

Impact of Natural Hazards on Agricultural Economy in China: Based on a General Equilibrium Analysis¹

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1. Introduction

In China, various natural disaster inducing factors with various hazard formative environments, such as population, properties, natural resources and ecological condition, can result in different extent of casualties, property and economic losses as well as damage of natural resources and environment. Overall, drought widely occurred and caused the most serious losses in historical periods examined while flood was the most frequent natural disaster.

2. Hypotheses

With the limitation of water supply at the regional level, this study aims to test the following hypothesis in the cases of drought and flood happening: hypothesis 1 (H1): All of agricultural productions will be significantly stressed, thus their domestic output will decrease into a lower level; hypothesis 2 (H2): All of households will suffer losses in welfare; furthermore, rural household will become worse than urban household; hypothesis 3 (H3): Food consumption by all households will be reduced, and the decrease in rural household will be more than in urban household.

3. Modeling framework and data

We construct a computable general equilibrium (CGE) model for above hypothesis testing. Main production sectors include: i) agriculture and construction requiring inputs containing multi-regional land, water, and agricultural labor combined with one non-agricultural labor; ii) food and energy sectors requiring multi-energy inputs; iii) multi-regional water productions (16 regions). Data is based on a Social Accounting Matrix contributed by J. GE and S. TOKUNAGA (2011)¹. We divide water sector into 16 regions combined with relative regional land use for crop productions (see figure 1). It is a static equilibrium model. The domestic prices of imports and exports are in Chinese Yuan (RMB). The wage of non-agricultural labor is exogenously fixed as the numeraire price index. Domestic product and export are presented by a constant elasticity of transformation (CET) function; domestic product and import are regulated by Armington function. Values of elasticity in above functions are given by previous studies. Consumption behaviors of households (16 regional rural household and one urban household) are described by Stone-Gary utility function with diversity in income elasticities of commodities. Measurement for the changes in welfare is marked by the equivalent variation (EV): if EV is positive, the simulation increased welfare, and if it is negative, the simulation decreased welfare. Water supply is fixable at regional level, and regional prices of water are independent of each other.

¹The authors appreciate the help of Professor Ge, Jianping for permitting us to use his multi-regional social accounting matrix, which was one of his contributions in his Ph. D thesis.

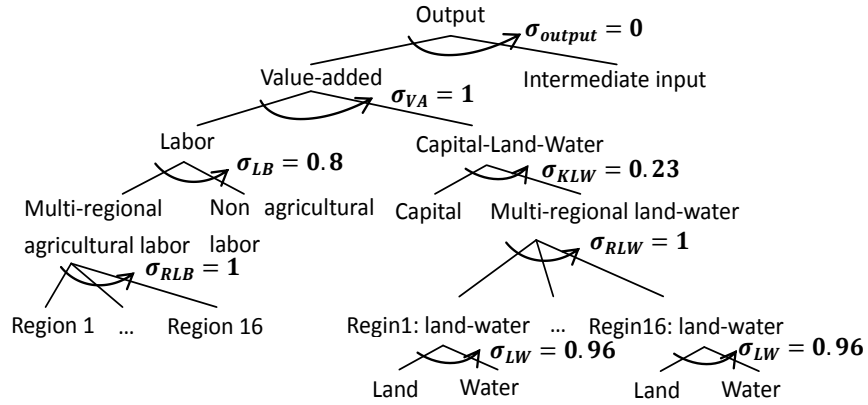


Figure 1, production structure of crop sectors

Note: $\sigma_{LB} = 0.8$ and $\sigma_{RLB} = 1$ are given from Jianping GE and Suminori TOKUNAGA (2011); $\sigma_{KLW} = 0.23$ and $\sigma_{LW} = 0.96$ is from the GTAP-W model defined by A. Calzadilla, K. Rehdanz and R.S.J. Tol (2011); $\sigma_{output} = 0$ and $\sigma_{RLW} = 1$ are related to Leontief and Cobb-Douglas assumptions respectively.

4. Empirical application and simulation results

4.1 simulation design

We set the year in 2007 as benchmark, and then discuss three scenarios as simulations:

(1) Baseline scenario (BS): cultivated land increasing in 2008; (2) Drought scenario (S1): cultivated land decreasing in 2008 because of drought; (3) Flood scenario (S2): cultivated land decreasing in 2008 because of flood (see figure 2).

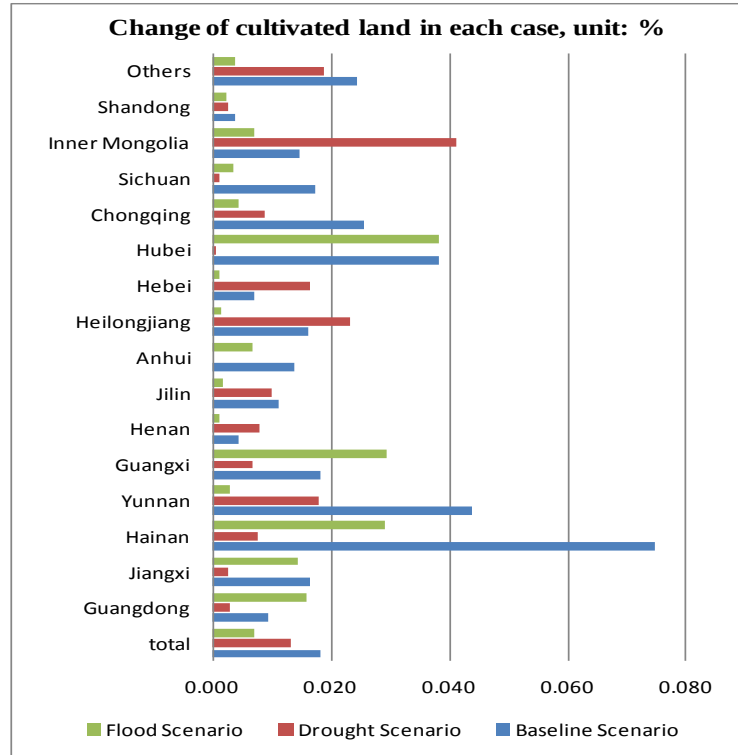


Figure 2, change of cultivated land in each case in all regions

4.2 Hypothesis testing

According to table 1, we can test H1 based on the following finding. Total output of crops will be reduced in S1, and be increased in S2. Some crops will be better in S1 including corn, oil seed and potato; some crops will be better in S2 including paddy, wheat, corn, fruit, potato; and there also some crops which will be better in both S1 and S2 including corn and potato.

Table 1, change in the output of crop productions in each case

unit:%	BS	S1	S2
paddy	-0.006	-0.001	0.245
wheat	0.035	-0.128	0.161
corn	-0.056	0.060	0.092
vegetable	0.004	-0.258	-0.312
fruit	-0.067	-0.049	3.771
oil seed	0.357	0.008	-0.086
sugarcane	0.075	-0.294	-0.050
potato	0.001	0.004	0.208
sorghum	0.003	-0.006	-0.008
other crops	0.013	-0.001	-0.157
total	0.013	-0.038	0.059

For testing H2, table 2 shows that compared with urban household, rural household will be worse in S1 but be better in S2. In detail for rural households, some of them will be better in S1: Yunnan, Henan; and some of them will be worse in S2: Guangxi, Henan, Jilin and Shandong; but some of them will be worse in both S1 and S2: Guangxi and Jilin.

Table 2, change in the welfare of household in each case

Unit: 0.1 billion yuan		BS	S1	S2
multi-regional rural household	Guangdong	2.734	-16.730	21.287
	Jiangxi	0.926	-5.667	10.430
	Hainan	0.249	-0.082	0.822
	Yunnan	1.018	1.621	26.409
	Guangxi	0.448	-2.210	-1.587
	Henan	0.334	3.909	-5.832
	Jilin	0.639	-12.370	-9.992
	Anhui	-1.422	-5.454	16.495
	Heilongjiang	0.006	-1.705	4.140
	Hebei	-2.254	-3.365	25.237
	Hubei	-0.096	-1.844	18.964
	Chongqing	0.323	-2.810	14.008
	Sichuan	1.072	-18.183	33.853
	Inner Mongolia	-0.302	-0.037	7.522
	Shandong	-0.267	-46.772	2.389
	Others	6.765	-35.552	163.756
	total change in rural household	10.173	-147.250	327.901
	total change in urban household	-5.572	17.121	-74.785

Table 3 shows similar results as table 2 that: compared with urban household, rural household will be worse in S1 but be better S2; rural household in Yunnan and Henan will be better in S1; and those in Guangxi, Henan, Jilin and Shandong will be better in S2, however, those in Guangxi and Jilin

will be worse in both S1 and S2. It means that for rural household, their welfare has close relations with their food consumption level.

Table 3, change in the food consumption by household in each case

Unit: %		BS	S1	S2
multi-regional rural household	Guangdong	0.014	-0.088	0.091
	Jiangxi	0.007	-0.055	0.069
	Hainan	0.013	-0.026	0.048
	Yunnan	0.009	0.003	0.183
	Guangxi	0.005	-0.039	-0.008
	Henan	0.007	0.021	-0.088
	Jilin	0.009	-0.157	-0.116
	Anhui	-0.004	-0.043	0.068
	Heilongjiang	0.002	-0.036	0.032
	Hebei	-0.009	-0.033	0.114
	Hubei	0.002	-0.031	0.083
	Chongqing	0.006	-0.053	0.169
	Sichuan	0.006	-0.082	0.117
	Inner Mongolia	-0.001	-0.007	0.076
	Shandong	0.001	-0.157	-0.009
	Others	0.005	-0.035	0.077
	total change in rural household	0.005	-0.049	0.071
	total change in urban household	0.002	-0.001	-0.028

Note: “food” in this study includes crops and the products from food industries covering 5 kinds of products: meat, milk, vegetable oil, grain, sugar, and other food

4.3 Simulation Analysis

4.3.1 Analysis for those crops better in each case

Lower price is the main reason for those increases of crops in domestic and foreign demand: in S1, domestic demand increases in corn and potato and foreign demand increases in oil seed; in S2, foreign demand increases only in corn, and both domestic and foreign demand increase in paddy, wheat, fruit, and potato. Furthermore, the import of vegetable increase in both two cases (see table 4).

Table 4, Change in domestic demand, export and import and their price level in each case

unit: %	S1: drought scenario			S2: flood scenario		
	Domestic demand	Export	Import	Domestic demand	Export	Import
paddy	-0.001	0.000	-0.003	0.134	6.368	-7.993
wheat	-0.040	-1.659	2.014	0.067	1.790	-2.037
corn	0.064	-0.001	0.087	-0.027	1.981	-0.742
vegetable	-0.101	-6.053	4.247	-0.120	-7.459	5.309
fruit	-0.010	-0.452	0.278	0.493	38.710	-18.579
oil seed	-0.002	0.025	-0.006	-0.139	0.000	-0.158
sugarcane	-0.294		4.275	-0.050		-2.233
potato	0.005	0.000	0.008	0.036	4.270	-2.701
sorghum	0.004	-0.025	0.022	-0.027	0.027	-0.059
other crops	0.007	-0.428	0.306	-0.092	-3.835	2.560
Price	Price of composite commodities	price of exports	price of imports	Price of composite commodities	price of exports	price of imports
paddy	-0.008	-0.007	-0.007	-1.679	-0.034	-0.034
wheat	0.446	-0.007	-0.007	-0.505	-0.034	-0.034

corn	0.011	-0.007	-0.007	-0.584	-0.034	-0.034
vegetable	1.711	-0.007	-0.007	2.105	-0.034	-0.034
fruit	0.108	-0.007	-0.007	-8.105	-0.034	-0.034
oil seed	-0.009	-0.007	-0.007	-0.041	-0.034	-0.034
sugarcane	1.801	-0.007	-0.007	-0.913	-0.034	-0.034
potato	-0.006	-0.007	-0.007	-1.137	-0.034	-0.034
sorghum	0.000	-0.007	-0.007	-0.046	-0.034	-0.034
other crops	0.112	-0.007	-0.007	1.019	-0.034	-0.034

Moreover, higher demand will motivate the crop productions to employ more labor, especially agricultural labor, which is the main reason why some crops will be better in S1 or S2 (see table 5).

Table 5, the change in the employment of crop production in each case

	S1: drought			S2: flood		
	composite capital-land -water	composite regional agricultural labor	non-agricultural labor	composite capital-land -water	composite regional agricultural labor	non-agricultural labor
paddy	-0.054	0.006	-0.004	-2.849	0.709	-2.312
wheat	-1.051	-0.039	0.581	1.603	0.017	-0.629
corn	-3.304	0.499	0.161	-0.581	0.194	-0.542
vegetable	1.058	-0.495	1.197	1.303	-0.603	1.476
fruit	0.201	-0.140	0.188	-21.059	14.493	-13.661
oil seed	-1.644	0.304	0.056	0.370	-0.165	-0.168
sugarcane	-0.734	-0.311	1.937	-1.685	0.102	-1.154
potato	-1.566	0.206	0.040	-0.663	0.342	-0.757
sorghum	0.030	-0.012	-0.008	-0.147	0.016	-0.041
other crops	-0.674	-0.001	0.123	0.160	-0.183	0.921

4.3.2 Analysis for households' welfare

In S1, for rural households, their welfare and utility level highly depend on the food consumption level, but urban household do not; for both rural and urban households in S2, decrease in food consumption would reduce their welfare and utility, only except rural household in Shandong. For most rural households except the one in Henan, increasing income will enhance their food consumption level (see table 6).

Table 6, Change in income and utility level for households in each case

Unit: %		S1		S2	
		Income	Utility level	Income	Utility level
rural	Guangdong	-0.110	-0.401	0.130	0.510
	Jiangxi	0.034	-0.220	0.046	0.404
	Hainan	0.024	-0.020	0.016	0.204
	Yunnan	0.078	0.069	0.250	1.124
	Guangxi	-0.002	-0.083	-0.050	-0.059
	Henan	-0.001	0.102	0.028	-0.153
	Jilin	-0.179	-0.900	-0.211	-0.727
	Anhui	-0.008	-0.159	0.137	0.479
	Heilongjiang	0.037	-0.098	0.062	0.237
	Hebei	0.007	-0.105	0.239	0.791
	Hubei	0.081	-0.058	0.173	0.592
	Chongqing	0.044	-0.221	0.315	1.102

Sichuan	-0.030	-0.391	0.174	0.728
Inner Mongolia	0.032	-0.003	0.210	0.605
Shandong	-0.218	-0.834	0.038	0.043
Others	0.025	-0.118	0.146	0.543
Urban	0.003	0.008	0.001	-0.036

5. Conclusion

Hypothesis testing 1 (H1) did not pass the test according to the results: in S1, crop outputs would increase in corn, oil seed and potato due to increasing domestic (corn and potato) or foreign demand (oil seed); to meet that higher demand, agricultural labor would be integrated into above crop productions; In S2, crop outputs would increase in paddy, wheat, corn, fruit, and potato due to foreign demand (corn) or both domestic and foreign demand (others); to meet that higher demand, above crop productions would employ more agricultural labor. The main reason for above increasing in those crops is the lower price level of domestic and import market, which would motivate domestic demand and foreign demand. According to the results of the employment changing, agricultural labor plays as the key role for crop productions in the case that drought and flood occur. These results also prove that for crop productions, drought was as a more serious problem than flood due to more crops would be impacted to decline in output.

Hypothesis 2 (H2) were also not found in results: in S1, households in Yunnan and Henan would be better in welfare; in S2, most of rural households would be better except those in Guangxi, Henan, Jilin and Shandong. Those rural households with better or worse welfare were marked by the similar change in their food consumption in drought or flood cases. In other word, more food consumption would contribute higher welfare for rural households. Compared with urban household, the welfare of rural household at total level would be worse in S1 but would be better in S2. The reason behind this is that the income of urban household would be increased more in S1 than in S2 and further its food consumption would be reduced more in S2 than in S1.

Furthermore, hypothesis 3 (H3) were still not proved by results: In both S1 and S2, rural households with higher welfare and utility level were those with more food consumption. That's because for those rural households, food consumption accounts for large proportion in within total consumption, some of them even larger than 30% according to survey. In S2, for most rural household only except the one in Henan, their higher income might be the main reason for more food consumption. And these higher incomes were mainly from the more employment of land and agricultural labor for those crops with more output.

Other findings include: i) for crop productions, corn and potato would be better in both S1 and S2, because they can employed more agricultural labor in both two case to meet higher demand for them; ii) The import of vegetable would be increased in both S1 and S2 due to higher domestic price and lower import price. Thus the domestic output would be limited.

Reference

GE, Jianping and Suminori TOKUNAGA. 2011. "Evaluating the Effects of Expanding Grain-Based Fuel Ethanol on Chinese Economy Using a Computable General Equilibrium Model." *Studies in Regional Science*, 41(1), 195-218