IMPACTS OF CLIMATE CHANGE AND GRAIN SECURITY IN CHINA

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Abstract

Climate changes through change in temperature, precipitation and extreme weather events affect grain production, thereby influence the grain supply on the market, price and imports and exports trade. How to analyze climate changes on Chinas grain market and trade effects? How to evaluate the effects of different adaptation measures relating to climate changes? These are issues we need to focus on.

In this paper, eight different regions in China due to their natural and geographical conditions are considered. Based on the prediction of results derived from a regional climate model (Providing Regional Climates for Impacts Studies, PRECIS) and a crop modelling system (Crop Environment Resource Synthesis, CERES), of the above regional output changes of maize in the 2020s and 2040s, a spatial equilibrium model on Chinas maize is developed. It examines the impacts of changes in maize outputs and population growth on regional supply and demand of maize, equilibrium price, inter-regional trade (direction and flows) as well as external imports and exports trade. In addition, the potential economic effects of different climate exchanges adaptation policies and measures will be analysed and compared. Finally, some interesting conclusions will be drawn.

Key Words: climate change, food security, maize, China

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1. Introduction

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In Section 2, the concept, development and applications of spatial equilibrium model will introduced; In Section 3, a spatial equilibrium model for maize is developed to examine the impacts of climate change and population growth on China's grain security; Finally a conclusion will be drawn.

2. Spatial Equilibrium Model and Data

Several methods, including the regression analysis and the general equilibrium approach, were used to examine the impact of climate change on economics and agriculture sector

Wang et al. (2008) used regression analysis model to study, under the background of the climate change, the rational utilization of water resources and the best choice of crop varieties.

Gunasekera, Don et al. (2007) analyse the impact of climate change, according to Stern's (2006) climate change scenarios, on the world and Australia's wheat, beef cattle, dairy, sugar and other industrial production, exports and national economy (GDP), using a multi-regional dynamic general equilibrium model.

Here, the concept of spatial equilibrium and spatial equilibrium analysis will be introduced.

2.1 Spatial Equilibrium Model

Spatial equilibrium model is one of the partial equilibrium models. It tends to realize the equilibrium of quantity and price of one or some products among spatial markets, rather than the equilibrium of the entire market. Spatial equilibrium model links an equilibrium model in economics with a commercial transportation. Due to different geographical distribution, there exist usually more than one market, while these markets are independent of each other; on the other hand, goods can flow between these markets, i.e. from a market at a lower price of commodity to another market at a higher price. In general, the same commodities in different regions have deferential prices, the condition of space arbitrage is that the price difference between the two places is higher than the cost of transportation, and spatial equilibrium model can address these issues properly, eventually achieve a balance of volume and price of markets located in different spaces.

The concept of spatial equilibrium was put forward by Stephen Enke's. It is not until 1838 that Cournot begun his research on spatial equilibrium model. In 1952, Samuelson make use of social welfare as the objective function in his spatial equilibrium model. Martin and MacAulay (1981), Casey (1987) and Takayama etc. make use of social net income as objective function to construct the model.

Spatial equilibrium model is also widely used in economic analysis and policy simulation. MacAulay (1976) developed a recursive spatial equilibrium model to examine the United States and Canada beef trade, Koo et al (1986) use a spatial equilibrium model to study the wheat trade among the United States, Canada and the the European Union. Rutherford (1996) analyse Australia's beef exports, using a linear spatial equilibrium model, Minot and Gilletti (2000) constructed a more complex spatial equilibrium model to study the impacts of Vietnamese rice market liberalization on poverty in Vietnam.

2.2 The Scenarios' Setting

- B2 climate scenarios: a scenario with low or mid-emission and a slow growth of global population;
- The base year is in 2005;
- Based on the prediction of results derived from a regional climate model (Providing Regional Climates for Impacts Studies, PRECIS) and a crop modelling system (Crop Environment Resource Synthesis, CERES), of the above regional output changes of maize in the 2020s and 2040s by the Institute of Environment and Rural Development, Chinese Academy of Agricultural Sciences;
- Under the B2 climate scenario, maize yield is acted as an exogenous

variables (shocks) in the model;

✧ Set other factors, such as inflation, grain food imports not change

2.3 Simulation

In accordance with the similar type climate and geography, the country is classified into the following eight regions:

Northeast China Plain: Liaoning, Jilin, Heilongjiang;
North China Plain: Beijing, Tianjin, Hebei, Shanxi, Shandong, Henan, Shaanxi;
North arid grassland ecology: Inner Mongolia, Gansu, Ningxia;
Central China: Shanghai, Jiangsu, Zhejiang, Anhui; Jiangxi, Hubei, Hunan;
South China: Fujian, Guangdong, Guangxi, Hainan;
Southwest China: Chongqing, Sichuan, Guizhou, Yunnan;
Xinjiang: Xinjiang;
Tibetan Plateau: Tibet, Qinghai.

The first step: to outline the changes of maize outputs in different regional (as shown in Table 1) under the B2 climate scenarios. In 2020s, the outputs of maize in the North of China, Northeast will increase, outputs in other regions will reduced, compared with the baseline. In 2020s the national outputs of maize will decrease by 3.73%; In 2040s, the climate change will bring a positive impact on the outputs of maize in North of China, Centre of China and South of China, but other regions have negative effects. In 2040s, national maize outputs will decline by 5.84%.

Table 1
Forecasts of Sub-Regional Maize Outputs under B2 Scenario

Region	Base year	Forecasts (2020s)		Forecasts (2040s)	
		Outputs (million ton)	Change (%)	Outputs (million ton)	Change (%)
North-East	35.14	35.71	1.63	33.22	-5.46
North	42.72	39.01	-8.70	35.99	-15.77
Central-North	8.45	8.84	4.60	8.83	4.46
Central	13.27	12.40	-6.57	14.01	5.55
South	7.21	6.82	-5.40	8.33	15.44
South-West	11.40	11.08	-2.85	10.96	-3.84
Xinjiang	3.91	3.70	-5.36	3.65	-6.64
Qing-Tibet	0	0	0	0	0
National	**122.11**	**117.56**	**-3.73**	**114.98**	**-5.84**

Results projected by the Institute of Environment and Rural Development, Chinese Academy of Agricultural Sciences

Step Two: using the Chinese Maize Spatial Equilibrium Model (CMSPM) to simulate the effects of the changes in outputs of maize on the equilibrium quantity and price of China's maize market under the B2 climate scenario, assuming zero population growth.

Third step: under the B2 scenario, to simulate the effects of the climate change as well as population growth (as shown in Table 2) on the equilibrium quantity and price of China's maize market.

Table 2
Prejection of National Population under B2 Scenario

Base year (2005)	Forecasts (2020s)		Forecasts (2040s)	
Population (million)	Population (million)	Change (%)	Population (million)	Change (%)
1,307.56	1,431.05	9.44	1,499.55	14.68

Results projected by the Institute of Environment and Rural Development, Chinese Academy of Agricultural Sciences

Step Four: To compare the impacts of climate change on food security in different periods and to analyse on the social-economic effectiveness of different adaptation measures concerning climate change.

3. Simulation and Analysis

The simulation results derived from the CMSEM show that: the overall impacts of climate change on maize production is negative. Although maize production in some regions will increase under the climate change, maize production in most of the other regions will reduce.

3.1 The Overall Impacts

First, to assume that for the moment, we only consider the impacts of climate changes on the domestic supply of maize, especially the equilibrium quantity and price, but not concern with the growth of population and food grain consumption.

Table 3
Impacts of Climate Change on the Maize Market in China

Year	Equilibrium Quantity		Equilibrium Price	
	Quantity (million tons)	Change (%)	Price (yuan /kg)	Change (%)
Baseline	139.90		1.31	
2020s	137.58	-1.66	1.48	12.98
2040s	134.83	-3.62	1.71	30.53

Model simulation results

From the simulation results (as shown in Table 3) shows that maize production because of climate change to drop, will greatly enhance the price of corn.The base period, 2020s China's corn production cuts due to climate change, 1.66%, resulting in market prices 12.98%; 2040s continue to cut our corn nearly two percentage points to

3.62%, corn prices reached 30.53 percent.

Next, we introduce the changes in population, natural increase of population led to increased demand for corn, and corn supply and demand balance in China impact.In theory, without taking into account inflation, food imports and other factors, circumstances, 2020s caused by climate change and changes in corn production due to natural population growth due to increased consumption of corn, the performance of the combined effect of the number of domestic corn market equilibriumincreased 1.27% over the same period China's corn price will increase to 2.33 yuan / kg, or 78.02 percent; to the 2040s, as population growth led to a further increase in demand, corn prices will reach 3.43 yuan / kg, compared with the base period, or up to162.48% (as shown in Table 4), mainly due to the existence of large domestic maize market supply and demand gap.

Table 4
Impacts of Climate Change and Population Growth on China's Maize Market

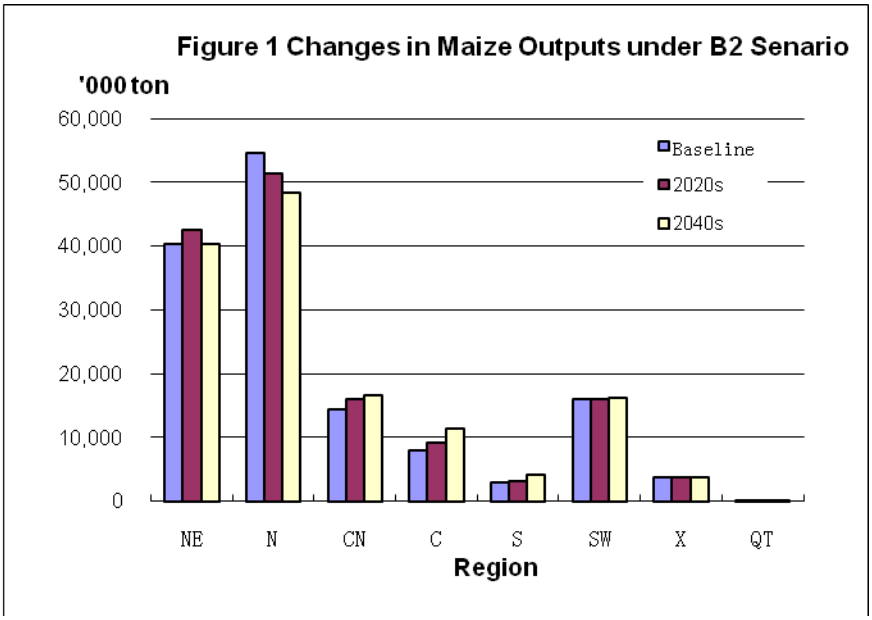
Year	Equilibrium Quantity		Equilibrium Price	
	Quantity (million tons)	Change (%)	Price (yuan /kg)	Change (%)
Baseline	139.90		1.31	
2020s	141.68	1.27	2.33	78.02
2040s	140.89	0.71	3.43	162.48

Model simulation results

Above results show two things: first, our long-term price of corn will rise; second, if no great technological progress, China will need high levels of external 进口 corn in order to make up of supply.

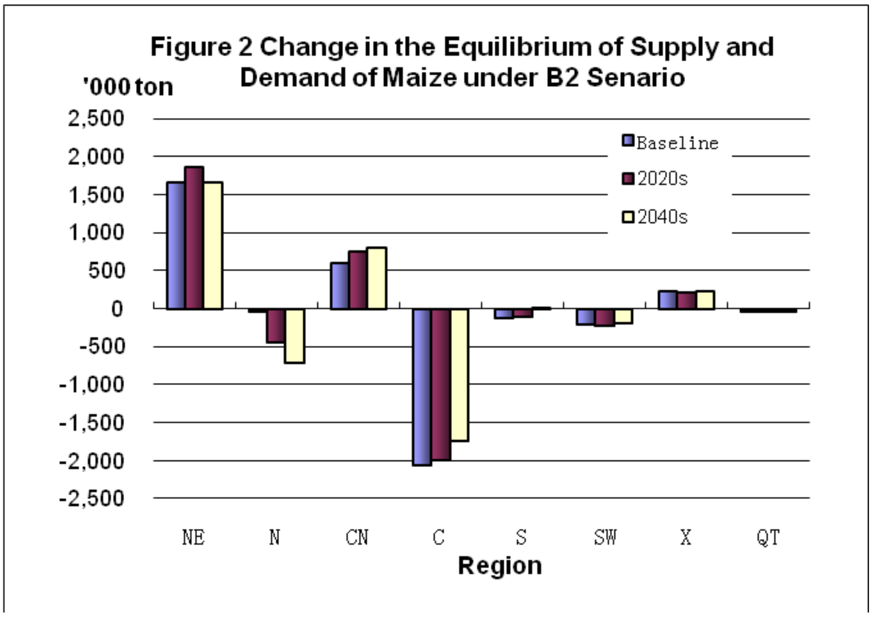
3.2 in different regions of

Regions due to different natural conditions and geographical location, the extent of climate change impacts will vary.



Model simulation results

As can be seen from Figure 1, north, northeast, north and southwest China in the major maize growing areas, its output accounts for 90% of the total maize production over.However, from the corn supply and demand balance each region, northeast and in northern areas of corn production in addition to meeting the region's consumption, it also can make up for deficiencies in other regions; and Central China, North China's corn supply and demand gap is larger (as shown in Figure 2).



Model simulation results

The changes in regional demand and supply and liquidity, will directly affect the size of the domestic corn market and the price level.Here we take a look at how climate change and population growth affect the various regions of maize in the region and interregional circulation.

Table 5

Changes on Inter-Regional Flows of Maize in 2020s (1,000 tons)

Flow In / Flow our	North-East	North	Central-North	Central	South	South-West	Xinjiang	Qing-Tibet	**Total**
North-East	213	1,912		217	-114				**2,228**
North		-1,570		-1,656					**-3,226**
Central-North		369	83			1,104			**1,556**
Central				1,093					**1,093**
South					172				**172**
South-West				-468		443			**-26**
Xinjiang				1,223		-1,289	8	8	**-51**
Qing-Tibet								-1	**-1**
Total	**213**	**711**	**83**	**408**	**58**	**258**	**8**	**7**	**1,745**

Model simulation results

Under B2 scenario, in 2020 the area northeast flow and supply of maize in North China, Central China has increased the number, but the supply reduction in the number of southern China; North China Mobile and supply of maize in the region the number of central China were reduced by 1.57 milliontons and 1.656 million tons; in the north flow and supply of maize in the region of North China, Southwest China have increased in number (as shown in Table 5).

Table 6

Changes on Inter-Regional Flows of Maize in 2040s (1,000 tons)

Flow In / Flow our	North-East	North	Central-North	Central	South	South-West	Xinjiang	Qing-Tibet	**Total**
North-East	41	2,129		-916	-1,114				**141**
North		-2,249		-3,926					**-6,175**
Central-North		522	27	440		1,059			**2,048**
Central				3,409					**3,409**
South					1,159	120			**1,278**
South-West				-355		616			**261**
Xinjiang				1,618		-1,620	-6	5	**-3**
Qing-Tibet									**0**
Total	**41**	**402**	**27**	**270**	**45**	**175**	**-6**	**5**	**959**

Model simulation results

By 2040, the trend has been expanding: region in Northeast China Mobile and supply of corn in North China the number is still increased, but the supply of central and southern China to reduce the number and distribution of maize in the region in 2040 from 2020 incrementalof 2.228 million tons down to 141,000 tons; North China Mobile and supply of maize in the region the number of central China continue to decline sharply (compared with the base period, circulation of corn in North China in 2020 dropped 3.226 million tons, down by 2040 circulation reached6.175 million tons); in North flow and supply of maize in the region of North China, Southwest China to maintain a small amount of growth momentum; It is worth noting: maize area in central China at this time greatly increased flow of incremental, from 109.3 in 2020tons, expanding to 2040 3.409 million tons (as shown in Table 6).

4.Conclusions and recommendations

4.1 Conclusion

In this paper, a spatial equilibrium model and database to simulate the B2 climate change scenarios, changes in corn production on the domestic corn market supply and demand and prices.Simulation results show that:

(1) the impact of climate change, 2020s and 2040s China's corn production (without regard to population growth factor) decreased; if the population growth factor into account, the output was first increased, then a downward trend;

(2) assumes that, without considering inflation, food imports and other factors the case, due to production decline, China's corn market prices ranges from 12-30%; the introduction of the population growth factor, corn prices will reach the market78-162%;

(3) in the B2 climate change scenarios, maize production in Northeast China was the first increase and then decline; in the North region continued to grow maize, the corn can supply other regions increase in the number; decreased corn yield in North China, the Districtbasic balance of demand and supply situation will be broken, the future needs of a large number of purchases from other areas into corn to meet growing demand; the increase in corn production in central China, to supply and demand gap narrowing.

4.2 recommended

The above analysis showed that: in the B2 climate scenarios, the country two corn-producing areas in Northeast and North China, by air temperature and precipitation to reduce the impact of a downward trend in maize production, for which we propose:

(1) targeted in these two regions to strengthen agricultural infrastructure, the development of dryland agriculture and new technologies, strengthen the unified management of water resources, improve water use efficiency, climate change caused by pests and diseases control;

(2) In addition to these adaptive measures to mitigate climate change on food production and food security, but also should strengthen the economic evaluation of various adaptation measures, to prevent regardless of cost, do not speak the blind

development effectiveness;

(3) appropriate adjustment of crop planting structure and rational distribution of land and water and other scarce resources, give full play to regional advantages;
(4) to ensure national food self-sufficiency where, on the productivity and resource utilization efficiency of the product Shixingbufen Jiaodi import, to the natural growth and income Huanjierenkou highly improve the constantly Extended Consumption Demand Yali, stabilize market prices.

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