Household Vulnerability Analysis of Climate Change Impact to Food Insecurity

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September 2013

Methodology

Model Specifications

The model specification and estimation will have different scenarios depending on the available of data. First, data mapping will be discussed to assess matching of variables across different surveys based on the FAO study. Basically, there will be a discussion on the situation wherein agricultural productivity has been estimated (modeled) already by the National Economic Development Authority (NEDA) Team. On the other hand, another discussion will focus on adopting similar model as executed in the FAO study.

Data mapping

Identifying the variables for the model as executed in the FAO study is almost straightforward on the national surveys of the Philippines namely, Family Income and Expenditure Survey (FIES) and Annual Poverty Indicator Survey (APIS), as well as on Community-Based Monitoring System (CBMS) data of local government units (LGUs). Table 1 shows mapping of the variables (dependent, explanatory and instruments) used in the FAO study with FIES and CBMS data.

Table 1. Data and variable mapping

Model variable		**Metrics or substitute metrics**			
		FAO model	*FIES data*	*APIS data*	*CBMS data*
Dependent variable	Food security	Value of food consumed per adult equivalent	***foodexp***: Food expenditure over number of adult members (15 years old and above)	***hunger*** Hunger due to food shortage	***hunger*** Hunger due to food shortage
			subp: HH is food poor		
Explanatory variables	Agricultural productivity	Value of agri production per acre	[counterpart metrics were requested but not yet available]		***cropvolval:*** Value of crop production per hectare

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Model variable		**Metrics or substitute metrics**			
		FAO model	*FIES data*	*APIS data*	*CBMS data*
					palayvol: Volume of palay production per hectare
					cornvol: Volume of corn production per hectare
			cropinc: Income from crop farming per adult member		
	Characteristics of the head of the household	Age of HH head	***age_yr***: Age of HH head		
		Years of education of HH head	***educlvl*** : Categorized educational attainment		***educyrs*** : Years of education of HH head
		Single head	***sghead:*** Single head		
		Female Head	***fhead:*** Female Head		
		Indigenous HH	[no counterpart metric]		***ipindHH:*** Indigenous HH
	Access to migration channels	Access to HH migration network	***conab:*** Amount of cash receipts, gifts, relief and assistance from abroad		***conab:*** Amount of cash receipts, gifts, relief and assistance from abroad (remittance from OFWs combined with other support from abroad)
	Characteristic of household dwelling	Number of rooms in dwelling	[no counterpart metric]		
			mshous: HH with strong construction materials of walls and roof		
	Access to information and non-agri assets	HH has access to safe water	***sws:*** HH has access to safe water		
		Number of	***nradio:***		

Model variable		**Metrics or substitute metrics**			
		FAO model	*FIES data*	*APIS data*	*CBMS data*
		radios owned	Number of radios owned		
		Number of TV sets owned	***ntv:*** Number of TV sets owned		
	Communication infrastructure	Time to nearest health facility (min)	[no counterpart metric]		
			ntele: Number of telephones owned		
		Time to nearest primary school (min)	[no counterpart metric]		
			[no counterpart metric]	***ncp:*** Number of cellphones owned	
	Household transportation	Number of bikes in HH	***ncar:*** Number of motorcycles/ vehicles owned		
	Availability of farmland	Agri land operated (imputed)	*(as agricultural asset in instruments)*		
	Social infrastructure	Participation in community organization	[no counterpart metric]		***mworg:*** Number of HH members who participate in community organization
		HH received loan	***payloan:*** Indicator on HH Cash loan payments	***recloan:*** HH received loan	***recloan:*** Household access to credit programs
	Social welfare infrastructure, social protection	Number of government programs accessed	[no counterpart metric]	***govtpind:*** Government programs accessed	
		Number of NGO prgrams accessed	[no counterpart metric]		***privpind:*** NGO prgrams accessed
			payprem: Indicator on HH expenditure on life		

Model variable		**Metrics or substitute metrics**			
		FAO model	*FIES data*	*APIS data*	*CBMS data*
			insurance and retirement premiums		
		Illness shock	[no counterpart metric]	***illshock:*** HH head got sick	***illshock:*** At least one member of HH got sick
Instruments	Climate variables	Temperature (change)	***tempch, rainch, typh:*** Temperature, rainfall from Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)		
	Agricultural Assets	HH participates in agricultural producers organization	[no counterpart metric]		***agriorg:*** Membership in agricultural organization
		HH used chemical fertilizer	[expenditure on utilities requested but not yet available]		***fert*** : HH used fertilizer
		HH used organic fertilizer			
		HH used pesticides			***pest*** : HH with insecticide/ pesticide sprayer
		[additional variables on post harvest facilities, equipment and workers]	[requested but not yet available]		***plow/ harrow/ thshel/ dryer/ irpump/ seed/:*** Agri or post harvest equipment/ facilities used by HH other than insecticide/ pesticide sprayer (plow, harrow, thresher/sheller, seed purchase, irrigation pump)
					agriland: Area of agricultural land (Categorical)
			nagriwrk: Number of agriculture workers		
	Agricultural assistance/ infrastructure	[additional variable on agricultural assistance]	[no counterpart metric]		***irfa_crop / nia_irr / farmroad / training:*** Crop insurance, irrigation, farm to market roads, training

Model variable		Metrics or substitute metrics			
		FAO model	*FIES data*	*APIS data*	*CBMS data*
	Infrastructure	[additional variable on road infrastructure]	***road_den:*** Road density (from DPWH; possibly with squared term due to expected non-linearity)		

Model scenarios

Consider the following model

$$\text{food security} = f\begin{pmatrix} agri\ productivity,\ hh\ head\ characteristics, \\ access\ to\ migration\ channels, \\ household\ dwelling,\ non-agricultural\ assets, \\ communication\ infra, \\ household\ transport,\ social\ infra,\ social\ protection \end{pmatrix} + u \qquad (1)$$

$$\text{agri productivity} = f\begin{pmatrix} climatology,\ agri\ assets, \\ agri\ assistance/infrastructure,\ etc. \end{pmatrix} + v \qquad (2)$$

where the dependent variable has finite mean and the explanatory variables can be continous or categorical. By assumption, the error terms *u* and *v* has zero mean and zero correlation with any of the explanatory variables.

In the event that at least one of the explanatory variables, say agricultural productivity, is correlated with the error term, estimates for the coefficients of the independent variables can be inconsistent[2]. IV method addresses this by introducing observable variable, that is uncorrelated with the error term but partially correlated with the endogenous variable.

Similar to FAO study, modeling using FIES dataset will work around the two-stage least squares (2SLS) method in estimating the coefficients, and potentially addressing heteroskedasticity.

$$foodexp = \beta_0 + \beta_1 cropinc + \beta_2 age_{yrs} + \beta_3 educlvl + \beta_4 sghead + \beta_5 fhead + \beta_6 conab + \beta_7 mshous + \beta_8 sws + \beta_9 nradio + \beta_{10} ntv + \beta_{11} ntele + \beta_{12} ncar + \beta_{13} payloan + \beta_{14} payprem + u$$

$$cropinc = \phi_0 + \phi_2 age_{yrs} + \phi_3 educlvl + \phi_4 sghead + \phi_5 fhead + \phi_6 conab + \phi_7 mshous + \phi_8 sws + \phi_9 nradio + \phi_{10} ntv + \phi_{11} ntele + \phi_{12} ncar + \phi_{13} payloan + \phi_{14} payprem + \gamma_1 tempch + \gamma_2 rainch + \gamma_3 typh + \gamma_4 nagriwrk + \gamma_5 road\_den + \boldsymbol{\delta} regn + v +$$

where the variables with γ coefficients are the excluded instruments for agricultural production. The error terms *u* and *v* have zero mean and uncorrelated.

[2] In the case of this study, agriculture production is potentially endogenous in explaining food consumption.

In the case of APIS wherein the dependent variable *hunger* is dichotomous, Maximum Likelihood Estimation (MLE) will likely be used to implement instrumental variable regression using probit function. Consider the following relationship

$$P(hunger = 1|\boldsymbol{X}) = \Phi(\boldsymbol{X\beta})$$

with latent variable $hunger* = \boldsymbol{X\beta} + u$, where $u \sim N(0,1)$ such that $hunger = \mathbb{I}_{\{hunger*>0\}}$. It can be verified that

$$P(hunger = 1|\boldsymbol{X}) = P(hunger*> 0) = P(u > -\boldsymbol{XB}) = P(u < \boldsymbol{XB}) = \Phi(\boldsymbol{X\beta})$$

The specification for APIS given the previous equation is

$$\begin{aligned} hunger* = {} & \beta_0 + \beta_1 cropinc + \beta_2 age_{yrs} + \beta_3 educlvl + \beta_4 sghead + \beta_5 fhead + \beta_6 conab \\ & + \beta_7 mshous + \beta_8 sws + \beta_9 nradio + \beta_{10} ntv + \beta_{11} ntele + \beta_{12} ncp + \beta_{13} ncar \\ & + \beta_{14} recloan + \beta_{15} govtpind + \beta_{16} illshock + u \end{aligned}$$

$$\begin{aligned} cropinc = {} & \phi_0 + \phi_2 age_{yrs} + \phi_3 educlvl + \phi_4 sghead + \phi_5 fhead + \phi_6 conab + \phi_7 mshous + \phi_8 sws \\ & + \phi_9 nradio + \phi_{10} ntv + \phi_{11} ntele + \phi_{12} ncp + \phi_{13} ncar + \phi_{14} recloan \\ & + \phi_{15} govtpind + \phi_{16} illshock + \gamma_1 tempch + \gamma_2 rainch + \gamma_3 typh \\ & + \gamma_4 nagriwrk + \gamma_5 road\_den + \boldsymbol{\delta} regn + v \end{aligned}$$

Similar to APIS, IV probit regression will be implemented on CBMS data with dependent variable *hunger* with some additional variables,

$$\begin{aligned} hunger* = {} & \beta_0 + \beta_1 cropinc + \beta_2 age\_yr + \beta_3 educyrs + \beta_4 sghead + \beta_5 fhead + \beta_6 ipindHH \\ & + \beta_7 conab + \beta_8 mshous + \beta_9 sws + \beta_{10} nradio + \beta_{11} ntv + \beta_{12} ntele + \beta_{13} ncp \\ & + \beta_{14} ncar + \beta_{15} recloan + \beta_{16} govtpind + \beta_{17} privpind + \beta_{18} illshock + u \end{aligned}$$

$$\begin{aligned} cropinc = {} & \phi_0 + \phi_2 age\_yr + \phi_3 educyrs + \phi_4 sghead + \phi_5 fhead + \phi_6 ipindHH + \phi_7 conab \\ & + \phi_8 mshous + \phi_9 sws + \phi_{10} nradio + \phi_{11} ntv + \phi_{12} ntele + \phi_{13} ncp + \phi_{14} ncar \\ & + \phi_{15} recloan + \phi_{16} govtpind + \phi_{17} privpind + \phi_{18} illshock + \gamma_1 tempch \\ & + \gamma_2 rainch + \gamma_3 typh + \gamma_4 nagriwrk + \gamma_5 agriorg + \gamma_6 agriland + \gamma_7 plow \\ & + \gamma_8 harrow + \gamma_9 thshel + \gamma_{10} dryer + \gamma_{11} irpump + \gamma_{12} seed + \gamma_{13} pest \\ & + \gamma_{14} irfa\_crop + \gamma_{15} nia\_irr + \gamma_{16} farmroad + \gamma_{17} training + \gamma_{18} road\_den \\ & + \boldsymbol{\delta} regn + v \end{aligned}$$

Separate runs will be implemented for corn and palay with possible control for spatial location (spatial autoregression) in CBMS areas with digitized maps. Standard assumptions on the error terms are to be validated and test for weak instrument and overidentification are to be undertaken through the instrumental variable regression module in Stata.

Climatology measures

Three measures of climate variables will be explored: absolute, volatility and seasonality. These are measured in three different reference periods: last three, five and ten years. Absolute measure is a function of the (moving) average of the monthly values of the climate variables, i.e.

$$\overline{RF_t} = \frac{1}{12y}\sum_{i=1}^{12t} RF_i$$

Where RF_i represents the rainfall value at month i and $t$is the number of years. Volatility is the coefficient of variationgiven the number of years

$$CV_t = \frac{SD_t}{\overline{RF}_t}$$

whereSD_t is the standard deviation while the seasonality index takes on Walsh and Lawler's (1981) measure

$$SI_y = \frac{1}{\overline{RF}_{1|y}} \sum_{i=1}^{12} \left| RF_{i|y} - \frac{\overline{RF}_{1|y}}{12} \right|$$

That is, for a given year y, $\overline{RF}_{1|y}$ is the average for the year and $RF_{i|y}$ is the value of rainfall on thei^{th}month. The seasonality index facilitates measurement of the variability of rainfall in terms of seasonality over the year. Sumner, et al (2001) provides indicative classification based on SI_y as shown in Table 1.

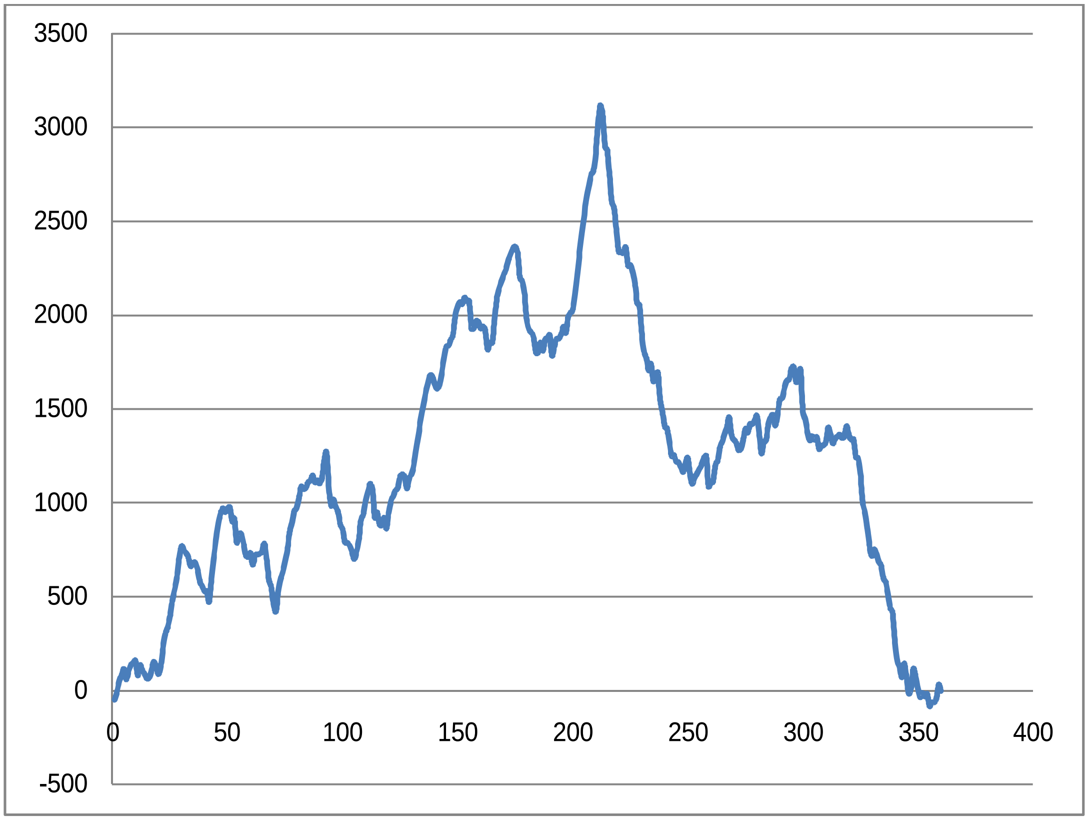
Table 1.Rainfall seasonality based on SI_y

<0.19	Precipitation spread throughout the year
0.20–0.39	Precipitation spread throughout the year, but with a definite wetter season
0.40–0.59	Rather seasonal with a short drier season
0.60–0.79	Seasonal
0.80–0.99	Markedly seasonal with a long dry season
1.00–1.19	Most precipitation in <3 months
>1.20	Extreme seasonality, with almost all precipitation in 1–2 months

Reference years

In determining reference years for the climatology measures, adoption of change point algorithmsfor signal processing (Khmaladze, 2007)has been explored. It can be seen in Figure 1 that the interpolated monthly rainfall values have changed in trend in August 1998. This should be a guide in choosing the time lags to include in predicting productivity or agriculture metric.

Figure 1.Change point (Aug 1998) in the interpolated rainfall values



For instance, given the year 2010, measures for reference years 3, 5, and 10 are to be explored. For instance, the distribution of actual values of seasonality indexfor 3, 5, and 10-year average is shown inFigure 2. Based on the regime in Table 1, many of the provinces are “rather seasonal with a short drier season” with most provinces can be classified in this category using the 10-year average. There is another prominent group with “most precipitation in <3 months” and visible as well using the 10-year average.

Figure 2. Distribution of 10, 5, and 3-year seasonality index in 2010