

中国粮食生产 适应气候变化政策研究

黄德林 覃志豪 罗其友 著

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本书源于国家重点基础研究发展计划（“973”计划）“气候变化对我国粮食生产系统的影响机理及适应机制研究”（SQ2010CB553502项目，首席科学家唐华俊）。该项目共分为四项研究课题，本书为第四项研究“气候变化驱动的我国粮食生产系统空间数值模拟预测研究”（2010CB951504，课题负责人覃志豪）的子课题——中国粮食生产适应气候变化政策研究（2010CB951504-5，子课题负责人黄德林）的成果。本子课题研究成员有李喜明、李新兴、蔡松锋、李向阳、鞠劭芃。

前 言

“973”计划全球变化研究——“气候变化对我国粮食生产系统的影响机理及适应机制研究”针对指南中的第15重点支持方向：气候变化对粮食、社会经济、人口健康影响与适应机制研究。将面向4个国家重大需求：粮食生产稳定发展、国家粮食安全、粮食主产区农村社会经济发展和农民收入增长、国际气候谈判与责任。研究气候变化对我国粮食生产的影响过程，摸清气候变化对我国粮食安全的影响程度和适应能力，不仅是国家制定应对气候变化政策和行动、保持我国粮食生产持续稳定发展、保障国家粮食安全、促使粮食主产区农村社会经济发展和农民收入增长的迫切需要，同时也是我国参与国际气候谈判和履行国际职责的需要，对全球气候变化农业领域和众多相关学科理论方法发展也有重要贡献和支撑作用。

首先，项目拟解决的关键科学问题是，气候变化对我国粮食生产系统的影响机理与适应机制，主要包括：①气候变化导致的粮食生产资源要素（水、土、气、品种等）变化规律；②气候变化对我国粮食种植制度、生产结构和区域布局的影响过程及其适应机制；③气候变化介导的农业灾变规律。

其次，项目主要研究内容包括：①气候变化对我国粮食生产水土气资源要素时空变化的作用过程；②气候变化诱发的粮食作物品种、基因资源抗逆性和生长发育特征变化及其对品种改良的影响；③气候变化对我国粮食作物种植制度与区域布局的影响机理与适应机制；④气候变化背景下粮食主产区主要病虫害时空格局消长动态和大规模流行暴发生态学机理；⑤气候变化条件下农业旱涝等气象灾害的时空格局演化规律；⑥气候变化对我国粮食产量、国家粮食安全、粮食区域平衡、粮食主产区农村经济发展和农民收入增长的影响程度，应对气候变化的政策和技术体系。课题“中国粮食生产适应气候变化政策研究”服务于项目主要研究的第六项研究任务。

项目研究的前五项内容属于自然科学研究的范畴。第六项属于农业经济学研

究的范畴。毋庸置疑,做好项目研究的方法论至关重要。属于农业经济学研究范畴的气候变化对我国粮食产量、国家粮食安全、粮食区域平衡、粮食主产区农村经济发展和农民收入增长的影响程度,应对气候变化的政策和技术体系采用什么样的研究方法具有挑战性。

根据均衡理论建立的可计算一般均衡模型可以在微观和宏观两个层面对课题进行研究。可计算一般均衡模型通过生产者理论、需求理论、价格理论和市场出清理论,刻画社会经济各部门特别是农业粮食生产部门针对气候变化所产生的产量、耕地面积、价格、技术变化的影响进而对整个社会经济各部门和宏观经济产生影响。在宏观经济和部门经济上,有 GDP、就业、CPI、出口、进口、价格、消费、生产要素(土地、资本、劳动力)、技术进步、部门产出、部门价格、部门进出口、部门家庭消费、部门中间消费、部门政府消费、部门就业、部门技术进步等指标。这些指标足以刻画气候变化条件下的国家粮食安全、粮食区域平衡、粮食主产区农村经济发展和农民收入增长的影响程度,应对气候变化的政策和技术体系。

均衡模型分析难点和重点在于如何构建气候变化对粮食生产部门的影响程度。国际上,把 GCM(大气环流)影响因子嵌入作物和畜牧业生产和水资源模型,进而产生水资源利用、作物生产、畜牧业生产的成本与收益,由此构建一般均衡模型的社会矩阵数据库,进而进行气候变化的影响和适应性政策分析,是理想的综合分析模型。实际上,本研究沿用了课题组嵌入 RCM(区域大气环流)气候变化因素到作物模型(CERES-小麦、玉米、水稻),考虑和不考虑 CO₂ 肥效和 A2、B2 两种气候模式的研究成果。

本研究成果分为四大部分八个章节。四大部分内容分别是关键科学问题、解决关键科学问题的技术途径、适应气候变化的我国粮食生产政策与战略研究以及粮食生产适应气候变化的经济对策研究。

第一部分关键科学问题由第一章绪论组成。主要阐述了项目研究的目的意义、立项依据和国内外综述,研究方法与研究创新。

第二部分解决关键科学问题的技术途径主要由第二章一般均衡、局部均衡理论与模型组成。课题组构建的可计算一般均衡动态模型由生产函数(投入与产出水平、产出水平与产出)、生产中投入需求与产品供给;成本最小化问题与收入最大化问题(生产中对投入需求;成本最小化问题、产品供给;收入最大化问题)、固定资本生产中对投入需求、家庭需求、产品的出口需求、政府需求、对

流通品需求、价格系统、产业间投资分配、市场出清方程、总进口、总出口及贸易平衡、宏观指数和工资指数；动态机制（有形资本积累、外资÷外债积累、工资滞后调整）。数据库为基于 2007 年中国统计局发表的投入产出表构建。

可计算区域一般均衡模型分为静态与动态两种，静态区域模型结构为国产和进口商品之间的用户的选择、劳动力需求、初级要素需求、对中间投入组合和基本要素组合需求、生产税、产出矩阵、家庭需求、投资需求和投资品价格指数、政府需求、区域需求、各部门投资需求、动态机制包括生产模块、资本形成模块、消费模块、公共（政府）需求模块、价格模块、流通服务及成本计算方程、商品税、区域动态模型的供需平衡模块、区域动态模型的动态机制模块。区域静态和动态模型的数据库均基于 2007 年中国统计局发表的国家 and 31 个省、市、自治区投入产出表构建。

局部均衡（CAPSIM）模型是中国农业政策研究中心构建的农业局部均衡模型，本研究采用该模型进行适应气候变化的粮食供需平衡研究。

全球贸易一般均衡（GTAP）模型在原理上同属一般均衡理论，在区域上有 113 个国家和 55 个部门。该模型由美国普渡大学开发。本研究借鉴该模型进行针对适应气候变化的我国粮食国际贸易政策研究。

第三部分适应气候变化的我国粮食生产政策与战略研究由第三章气候变化条件下我国粮食生产发展战略（气候变化条件下我国粮食生产发展战略、气候变化条件下我国小麦生产发展战略、气候变化条件下我国玉米生产发展战略、气候变化条件下我国水稻生产发展战略）、第四章气候变化条件下我国粮食生产区域发展战略（气候变化条件下我国粮食生产区域发展战略、气候变化条件下我国小麦生产区域发展战略、气候变化条件下我国玉米生产区域发展战略、气候变化条件下我国水稻生产区域发展战略）、第五章气候变化条件下我国粮食生产耕地、价格、补贴与技术进步政策组成。气候变化条件下我国粮食生产发展战略是在国家水平一般均衡理论上，利用气候变化对粮食作物单产影响成为作为冲击变量，而获得模型对粮食部门影响的模拟结果和宏观经济影响结果，从而提出国家水平的气候变化条件下我国粮食生产发展战略（总体和分品种）。气候变化条件下我国粮食生产区域发展战略是在区域（31 个省、市、自治区）一般均衡理论上，构建多区域一般均衡模型，利用气候变化对粮食作物单产影响作为模型冲击变量，获得的对粮食部门影响结果和宏观经济影响结果，从而提出区域水平的气候变化条件下我国粮食生产发展战略（总体、分品种）。气候变化条件下我国粮食生产

耕地、价格、补贴与技术进步政策研究基于国家水平一般均衡理论,设定应对气候变化的粮食作物耕地、价格、补贴、技术进步变化为冲击变量,从而获得国家水平上的候变化条件下我国粮食生产耕地、价格、补贴与技术进步政策研究结果。

第四部分粮食生产适应气候变化的经济对策研究由第六章适应气候变化的我国粮食生产供给能力研究(适应气候变化的我国粮食生产供给能力研究、适应气候变化的我国区域粮食生产供给能力研究)、第七章适应气候变化的粮食需求与消费政策研究(适应气候变化的粮食供需平衡、适应气候变化的区域粮食需求与消费政策、适应气候变化的小麦需求与消费研究、适应气候变化的玉米需求与消费研究、适应气候变化的水稻需求与消费研究)和第八章适应气候变化的我国粮食国际贸易政策研究组成。

适应气候变化的我国粮食生产供给能力研究分为适应气候变化的我国粮食生产供给能力研究和适应气候变化的我国区域粮食生产供给能力研究。利用国家水平的动态一般均衡和区域一般均衡模型(静态、动态),分析了考虑 CO_2 肥效和不考虑 CO_2 肥效,两种气候条件下粮食生产供给能力研究。适应气候变化的粮食需求与消费政策研究分为适应气候变化的粮食供需平衡和适应气候变化的区域粮食需求与消费政策。前者是利用农业局部均衡模型研究我国粮食供需平衡。后者是利用区域模型分析的结果,还原成区域粮食产量,研究区域粮食供需平衡。适应气候变化的我国粮食国际贸易政策研究利用全球贸易模型分析了适应气候变化的我国粮食国际贸易政策。

作 者

2014 年 10 月

PREFACE

“Climate Change’s Impact on China’s Grain Food Production System and Adaptation Mechanisms (2010CB951504).” Which is the National Key Research Initiatives (Project 973) project, Global Change Research, point to the Key support direction of Article 15 in Guide; impacts and adaptation mechanisms Studies of climate change on food, socio-economic and population health. Will satisfied 4 National needs: Stable development of grain production, National food security, Social and economic development in rural areas and farmers’ income Growth in Major grain producing areas, International climate negotiations and responsibility. To research the Impact process of Climate change on China’s grain production, To find out The impact of climate change on food security in China and adaptability, not only is the Urgent need of national policy and action on climate change, Maintain sustained and stable development of China’s grain production.

Ensure national food security, promote social and economic development and growth in rural incomes of farmers in major grain producing areas. But also the need of China’s participation in international climate negotiations and to cover the line of international responsibility play an important contribution and support role in Agricultural sector of global climate change, and development of many related disciplines theory and Method.

Project intends to solve key scientific problems include the impact and adaptation mechanisms of climate change on food production systems, which is the variation of climate change leads to food production resource elements (water, earth, air, species, etc.). the impact process and the adaptive mechanisms of food cropping systems, the production structure and regional distribution under the climate change. The regulation of Agricultural disaster mediated by climate change.

The main contents include: ① The role of the process of the temporal changes of

China's grain production of water, soil, air resource elements. ② Crop varieties, resistance of gene resources, changes in growth and development characteristics and its impact on the breed improvement induced by climate change. ③ The impact mechanism and adaptation mechanisms of climate change on crop planting system and regional distribution. ④ Dynamics variation of spatial and temporal pattern of major pests and Ecology mechanism of Pandemic outbreak under climate change in major grain producing areas. ⑤ Evolution regulation of Spatial and temporal pattern of Agricultural drought and other weather disasters under climate change conditions. ⑥ The degree of influence of climate change on China's grain production, national food security, regional balance of grain, rural economic development and farmers' income growth in major grain producing areas, Policy and technology system adaptation to Climate Change.

Services for task of The sixth major research project of Project "Policy Research of China's grain production to adapt to climate change". The previous five content of Research project belong to Natural science research areas.

The Sixth belong to Category Study of Agricultural Economics. Needless to say, Project methodology is essential for research. What kind of method adopted to conduct the research is a challenge.

Computable general equilibrium model established according to equilibrium theory can study the subject at the micro and macro levels. by producer theory, theory of demand, price theory and market clearing theory, Computable general equilibrium model can simulate the impact of climate change on Socio-economic sectors Particularly Yield, arable land, price, technical changes of agricultural food production sector. On the macroeconomic and sectoral economic, there are Indicators. of GDP, employment, CPI, exports, imports, prices, consumption, production factors (land, capital, labor), technological progress, sector output, the price department, import and export department, department of household consumption, middle sector consumption, government consumption sector, sector employment, technical progress, etc. These indicators enough to portray the national food security under climate change, the food regional balance, Economic development and the impact of rural farmers' income growth in major grain producing areas, response to Climate change policy and technology system.

The difficulties and focus of Equilibrium Model Analysis is how to build the impact of climate change on food production sector. Internationally, the ideal model for a comprehensive analysis is that embedded the impact factor of The GCM (General Circulation) to crop and livestock production and water models to get input and output of water resources utilization, crop production, livestock production to establish database of social accounting matrix of general equilibrium model to analysis the impacts and adaptation policy to climate change. In fact, this study follows the Research results of Project Group, which Embed climate change Factor of RCM (regional atmospheric circulation) into the crop model (CERES- wheat, corn, rice), With and without CO₂ fertilization and A2, B2 in two different climate models.

The research is divided into four parts, eight chapters. four parts contain the key scientific issues, Key scientific approach to solve the technical problems, Adaptation to climate change policies and strategies of China's grain production research, Economic Research Strategies to adapt to climate change and food production. The first part of the key scientific questions composed by the first chapter. Expounds the purpose and significance of the research project, Summary of the project on the basis of domestic and foreign, research methods and research innovation.

The second part of the technical approach to solve the key problems primarily Composed by the second chapter of general equilibrium, partial equilibrium theory and model. Dynamic computable general equilibrium model established by the research group contain construction Production function (input and output level, output level and output), Investment demand and product supply in production, cost minimization problem and income maximization problem (Investment demand; cost minimization problem, product supply, revenue maximization problem in production).

Demand for investment, household demand, export demand for the product, the government needs, demand on the circulation of goods, price system, inter-industry investment allocation, market clearing equation, total imports, total exports and trade balance, macroeconomic and wage index; dynamic mechanism (physical capital accumulation \div foreign debt accumulation, wages lag adjustment). Database established based on input-output table of 2007, published by China Statistics bureau.

Regional computable general equilibrium model is divided into static and dynamic

model. Static region model is composed by the user's choice between domestic and imported goods, the demand for labor, the primary elements of the demand for intermediate inputs combinations and combinations of the basic elements of demand, production taxes, output matrix, household demand, investment demand and investment goods price index, government demand, regional demand, Investment demand sectors. Dynamic mechanisms include the production module, the module capital formation, consumption module, public (government) demand module, module prices, distribution services and costing equation, commodity tax, supply and demand balance module of regional dynamic model, dynamic mechanism module of Regional dynamic model. All database of regional static and dynamic model based on the input-output tables of 31 provinces and autonomous regions published by China's National Bureau of Statistics.

Partial equilibrium (CAPSIM) model is a partial equilibrium model of agriculture, established by China Agricultural Policy Research Center. Using this model, we analysis the balance of food supply and demand under the climate change condition.

Global Trade Analysis Project GTAP in principle belong to general equilibrium theory, there are 113 countries and 55 sectors. The model was developed by Purdue University. we used it to simulate International Food Trade Policy adaptation to climate change for China.

The third part of national food production policies and strategies to adapt to climate change contain Chapter III China's grain production development strategy under climate change (under climate change, China's grain production development strategy; under climate change, China's wheat production development strategy; Under climate change, China's corn production development strategy; Under climate change, China's rice production development strategy).

Chapter IV, Regional Development Strategy of China's grain production Under climate change (under climate change China's grain production area development strategy, under climate change development strategy of China's wheat production areas, under climate change China's corn production regional development strategy, under climate change regional development strategy of China's rice production).

Chapter V, under climate change, policies of China's grain production and arable land, prices, subsidies and technical progress.

Under climate change China's grain production development strategy is analyzed by using the impact of climate change on crop yields as the impact of variables to simulate the impact of climate change on the food sector, macroeconomic. the development strategy of China's grain production (total and sub-species) can be made.

Based on multi-regional (31 provinces and autonomous regions) general equilibrium theory, multi-regional general equilibrium model is constructed. Under climate change regional development strategy of China's grain production is analyzed by using the impact of climate change on crop yields as the impact of variables to simulate the impact of climate change on regional food sector, macroeconomic.

The development strategy of China's regional grain production (total and sub-species) is made. Under climate change policy research on China's grain production, arable land, prices, subsidies and technical progress is analyzed by using the impact of climate change on crop yields as the impact of variables to simulate the impact of climate change on China's grain production, arable land, prices, subsidies and technical progress.

Part IV, economic research strategies of food production to adapt to climate change. Chapter VI, contain production and supply capacity of China's grain to adapt to climate change (adapt to climate change of China's grain production and supply capacity, (Adapt to climate change of China's grain production and supply capacity. The study, adaptation to climate change of research on the supply capacity of grain production). Chapter VII, policy research of adaptation to climate change of Food demand and consumption (adapt to climate change of food supply and demand balance, adaptation to climate change policy of regional demand for food and consumer, adaptation to climate change policy of regional wheat demand and consumption, adaptation to climate change of regional Corn demand and consumption, adaptation to climate change of regional demand and consumption of rice). Chapter VIII, chinese food trade policy research on adaptation to climate change in International Market (The research on China's grain production and supply capacity to adapt to climate change contain adaptation to climate change of China's grain production and supply capacity, Adaptation to climate change of regional food production and supply capacity)

Adopt dynamic general equilibrium at national level and multi-regional general equilibrium model (statistic and dynamic), food production and supply capacity is sim-

ulated with the consideration of CO_2 fertilization and no consideration of CO_2 fertilization under both climatic conditions. Policy Research of food demand and consumption to adaptation to climate change contain research of food supply and demand balance to adaptation to climate change, regional food demand and consumption policies. research to adaptation to climate change, the former simulation is conducted by agricultural partial equilibrium model. The latter is simulated by multi-regional general equilibrium model, reduct the result into yields of grain, the regional food supply and demand balance . is analyzed. Research on China International Food Trade Policy to adaptation to climate change is simulated by global trade projected model (GTAP).

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后记

第一部分 关键科学问题

第一章

绪 论

1.1 立题依据

1.1.1 目的和意义

1.1.1.1 目的 气候变化将通过各种途径直接影响我国粮食生产,其中,气候变暖导致我国部分地区的农作物产量下降,但气温升高特别是冬季气温升高,将有利于冬季作物的越冬、分蘖,使冬种面积扩大,产量增加。在此情况下,将使小麦、玉米生产潜力分别提高20%和5%。水稻的气候生产潜力,将由于温度升高使呼吸消耗加快、光合作用减弱,生育期缩短而有所降低。初步研究表明,如果不采取任何措施,到2030年我国种植业生产能力在总体上可能会下降5%~10%。到21世纪后半期,我国主要农作物如小麦、水稻和玉米的产量可能会下降更多。今后20~50年我国粮食生产将受到气候变化的严重冲击,气候变化将严重影响我国长期的粮食安全。

从农业生产能力的角度考虑,气候变化引起粮食作物生产的资源、品种、热量、水分等生产要素的变化,导致粮食产量变化,影响粮食安全。在这种条件下,粮食生产适应气候变化的策略与措施主要包括资源战略、极端气候应对战略、区域布局战略的变化。

从农业生产的经济学角度考虑,气候变化主要导致了粮食作物供给与需求的变化。气候变化导致的粮食作物供给变化主要体现在土地、资本(投资)、劳动力、基本要素的变化。气候变化导致的粮食作物需求变化主要体现在粮食作物价