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Overuse of Agricultural Inputs and Awareness of Environmental Consequences – The Case of Hebei Province, PR of China

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Motivation

The overuse of chemical fertilizers is a major threat to sustainable agriculture in the Hebei province, PR of China. Farmers are the main decision makers regarding the use of chemical fertilizers. Qualitative and quantitative methods are combined in this study to assess farmers' fertilization behavior and their awareness of negative environmental effects such as nitrate leaching or the decline of soil biodiversity and fertility (Hu and Cao, 2008) stemming from intensive agricultural production. The motivation for this combination of methodologies stems from the possibility to access a secondary household level panel data set and to undertake qualitative surveys in the same area were the quantitative data are collected. During former studies farmers mentioned quality problems with respect to the nutritional contents of chemical fertilizers. Therefore it is also aimed to combine a socio-economic perspective on the fertilizer use with a chemical assessment of the fertilizer contents.

Nitrogenous fertilizer is one major source of chemical depletion of soils or other negative environment externalities found in the study region. Urea is chosen as object of the quantitative study because it is a widely used nitrogenous fertilizer in the villages contained in the available RCRE data set and sufficient quantitative data are available to assess socio-economic drivers of urea application.

Methodologies

The data set provided by the Research Centre for Rural Economy, Ministry of Agriculture, Beijing (RCRE) is a micro-level unbalanced panel data set containing household information and covering 6-11 villages in Hebei province over the period 1986 to 2006. Due to structural breaks in the data set only data for the period 1995-2002 are used. The data set used consists of 3589 observations for the full sample and 1376 and 2213 observations for the cases of only full time or only part time farm households respectively.[1]

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A Wooldridge test for serial correlation (Drukker, 2003) indicates first order autocorrelation for the unbalanced panel data set at hand therefore random effects models are estimated using the xtregar procedure (random effects generalized least squares estimator) in Stata for linear random effects models.[2] Different partial equilibrium models are estimated with either including or excluding location specific dummy variables and households' allocation of labor time.

Linear one-way error component random effects models:

$$y_{it} = \alpha + \beta \mathbf{x}_{it} + u_{it}, \qquad i \in \{1,\ldots, N\},\ t \in \{1,\ldots, T\}$$

$$u_{it} = \mu_i + \nu_{it}$$

where i = household index, t = time index, α = constant, β's = coefficients of respective variables to be estimated, $\mathbf{x}_{it}$ = vector of explanatory variables, u_{it} = error term, μ_i = individual random disturbance, υ_{it} = remainder stochastic disturbance term

are used for the regression analysis. As long as the panel was drawn randomly, random effects models allow estimating individual effects that are characterized as random and inference pertains to the population (Baltagi, 2008).[3]

Qualitative interviews regarding environmental awareness of farmers were conducted 2008 in 6 Villages in south and central Hebei. The farmers interviewed are chosen purposively to enable a broad range of answer possibilities regarding environmental awareness. In a first step the village head names a large household that is comparably successful in agricultural production and a smaller household that is less successful. In the second step those households are visited and interviewed. Other respondents as fertilizer sellers and extension service workers are interviewed if ever they are accessible.

For the chemical quality analysis different kinds of nitrogenous fertilizer are collected due to the difficulties of accessing fertilizer retailers. Limiting the collection only to urea fertilizer would have led to a rather small sample size. Therefore also N-P (phosphorous) -K (potassium) fertilizer is analyzed. Fertilizer samples were taken in the villages where the qualitative interviews were conducted.

Results

The model specifications including village location effects by respective dummies are preferred for the analysis of socio-economic determinants of urea use.[4] It is assumed that inter-village differences in farmers' fertilization behavior are larger than intra-village differences. Most of the village dummies are significant and positive but for village 4 the dummy variable shows a significant negative effect.[5] As expected the price of urea fertilizer has a strong significant negative effect on urea application. The price elasticity of demand is rather low for full time

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1 According to the available information about the households' time allocation all households that state that they are engaged full-time in agriculture are considered as full time farm households in the study at hand and all the other households as part time farm households.

2 A Hausman-test was applied to test for the appropriateness of the random effects model. H_0, that the difference in coefficients is not systematic, is rejected for the full sample with the Hausman test statistic of 1076.40 that is distributed as χ^2_6. The Durban-Watson specification is used to compute autocorrelation.

3 The sample provided by the RCRE can be considered as being drawn randomly from the population (Benjamin et al., 2005). A description of the variables used in the regressions and their summary statistics is omitted here due to limitations in space but is available upon request.

4 The results of the regression analysis are not presented in detail for all covariates. They are available upon request.

5 Since no village level data are available no further explanation for this difference can be provided here.

farmers (-0.22) were it is higher for part time farm households (-0.70). This is an indirect indication that part time farmers might use less chemical fertilizer because they depend less on agricultural production due to income diversification. A direct effect of the share of off-farm income on the application of urea is not found. Also this difference in the price variable shows the importance of analyzing full- and part-time farm households separate because they differ in their characteristics and decisions. An interesting and unexpected result is the positive and significant effect of the ratio of agricultural laborers to the total arable land of the household. So there is no substitution relation between labor and urea fertilizer application. For the variable area of arable land available per household the coefficient is as expected negative and significant. Especially for part time farm households a higher amount of arable land available leads to a lower amount of urea applied.

Time dummies can capture climatic or crop rotation conditions that might call for higher or lower application levels of nitrogenous fertilizer. More relevant for the agricultural production in China seem to be fluctuations of fertilizer prices either by market driven forces or by policy measures such as direct and indirect subsidies. In 1996 fertilizer prices rose less than in former years and in 1997 fertilizer prices even declined (Chen, 2009). This offers an explanation for the significance of the time dummies for both years in the full sample and for the sub sample of part-time farm households. For the years 2000 and 2001 the time dummies are positive and significant for full-time farm households only.

The level of education attained by the household head does not have a significant influence on farmers' urea application decision.[6]

During the qualitative interviews in villages in southern Hebei farmers revealed mistrust against the nutritional contents of the regional available fertilizers. They considered the chemical contents of N as not as high as stated on the bags. Among the farmers there is no sense of an economic value assigned to natural resources as soil and water but they are aware that degraded soils and water resources endanger crop production and yields. This awareness arises from past experiences and observation. Farmers mention that they prefer cheaper fertilizer even if they figure out that it is of less quality. So there is a sensitivity regarding price variations that even masks potential yield losses due to low-quality fertilizer.[7] Farmers hardly have information about soil quality and nutrient balance or about official fertilizer recommendations. In the study region information relevant for farm and crop management are mainly provided by radio, TV and written materials. If the local extension service provides information they do not cover the topic of soil and water degradation caused by chemical fertilizer residues.

In 2008 and 2009 46 samples of nitrogen containing fertilizer have been collected at various locations in Hebei. As shown in Figure 1 some fertilizer samples contained more N than was labeled but most of the samples contained less. The fluctuations found confirm some of farmers' concerns regarding the reliability of the nutritional content of the purchased fertilizer. If the composition of the fertilizers varies to strong it becomes difficult for scientists or extension staff to provide farmers with reliable application levels.

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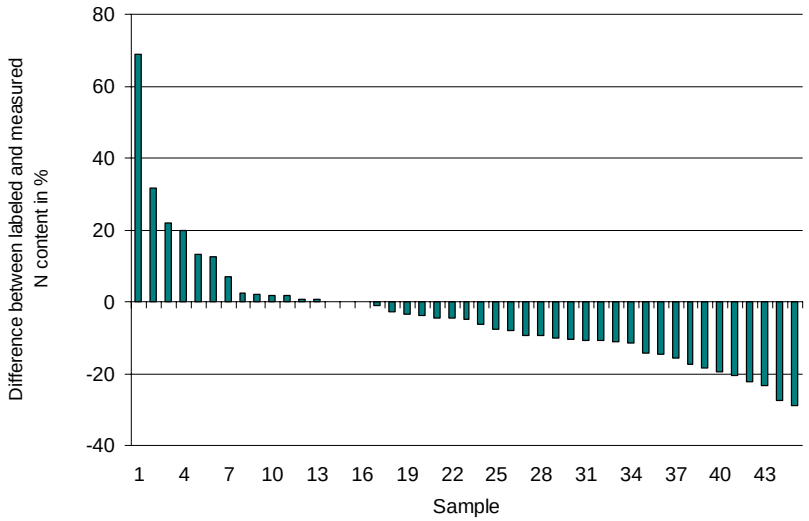
[6] The variables age of main laborer and its attained education level are negatively correlated. If both variables are included in the regressions then they outweigh each other and neither of them has a clearly identifiable effect on the use levels of fertilizer. After testing several model specifications the education level attained by the household head is considered as the more favorable variable for the application level analysis and included in the regressions presented here.

[7] Resulting from an increasing use of mineral fertilizers in the last two decades there is some evidence of over fertilization in the study region. So even if the fertilizer applied in one period has fewer nutrients than expected there seems to be no direct yield effect because nutrients left in the soil or due to an overall too high amount of fertilizers applied.

Figure 1: Difference in N between label and measurement in %



Source: Own calculations based on fertilizer analyses carried out by the Institute of Plant Nutrition and Natural Resources, Beijing Academy of Agriculture and Forest Sciences and the Institute of Plant Nutrition at the China Agricultural University, Beijing.

Conclusion

A combination of quantitative and qualitative methods allows to assess socio-economic determinants of urea fertilizer use in the Hebei province but also to understand farmers' attitudes with respect to environmental consequences of their production decisions. Urea fertilizer pricing has the most direct effect on farmers' purchase decisions and can be even identified to have stronger effect in specific years. But only regulating the application levels and preventing over fertilization by policy measures that influence the price of urea would be too short-sighted. Explicit measures as Pigouvian taxes would have to be introduced and subsidies should be applied with care. Farmers have to be equipped with sufficient knowledge about the interdependencies of their farming practice, especially with respect to chemical fertilizers, and the nutritional needs of their produced crops under consideration of local soil properties. Also the local extension service has to be supported to be able to provide farmers with facilities to test the quality of fertilizers and soils. Since differences in fertilizer application determinants are found between full and part time farm households over time it is necessary to design group specific training in up to date application methods of chemical fertilizers.

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