

The value of seasonal forecasting and crop mix adaptation to climate variability for agriculture

Hyung Sik Choi ¹⁾²⁾, Uwe Schneider ²⁾, Erwin Schmid ³⁾, Hermann Held ²⁾

International Max Planck Research School on Earth System Modeling ¹⁾, Research Unit Sustainability and Global Change, University of Hamburg, Germany ²⁾
 Institute for Sustainable Economic Development, University of Natural Resources and Applied Life Science, Austria ³⁾

hyung.choi@zmaw.de



1. Introduction

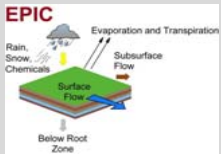
In this study, we investigate the impacts of climate variability in Spain on the agricultural sector and international agricultural markets with and without seasonal climate forecasting.

To quantify the potential benefit of employing seasonal climate forecasts for consumers, producer, and society, we simulate the impact of historical climate variability (year 1961 ~ 1990) on crop production and integrate the results in a stochastic agricultural sector model.

2. Methodology

Climate data : REMO

Regional climate model output on the period of 1961 ~ 1990 , resolution (25 × 25 km)
 Bias corrected as a reference period



Study region : Spain (~ 6800 sites)
Study crops : Barely, Wheat, Rice
 Corn, Potato, Cotton seed

EPIC crop yield outputs are calibrated to the average crop yields in Spain. (Fig. 1) (FAO, 1995 ~ 2004)



Agricultural sector economic model

Stochastic decision

$$W_S = \max_X \sum_S P_S W(X, Y_S, \xi_S)$$

Stochastic decision with perfect climate information

$$W_{PI} = \sum_S P_S \max_X W(X, Y_S, \xi_S)$$

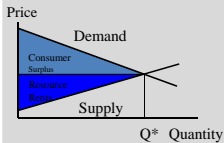
Crop mix adaptation

$$-\sum_a h_{r,c,a} CMIX_{r,a} + \sum_t X_{r,c,t,l(s)} \leq 0$$

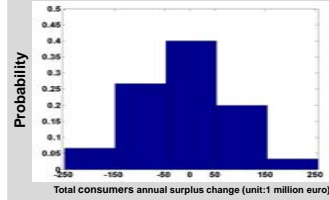
W: market welfare
 X: crop management
 Livestock feed, trade (control variable)
 Y: water use (state variable)
 ξ: crop yield (random variable)
 P: probability of state
 s: state of nature

r: region (Spain)
 a: alternative
 h: crop specific area (FAO, 1995 ~ 2004)
 t: technology
 CMIX: crop mix variable

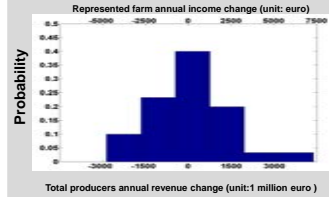
Historical mix : h - observed crop specific areas (1965 ~ 2004)
Strategic mix : h - areas up to 10% larger or smaller than historical bounds depending on weather impacts on crop productivity



3.1 Damages by historical climate variability



Due to the climate variability over the years 1961~ 1990 in Spain, consumer surplus decreases up to 206 million €



Producers revenue decreases up to 2.59 billion € and represented farm incomes decrease up to 4,262 €

Fig. 2 30 years (1961~ 1990) climate variability impacts on total consumer surplus (top) and total producers revenue, represented farm income shift (bottom)

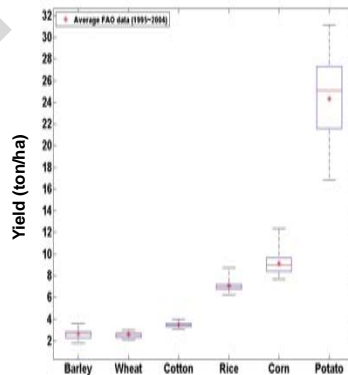


Fig. 1 Simulated annual crop yields in Spain with 30 years annual climate variability (1961 ~ 1990)

3. Results and Conclusions

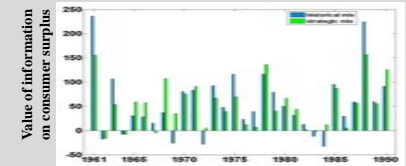
3.2 Adaptation with climate information and crop mix

Table 1. 30 years average value of climate information to consumers and producers in Spain.

Spain	No information	Perfect information	
	Baseline	Historical mix	Strategic mix
Consumer surplus	0	(+ 51.2)	(+ 48.9)
Producer revenue	17,157.886	17,531.493 (+ 513.8)	16,936.820 (- 170.2)

* () indicate the value of information from the baseline (unit : 1 million euro (2000))

- **Consumers** in Spain and the rest of the world may benefit from climate forecasts. **Producers** benefits are ambiguous : Climate information could lead to the oversupply of specific crops and the decline of market prices. It results in the decrease of producer revenue under specific climate conditions (Table 1).



- The comparison of historical mix and strategic mix adaptation demonstrates that a historical mix condition is necessary for Spain to enhance both consumers and producers

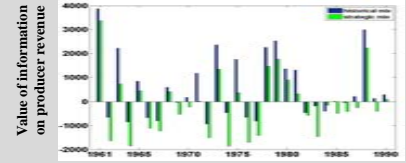


Fig. 3 Annual value of climate forecasting in Spanish agriculture in each year with two different crop mix adaptation options. (unit: 1 million euro)

3.3 Distributional impacts of climate information

Table 2. 30 years average value of climate information to consumers and producers on the rest of world.

Rest of the world	No information	Perfect information	
	Baseline	Historical mix	Strategic mix
Consumer surplus	0	(+ 193.0)	(+ 667.2)
Producer revenue	908,369.9	919,969.2 (+ 11,599.2)	898,445.2 (- 9,924.7)

* () indicate the value of information from the baseline (unit : 1 million euro (2000))

- Employing climate in agriculture increases the global welfare value. Consumers take most of the benefits from the climate forecasting.