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Climatic risk and farm planning: a mathematical programming model for typical farm households in the mountainous upland of Thua Thien Hue province, Viet Nam

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Abstract

Weather calamities partly attributable to global climate change are increasingly affecting the central part of Vietnam. Such shocks add to adversities like pest outbreaks and the Avian Flu. In addition, the recent hike in food prices adds additional burden to the often food-deficit farm households in the mountainous areas of Thua Thien Hue province. Thua Thien Hue is one of three Vietnamese provinces where a large scale household panel survey was undertaken in the context of the DFG research project "Impact of Shocks on the Vulnerability to poverty: Consequences for Development of Emerging Southeast Asian Economies". Data were collected in a panel survey from 239 households in the mountain stratum of Thua Thien Hue province.

Using a mathematical programming model including risk following the concept of typical farm households the effect of risks on household food security and the probability to fall into poverty is analyzed. The model represents the main economic components of rural households in the mountainous upland of Thua Thien Hue province such as farm and forest based income generating activities. External climatic shocks are incorporated in the model by means of a MOTAD approach which models risk-averse behavior. Extensions of the model will allow capturing the dynamic nature of changes in natural resources such as forest land and soil fertility. Furthermore demographic changes and household dynamics as well as changes in asset positions will be included in future versions of the model. Results are expected to be useful for the design of policies which aim at reducing vulnerability to poverty while taking into consideration households' medium- and long-term economic development.

Keywords: Climatic risk, farm planning, mathematical programming, Viet Nam

Introduction

Farm households in developing countries face considerable risk in their agricultural production due to the adverse effects of a wide range of shocks, such as weather calamities, pest outbreaks and fluctuations in input and output prices (Dercon 2002). Climatic risk is a particularly relevant concern in times of global climate change which is argued to bring about an increased number and severity of extreme weather events (Trapp et al. 2007, Diffenbaugh et al. 2007, Emanuel 2005). Weather-related shocks make farm households vulnerable to become poor or to fall deeper into poverty. This vulnerability to poverty has been the subject of various recent studies which have aimed at eliciting how farm households can improve their ability to effectively cope with shocks and to manage risk (e.g. Kozel et al. 2007). Important elements of such vulnerability analyses are vulnerability indicators which help to pinpoint vulnerable parts of the population and to identify sources of vulnerability to poverty (e.g. Chaudhuri et al. 2002, Ligon and Schechter 2003). To date, due to their ease of operation, most vulnerability measures are regression-based. However, it is argued that vulnerability measures should be based on a structural dynamic model of inter-temporal optimization under uncertainty, a requirement which regression-based vulnerability measures do not meet (Elbers and Gunning 2003).

In this study the probability to fall into poverty of a typical farm household in the mountainous upland of Thua Thien Hue province, Vietnam is derived. The study area belongs to the sparsely populated and predominantly rural mountainous parts of Vietnam's North Central Coast region. The empirical approach applied is based on a dynamic analysis of farm households which takes into account the effects of risk.

Study area and data source

The data that form the basis of this study were gathered as part of the project "Impact of shocks on the vulnerability to poverty: consequences for development of emerging Southeast Asian economies" (DFGFOR756[1]) in two waves of a panel survey conducted in 2007 and 2008 among about 4200 households in six provinces in Thailand and Vietnam. The surveyed households are representative of the rural population in the six provinces. The mountainous upland of Thua Thien Hue, which is represented by 239 households in the panel survey, was chosen as research area for this study because a descriptive analysis of data from the 1st wave of the panel survey indicated that the major share of its population is made up of farm households which are often poor and/or frequently affected by weather-related shocks. The research area thus comprises a manageable level of heterogeneity of natural frame conditions.

However, since the data from the panel survey give a rather broad view of household characteristics, additional information on the consumption-production situation and decisions of farm households was needed, including existing options and restrictions, and shocks that have occurred in the past. Therefore a sub-sample of 60 households was purposively selected to be interviewed in an additional in-depth survey which was carried out in two waves in May 2008 and January 2009. These 60 households are supposed to be indicative for the prevailing structure of farm households in the research area. The selection of the surveyed households was carried out by means of several ad hoc criteria which ensured that selected households had the following common characteristics. First, they were income poor or most likely vulnerable to income poverty, meaning that their income was not above 200% of the rural poverty line. Second, they were farm households engaged in own agriculture. Third, they were typical for the study area with regards to their agricultural production portfolio and their general income portfolio, meaning that they used at least 20% of their total land for cropping and that they did not receive remittances that made up 60% or more of their average per capita income. Fourth, they had experienced at least one shock of at least medium severity in a reference period of 5 years.

A descriptive analysis of those households which met these criteria revealed three household groups which were distinct with regards to their portfolio of income-generating activities and their income level. To account for differences across these three groups of

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1 DFGFOR756 is a Deutsche Forschungsgemeinschaft (DFG)-financed collaborative research unit of the Universities of Gießen, Goettingen, Hannover (all in Germany), Kasetsart University (Bangkok, Thailand), and the Centre of Agricultural Policy (Hanoi, Vietnam). For further information see: http://www.ifgb.uni-hannover.de/vulnerability.html or http://www.dfg.de

households that could affect the intended quantitative modeling, detailed information from a similar number of households per group was collected. As a first step of this study, the analysis focuses on one group of typical households, namely those exclusively engaged in own agriculture and the extraction of natural resources. The modeled households are small-scale farm households with four family members and a land endowment of 0.255 hectares. A comparative analysis of data from the other two groups, which comprise households additionally engaged in off-farm wage- or self-employment, will be conducted at a later stage.

Methodology

In order to obtain an estimate of a typical household's vulnerability to poverty, first, a structural farm household model is solved by means of mathematical programming. The model comprises the household's production and consumption, modeled as the result of income maximization under uncertainty.

In setting up the farm household model, the Minimization of Total Absolute Deviations (MOTAD) approach is used so that risk-averse behavior is taken into consideration. The MOTAD model maximizes expected household income less a risk aversion coefficient times the sum of all negative absolute deviations in a set of weather shock scenarios from the mean expected income. Thus, the model assumes that risk-averse decision makers will trade expected income for reduced negative variance. The model covers a one-year time period and includes the main income-generating activities of a typical household in the research area. Constraints which the farm household faces regarding the availability of production factors and its own consumptions requirements are accounted for in the model as well as seasonal differences in activity options and capacity restrictions. In order to define the set of weather shock scenarios which are incorporated in the model, first, the most relevant weather-related shocks are identified, i.e. unusually cold weather, drought, and unusually heavy rainfall, storms and flooding. Each of these shocks is different with regards to its typical time of occurrence, which crops it affects and how much respective yield is reduced. Based on the collected survey data corresponding crop gross margins are quantified and the subjective probability of occurrence of each shock type is determined based on the expectations of the surveyed households. This information is then used to construct different shock scenarios and, by assuming that the shocks are independent of each other, to determine the probability of each scenario.

The outcome of the MOTAD model indicates the optimal portfolio of farm household activities and a corresponding expected level of income. Based on that optimal activity portfolio, the income that would be realized in each of the shock scenarios is then calculated as a second step of the analysis[2]. Finally, by using the resulting cumulative probability distribution of annual household income and by assuming a poverty line the probability of a household to fall below that line is obtained.

Results

Table 1 shows the optimal crop portfolio of the typical household. According to the outcome of the MOTAD model, crop land is allocated to the cultivation of three main crops: rice, banana and corn. The harvest of all crop types is used for subsistence purposes while only spring and autumn rice are additionally being sold. The livestock system is subsistence-oriented in pig and poultry production. Furthermore the household extracts forest products from local forest, that is, mainly fuel wood for subsistence purposes and different non-timber forest products for both own

[2] It is assumed that the typical household determines its activity portfolio ex-ante at the beginning of the modeled time period based on its expectations regarding different shock scenarios (first step of the analysis). After the household has made that decision one of the shock scenarios will occur and a corresponding level of income will be realized (second step of the analysis).

consumption and sale. The expected annual household indicated by the MOTAD model resembles the actual income which can be observed from the survey data and is about 10.7 million Vietnamese Dong. That is slightly above the poverty line for rural Vietnam that was specified by the General Statistics Office (GSO) Vietnam for the time period from 2006 to 2010.

Table 1: Optimal crop portfolio

Activity	Unit	Activity level
Spring rice	Hectare	0.244
Amount produced	Kilogram	721.3
Amount consumed	Kilogram	280.0
Autumn rice	Hectare	0.244
Amount produced	Kilogram	812.5
Amount consumed	Kilogram	240.0
Corn	Hectare	0.006
Amount produced	Kilogram	12.5
Amount consumed	Kilogram	12.5
Banana	Hectare	0.005
Amount produced	Kilogram	2.000
Amount consumed	Kilogram	2.000

Note: Inconsistencies are due to rounding errors. Spring and autumn rice are rotated on the same land area.

The cumulative probability distribution of annual household is depicted in figure 1 and shows that income drops considerably when climatic shocks happen as compared to a situation without shocks. The figure furthermore indicates the probability of the household to fall into poverty which is about 10% when the GSO poverty line for rural Vietnam (PL1) is used. However, adjusting that poverty line for rising consumer prices, which have occurred since 2006, yields a higher poverty line (PL2). The corresponding probability to become poor then rises to 50%.

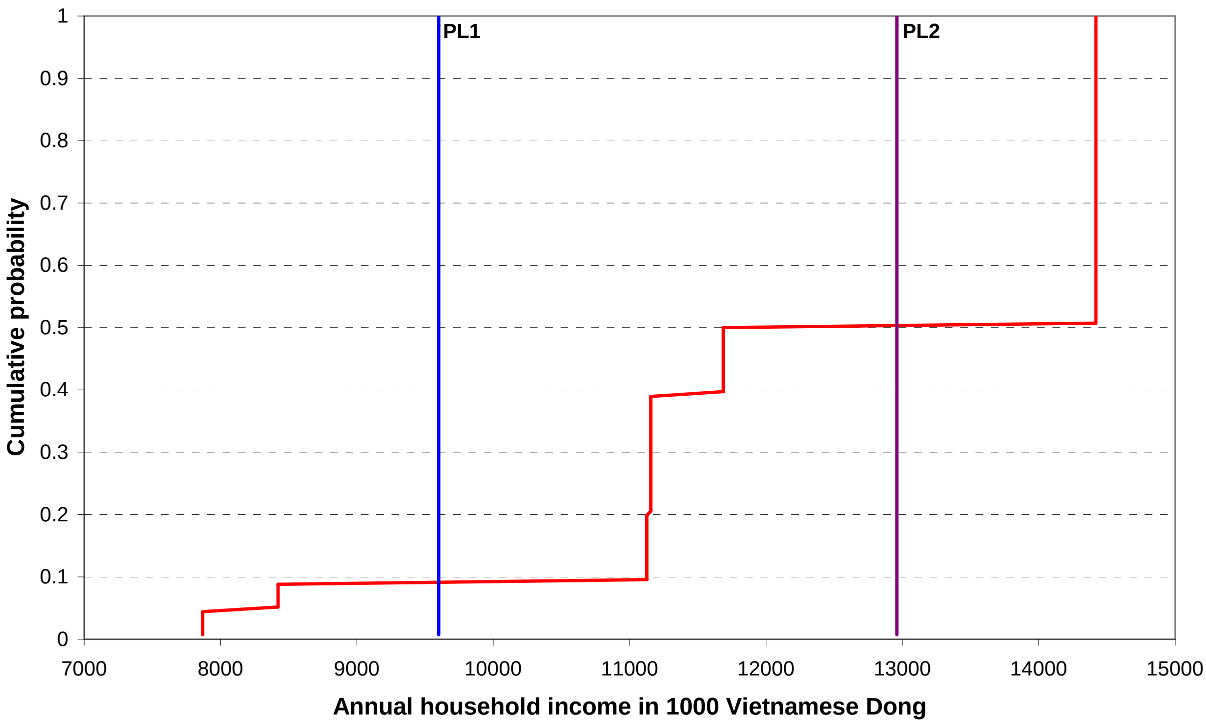

Figure 1: Cumulative probability distribution of annual household income across weather shock scenarios

Conclusions and outlook

The MOTAD model, which has been developed as a first step of the intended quantitative modeling, has produced a realistic outcome which enabled deriving a cumulative probability distribution of household income. The household's probability to fall into poverty can be seen from the cumulative probability distribution, being sensitive however to the selection of the poverty line. Several enhancements of the model are planned. First, activity portfolios will be allowed to vary across shock scenarios in order to account for the ability of households to adjust their activity portfolios after a shock has occurred. Second, the model will be extended to multiple periods to capture the dynamics of risk response in the medium- and long-term. Finally, once a comprehensive model has been set up, potential future scenarios will be simulated in which ecological, demographic and institutional frame conditions change.

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