethnic group, 0 otherwise	0.12	0.33
Magar	= 1 if part of Magar ethnic group, 0 otherwise	0.07	0.26
Tamang	= 1 if part of Tamang ethnic group, 0 otherwise	0.05	0.21
Others	= 1 if not part of the four ethnic groups above, 0 otherwise	0.59	0.23
Season1	= 1 if survey time is Jan, Feb and Mar, 0 otherwise	0.28	0.45
Season2	= 1 if survey time is Jan, Feb and Mar, 0 otherwise	0.20	0.40
Season3	= 1 if survey time is Jan, Feb and Mar, 0 otherwise	0.33	0.47
Season4	= 1 if survey time is Jan, Feb and Mar, 0 otherwise	0.19	0.42

households were dropped from the original 4,008 due to missing information. Of the remaining 3,995 household, the 2,751 households in the rural areas were used since these rural households were 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 were crop income (*Income*) and total food calorie intake (*Calorie*). The rural households in Nepal have an average intake of about 2,540 calories/day which is slightly

above the 2,250 calories/day minimum food calorie requirement for an adult male advocated by FAO (Waterlow & 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 2005).

As mentioned in the previous section, we were interested in accurately estimating the effect of grain output price uncertainty on production income, and then how this uncertainty (working through income) affected caloric intake decisions. Hence, the first equation that needed to be specified was the crop income equation where the

independent variables included price uncertainty variables, yield uncertainty variables, and observable control covariates (see Eq. 7). The output price uncertainty variables used in the crop income equation were estimated rice and wheat price uncertainty from Eq. 4. The yield uncertainty variables in the crop income equation were estimated rice and wheat uncertainty measures from Eq. 6. The observable control covariates in the crop income equation included: age (*Age*), household size (*Household Size*), female household head dummy (*Female*), household with high school degree dummy (*High School*), land ownership dummy (*OwnLand*), seed input cost (*SeedCost*), fertilizer input cost (*FertilizerCost*), drought dummy (*Drought*), flood dummy (*Flood*), fruit income dummy (*Fruit*), season dummies (*Season1*, *Season2*, *Season3*), and rural agro-ecological region dummies (*Mountain* and *Hill*, with *Tarai* omitted). Note that a travel time to major market (*Travel Time*) was included in the specification as an instrument. The observable farm-specific control covariates included in the crop income specification followed Sarris and Karfakis (2006) where they argued that these observable variables determine farm-level productivity and income based on past studies.

In the food calorie intake equation (see Eq. 8), the main independent variables in the specification were the predicted crop income from the first-stage equation, the price (rice and wheat) and yield (rice and wheat) uncertainties, the price of staple foods, and observable control covariates. The cross-sectional prices included in the food calorie intake equation were rice price (*Rice price*), wheat price (*Wheat price*), and maize price (*Maize price*). The other control covariates included in the food calorie intake specification were: household head age (*Age*), female household head dummy (*Female*), household head with a high school dummy (*High School*), a land ownership dummy (*OwnLand*), number of cows raised (*NumCows*), number of sheep raised (*NumSheep*), number of chickens raised (*NumChicken*), fruit income dummy (*Fruit*), value of durables (*Durables*), value of remittances (*Remittances*), value of housing (*Housing Value*), healthcare cost (*Health Cost*), rural agro-ecological region dummies (*Mountain* and *Hill*, with *Tarai* omitted), season dummy variables (*Season1*, *Season2*, *Season3*), and an index for household's ethnicity dummies (*Chetri*, *Brahmin*, *Magar*, *Tamang*, with *Other* ethnic groups omitted). The four ethnic groups with explicit dummy variables are within the top five ethnic groups in Nepal. These four groups account for approximately 40% of the population (Central Bureau of Statistics, 2002).

A number of the preceding farm-specific variables (i.e., *Age*, *Female*, *High School*, *OwnLand*, etc.) were included in the specification because it has been found in previous studies that these are determinants of food consumption

behavior (See, among others, Lazaridis 2004; Ying & Yao, 2006). Note that the value of remittances (*Remittances*) was specifically included in the specification to account for the large number of Nepalese workers who work abroad and send remittance income to their family in Nepal. It is reported that remittances represented more than 10% of GDP in Nepal in the late 1990s (Gaudel 2006; Khatri 2008). Remittances are additional income that helps to meet the needs of poor Nepalese farm households. The value of durables (*Durables*), housing values (*Housing*), and health care costs (*HealthCost*) are included in the specification to represent the non-food alternatives that affect household food consumption. Last, ethnicity dummies were included to account for the cultural (i.e., caste-specific) aspect of food consumption in Nepal.

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 were 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 Law of One Price 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 in Nepal, as well as the corresponding standard errors, are presented in the second and third columns of Table 5. Our results indicate that the following variables had statistically significant positive effects on Nepalese rural crop income: (a) high school education, (b) land ownership, (c) fertilizer and seed costs (input), (d) fruit and agricultural economic zone variables. These results are consistent with our *a priori* expectations. Nepalese farmers who have high education and own their land tend to have higher incomes, which is similar for farmers in other countries (Dribe and Stanfors forthcoming). The positive and significant effects of the fruit dummy variable indicate that Nepalese farmers

Table 2 Effects of Indian rice price on some Nepal district rice price and Granger causality tests (Jan 1995–Dec 2004, Standard error is in parenthesis)

Variables	Districts in Nepal										
	Bhojpur	Chitwang	Dhankuta	Doti	Ilam	Jhapa	Kailali	Kathmandu	Morang	Palpa	Parsa
Constant	0.33(1.14)	0.66(0.56)	0.10(0.54)	0.12(0.52)	0.10(0.54)	0.11(0.72)	0.34(0.35)	−1.12(0.99)	2.81(1.78)	0.75(0.46)	0.59(0.35)
P_{t-1}^{PN}	0.73*** (0.13)	0.79*** (0.06)	0.61*** (0.06)	0.85*** (0.04)	0.61*** (0.06)	0.69*** (0.06)	0.84*** (0.06)	0.72*** (0.09)	0.10(0.08)	0.85*** (0.05)	0.94*** (0.08)
P_{t-2}^{PN}	0.13(0.10)	−	−	−	−	−	−	0.05(0.08)	−	−	−0.02(0.11)
P_{t-3}^{PN}	−	−	−	−	−	−	−	−	−	−	−0.12*(0.08)
P_{t-1}^{PI}	−1.95*** (0.55)	0.21*** (0.07)	0.52*** (0.10)	0.20*** (0.07)	0.52*** (0.07)	0.40*** (0.10)	0.17*** (0.07)	1.35*** (0.44)	0.88*** (0.18)	0.14*** (0.07)	0.34(0.18)
P_{t-2}^{PI}	2.26*** (0.55)	−	−	−	−	−	−	−0.87*** (0.44)	−	−	−0.45** (0.22)
P_{t-3}^{PI}	−	−	−	−	−	−	−	−	−	−	0.31*(0.17)
Granger causality test	17.83	8.87	27.96	7.81	27.96	16.92	6.46	20.70	23.45	4.32	18.47
(χ square) for India											

Note: * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$

who have more diversified operations tend to have higher income. The statistically significant season variable is suggestive of the seasonality in agricultural production income.

On the other hand, the variables that had a statistically significant negative effect on crop income were: (a) household size, (b) female household head, (c) flood, rice and wheat price uncertainties, and (d) rice and wheat yield uncertainty variables, which is again consistent with our *a priori* expectations. The important result here is the strongly negative effect of rice and wheat price uncertainties. Nevertheless, these results suggest that uncertainty about the prices that farmers will receive at harvest (both rice and wheat) tend to depress incomes. This may be due to reduced efforts or underinvestment during the production process as a result of uncertainty in prices.

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 the second half of Table 5. The variables that had statistically significant positive effects on caloric intake were: (a) income, (b) age, (c) female dummy variable, (d) number of chickens raised, (e) value of durables, (f) value of remittances, and (g) some of the ethnicity variables. 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 Tarai region. The significance of the crop income variable is as expected since households with higher expected crop incomes produced more grains than other households. Similarly, chickens are one of the major animals that the household typically sell or consume in Nepal. Hence, similar with the crop income effect, if more chickens are sold then the family potentially has more funds to purchase food and increase caloric intake. If the household consumes the meat from chicken and eggs, the calories also tend to be high (which may also explain the positive effect). Hence, the chickens 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.

Note that the calculated calorie-income elasticity from this study (0.21) is consistent with the existing estimates in the literature. Reutlinger and Selowky (1976) estimated income elasticities of calorie intake at around 0.17 (evaluated at the mean) using cross-sectional, cross-country data. Timmer and Alderman's (1979) estimates using household data for Indonesia are 0.26 and 0.47 for urban and rural households, respectively. Behrman and

Table 3 Effects of India wheat price on some Nepal district wheat price and Granger causality tests (Jan 1995–Dec 2004)

Variables	Districts in Nepal										
	Achham	Banke	Chitwang	Dhankuta	Dhanusha	Doti	Ilam	Jhapa	Jumla	Kailali	Kaski
Constant	−0.66(1.54)	−0.91*(0.51)	0.13(0.87)	0.32(2.47)	−0.95(0.89)	1.80**(0.90)	0.93(0.64)	−0.14(0.52)	−0.69(4.04)	−0.34(0.48)	0.53(0.80)
P_{t-1}^N	0.86*** (0.05)	0.76*** (0.06)	0.44*** (0.07)	0.28*** (0.08)	0.54*** (0.07)	0.50*** (0.07)	0.82*** (0.07)	0.70*** (0.05)	0.75*** (0.06)	0.80*** (0.05)	0.61*** (0.079)
P_{t-2}^N	−	−	−	−	−	−	−	−	−	−	−
P_{t-1}^I	0.52*** (0.26)	0.58*** (0.14)	1.12*** (0.18)	1.71*** (0.38)	1.04*** (0.19)	0.87*** (0.16)	0.30*** (0.09)	0.61*** (0.13)	1.40*** (0.64)	0.41*** (0.11)	0.79*** (0.19)
P_{t-2}^I	−	−	−	−	−	−	−	−	−	−	−
Granger causality test(χ square) for India	3.89	17.20	39.67	20.92	30.50	28.47	10.62	21.29	4.74	14.24	17.48
Variables	Districts in Nepal										
	Kathmandu	Morang	Nuwakot	Parsa	Ramechhap	Rolpa	Rupandehi	Surkhet			
Constant	−0.27 (0.56)	−1.02 (0.57)	−0.73 (0.80)	−0.53(0.82)	4.54*** (1.79)	1.64* (0.89)	−3.30(4.77)	2.61** (1.03)			
P_{t-1}^N	0.77*** (0.05)	0.57*** (0.09)	0.84*** (0.05)	0.62*** (0.07)	0.42*** (0.09)	0.63*** (0.08)	−0.05(0.08)	0.76*** (0.07)			
P_{t-2}^N	−	0.11(0.08)	−	−	−	−	−	−			
P_{t-1}^I	0.55*** (0.13)	1.32*** (0.24)	0.47*** (0.15)	0.82*** (0.19)	0.90*** (0.26)	0.68*** (0.16)	2.67*** (0.65)	0.46*** (0.16)			
P_{t-2}^I	−	−0.56*** (0.25)	−	−	−	−	−	−			
Granger Causality test(χ square) for India	18.09	36.61	9.95	18.89	12.26	17.91	16.83	23.53			

Note: * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$

Table 4 Summary statistics of uncertainty measures (12-month-ahead forecast variance)

Uncertainty measures	Mean	SD
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

Deolalikar (1987) for India, Bouis and Haddad (1992) for the Philippines, and Ravallion (1983) for Indonesia also estimated calorie-income elasticities ranging from 0.03 to 0.15 (Dawson & Tiffin 1998), which are close to the estimate in our study.

With the strongly positive income elasticity in the calorie intake equation, one can argue that the price uncertainty in the crop production process causes lower caloric intake. That is, the presence of 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 of rural households (i.e., due to the positive income elasticity of calorie demand).

Interestingly, the rice yield uncertainty variable in the calorie intake equation was negative and significant. This suggests that yield uncertainty has a direct calorie-reducing effect. This may be due to the subsistence nature of production in Nepal where households tend to consume less during times when the production output is uncertain (i.e., precautionary behavior to account for the possibility of having a yield shortfall and less food to consume).

Another important result to take note of in Table 5 is the insignificant effect of the rice and wheat price variables, as well as the price uncertainties (both for rice and wheat). The highly price inelastic demand for calories in this study is consistent with the findings of Beatty and LaFrance (2005). This indicates that caloric intake decisions are not significantly 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 income is the major factor that drives food consumption and caloric intake decisions. This may be due to the subsistence nature of rural farm household production in Nepal. That is, most of the staple foods they produce are intended for home consumption and, thus, farm households in Nepal do not respond quickly to price signals (i.e., they do not care much about the prices because their production is mainly for home use). In addition, many of these subsistence farmers in Nepal typically sell their products early during the harvest rather

than wait for a better price later. This allows them to pay off debts and have liquid cash available to meet family and social needs. These factors contribute to the result that rural farm households in Nepal are not very responsive to price changes.

Conclusion and Policy Implications

Since most rural farm households in Nepal are subsistence 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 in how the price uncertainty in production ultimately influences caloric intake decisions of farm households. This is because 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.

Using time-series approaches to provide measures of uncertainty, together with a 3SLS regression approach, we found that output price uncertainty (especially for rice and wheat) significantly reduces the expected crop income of rural Nepalese households. We also found that calorie intake had a significant direct relationship with the crop income of the household, but food prices tended not to affect calorie intake substantially (i.e., highly price inelastic). Therefore, given these results, one can argue that output price uncertainty during the production process may reduce caloric intake among rural Nepalese households since the price uncertainty 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.

On the basis of this research, it should not be claimed, and would not be claimed, that all the grain uncertainties

Table 5 Determinants of rural crop income and food calorie intake in Nepal

Dependent variable	Ln(<i>income</i>)			log(<i>food calorie intake</i>)		
Variables	Expected sign	Parameter estimate	St. error	Expected sign	Parameter estimate	St. error
Intercept		−5.83***	0.65		9.46***	0.76
ln(Income)		—	—	+	0.21***	0.01
ln(Age)	Ambiguous	0.10	0.12	Ambiguous	0.06***	0.02
ln(H size)	Ambiguous	−0.20***	0.07		—	—
Female	Ambiguous	−0.48***	0.11	+	0.08***	0.02
HighSchool	+	0.79*	0.42	+	0.18**	0.08
OwnLand	+	3.81***	0.12	+	0.71***	0.03
ln(NumCow)		—	—	+	0.007	0.006
ln(NumSheep)		—	—	+	−0.0004	0.006
ln(NumChicken)		—	—	+	0.02**	0.01
Travel time	Ambiguous	−0.02	0.08		—	—
ln(SeedCost)	+	0.19***	0.03		—	—
ln(FertilizerCost)	+	0.22***	0.03		—	—
Drought	—	−0.09	0.10		—	—
Flood	—	−0.19***	0.08		—	—
Fruit	+	0.83***	0.09	+	0.17***	0.02
ln(Durables)		—	—	+	0.02***	0.004
ln(Remittances)		—	—	+	0.02***	0.002
ln(Housing)		—	—	+	0.001	0.003
ln(Health cost)		—	—	—	0.002	0.002
ln(Rice price)		—	—	—	−0.11	0.35
ln(Wheat price)		—	—	—	−0.03	0.03
ln(Maize price)		—	—	—	0.05	0.07
ln(Rice price Uncertainty)	—	−0.11**	0.05	—	−0.02	0.02
ln(Wheat price Uncertainty)	—	−0.16***	0.06	—	−0.03	0.03
ln(Rice yield uncertainty)	—	−0.21***	0.07	—	−0.03***	0.01
ln(Wheat yield uncertainty)	—	−0.14*	0.08	—	−0.02	0.02
Season 1	Ambiguous	0.29**	0.12	Ambiguous	−0.11***	0.02
Season 2	Ambiguous	0.15	0.13	Ambiguous	−0.06**	0.03
Season 3	Ambiguous	0.13	0.12	Ambiguous	−0.05*	0.02
Mountain	Ambiguous	0.95***	0.14	Ambiguous	−0.38***	0.03
Hill	Ambiguous	0.87***	0.10	Ambiguous	−0.27***	0.02
Chetri				Ambiguous	−0.02	0.02
Brahmin				Ambiguous	0.03**	0.02
Magar				Ambiguous	0.009	0.03
Tamang				Ambiguous	0.005	0.02
Likelihood value		2447				
Adjusted R square		0.22			0.18	

Note: * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$

are caught by the variables used in this research. More time series data such as maize price may provide more detailed analysis in the future. However, it is proposed that, given the results of this research, there is strong evidence in support of the grain price and yield uncertainties on nutrition intakes.

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