Farmers' Inefficient Response to Drought and the Reason
- A Case Study of Wheat Production in Adana and Konya Regions -

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1. Introduction

Two types of methodology have been used mainly to assess the impact of climate change on agricultural economy. One is mathematical modeling approach and another one is statistical approach. The key issue of these analysis is how capture the interactions of climate change and human activity. For example, a mathematical model which does not consider technical improvement in future will be over estimate the impact of climate change on agricultural and rural economy.

Because of this, some studies have made an attempt to incorporate the interactions between climate change and human activity into mathematical models or statistical models. Adams et al. (1999) assessed the impact of global warming on US agriculture, using agricultural sector model. The parameters of each crop yield which are required by ASM are based on some crop simulation models which project the yield under climate change scenarios. However, they set the parameter of grain yield as farmers can reduce the negative impact of global warming on grain production by 25 - 50%, based on the statistical analysis conducted by Segerson and Dixon (1999). Kaiser et al. (1993) incorporated risk averse assumption in their farmer's behavior model under climate change.

These approach can consider the interaction between climate change and human activity in quantity or theoretical way. However, these can not explore how farmers actually response to or interact with climate change. Chiotti and Johnston (1995) argued that "The natural hazard literature extends this criticism, by providing a vocal and critical theoretical challenge to the natural hazards 'paradigm' which underlies conventional climate change research.(p.336)"

Our purpose of this study is to explore how farmers actually response to weather shocks, and construct farmers behavior model under weather change by examining the household farm data collected in Adana and Konya regions. We have conducted the farm household surveys three times in Adana and Konya regions of Turkey from 2002 to 2004[1]. Farmers were affected by the drought shock in 2004, especially in Adana region. On the contrary, 2002 is said to be normal weather year. By comparing the farm household data of 2004 with these of 2002[2], we can examine the impact of drought on agricultural production.

In section 2, the result of our presentation in ICCAP Kyoto Work Shop 2005 will be shown briefly. In section 3, the interpretation of this result related climate change research will be discussed. In section 4, the development and problem of this result will be discussed. Finally, in section 5, we present the research plan of this study in near future.

2. Farmers' Rational Perception and Inefficient Response to the Drought

From household data, we showed that the farmers in Adana and Konya regions think that they should reduce the fertilizer use for wheat production when they meet drought shock, because the productivity of fertilizer decreases, and also too much fertilizer use may have negative effect on wheat production. We estimated production function of wheat to examine whether this farmers' perception is rational or not.

By using OLS (Ordinary Least Squares)

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[1] The farm survey was conducted one time in each year.
[2] Because the survey data of 2003 lacks the information to estimate production function, the data of this year was excluded from this analysis.

estimation procedure, Cobb-Douglas production function of wheat of each area is computed[3]. Dependent variable is log of wheat production (LWHTPRDUCT). Independent variables are log of planted area of wheat (LWHTAREA), log of the fertilizer input to wheat (LFERTILIZER), and coefficient dummy variable of the fertilizer input (LFERTILIZER_CDM). Coefficient dummy takes zero in normal year and takes log of fertilizer input in drought year. This variable reflects the impact of drought and high temperature shocks on technological relationship between input and output .

Table 1 shows the result of estimation. The sign condition of coefficient dummy of the fertilizer input which captures the impact of drought on wheat production are minus in all areas. This means that the farmers' perception described above is rational.

Furthermore, we examined whether farmers can response optimally to the drought or not, , by comparison between the optimum and the actual level of input in the case of drought. The results of calculation are shown in Table 2[4]. Compared to normal year(2002), the optimum input levesl of fertilizer have decreased in drought year(2004) in all areas. The actual input levels of fertilizer, however, increased in drought year in three areas except for Konya non irrigated. In Konya non irrigated area, farmers has not reduced fertilizer use so much, even though they did not increase fertilizer. These facts imply the important characteristics of farmers' action in Adana and Konya, that is, farmers could not respond optimally to the drought shock of 2004. Even though they have the rational perceptions that fertilizer should be reduced in the case of drought, they do not obey their perception.

[3] Research area was divided into the following four groups according to their attributions, that is, 1. Adana irrigated area 2. Adana non irrigated area 3. Konya irrigated area 4. Konya non irrigated area.

[4] According to the production economics theory, profit can be maximized at the point that marginal productivity of the input is equal to the price ratio between the input(fertilizer) and output(wheat), supposing other inputs are given. This point, therefore, can be defined as optimum level. These data can be calculated by the estimated production elasticities and the collected price data in farm survey.

Table 1. Results of the estimation of production function

Adana	IR Area			NIR Area		
	Coefficient	t-value		Coefficient	t-value	
LWHTAREA	1.028	20.21	***	0.676	4.92	***
LFERTILIZER	0.071	2.46	**	0.355	2.88	**
LFERTILIZER_CDM	-0.057	-5.24	***	-0.091	-8.22	***
CONSTANT	5.613	24.05	***	4.162	8.22	***
No. of observation	33			65		
Adj. R-squared	0.943			0.905		
BPG test statistics	0.31			0.45		

Konya	IR Area			NIR Area		
	Coefficient	t-value		Coefficient	t-value	
LWHTAREA	1.021	27.74	***	0.615	6.12	***
LFERTILIZER	0.028	1.20		0.276	4.77	***
LFERTILIZER_CDM	-0.005	-0.60		-0.029	-1.27	
CONSTANT	5.721	45.69	***	5.010	13.71	***
No. of observation	54			36		
Adj. R-squared	0.975			0.802		
BPG test statistics	0.05			0.09		

** Significant at 5% level, *** Significant at 1% level.
BPG (Breush-Pagan-Godfrey) test statistics test heteroskedasticity of multiple regression

Table 2. Optimal and actual input of fertilizer to wheat

		Marginal Productivity		Fertilizer input (kg/da)	
		Optimal	Actual	Optimal	Actual
Adana IR	2002	1.3569	0.8466	27.5	47.5
	2004	1.0066	0.0953	4.7	57.2
Adana NIR	2002	0.9591	1.6006	165.6	61.5
	2004	0.9882	0.6740	34.7	69.0
Konya IR	2002	1.0589	0.7792	10.4	34.3
	2004	1.1360	0.1559	8.3	42.2
Konya NIR	2002	1.1368	2.4612	74.3	28.6
	2004	1.3858	1.7773	33.9	21.6

IR means irrigated area, NIR meand non irrigated area.

3. Relation to Climate Change Research

We discuss the interpretation of the above analysis related to climate change research, by comparing to the study conducted by Kaufmann and Shell (1997). They estimated a model that determinants corn yield in the United States, with pooled cross-sectional data from counties. They compared two models, one contains only climatic variables, and another contains climatic and social variables. The result showed that the parabolic effect of climatic variables on yield estimated by the model which contains only climatic variables are steeper than the parabolic effect estimated by the model which contains climatic and social variables[5]. This findings is consistent with the economical theory. Unfavorable weather conditions reduce the productivity of agricultural inputs., and also reduce the optimal use of inputs. Because of this, farmers will reduce the actual use of input, when they meet unfavorable weather conditions. So, the effect of

[5] The effects of climatic variables on yield are captured by quadratic form.

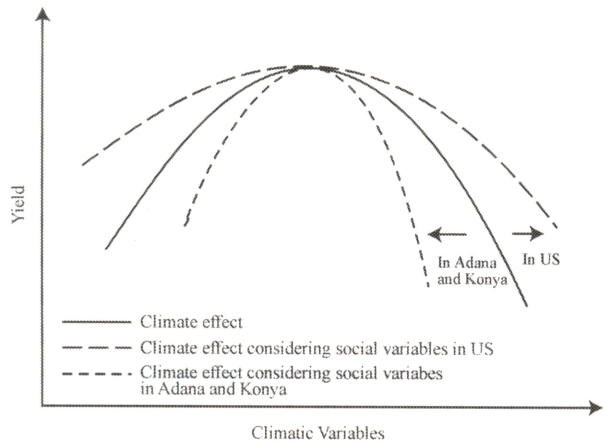

Fig. 1 The effect of climatic variables on yield with and without social factors

unfavorable weather conditions on yield will be exaggerated by farmers' responses based on economical optimization.

The result of our research described above suggests that farmers in Adana and Konya regions responded to weather change in a opposite way to the response of US farmers. The farmers in Adana and Konya regions did not reduce the use of fertilizer input, even though they recognized that they should reduce the use of input. This response means that the effect of climatic factors on wheat yield may become moderate, by incorporating social factors. Figure 1 shows the conceptual difference of the farmers' response between US and Turkey. We assume that the solid line expresses the estimated effect of one climate factor (such as monthly total rainfall or monthly average temperature) without consideration of social factors in US and our research regions of Turkey. Then, the rough dotted line expresses the estimated effect of the climate factor on yield with consideration of social factors in US, and the small dotted line expresses the effect in Adana and Konya regions.

This result suggests important insights for assessing the impact of climate change on agriculture and agricultural economy in Adana and Konya region of Turkey. The farmers in our research areas contain the use of fertilizer input, though the marginal productivity of this decreases in the case of unfavorable weather. We need to include this response in the farmers' behavior model. Otherwise, under the assumption that the structure of agriculture is hold in future, we may over estimate the impact of climate change in the research areas on wheat yield, on the other, under estimate the impact on farmers' profit derived from wheat production, if climate change has negative influence on wheat production in a sense of agronomy Also, we may mislead the cropping pattern in future.

The above discussion is not the determined one. If the statistical analysis using similar data to Kaufmann and Shell (1997) has consistent result with the household data analysis, this discussion will become more reliable one. Also, one question arises about this farmers' response, that is, why farmers can not respond efficiently to weather shocks, although they know the rational response. This question is discussed in following section.

4. The Reason of Farmers' Inefficient Response

We implies the following three hypotheses that explain the farmers' inefficient response to drought in the report of ICCAP Kyoto Work Shop 2005.

1) Customary behavior of farmers

In spite of enlightened knowledge about drought shock, farmers do not want to change his every days' customary behavior.

2) Remained fertilizer for second crop

Just after harvesting first crop wheat, farmers must start to sow second crop maize in irrigated area. The remained fertilizer in the soil, that is originally input for wheat, is said to be effective in growing maize. Farmers dislike to reduce the fertilizer input, even though they are affected by drought.

3) Self consumption use

Wheat is grown for not only sale but self consumption in non irrigated area. Farmers can not decrease the amount of wheat production for their subsistence. Even though they know that fertilizer input must be reduced to profit maximization, they can not reduce fertilizer and reduce their wheat production.

To examine these hypotheses, we calculated each farmer's optimal use of fertilizer input, and also calculated the difference of the each farmer's actual use of fertilizer from the optimal use. And then, we estimated some rough models which determine the factors that influence to the difference of actual use from optimal level. We chose household size,

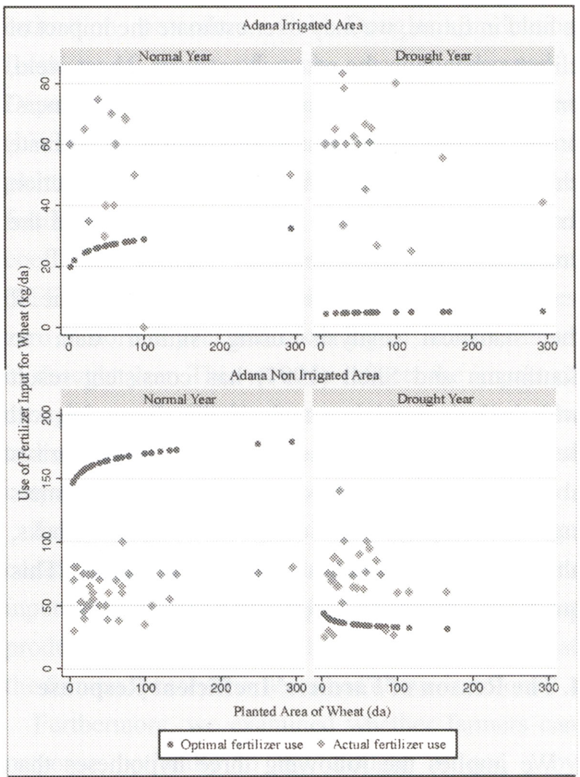

Fig. 2 Optimal and actual use of fertilizer per unit area

education level, farm size, off-firm income, use of credit, and etc. as the explaining variables. However, the results of any estimation was not good. Coefficients of any explaining variables were not statistically enough, and also not robust to some change of estimated models.

There is some possibility that this failure stems from the miss choice of explaining variables or miss formulation of estimated models. However, the estimation of production function in section 2 may be more problematic. Figure 2 shows the each farmers' optimal and actual use of fertilizer in Adana region. The actual use of fertilizer of all farmers in Adana irrigated area in both years are larger than the optimal levels. On the other, the actual use of fertilizer of all farmers in Adana non irrigated area in normal year are lower than the optimal levels. This implies the possibility that the production function under estimated the productivity of fertilizer in irrigated area, on the other, over estimated the productivity in non irrigated area.

This over or under estimate of the productivity of fertilizer may attribute the following two factors. 1. We estimated the production function of wheat separately in irrigated area and in non irrigated area. Because of this, each coefficient of land captures the absolute (e.g. do not consider the difference between irrigated land and non irrigated land) productivity of land. However, it is proper to estimate together the production function in irrigated area and in non irrigated area and to consider the difference of land situation in the same model because we can not capture the effect of irrigation use in the estimation model[6]. 2. Household farm data are apt to suffer sample bias which attributes the characteristics of individual farmers. Production function should capture only the technical relationship between input and output. However, the estimation with household data may be influenced by sample bias, and the result of estimation may contain some effects of the sample bias.

5. Research Plan in Near Future

To solve the problem of the estimation of production function, we will estimate again the production function of wheat, using stochastic frontier production function model which captures the effects of sample bias related to household data. Also, we will estimate the model which explicitly distinguish the irrigated land and non irrigated land. Also, we will construct a model which explains the factors hat differentiate the actual use of fertilizer from the optimal use on the basis of household model or decision making model. And then, we will examine the effect of these factors, using the household data.

Also, we will estimate a wheat yield determinants model, with the pooled cross-sectional data from the district in Adana and the near provinces. The purpose is to confirm the discussion in section 3.

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