Shiwei Xu *Editor*

Proceedings of 2013 World Agricultural Outlook Conference

Springer

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Beijing, China

ISBN 978-3-642-54388-3 ISBN 978-3-642-54389-0 (eBook)
DOI 10.1007/978-3-642-54389-0
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2014939310

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

2013 World Agricultural Outlook Conference Overview

It has always been the major concern in the world to safeguard food security and to ensure the sufficient supply of agricultural products, which is also the corner stone for the world and regional stable economic growth. Taking into consideration global agricultural development trends, agricultural production will enter into a new stage featured with high cost, high risk and much more strict resource and environment constraints in the future, which will further increase uncertainties of agricultural development. In response to the daunting task of enhancing world food security, it is imperative to make projection and analysis of the future agricultural production and market trend, to facilitate in-depth communication and knowledge sharing, to formulate policy options on the agricultural development, and ultimately to promote the predictability and management competence over agricultural market.

"2013 World Agricultural Outlook Conference (WAOC)" supported by Ministry of Agriculture of the People's Republic of China, co-organized by United Nations Food Agriculture Organization (FAO) and Organization for Economic Co-operation and Development (OECD), was hosted by Agricultural Information Institute (AII) of Chinese Academy of Agricultural Sciences (CAAS), such as FAO, OECD and IFPRI. Other countries participated in the conference.

WAOC held on June 6–7, 2013, at Beijing Friendship Hotel, discussed current situation and future challenges facing agricultural development in the next decade. Conference contents were as following:

1. **Opening Ceremony and Press Release:** FAO/OECD presentation on 2013 World Outlook (summary), AII presentation on 2013 China Outlook (summary)
2. **Key Policy Challenges for the Next 10 Years and Approaches:** keynote speeches by FAO, OECD, IFPRI, USDA, CAAS, etc.
3. **Global and China Commodity Outlook:** grains, oilseeds, biofuel, cotton, sugar, livestock, and dairy, by specialists from international organizations and national institutes

4. **Scenario Analysis on Macro-economy and Hot Topics on Food Projection:** agricultural early-warning and monitoring system, resource constraints, climate changes, biofuel, population growth and change, by specialists from different regions.

Beijing, People's Republic of China Shiwei Xu

Contents

Chapter 1
Construction of China Agriculture Monitoring and Early-Warning System (CAMES)

Shi-wei Xu

Abstract The prices of agricultural products fluctuated extraordinary in recent years. To understand the agricultural price changes in domestic and abroad markets and quantitative judge their future trends, it is very imperative to establish China Agriculture Monitoring and Early-warning System (CAMES). According to the characteristics of China's agricultural market, such as production, consumption, price and etc, this paper proposes the construction of China Agriculture Monitoring and Early-warning System, which integrates short-, medium- and long-term forecast and early-warning, including its theoretical basis, characteristics, functions and framework. This system is a scientific tool which will improve the monitoring and early-warning work for China's agricultural products.

Keywords Agricultural products • Monitoring • Early warning • China Agriculture Monitoring and Early-warning System

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This work is supported by Key Project of National Key Technology R&D Program (Project No.2012BAH20B04).

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_1, © Springer-Verlag Berlin Heidelberg 2014

1.1 Introduction

Agricultural market monitoring and early warning is mainly through monitoring and analyzing agricultural production, demand, inventory, import and export, market prices, and achieves early warning and forecast, and provides scientific decision references for government, producers and operators (Mao 2010). In recent years, China's agricultural market has changed a lot, the market prices of fresh agricultural products fluctuate volatility, which attracted the attentions of the government, producers, operators, consumers. Agricultural market monitoring and early warning has become one of government's important works. Chinese government explicitly proposed to strengthen the work of agricultural market monitoring and information services in 2010. The government emphasized further to strengthen the domestic and broad agricultural market monitoring and early warning to stabilize domestic agricultural market in 2012. Therefore, to understand and grasp the development and changes in domestic and international agricultural products markets, and judge its future trends accurately, it is imperative to establish China Agriculture Monitoring and Early-warning System.

1.1.1 The Necessity of the Establishment of China Agriculture Monitoring and Early-Warning System (CAMES)

1. As one of the major agricultural producing countries in the world, the strengthen of China agricultural market monitoring is not only for China's food security management, but also for the world of food security.

   In recent years, with the steadily growth of China's agricultural productions, China has become the largest producer in the world of major agricultural products. China's productions of grain, cotton, meat, vegetables and other major agricultural production ranked the first in the world, and all of them accounted for more than one of fifth of world total production. China's total grain output was 589.57 million tons in 2012, which accounted for 23.6 % of the world total production; meat output was 83.84 million tons and accounted for 27.9 % of the total production in the world. Vegetable production was 677 million tons and accounted for 65.3 % of the total production in the world. With the economic development and population growth, Chinese demand for agricultural products is also showing upward, which leads to the gap of the supply and demand expanding continuously. The net imports of rice, wheat, and corn were 2.09 million tons, 3.42 million tons and 4.95 million tons, respectively, and the import of soybean reached 58.38 million ton in 2012. With the increasing imports, China plays an important role in the international market. The changes of both China's agricultural production and demand have important impacts on world agricultural market. Therefore, it is very important to monitoring China major agricultural market. It not only satisfies the demand of Chinese food security management, but also contributes to the world food security.

2. Considering the conflicts of China's small-scale production and big market, it is imperative to establish CAMES which reflects China's production and consumption pattern.

   Compared with other countries, China's agricultural production is dominated by smallholders (States and Organizations Concerned to Carry out Agricultural Work Experience and Enlightenment Outlook, 2011). China has 250 million farmers with the average of 0.49 ha of arable land, which is only 37 % of the world average level. Only 16.4 % of the farmers have joined the farmers' professional cooperative organizations. The conflicts of small-scale production and big market are very obvious. Thousands of small householders are difficult to adapt the ever-changing big market. The lag market information and asymmetry information transmission result in the frequent volatility of the market price with the undersupply at some time or oversupply of agricultural products at some other time. Therefore, it is necessary to establish China Agriculture Monitoring and Early-warning System. At present, the developed countries have gained some achievements of the methods and systems regarding to agricultural market monitoring and early warning, monitoring and early warning models have been applied widely. In China, most popular models are mainly on the national level, while there are very few regional and county level or household level models. Considering Chinese special circumstances of thousands of scattered operating independently smallholders, CAMES should be developed which reflect Chinese agricultural production and consumption patterns.

3. China is a country that is prone to natural disasters. The establishment of China Agriculture Monitoring and Early-warning System should be based on the mechanism of agricultural output growth.

   China has a typical monsoon climate, frequent climate changes and many disasters. All these caused agricultural production serious losses (Xu et al. 2011). According to the statistics, the average annual grain loss was more than 50 million ton, which equivalents to 1/10 of the annual output. Although in recent years, China's agricultural comprehensive production capacity has been strengthen, natural disasters are always an important factor which affects agricultural production, and on the whole, the agricultural production loss continues to showing upward. With global climate change, China's agricultural production affected by meteorological disasters will become prominent, future agricultural crop production forecast should consider the impacts of meteorological factors on agricultural production according to the crop or animal growth mechanism. At present, domestic and international early-warning models are based on only economic theory. Most of these models are equilibrium model according the "market-clearing mechanism". Meteorological disaster monitoring should be emphasized, and the agricultural market monitoring and warning system should take into account the growth mechanism.

4. The agricultural products affect each other for their apparent consumption substitutions. Therefore, agricultural market monitoring and warning system should build the multi linkages among agricultural products.

With the development of modern technology, the substitute consumption relationships among agricultural products have increased obviously (Xu et al. 2012). The interactions among agricultural products that are due to the changes of supply and demand are strengthening. The prices of wheat and corn were significant “upside down”. Wheat instead of corn that was used as feed has kept increasing since 2010. In 2012, the substitution of wheat to core recorded the highest level with more than 24 million tons used as feed. The corn distillers grains (DDGS) also increased rapidly to 2.38 million tons, which equivalent to import 70 million tons of maize. As technology continues to progress, the future consumption substitution relationships among agricultural products will become more obvious. Agricultural trade will also be more active. The interaction substitution impacts among the agricultural products will become increased, particularly the impacts of the supply and demand substitution of wheat, corn, soybean, rapeseed and other oil will be higher. Therefore, agricultural market monitoring and warning system should include multiple linkages among agricultural products.

1.2 Objective and Function of CAMES Model

Recently, Agriculture Information Institute of CAAS organized a number of national and international experts in economy, agriculture, aerography and computer to research and develop China Agriculture Monitoring and Early-warning System (CAMES). After several months of hard work, the CAMES overall framework has already been formulated. CAMES fuses biological mechanism and economic mechanism together, creates tens of thousands of equations, and has shaped into an integrated China Agriculture Monitoring and Early-warning System which covers multi-variety, multi-market and multi-area, including 11 kinds and 953 species such as grain, oil plants, sugar crops, vegetables, fruits, meat, eggs, dairy products, aquatic products, cotton and hemp. Its foundation is not only a technology innovation, but also fills the blank of agricultural product market analysis and application in some extend.

1.2.1 Objective of CAMES Model System

The Objective of building CAMES is to create an integrated agricultural multi-market, multi-product, multi-area, and multi-function Monitoring and Early Warning System, and to develop an integrated modeling system, incorporating mechanism model of crop cultivation, livestock breeding, aquaculture breeding, with the statistical models of material, technical, and human resource inputs (http://www.ifpri.org/book-751/ourwork/program/impact-model). Through real-time monitoring and analyzing all kinds of variables, dynamic monitoring, evaluating, simulating, prospecting and early-warning about agricultural products’ production, consumption and price, timely delivering monitoring and early-warning information, it can become a powerful monitoring and analyzing tool providing slow fluctuations and risk aversion to agricultural product market. Each model objective is described as follows:

(a) To monitor and provide early warning for agricultural products, comprehensively covering main varieties and product types in China's agricultural market.
(b) To generate all-weather and real-time monitoring, analysis, and to disseminate agricultural products information.
(c) To analyze and provide early warning for different products and diverse areas.
(d) To accomplish simulation and digitalization through analysis mechanism and analysis process.
(e) To predict accurately future trends on production, consumption and price of agricultural products, and directly serving government regulatory agencies.

1.2.2 Functions of CAMES Model

CAMES Model System has four unique functions of monitoring, simulating, forecasting and early warning. The functions are as follows:

1. Monitoring function

   The monitoring function consists of real-time monitoring of market changes, dynamic monitoring of the supply-demand trend and monitoring the impact of agricultural policy implementation (Zhang 2004). Through market information collection equipment, this system can timely monitor the production, consumption and price of all kinds of agricultural products, combining with the agriculture conditions information system and wholesale market in the designated information system of ministry of agriculture. Though the analysis of essential data and dynamic data, it can dynamically analyze the agricultural products supply-demand trends by regions, varieties and periods. According to all kinds of national regulation and management policies about production, consumption and price of agricultural products, it can monitor and analyze the scopes, extents and effects of policies.
2. Simulating function

   The simulating function includes production risk simulation, consumption substitution simulation, price transmission simulation and policy impact simulation. Production risk simulation is to conduct real-time simulation on production and risks via monitoring weather, inputs, and production management factors. Consumption substitution simulation is to estimate the degree of consumption substitution by means of analyzing changes of production, consumption, and prices. Price transmission simulation is to make simulations and analysis on the path, intensity, and form of agricultural product price transmission in discrete markets, products, areas and periods. Policy impact simulation is to analyze and determine the condition, impact and effectiveness of policy implementation through scenario simulation and design.

3. Forecasting function
   The function of forecasting includes production forecast, consumption forecast and price forecast in short, medium and long term (Li et al. 2013). Production forecast means to conduct projection of agricultural product yields in short-term (within 1 year, inclusive), medium-term (from 1 to 10 years), and long-term (longer than 10 years) by the system mechanism model and statistical model. Consumption forecast means to carry out the consumption analysis by product classification, and to conduct projection of agricultural products consumption in short-term, medium-term, and long-term. Price forecast means to project the trend of agricultural product prices through a comprehensive analysis of production and consumption.
4. Early-warning function
   The early-warning function can be divided into category-specific early warning and area-specific early warning. Category-specific early warning is to provide early warning for agricultural products by categories: aggregated sector, sub-aggregated sector, sector, detailed sector. Area-specific early warning is to provide early warning at country, regional, provincial, and county levels.

1.3 CAMES's Principle and Characteristics

1.3.1 Principle of CAMES

CAMES is a large modeling system to provide full-featured applications and to cover a broad range of varieties, numerous variables and complicated structure. Its development is based on the following three basic principles:

1. Unification principle
   In accordance with standards, all the agricultural products circulated in the market have been divided into 6 major categories: aggregated sector, sub-aggregated sector, sector, detailed sector, product and idem, and have been incorporated into CAMES analytical framework. According to the unified modeling methodology and the similarity of factors, and in combination of natural science and economics, a model group is developed to monitor and provide early warning of the production, consumption, price, and trade of system's end-products.
2. Correlation principle
   The correlation principle includes correlation among products, correlation between biological dimension and market mechanism and domestic and international correlation. Correlation among products is to reflect complementary and substitutable relationship between different agricultural products, and to establish correlation through the consumption substitutable variables. Correlation between biological dimension and market mechanism is to fully consider the impact of natural conditions on socio-economic aspects. The biological

dimension is based on the growth rhythm of livestock and crops, while the market mechanism model is based on the inputs, prices, management, and policy factors. Domestic and international correlation is to take into account of international and domestic resources and markets from global perspective, and to establish linkage by means of trade and price transmission as generated from supply and demand models.

3. Balance principle

   Balance principle includes balancing supply and demand of aggregate agricultural production, balancing area-specific Supply and demand of agricultural products and dynamic balancing supply and demand of agricultural products in different periods. Balancing supply and demand of aggregate agricultural production is not only to guarantee agricultural products supply-demand balance at various levels of categories: aggregated sector, sub-aggregated sector, sector, detailed sector, product and idem, but also to ensure balance between different varieties. Balancing area-specific supply and demand of agricultural products is to ensure agricultural products supply-demand balance at national, regional, provincial, urban and county levels. Dynamic balancing supply and demand of agricultural products in different periods is to ensure temporal agricultural products supply-demand balance in aggregates, regions and varieties.

1.3.2 CAMES's Characteristics

CAMES has many kinds of characteristics include a variety of agricultural products, large scale spatial distribution, long-term early warning, and detailed demand equation model. Its characteristics are detailed as follows:

1. Coverage of a broad variety of agricultural products

   According to the ministry of agriculture industry standard, agricultural products can be classified into aggregated sector, sub-aggregated sector, sector, detailed sector, product and idem 6 levels and 953 varieties. CAMES has established variety-specific analysis and early warning models. On this basis, adopting the polymerization method, from aggregated sector to sub-aggregated sector, from sub-aggregated sector to sector, from sector to detailed sector, from detailed sector to product and idem, CAMES conducts effective monitoring and early warning on the agricultural product supply-demand balance and market changes at different levels and different types, reflecting the features of China Agriculture Monitoring and Early-warning System, namely specification and comprehensiveness.

2. Large-scale spatial distribution and strong regional

   CAMES has conducted spatial division at national, regional, provincial and county levels, in line with the agricultural zoning standards. Addressing diverse spatial scales, the system has established different spatial monitoring and early warning models, to match crop varieties with cropping patterns, and to balance supply and demand. CAMES has also accomplished effective spatial monitoring and early warning, and coordinated the work at national and regional levels.

3. Consisting of short-term, medium-term and long-term monitoring and early warning

   CAMES models, based on the characteristics of agricultural products, are designed to meet short-term (within 1 year, inclusive), medium-term (from 1 to 10 years), and long-term (longer than 10 years) monitoring and early warning requirements, thus harmonizing the short-, medium-, and long-term monitoring and early warning.

4. Covering factors related to weather, inputs and management

   CAMES has successfully integrated biological dimension of agricultural product monitoring and early warning, like light, temperature, water and gas, and economic theory, like investment, management and technology progress, in line with characteristics of agricultural production, which combines natural reproduction and economic reproduction.

5. Careful classification of model demand equations and introduction of virtual demand variables into equations

   CAMES models conduct careful analysis of consumption according to diverse product usages. For example, for early indica rice, CAMES divides consumptions into processing consumption, feed consumption, meal consumption, seed consumption, loss and other consumptions, etc. When estimating meal consumption, CAMES has taken a full account of consumption environment, bursty events and product substitution, and introduced the concept of virtual demand to some data lack of demand variables.

1.4 Basic Framework of CAMES

Taking China's agricultural product supply and demand as research object, CAMES has combined monitoring and forecasting together and covered a quantity of varieties and distracts. Through monitoring and analyzing the supply and demand of agricultural products, CAMES can deduce the trend of market price. The main function of CAMES is monitoring the effects that all kinds of factors have on agricultural products supply and demand, forecasting the changes of supply and demand in diverse regions and periods, namely short-term (within 1 year, inclusive), medium-term (from 1 to 10 years), and long-term (longer than 10 years) (Huang and Li 2004).

In strict accordance with industry standards agricultural market information classification coding with the computer (NY/T 2137-2012), which contains 953 agricultural products varieties, CAMES has covered 9 major categories which include grain, animal products, oil plants, sugar, cotton, vegetables, fruits, aquatic products and milk, containing not only original products, but also primary processed products (Lu and Huang 2004).

Through building basic unit model based by cities or counties, CAMES gathers them together and shaped province-level and nation-level models, covering several-levels regions. All varieties will build national and 31 regional (province, except

Hong Kong, Macao and Taiwan), and models' minimum space scales maybe vary from different varieties.

The indexes in equations include production index, consumption index, trading index, processing index, inventory loss and seeds index.

1.5 Development of CAMES

1.5.1 Requirements Analysis

CAMES is a system with management and operation of CAMES models and provides functions of predicting and early warning for production, consumption, prices, supply and demand balance of agricultural products. The system provides a unified operating environment and database for running CAMES models. The system is designed to provide domain experts and peers with a unified platform for interactive forecast and early warning of agricultural products. In addition, it can also effectively achieve functions such as running model, showing results, forecasting and early warning, expert consultations, and information dissemination. Characteristics of the CAMES system are as follows.

In connection with the problems of existing models, CAMES is developed for use by domain expert users. The system has the following main characteristics:

1. It provides an integrated operating environment for various forecast and early-warning models. Given a user specified forecasting and early-warning query, it achieves automatic matching, automatic invocation, and automatic result presentation of models. It also achieves the full configuration of models.
2. A unified OLAP data warehouse including agricultural meteorology, plant cultivation, animal farming and market information is constructed. It is effective not only for multi-dimension and multi-granularity online data analyzing and processing including time, place, product, variable dimensions, but also for data sharing among multiple analyzing and forecasting models.
3. With the application requirement of expert consultation, the system supports real-time adjustment of models and parameters, and real-time updates of results. It also provides the closed-loop export consultation process for query forecast and early warning, query results display, expert discussions, models and data adjustment, and result presentation update.
4. The CAMES system supports model constraints with multiple products, therefore is capable for multi-constraint optimization and problem solving. It can effectively achieve prediction result linkage among multiple varieties of agricultural products.
5. An integrated model results display system is established to provide rich and intuitive data support to facilitate decision making by domain experts and government agencies.

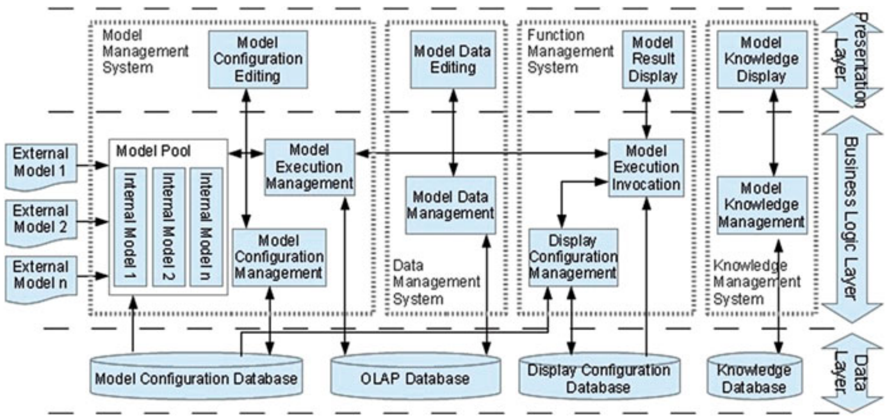

Fig. 1.1 System architecture

1.5.2 System Development

CAMES system is developed based on the Java language, Eclipse platform and SQL Server database development environment. The system architecture is divided into data layer, business logic layer and presentation layer, which is shown in Fig. 1.1.

As can be seen from Fig. 1.1, the data layer is mainly used to add data, delete data, modify data, query data, and store model files. The service layer is responsible for the management of the model, configuration model, call model, operation model and display model. The presentation layer is mainly used for data query, data analysis, model prediction result presentation, the model early-warning result presentation.

The online analytical processing database in the data layer of the system is an important data storage system, which provides a common multidimensional data model, allowing to store various kinds of data that are needed by the models, and providing data sharing among multiple models. Its multi-dimensional data structure is shown as follows (Fig. 1.2):

Our data model supports data storage on four dimensions, namely time, place, product, and variable. Besides, it supports data drilling up and drilling down on given dimensions, and supports data slicing. The four dimensions are as follows:

1. Time: includes year, quarter, month, day and other related information;
2. Location: a hierarchical structure including province, city (district) and county;
3. Varieties: including 11 categories 953 kinds of varieties;
4. Variables: contains historical (measured) values, and predicted ones.

The CAMES system merges multiple variables from existing models to provide a unified data management mechanism, mainly including meteorological, planting,

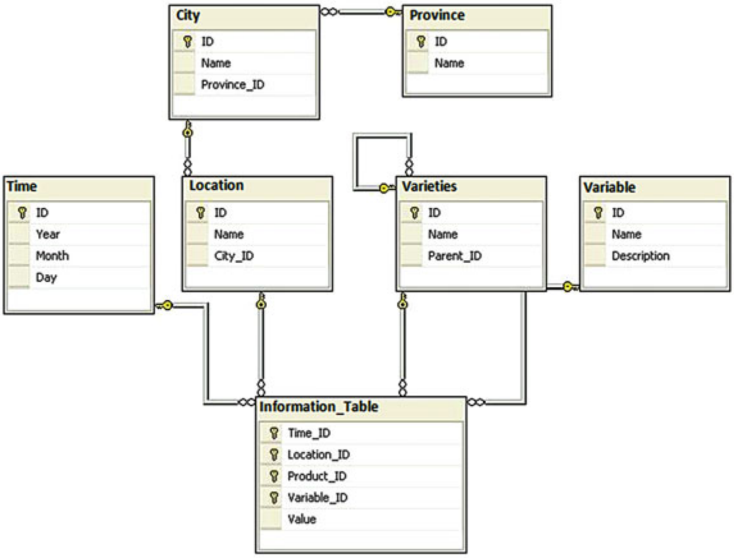

Fig. 1.2 Multi-dimensional data structure

economic, and parameter information that is used as historical data and predicted result data. The main data structure is shown in Fig. 1.3.

1.5.3 System Functions

The system consists of four sub-systems including Function Management System, Data Management System, Model Management System and Knowledge Management System. Its functional structure is shown in Fig. 1.4. Specific system functions are as follows:

1. Function Management System provides a unified query interface that allows a user to specify a combination of location and product, and a time period and the indicator that needs to be forecasted. The system would automatically match an appropriate model to run and display the results in graphical and table form. The selection of prediction conditions and predicted results are shown in Fig. 1.5. Expert users can read and modify the model equations, model procedure and model data. The system can update and feedback the revised forecast and early warning results in real time according to the users' modifications.
2. Data Management System is mainly used to achieve unified management of the database. The database system includes three databases, i.e., historical database, pricing information real-time monitoring database and model running results database.

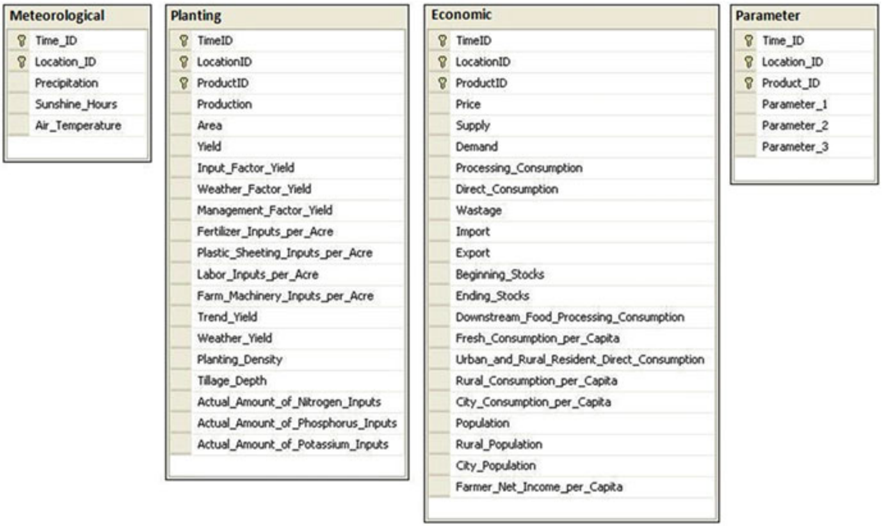

Fig. 1.3 Main data structure of CAMES system

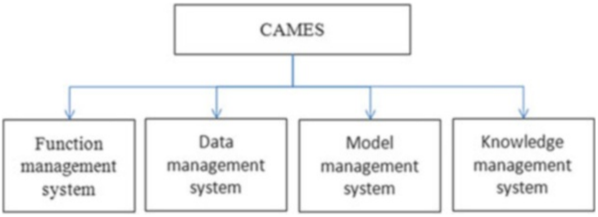

Fig. 1.4 Function and structure of system

Fig. 1.5 Predicted interface. (**a**) Selection of prediction conditions. (**b**) Predicted results

3. Model Management System allows users to create model, modify model, delete model and configure the running environment of models. The execution method, input and output data, and applicable conditions are configured. The system supports Stata, EViews, Excel and other statistical analysis software for the preparation of a model.
4. Knowledge Management System provides the functions for concept management and querying for agricultural product forecasting and early-warning in the system. It provides the introduction and detailed explanation of related concepts.

1.6 Conclusion

This paper has presented necessity, objectives, functions, underlying theoretical basis, characteristics and basic framework for China's agricultural market monitoring and early warning system. CAMES that with management and operation of CAMES models and providing functions of predicting and early warning for production, consumption, prices, supply and demand balance of agricultural products was developed by JAVA language. Through the system construction and model test running, the CAMES system has shown great advantage in the agricultural product monitoring and early-warning field. It provided domain expert users a unified interactive model runs, data management platform. It would give great contribution to China's monitoring and early warning for agricultural products.

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Chapter 2
Design and Implementation of Agricultural Product Prices Short-Term Forecasting System

Chuan Wang, Anping Zhao, and Yousen Zhao

Abstract This paper is to construct the agricultural product price short-term forecast system (hereafter refers to the system) aiming at service oriented and business oriented. The system is based on B/S mode, by using SSH framework and JAVA and referring to Spring, Struts and other open source projects, embedding Eviews and Easyfit to achieve four main business functions: agricultural product price short-term prediction, agricultural product market risk dynamic early warning, agricultural product entering Beijing routine map display and agricultural market situation analysis. The system converts economic model into an operable system tool, strengthening the guiding role of economic analysis to agricultural market management.

Keywords Agricultural products • Market price • Short-term prediction • System

2.1 Introduction

Frequent and violent fluctuation of agricultural prices not only affects the stable agriculture production, but also comes as a shock to consumers. Especially in recent years, parts of China have witnessed the problem of fresh agricultural products unsalable stock and roller coaster ride of agricultural product prices which have

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This paper contains partial research content of the Chinese Technology Support Project entitled, "Research and Demonstration of short-term forecasting system of Fruit and Vegetable market price" (Serial Number: 2009BADA9B05).

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_2, © Springer-Verlag Berlin Heidelberg 2014

become a public concerns as well as a focus of management decision-making and scientific research. Conducting the research of agricultural product market price forecasting early warning to accurately grasp the market change rule benefits the administrative department of agricultural market regulation and control to make scientific decision-making, helps farmers make reasonable production plan, and, to some extent, evades risk of price fluctuations on the impact of agricultural output and farmers' income.

There have been many studies and discussions about agricultural prices forecast methods at home and abroad in recent years. ARMA model and ARIMA time series model are often used in chicken, pork, cabbage and other major agricultural prices prediction (SuZhen Teng et al. 1995; Xiaoshuan Zhang 2003; Fu Runan et al. 2008; DeGgang et al. 2008; Feng liu et al. 2009; Jiheng Wang and Xinli Wang 2003; Hu Tao 2005). Multiple linear regression models are applied to predict the prices of vegetables, rice, wheat, and pigs (Anping Zhao et al. 2012; Bo Su et al. 2006; Xiaobin Ma et al. 2007). Intelligence methods such as neural networks method are also used to carry out the agricultural price forecast, for instance Chuan Wang (2008) built the agricultural product market risk early warning model based on BP neural network (Chuan Wang and Ke Wang 2008), Changshou Luo (2011) established an integrated forecast model to predict vegetable prices based on the BP neural network model, genetic algorithm neural network model and RBF neural network model (Changshou Luo 2011). Moreover, Xiaoxia Dong (2010) chose double exponential smoothing method, Holt – Winters no seasonal model and ARCH model to forecast fresh milk retail price short-term prediction (Xiaoxia Dong et al. 2010). Results of these studies provide a good reference to the agricultural products market price prediction, but at the same time, most research focused on the medium- and long-term prediction of agricultural prices, that is, most of them aim to predict future price movements in more than one year, and researches on the short-term forecasting of agricultural prices are relatively few.

This paper is aimed to build the short-term price forecasting early warning system with the combination of time-series forecasting techniques and risk measurement technology. The system, through software engineering technology can conduct a real-time, dynamic and quantitative prediction that reflects short-term future changes in the agricultural markets. In the paper, we take vegetable market in Beijing as an example to display the practical application of this software engineering technology. System development is based on B/S mode, using the SSH framework and JAVA programming language and embedding Eviews7.0 software to forecast short-term future agricultural prices changes and volatility determinant factors, embedding Easyfit software to fit agricultural price volatility risk probability distribution and risk measurement, embedding Flex technology to display the main routine of agricultural products into Beijing.

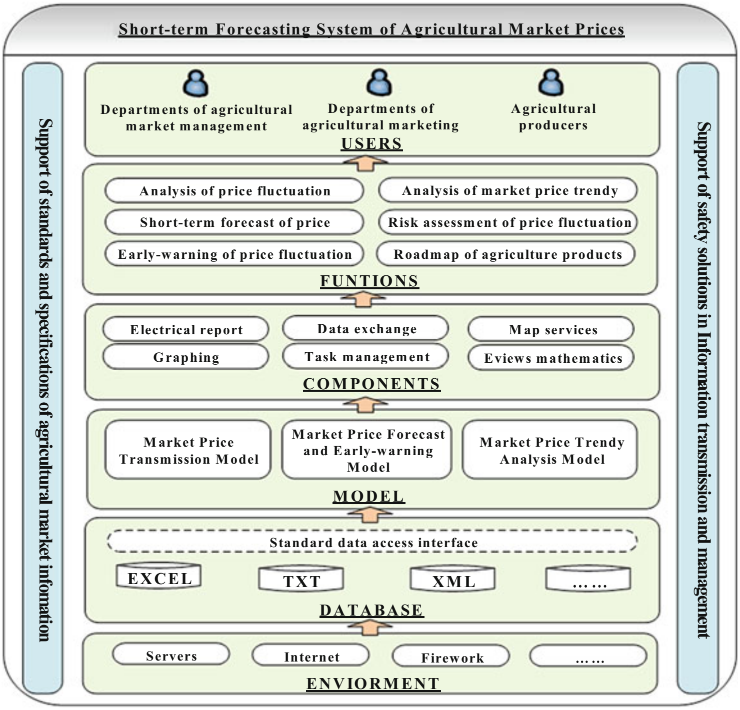

Fig. 2.1 System structure of agricultural product price short-term forecasting

2.2 Overall Design of System

2.2.1 System Structure Design

The design of agricultural product prices short-term forecasting system refers to the industry popular open source framework, such as Spring, Struts and other open source projects, and meanwhile forms its own technical characteristics and many years of accumulation of business functions. The system technical framework shows as Fig. 2.1. Framework is mainly composed of data base layer, system support layer, application service layer, and system user layer. The layout design is clear and easy to maintain and expand.

Data base layer is to support system to extract and management data, which includes data management center, self-service platform and virtual application components, and has a data standardization open interface, to implement data conversion and docking with EXCEL, XML, TXT and other various data resource formats. System support layer consists of two parts-technology support layer and model support layer, and it is the core of the system. Among them, the technical support layer provides a unified framework model of system design. It is a rapid development platform. The platform adopts modular programming, thus it has good expansibility and is easy to maintain. Through the platform's various services functions, it can be realized the technical support to the system, such as organization, permission services, forms service, data exchange service, resources services, logging services, etc.; the technical support layer is also an intelligent graphics analysis component. It can run in a variety of JAVA application servers, including analysis chart, histogram, maps and other graphic display, the management the dimension of the time and region, etc., and carrying the depth of drilling. Model support layer is the module to provide the underlying formula based algorithm, model and probability distribution function for the business function such as prediction, early warning, and market analysis. Application service layer is mainly to realize the business data management and system management. Business data management includes relative data extraction and conversion, factor data management, market data collection and forecasting configuration management, all of which are mainly produces of data arrangement.

2.2.2 System Operation and Development Environment

System is running under the network environment and consists of the database server, application server, and the corresponding network equipment. Oracle10g database is adopted as a database platform, Tomcat5.0 as a Web server and JSP engine, Windows 2003 Server as the Server operating system, Java 5.0 as development platform, J2EE as the architecture for development, Ellipse 4.0 as the front desk development tools.

2.2.3 Database Design

Oracle10g relational database is applied in this system, by using multiple table Spaces to improve the concurrent data access and data computing power. According to business requirements and data sources, this system mainly has two types of databases: one of databases is for business data, including time series model and multiple regression model to carry out quantitative forecast prices for agricultural products, with the method of value at risk (VaR) to measure price risk, and other method to carry out analysis of technical indicators and to display map of agricultural products into Beijing. The other database is support database, which supports to carry out prediction, early warning, statistical analysis, and multiple factors management.

2.3 System Functional Design and Key Technology Research

According to the system structure, procedures' intrinsic relationship and collaborative relationship, the system is divided into four business function modules: prediction management, early warning management, roadmap display, and market analysis, as well as the factors management, data maintenance and supporting technology such as system management function module, as well as other technical support function modules: factor management, data maintenance and system management. Among them, factor management and data maintenance are mainly to support forecast management and the background configuration and system management function is mainly about user's setting and management etc.

2.3.1 Design Agricultural Prices Prediction Function Module

Forecasting management module for agricultural market price includes two parts: prediction time series of agricultural product prices and forecast price fluctuation of agricultural products.

Prediction of agricultural product prices time series mainly use the Exponential Smoothing Model and difference autoregressive moving average (ARIMA) model for short-term prediction of agricultural products prices. It is on the base of the analysis of historical price data by using embedded Eviews, and combines the technique of data maintenance in time series configuration. After identifying a specific agricultural product variety and time dimension, the system will automatically display the variety-associated data processing method and the relative model equations, then, the system will trigger the Eviews, and invoke the command to carry out the forecast.

Agricultural prices time series forecast needs to resolve three problems. The first is time series data analysis, which involves the prejudgment and processing of time series data, such as taking natural logarithms, differentiating the time series to eliminate random fluctuation, taking the unit root test to judge the stability of data. The second is to configure parameters in prediction model for different agricultural products in advance. For instance, in ARIMA models, apart from sequence data processing, it also needs to choose the optimal equation by comparison. After the parameters are estimated, they are set relations to the corresponding agricultural products. The third is that the ultimate results need to be programmed into the original data format, i.e. restore the logarithmic, differential date into original data.

The effective degree of agricultural product price volatility factors are mainly estimated by the multivariate regression model with the aid of Eviews software. The agricultural product price volatility factors includes weather, transportation costs, market supply, seasonal effect and other factors influencing agricultural prices. The factor management module provides a supportive role in estimating the effective degree of factors. It is to add, set, data processing of the multiple factors, etc. For different agricultural products, the system carries out the multi-factor regression. The system gives the influencing factors of selection page, and calls Eviews form output page to evaluate the goodness-of-fitting regression model.

2.3.2 Design of Agricultural Market Early Warning Function Module

Early warning management module applies the method of VaR to measure the risk of agricultural product prices. It embeds the Easyfit software to automatically extract probability distributions, and it is based on the J2EE open architecture, through the Java Native Interface (JNI) to call C (language) code, to complete Easyfit DLL call.

The development of Agricultural market early warning function faces three difficulties. One is the determination of the probability distribution of the agricultural product price data. The system has eight kinds of distributions, which are commonly used to simulate vegetable price time series probability distribution, as candidates, including Lognormal, Gamma, Burr, Weibull, Beta, Normal, Logistic, and Log–Logistic. Another is how to embed Easyfit software. Easyfit software is used to fit the probability distribution model. The third one is to calculate the upswing and downswing intervals after determining the confidence interval the interval calculation. It needs to put the confidence level into the probability distribution function, and conduct bottom-up calculation.

Prices early warning operation process in general is that, after determining the variety of the agricultural products and time dimension, the system calculates the price data of the selected varieties at the given period of time, and then triggers Easyfit software to simulation the probability distribution of the price data, and sorts the goodness-of-fit of probability distributions. After inputting confidence interval values and clicking “confirm”, the system use the probability distribution function ranking first, to calculate the prices’ change rate of the absolute value of the ascending and descending range. We can conclude whether the price fluctuation in the given time period is under risk by determining the safety interval of agricultural product market price fluctuations and combining with predicted results.

2.3.3 Routine Map Display Function Module Design of Agricultural Products into Beijing

In the module of agricultural products into Beijing routine map display, we adopt the maps of nation and parts of province to show the source distribution of agricultural products and the market supply proportions of different source places, agricultural productions in major cities and counties, and other functions. The mapping function is realized by using the graphical display technology of Flex, by communicating between the Java and XML formats through delivery. Users can do flexibly browse, view, zoom, drag and drop mobile and drilling operations on the map.

The difficulty of routine map function development is the fusion of the map display and maps' data. The national map applies the Flex technology to display each province and city on the country's image display, and various provinces and cities area display are on the basis of correlation data, thus graphics can amplify and contract in accordance with the mouse position. Double-click on a certain province or city area, and the map layer will change into the province and city, then, municipal- and county-level related data information can be shown, and double click on any region again can return to the national map.

The routine map module realizes the image and accurate display of annual and monthly agricultural products wholesale markets from provinces and cities of source distribution entering into Beijing all over the country, and proportion information of these source places. It also makes the information graphical display with different main agricultural product's origin area, production, varieties, and the distance from Beijing at a given period of time, and makes the national and provincial regional map switch to each other.

2.3.4 Agricultural Market Analysis Function Module Design

Market analysis function module mainly aims to conduct the classification summary and comparison of vast and diverse market data statistics, and generate trend graph, quick estimate the technical indicators, etc. It applies JSP to develop front desk page, and uses the open source Eclipse BIRT technology to improve the system scalability and upgradeability.

In this module, apart from designing some of the conventional statistical function, we also initiatively put forward the calculation equation to estimate the contribution value and contribution rate of a variety of vegetable price changes to the whole vegetable market price to do the depth resolution the impact of vegetable varieties price changes to the overall of market volatility. (2.1) and (2.2) represent respectively calculation formula of the contribution rate and total contribution to the final mathematical.

$$cr_i = \frac{p_i w_i * \Delta p_i}{\sum_{i=1}^{n} p_i w_i} + \frac{p_i w_i * \Delta w_i}{\sum_{i=1}^{n} p_i w_i} + \frac{p_i w_i * \Delta p_i \Delta w_i}{\sum_{i=1}^{n} p_i w_i} \tag{2.1}$$

$$r = cr_i / \frac{p' - p_0}{p_0} \tag{2.2}$$

where the p_i represents prices of an individual in a category of vegetables, p_0 represents category weighted average price, w_i represents the weight of an individual in the whole vegetable market, p' represents the price of whole vegetable market in the next period, and Δp_i and Δw_i represent the rate of change of price and weight.

2.4 Realization of System Function

2.4.1 Agricultural Price Short-Term Prediction Function

The system can simultaneously use both exponential smoothing model and difference autoregressive moving average model to carry out short-term price prediction of common vegetables products, such as cucumber, tomato, cabbage, potato, etc, and the prediction results are shown in Fig. 2.2. With the help of the system, forecast management achieves the transition from a study into daily administration, and the analysts can carry out conveniently the short-term prediction research on daily, weekly and monthly basis. Therefore, the system provides a new tool to quantitatively predict prices for agricultural products.

The measurement of the effective degree of agricultural product price volatility factors, especially vegetable prices factors, has always been a problem in research field. The system builds the multivariate regression model to implement the measurement of effective degree of some varieties of vegetable price fluctuation factors. The factors include oil price, quantitative measurement of weather changes and seasonal fluctuations impact. The results with this model are shown in Fig. 2.3.

Take the effective degree of cucumber and spinach price volatility factor for example. Oil price is the major factor to raise the vegetable prices, from the regression model, we can see if gasoline price increases 1 yuan per liter, the prices of spinach and cucumber rise about 0.368 yuan/kg, 0.316 yuan/kg respectively. Seasonal influence factor has also relatively large impact on the vegetable prices, and as we can see the price of cucumber in the 2nd and 3rd quarter is lower than the fourth quarter by 0.5/kg to 0.6 yuan/kg, and the price in the first quarter is 0.8 yuan/kg higher than the last quarter. As for spinach, the highest price level appears in the third quarter, the lowest prices in the second quarter. With the now thickness growing 1 cm, the spinach price rises 0.05 yuan per kg and cucumber price rises 0.03 yuan per kg. With the spinach and cucumber market supply increasing every 10,000 t, the prices of vegetable separately fell 0.60 and 0.20 yuan/kg.

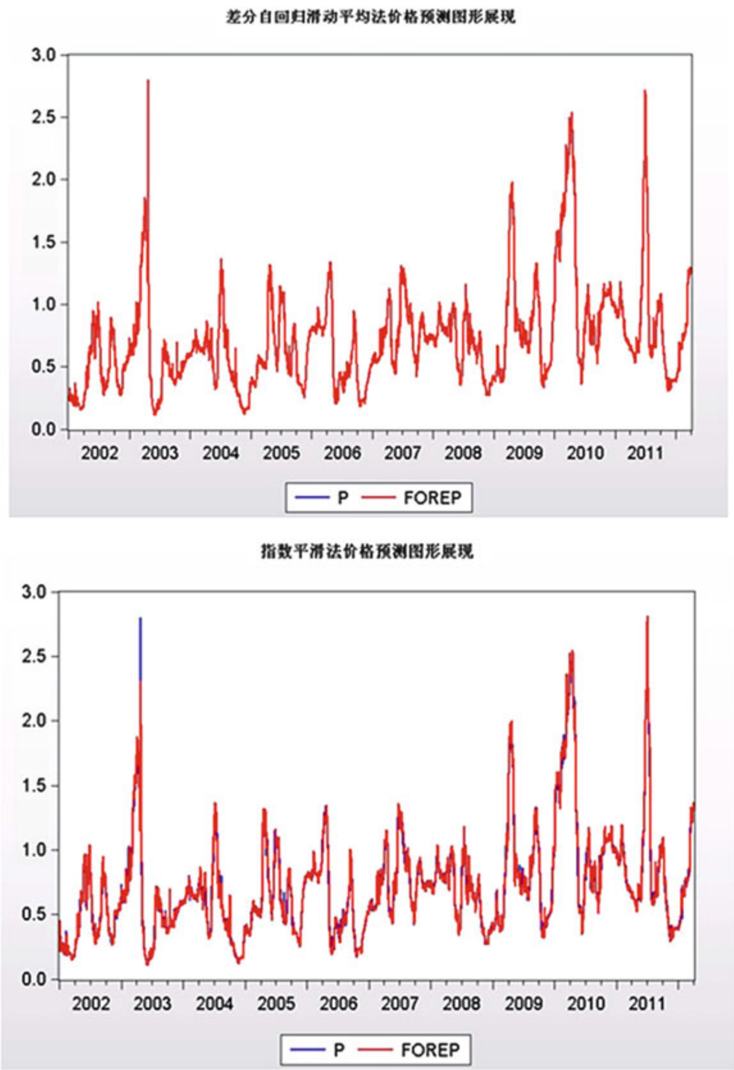

Fig. 2.2 Price forecast with difference autoregressive moving average

2.4.2 Agricultural Products Market Risk Early Warning Function

The system innovatively applies the VaR method into the agricultural price risk assessment and implements the short-term price risk measurement and evaluation of agricultural products. In the system, we make price prediction combine with price risk measurement, and mark prices early warning indicator in the main pages

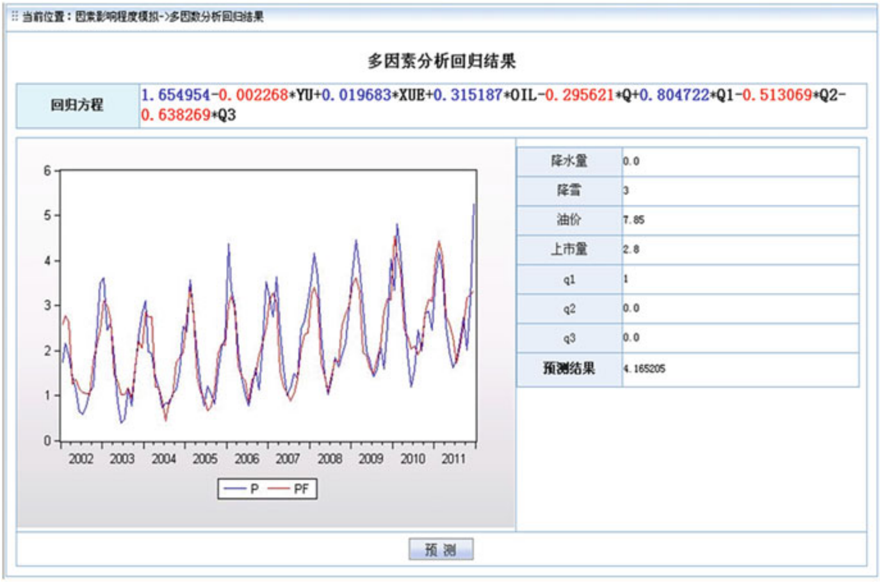

Fig. 2.3 Results of effective degree of agricultural price volatility factors

with a red light, green light and yellow light to represent the risk levels. We contrast the forecasting price with the VaR intervals: the red light means the future price level will exceed the highest value at a certain confidence level, the green means the price level is in a safe range, the yellow light means at a confidence level, there is a risk that the price level will be lower than the lowest value. The main page is shown in Fig. 2.4.

2.4.3 Routine Map Display Function of Agricultural Products Entering into Beijing

The agricultural products consumed in Beijing mainly rely on the supply of surrounding provinces and cities. According to the survey, Hebei province and Shandong province are the main source of vegetables supply in Beijing. The national agricultural products source distribution map developed by the system intuitively shows Beijing's vegetable supply source places distribution, and according to the survey data, we estimate the proportion of vegetables from different supply places, and mark respectively in different colors as shown in Fig. 2.5 (left).

Take the vegetable from Hebei into Beijing as example, we draw the routine map of vegetable from Hebei to Beijing on the basis of information of the county level supply. For each certain vegetable variety, we identify its production area,

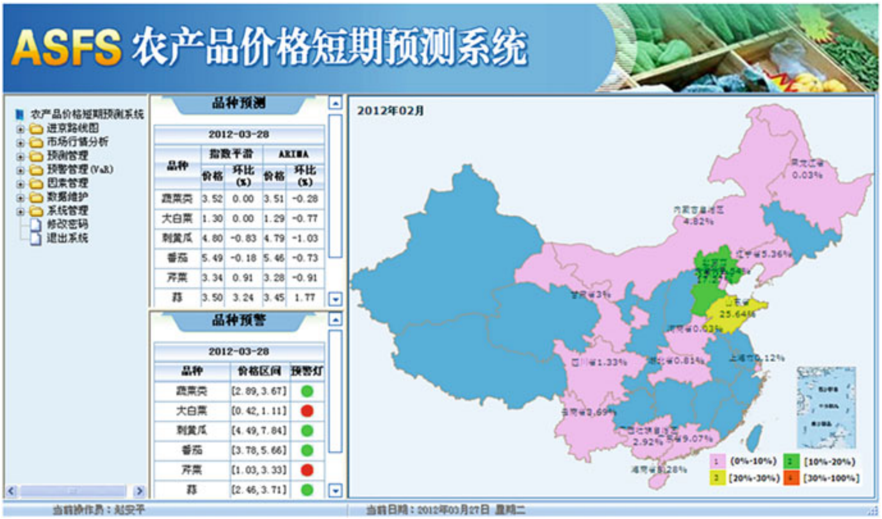

Fig. 2.4 Agricultural warning instructions page

Fig. 2.5 The proportion of vegetable source distribution and Beijing

production, miles from Beijing in each county. By click on the source distribution of agricultural products in Beijing, we can switch the map into vegetable production distribution in Hebei province. Figure 2.5 (right) shows the tomato source place distribution in Beijing and production distribution in Hebei province.

2.4.4 Agricultural Products Market Analysis Function

The system uses technical indicators of contribution analysis in market analysis module and outputs the page (Fig. 2.6) where we can get the information of vegetable market price changes and the mainly causes of the changes by a simple operation. Moreover, the role of contribution rates can be expressed by mathematic

Fig. 2.6 Agricultural products market price short-term forecasting analytic system

equation, which offers the market management and decision-making department accurate information reference.

2.5 Conclusion

The short-term forecasting system fully reflects the organic integration of the modern information technology, information analysis technology and economic analysis. The design of the system is aimed at service oriented and the system is based on B/S mode, referring to SSH framework and JAVA, Spring, Struts and other open source projects for, embedding Eviews and Easyfit to implement four functions: the agricultural product price short-term prediction, market risk into dynamic early warning, agricultural product entering Beijing routine map display and agricultural market situation analysis. The system not only makes great breakthrough about the difficulty of short-term price forecasting and early warning technology of the fresh vegetables and other agricultural products, but also succeeds to convert the economic models into an operable system tool, enhancing the economic analysis results' guiding role in the market supervision. We believe that the system will provide technical support for government departments to improve their scientific decision-making and market regulation ability.

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Chapter 3
Forecasting and Early-Warning Research on the Price of China's Corn and Late Indica Rice

Huijuan Wang, Feng Wan, Jianing Xiao, and Shuangshi Qu

Abstract In recent years, the import of corn and late indica rice is increasing and increasing, because the demand of corn continues to strengthen and price differences at home and abroad exists. This paper wants to establish a comprehensive price forecasting and early-warning system for corn and late indica rice to effectively monitor price fluctuations. In this paper, we first built a combinatorial optimization model to forecast monthly price. Second, we set the early warning signal system of price based on the level of price volatility. Finally, according to the forecast results calculated in the first part, we analyzed and predicted the warning prices of corn and late indica rice in the next 12 months. The result shows in the future 12 months, the price of late indica rice will increase steadily while the corn will fluctuate in a small range.

Keywords Price prediction • Time series analysis • Optimal combination • Early warning monitoring

3.1 Introduction

"Food is What Matters to the People". The fluctuation of grain price is closely related to the whole national economy. It also has the direct relationship with the profit of producers and consumers. After China joining the WTO, the agriculture

Supported by Program for Innovation Research in Central University of Finance and Economics and Study on Time Lag Input-Occupancy-Output Technique (61273208).

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_3, © Springer-Verlag Berlin Heidelberg 2014

marketization and internationalization have gradually deepened which brings intense competition. Because of market fluctuations and economic cycle, radical price volatility affects the enthusiasm of the farmers for production seriously. At present, the farmers play a vital role in production, but most of them blindly follow the past year's earnings to determine what to sow. It finally contributes to a vicious circle (Low price – reduction of cultivation – high price – expansion of cultivation – low price). In order to protect the farmers' interest and the safety of grain, there is an urgent need to set up a comprehensive price forecasting and early-warning system.

Because of the diversity of China's grain, many researchers used price index to build the price forecast system. However, the price changes of index cannot be offer practicable suggestion for farmers or government. On the contrary, the prices prediction and warning for different grain crops are more specific and more practical.

Rapid development of livestock and processing industry results in great demand on corn. China was a perennial corn exporter until 2010, the first year that it imported more than it sent out. In 2010, the import quantity is 18.6 times of the former year. Until 2012, the total quantity has reached 5.208 million tons and is 3.0 times of 2011 and 61.6 times of 2009. In the meantime, the import quantity of rice attracted world attention to China in 2012. The net rice import quantity of that year is 1.89 million tons which is four times of 2011. The Wall Street journal reported in January 8, 2013 that China has become an unexpected big rice buyer since 2012. Even though rice and corn are the main produces of China and increase yield year by year, the internal enterprises cannot resist the temptation of the price gap between aboard and home, which contributes to substantial import. So the prices forecasting and warning of corn and late indica rice not only give advice for the producer, but also can help operators' decision making to minimize the economic damage.

The second part of this paper is literature review, and the third part builds a short-term price forecasting model for corn and late indica rice. Then it's the price warning system. The last part draws a conclusion.

3.2 Literature Review

The agricultural production price prediction originates from an article entitled *Forecasting the Yield and the Price of Cotton* which was published by Henry L. M. in 1917. In this article, he built regression forecasting model for cotton yield and its price (Henry 1917). In 1975, Sarle C.F. Published *The Forecasting of the Price of Hogs* and built a regression model for price of hogs and many factors which included industrial stocks price, Chicago second class mixed corn future price and the price proportion of corn price to predict price of hogs (Sarle 1925). Later, Ezekiel M. (1927), Clifton B. Cox (1956), Wilbur R. Maki (1963) respectively forecasted the American Chicago hog, beef, seasonal pig of American, pork's price by using diversified factors regression model (Ezekiel 1927; Cox and Patrick 1956; Wilbur 1963). With the development of modern time series in 1970s, exponential smoothing, spectral analysis and VAR model are frequently used in agricultural production's price forecast (Jarrett 1965).

The domestic research of grain price also used factor regression and time series analysis. Liu Hongyu (2001) made an accurate prediction of the rice price of Yongzhou City by using Three Time Points Model (Liu 2001). Cheng Xianlu (2002) used diversified factors regression and Markov chain method to study the vegetable price of Beijing (Cheng 2002). Wang Suya (2009) forecast of the daily, weekly and monthly apple price by using GARCH, ARIMA, VAR models and pointed out that GARCH model was more proper for daily price forecast while ARIMA weekly and monthly price forecast (Wang 2009). With the development of intelligent forecasting model and combining forecasting model, neural network, genetic algorithm and combing forecast are adopted in the grain price forecast, especially the last one. Many researchers' studies, including Zhang XS et al. (2004), Sheng Jianhua (2008), and Li Ganqiong (2011), showed that combining forecasting is not only more accurate than single model, but also more stable (Zhang 2003; Sheng et al. 2008; Li et al. 2011).

Under the comprehensive analysis of the literature on forecasting grain prices, there are less literatures involved in specific grain varieties. In fact, grain prices of China went through a process from control to gradually loosen. Many factors such as supply and demand relation, exogenous shock, market characteristics, contribute to the increasing volatility of grain prices. Forecasting the major grain price is very necessary. This paper tries to fill the research blank. Based on the price of corn and late indica rice provided by Information Center, Ministry of Agriculture, this paper sets forecasting models to provide decision-making reference for producers, operators and relevant government departments.

Economic warning is one of the main tasks in macroeconomic analysis, which is used to forecast the economic operation of a future date. Food and Agriculture Organization (FAO), first applied warning analysis to agriculture, and created "The Global Information and Early Warning System of Food and Agriculture" in the early 1860s, which was used to collect and analyze food production, trade and price information to monitor food security; Tao JC (1995) (Tao and Li 1994), Gu Haibing et al. (1997) established the framework of the agricultural and food early warning system (Gu and Zhao 1997); Su bo et al. (2006) analyzed the impact factors affecting China's food prices using stepwise regression methods (Su et al. 2006); Zhao Yuxin (2007) constructed cybernetic model of food prices on the basis of food prices state defining (Zhao 2007). In this paper, we will build the early warning system for the monthly price of corn and late indica rice to predict the future price.

The paper builds the forecasting model of monthly price of corn and late indica rice based on time series forecasting model and the optimal combining model. According to the different characteristics of corn and late indica rice, we builds nonlinear combining forecasting model of SARIMA and X-12 model to forecast corn price, and builds decomposition forecasting models (DFM) and trend stationary model (TSM) model to forecast the late indica rice price. On the other side, this paper sets early warning system based on the historical data fluctuation of two kinds of grain.

3.3 Nonlinear Combining Forecasting Model

The basic data is domestic wholesale price of corn since 2000 and that of the late indica rice since 2004, provided by Information Center, Ministry of Agriculture. As Fig. 3.1 shows, fluctuations in the price of corn is relatively flat since 2000 with the average annual price growth rate being 0.57 %, compared with 0.72 % of average annual growth rate since 2010. The current price of corn is 2.46 times higher than that of January 2000 and 1.32 times the price of the January 2010. The growth rate of late indica rice price is constantly higher than that of corn with its average annual growth rate being 0.86 % since 2003 and the late indica rice price being 2.87 times the price of January 2003.

The planting cycles of corn and late indica rice are longer, of which prices are affected by supply and demand, showing a high seasonal variation. By using the multiplicative model of time series moving average ratio method, the seasonal factors of the price of corn and late indica rice are presented by Fig. 3.2. In recent years, the seasonal fluctuations of the corn price were stronger than that of the late indica rice. Affected by the time of harvest, corn usually hits the maximum price in August and September and reaches its minimum price in February. The late indica rice price reaches its bottom usually in September and October and hits its peak in April. The corn and the late indica rice price prediction model will be attached to the seasonal time series model required by strong and stable seasonal factors.

3.3.1 *Time Series Model of Corn Price*

SARIMA is a modification of ARIMA, which is modeled on stationary process. The ADF unit root test shows that the original sequence is not smooth, but the first difference is smooth, so formula (3.1) shows the prediction equation:

$$\begin{gathered}\left(1-0.578L+0.260L^2\right)\left(\Delta\Delta_{12}Corn_t-1.744\right)=\left(1-0.928L^{12}\right)\varepsilon_t \\ (6.986) \quad (-3.153) \qquad (1.758) \qquad (-41.548) \\ R^2=0.68 \quad Q_{(36)}=35.38 \quad \chi^2_{0.05(33)}=47.40\end{gathered} \tag{3.1}$$

$(1-0.578L+0.260L^2)$ represents the 2-order autoregressive operator, $(\Delta\Delta_{12}Corn_t-1.744)$ means that seasonal differential and simple differential $(d=1)$ price sequence, $(1-0.928L^{12})$ means the 12-order moving average operator. The coefficients have passed the test of significance and the Q-test value of the model is less than the value of chi-square test, showing that there is no autocorrelation in the model residuals. The inverse of the root of AR and MA process are less than 1, indicating that the time series after differencing is stationary and the model is valid.

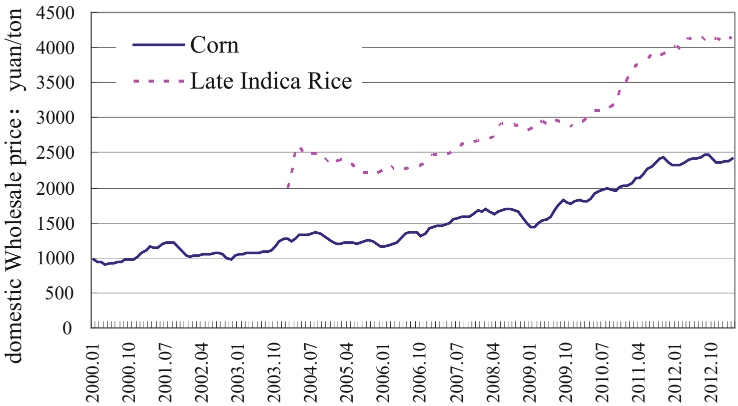

Fig. 3.1 Domestic wholesale price of corn and late indica rice

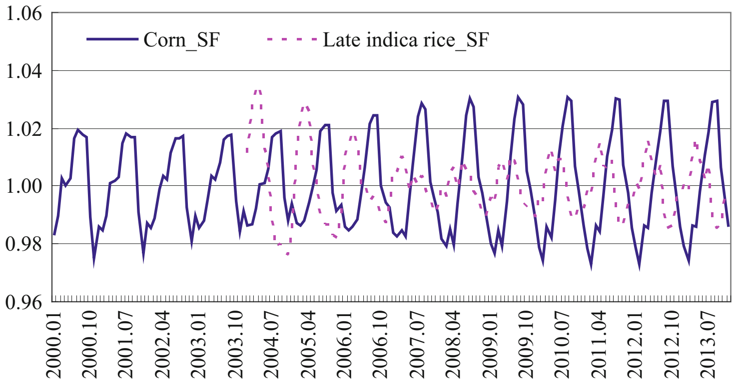

Fig. 3.2 Seasonal factors of the domestic wholesale price of corn and late indica rice

Seasonal factors separation model is an ARIMA model building after extracting the seasonal factor sequence (Corn_SF) from the original sequence by using X-12 methods. The prediction equation of Corn_SA is as follows:

$$\begin{gathered}(1-0.468L)\left(\Delta Corn\_SA_t-10.388\right)=\left(1-0.076L-0.411L^{12}-0.437L^{24}\right)\varepsilon_t\\ (5.79^*) \qquad\qquad (7.43^*) \qquad\qquad (-2.38^*) \quad (-5.59^*) \quad (-6.19^*)\\ R^2=0.40 \quad F=24.61 \quad Q_{(36)}=36.20 \quad \chi^2_{0.05(33)}=47.40\end{gathered} \tag{3.2}$$

$(1-0.467L)$ represents a first-order autoregressive operator, $(\Delta Corn\_SA_t-10.388)$ means the stationary series after the first difference.

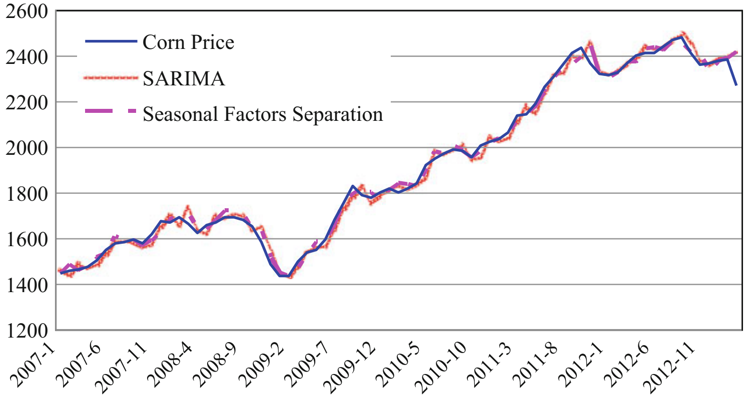

Fig. 3.3 SARMA and seasonal factors separation model fitted results

$(1 - 0.076L - 0.411L^{12} - 0.437L^{24})$ means that 24-order moving average operator, only the first-order, 2-order,12-order and 24-order moving average involves in the expression. The coefficients are all significant and the Q-test value is less than the value of chi-square, indicating that there is no autocorrelation in the model residuals; the inverse of the root of AR and MA process are less than 1, indicating that the time series after differencing is stationary and the model is valid.

SARMA and seasonal factors separation model fitted results are as shown in Fig. 3.3.

As shown in Fig. 3.3, SARMA and seasonal factors separation model fit the original series very well. The mean absolute percent error of SARIMA model is 1.30 %, and that of the seasonal factor separation model is 1.10 %, slightly higher than the SARIMA. Both models function performed well in predicting, which laid the foundation for the optimal combination of base model prediction to predict corn prices over the next 12 month, the results are shown in Table 3.1.

As shown in Table 3.1, corn prices will fluctuate within a small range in the next 12 months. The price of corn will show upward trend from June to October, when the corn harvest causes price to fall. Furthermore the seasonal factor separation model shows that corn price begins to fall since September; the SARIMA model predicts that corn prices will reach a short-term peak in December and April next year, and the seasonal factor separation model shows that corn price in the short term peak will appear in March next year.

3.3.2 The Indicia Rice Price Prediction Model

Using Moving Average Methods to remove seasonal factors (Rice_SF) from the monthly late indica rice price series and extract the underlying trend component of the series (Rice_SA), we can get a smooth estimate of the long-term trend component (Trend) and the cycle factor series (Cycle) of the Rice_SA by using the

Table 3.1 SARIMA model and seasonal factor separation model predicting results

Date	SARIMA model predicting	Seasonal factor separation model predicting
Apr-2013	2,205	2,224
May-2013	2,264	2,254
Jun-2013	2,300	2,259
Jul-2013	2,299	2,281
Aug-2013	2,310	2,318
Sep-2013	2,343	2,304
Oct-2013	2,280	2,256
Nov-2013	2,244	2,305
Dec-2013	2,326	2,267
Jan-2014	2,283	2,281
Feb-2014	2,292	2,244
Mar-2014	2,269	2,319
Apr-2014	2,345	2,268

Unit: Yuan/ton

Hodrick-Prescott Filter method on the Rice_sa, the EViews displays a Figure of the filtered series together with the original series as Fig. 3.4.

Then multinomial fitting method is used for describing the Trend series by defining t as the variable, and the results show that the fitting goodness of Cubic polynomial equation is better than others:

$$\begin{aligned} &RICE\_SA\_T = 2431.44 - 11.52^{*}t + 0.36^{*}t^2 - 0.000895^{*}t^3 \\ &\qquad (375.46)\,(-22.09)\,(34.22)\,(-15.44) \\ &\qquad \mathrm{R}^2 = 0.999 \end{aligned} \tag{3.3}$$

After that, we take the Unit Root Test on Cycle, which shows that it's a I (1) series. We convert the non-stationary series into stationary one by dealing with simple difference (d = 1), namely the unrest time series ARIMA (p, d, q) model is transformed to rest ARMA (p, q) model, and get the result:

$$\begin{aligned} &dRICE\_SA\_C_t = u_t - 0.86u_{t-1} \\ &\qquad\qquad (-32.82) \\ &R^2 = 0.38 Q_{(36)} = 49.5 \quad \chi^2_{0.05(35)} = 49.80 \end{aligned} \tag{3.4}$$

$dRICE\_SA\_C_t$ is the stationary series after simple difference (d = 1), u_t is the white noise processes. The result shows that R^2 is 38 %, Q-test shows that there is no autocorrelation in residual sequence.

The fitted value of the late indica price is equal to $(RICE\_SA\_T + RICE\_SA\_C_t) \times RICE\_SF$. We calculated the estimates as

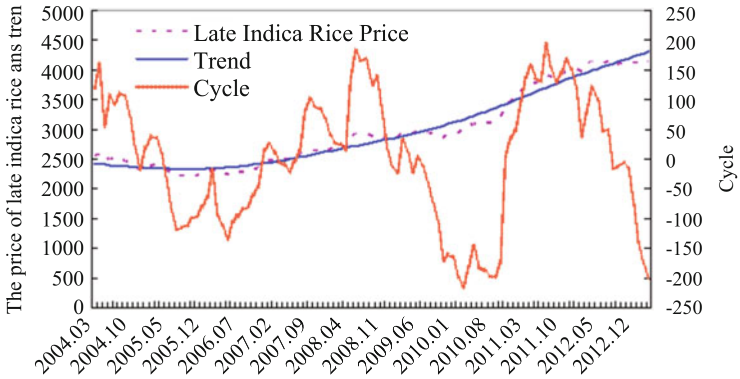

Fig. 3.4 The price of late indica rice and its trend and cycle

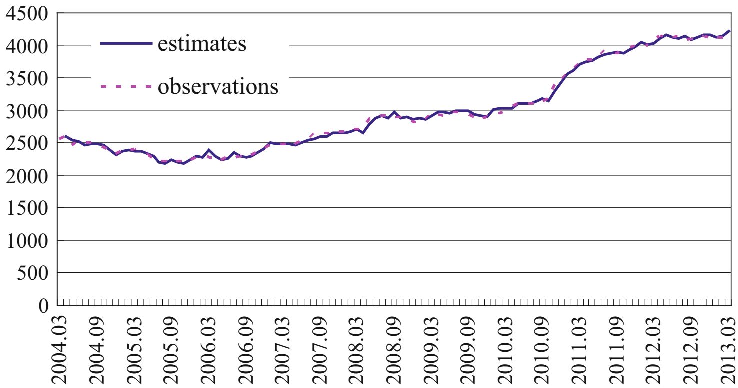

Fig. 3.5 Decomposition forecasting method of modeling curves

shown in Fig. 3.5. The Mean absolute percent error is 0.99 %, and Theil coefficient is 0.007. It can prove that this model fits the series well.

Trend stationary model is a special non-stationary process, the model expressed as:

$$\begin{gathered} y_t = \beta_0 + \beta_1 t + u_t \\ u_t = \rho u_{t-1} + v_t \\ \left(\rho < 1, v_t \sim IID\left(0, \sigma^2\right)\right) \end{gathered} \tag{3.5}$$

u_t is smooth, there exists only a temporary departure from the trend, the long-term predictive value of y_t is close to the trend line $\beta_0 + \beta_1(t + k)$. So it is called trend stationary process. ADF unit root test shows that the Rice_SA series is a trend stationary process, so using Eviews to build Rice_SA sequence trend stationary model, as shown in Eq. (3.6).

Table 3.2 The late indica price prediction

Date	DFM	TSM
Apr-2013	4,200	4,164
May-2013	4,208	4,173
Jun-2013	4,219	4,193
Jul-2013	4,243	4,207
Aug-2013	4,280	4,230
Sep-2013	4,285	4,236
Oct-2013	4,305	4,259
Nov-2013	4,362	4,320
Dec-2013	4,408	4,364
Jan-2014	4,490	4,438
Feb-2014	4,548	4,493
Mar-2014	4,654	4,596
Apr-2014	4,729	4,671

Unit: Yuan/ton

$$\begin{aligned} &\mathrm{RICESA} = 36.73 * @\mathrm{TREND}(2004\mathrm{M}03) + \mathrm{u}_t \\ &u_t = 0.97u_{t-1} + \left(1 - 0.25L^4 + 0.71L^{26}\right)v_t \\ &R^2 = 0.998 \quad (v_t \text{ is a white noise process}) \end{aligned} \tag{3.6}$$

@TREND(2004M03) represents the times variable defining 2004M03 as a starting point for the process, $(1 - 0.25L^4 + 0.71L^{26})$ means 26 order of the moving average operator. Only 4-order, 26-order moving average entered into the expression. Model parameters significance test shows that the variables are significant and the model fits well. Mean absolute percentage error is 0.78 %, and Theil coefficient is 0.005.

Using decomposition forecasting models (DFM) and trend stationary model (TSM) to predict the price in the next 12 months, the results are shown in Table 3.2. The late indica rice prices is in a stable upward trend, and the price of the average monthly growth rate are 0.99 % and 0.96 % respectively. The lowest value is in April 2013, the highest value in April 2014. Two forecast predicted results show the lowest price growth in September and March, the highest price growth.

3.3.3 Nonlinear Optimization Combination Forecasting Model

The development of combination forecasting method is based on comprehensive utilization of predictive information. Combing different forecasting models should reduce forecasting system error, and significantly improve prediction effects. The combined model is eclectic, because it will be a variety of different types of single forecasting model, involving more economic information and forecasting techniques. Obviously there is a certain uncertainty and loss of information in predicting prices of grain crops, so this part is based on nonlinear optimization method in order to build a combination model to effectively select the weight coefficient of each individual prediction model.

To build composite model we selected sample interval segment data from January 2007 to March 2013, in order to assess the predictive accuracy of the prediction model, this paper will optimize the objective function of MAPE optimization model shown as formula (3.7), where ${x_i}^t$ is the i-th model predictive value of t data, ${x_0}^t$ means that the true value of the t data, w_i means that the weight of the i-th prediction model.

$$\min \quad mape = \sum_{t=1}^{N} \left| \frac{\sum_{i=1}^{m} w_i {x_i}^t - {x_0}^t}{{x_0}^t} \right|$$
$$s.t. \begin{cases} \sum_{i=1}^{m} w_i = 1 \\ w_i \geq 0, i = 1, 2 \ldots m \end{cases} \tag{3.7}$$

Solving (3.7) of optimization model to get the weight of the combined model: the weights of the DFM and the TSM in the late indica rice combination optimization model are respectively 60.92 %, 39.08 %. The weights of SARIMA model and the seasonal factor separation model in the corn combination optimization model are respectively 29.62 %, 70.38 %. The late indica rice price prediction accuracy improves 0.06 % relative to the DFM, 0.10 % relative to the TSM; the corn price prediction accuracy improves 0.23 % relative to the SARIMA model, 0.03 % relative to the seasonal factor separation model. From combinatorial optimization comparison of prediction accuracy of the model with a single model, it can be seen that greater the weight of a single model, the smaller the superiority of prediction accuracy of optimize the combination to the single model prediction accuracy (Fig. 3.6).

Using nonlinear optimization combination forecasting model to predict the next 12 months corn and late indica rice in the domestic market, the result shows in the following table:

From Table 3.3, we can see that the late indica rice price in the next 12 months continued upward trend, which is the same in the two models respectively judgment; but the average monthly growth rate becomes 0.98 %, which is a compromise between the two models. In terms of the rate of increase of each month, in March 2014 achieved the highest growth rate of 2.32 %, while the lowest growth rate in September 2014 was 0.13 %, which is mainly due to changes in seasonal factors.

There is a slight difference in corn price between the results of the combination model and the basic model of the next 12 months. The model indicates that the price of corn continually increased from May, reaching peak in August and September. In

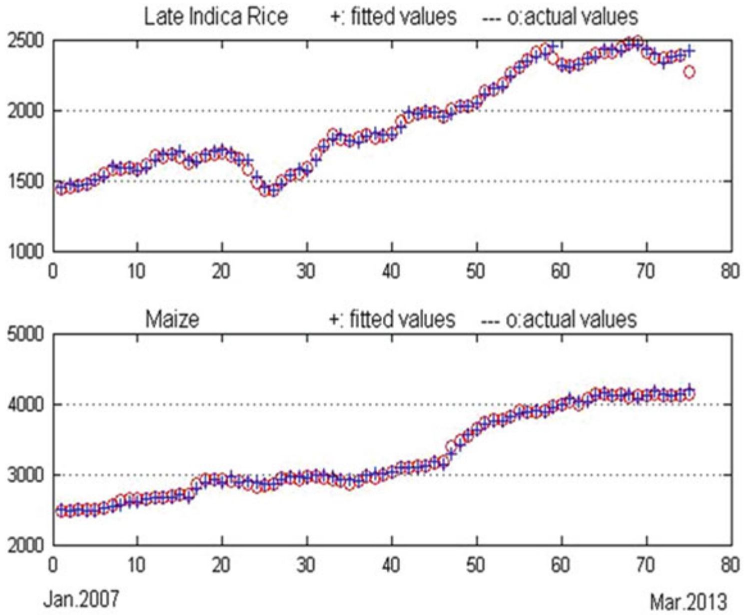

Fig. 3.6 Combination forecasting model fitting result

October corn prices will begin to decrease, the next few months the fluctuations of corn prices are minor and achieve a short-term peak in March next year.

3.4 The Establishment of an Early Warning System for Corn and Late Indica Rice Prices

Based on the historical data of grain prices, the change rates of the late indica rice and corn prices should be maintained in the normal state. Continuously or frequently ultra-high negative or ultra-high positive in the rates may indicate that a warning condition is reached. Therefore, the change rate of food prices is selected as the early warning indicator.

In this paper we selected the grain prices rate of change as the warning index system. The price of grain as an absolute index always has an obvious ascending tendency, which may cover some important information. The grain prices rate of change is a relative index with high volatility.

A continuous-time the change rate is defined to describe the monthly price fluctuations shown as below:

Table 3.3 The nonlinear optimization combination model forecasting

Date	The late indica price prediction	Corn price prediction
Apr-2013	4,186	2,219
May-2013	4,194	2,257
Jun-2013	4,209	2,271
Jul-2013	4,229	2,287
Aug-2013	4,260	2,316
Sep-2013	4,266	2,316
Oct-2013	4,287	2,263
Nov-2013	4,346	2,287
Dec-2013	4,391	2,285
Jan-2014	4,470	2,281
Feb-2014	4,527	2,258
Mar-2014	4,632	2,304
Apr-2014	4,706	2,291

Unit: Yuan/ton

$$PR_t = \ln p_t - \ln p_{t-1}$$

p_t and p_{t-1} represents the food price in period t and $t-1$ respectively, while PR_t represents the price fluctuations.

The average volatility of the late indica rice price is 0.7 % with the standard deviation of 1.35 % from January 2007 to March 2013; the average volatility of corn price is 0.61 % with a standard deviation of 2.16 %. The average of grain price volatility is selected as the warning degree standard, and the warning range is determined by the standard deviation. The Table 3.4 lists early warning degree, warning limit, signal lamp and the corresponding characteristics of the market state.

The warning signal lamps from March 2012 to March 2013 are shown in Table 3.5, from which we can see that during the past 13 months grain prices remained stable. Both the late indica rice and corn prices remained normal. If continuous crimson light or dark blue lamp lights shows in a period of time or alternately change, there may be a certain volatility of grain prices risk, the appropriate measures should be needed.

Using optimal model to predict the late indica rice and corn from April 2013 to April 2013, the corresponding lists of the month Alarming signals list in Table 3.6. It can be seen that within the next 12 months, under the premise of no major incidents occurred, late indica rice and corn prices will be stable and normal fluctuations. The corn prices shows larger declines in prices except for a few months, the rest are kept smooth fluctuations. In certain months of a larger decline in the state did not last long, and the price level in the short-term volatility phenomenon does not appear.

Table 3.4 Food price warning and warning range

Warning degree	Warning range	Signal lamp	Market state
Too low	$(-\infty, M-2\delta)$	● (dark blue)	Fell too low
Relatively low	$[M-2\delta, M-\delta)$	● (light blue)	Fell relatively low
Normal	$[M-\delta, M+\delta)$	● (green)	Steady
Relatively high	$[M+\delta, M+2\delta)$	● (pink)	Rose relatively high
Too high	$[M+2\delta, +\infty)$	● (red)	rose too high

Note: M means the experience of grain price volatility, δ means the standard deviation of price fluctuations

Table 3.5 Warning signal lamp March 2012–March 2013

Warning	2012.3	4	5	6	7	8	9	10	11	12	2013.1	2	3
Rice	● (light blue)	● (pink)	● (green)	● (green)	● (green)	● (green)	● (light blue)	● (green)	● (green)	● (green)	● (green)	● (green)	● (green)
Corn	● (green)	● (green)	● (green)	● (green)	● (green)	● (green)	● (green)	● (light blue)	● (light blue)	● (green)	● (green)	● (green)	● (dark blue)

Table 3.6 price prediction and warning information from April to December2013

Data	Late indica price	Signal lamp	Corn price	Signal lamp
Apr-13	4,186	● (green)	2,219	● (light blue)
May-13	4,194	● (green)	2,257	● (green)
Jun-13	4,209	● (green)	2,271	● (green)
Jul-13	4,229	● (green)	2,287	● (green)
Aug-13	4,260	● (green)	2,316	● (green)
Sep-13	4,266	● (green)	2,316	● (green)
Oct-13	4,287	● (green)	2,263	● (light blue)
Nov-13	4,346	● (green)	2,287	● (green)
Dec-13	4,391	● (green)	2,285	● (green)
Jan-14	4,470	● (green)	2,281	● (green)
Feb-14	4,527	● (green)	2,258	● (green)
Mar-14	4,632	● (green)	2,304	● (green)
Apr-14	4,706	● (green)	2,291	● (green)

3.5 Conclusions and Policy Recommendations

This paper builds time series models characterized with high precision based on the wholesale price of corn and late indica rice and makes prediction about the prices of them in the future 12 months. The results show that the late indica rice price has an increase trend, and the increase rate can be 0.98 %, while the corn price should fluctuate within a small range in the following 12 months and it is not positive for increase.

The establishment of early warning models to some extent gives the late indica rice and corn prices reasonable monitoring. If grain prices appear acute fluctuation within a certain period of time, the signal indicator will light continuous dark blue (red) light or the blue alternating red light will appear frequently, when timely measures should be supposed to be taken. Through this system, the warning model made by the late indica rice and corn prices show that, within the next 12 months, the prices of these two crops will not be in a seriously warning condition. In order to maintain the healthy development of domestic grain prices, we offer the following policy recommendations based on the above analysis:

Firstly, perfect regulation system of grain prices. Price analysis and early warning system through theoretical analysis also need to go through the test of practical application. Combined with a variety of factors and the linkage between forecasting and early warning system, macro-control policies are needed to make to avoid grain prices wild swings.

Secondly, provide forecasting information service for farmers. Fluctuations in grain prices are always caused by supply and demand. If the forecasting and early warning system was implemented, farmers could arrange the plant planning reasonably to steer clear of lowest prices. It also could help the government to make policies of supporting agriculture and giving favorable treatment to farmers.

Thirdly, improve the competitiveness of the domestic food price. Compared with imported food, domestic food is in disadvantage position mainly due to the food production. The scale effect for food production should be improved. Food production cooperatives should be established and supported to strengthen the technical service of agricultural distribution, machine service, specializing in plant protection and so on. A diversified, multi-level, multi-form operating service system should be formed to improve the competitiveness of the domestic food price.

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Chapter 4
Decomposition Study of the Agricultural Products Price

Zhong Wan, Lin Bai, Wei-jun Lin, Wei Fang, and Dong-xia Duan

Abstract According to the data characteristics of pigs, eggs and early indica rice, rice varieties broken down into the season, trend, cycle, and the random component, with the method of X-12, H-P Adjustments and estimate. It turns out that: random shocks in most years less the impact of pigs、eggs and early indica rice prices, deterministic trend is dominated by abnormal price fluctuations less. In addition, the pig、egg and early indica rice price since 2000 experienced a total of three complete cycles, average cycle length of 39 months.

Keywords Agricultural • Prices decomposition • Component estimates

4.1 Introduction

About the study of price fluctuations of agricultural products, the foreign scholar focuses on methods and models of innovation, has formed a measure of price fluctuations of agricultural products, factors explain price fluctuations mature steady-state theory. Study on the fluctuation of the price of agricultural products in early is mainly to price volatility measure, and the most famous is made by Schuhz, Tinbergen and Ricei, after Kaldor and Ezekiel to expand into the cobweb model (Engle 1982) Thereafter, Engle pioneering ARCH model (Engle et al. 1987; Bollerslev 1986) Bollerslev GARCH model (Fox 1953). All of these models into a mature method applied to study the price fluctuation of agricultural products. Sims groundbreaking proposed VAR model, VAR model, the VEC model and impulse response functions and variance decomposition techniques are widely applied to the

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_4, © Springer-Verlag Berlin Heidelberg 2014

study of fluctuations in the prices of agricultural products delivery (Gardner 1975). Empirical, Fox (Pindyck and Rotemberg 1990) to establish the spatial price equilibrium model from the demand point of view of the fluctuations in the prices of agricultural products; Gardner (Lapp and Smith 1992) balanced mobility model, and carried out pioneering research on the prices of agricultural products to pass a perfectly competitive market conditions; Pindyck (Trostle 2008) from the point of view of changes in macroeconomic or monetary factors studied changes in commodity prices; Lapp and Smith (1992) agricultural prices and volatility levels directly and indirectly affected by macroeconomic policies, especially monetary policy; Trostle (2008) studied the prices of agricultural products continued volatility normalized. Research on the prices of agricultural products, the domestic scholar focuses on the price monitoring and application of the model calculation and measurement of the amplitude of fluctuations in the prices of agricultural products and Empirical Analysis of influencing factors. The current fluctuations in the prices of agricultural products the relevant theoretical method is more mature, and lack of an objective and standardized study of the internal characteristics of the fluctuations in the prices of agricultural products, lack of for specific agricultural prices volatility system. It is based on the above study, this paper pigs, eggs, live chickens and early indica rice price fluctuations as the research object, its price is decomposed into a trend component, cyclical components, seasonal ingredients, and the random component of the system to study the price volatility characteristics.

4.2 Data Sources

In the present study, the egg and chicken price come from China animal husbandry, and early indica rice prices come from Chinese food network, and each month the consumer price index published by the National Bureau of Statistics them deflator, deflated by the corresponding the data is shown in Fig. 4.1.

4.3 Price Decomposition

In this paper, using the X-12 seasonal decomposition and HP filtering method, to decompose China's pig, eggs, live chickens and early indica rice prices. The price of agricultural products of the trend component, periodic component and the seasonal component and random component were shown in Table 4.1.

4.3.1 Trend Component

First, through the decomposition, we get the trend components of pigs, eggs, live chickens and early indica rice price, as shown in Fig. 4.2, PIG, Egg, Chicken and Rice on behalf of the pigs, eggs, live chickens and indica rice elimination of price

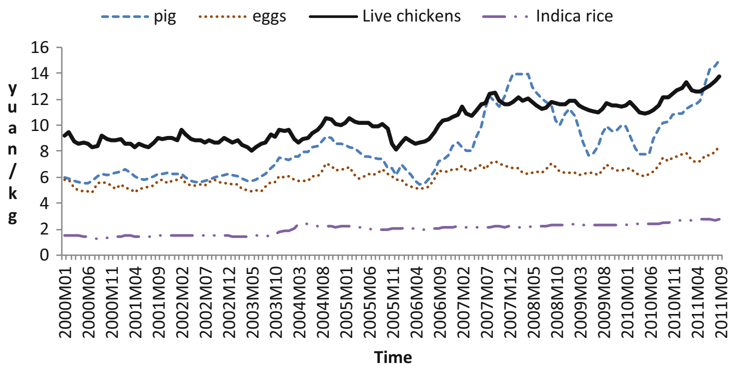

Fig. 4.1 January 2000–September 2011, pigs, eggs and live chickens and early indica rice price series

Table 4.1 Agricultural prices of each component contribution rate

	Trend component (%)	Periodic component (%)	Seasonal ingredients (%)	Random component (%)
Pig	86.23	9.40	3.07	1.29
Eggs	91.99	3.65	3.45	0.91
Live chickens	94.02	3.50	1.66	0.82
Indica rice	94.26	3.76	1.27	0.71

inflation, P1, E1, C1 and R1, respectively, representing a variety of agricultural prices decomposition trend component.

4.3.2 Cycle Component

By using the HP filtering method to calculate and decompose the periodic components, egg, chicken and pig price of early indica rice. Combination of prices of agricultural characteristics of the data, the cycle of pigs, eggs, live chickens and indica rice and other agricultural prices to be divided, as shown in Fig. 4.3.

According to the characteristics of the periodic component of the prices of agricultural products, live pigs and live chickens cycle is divided into peak to trough to trough to peak as a complete cycle, eggs and indica rice as a complete cycle. From January 2000 to September 2011, the price of live pigs and live chickens divided into two complete cycles, the third cycle will end in September 2011; eggs and indica rice prices divided into three complete cycles. According to Table 4.1, pigs, eggs, live chickens and indica rice price cycle probably were: 40–42 months, 32–47 months, 27–37 months and 30–49 months, and pigs, eggs, indica rice price cycle has a tendency to increase.

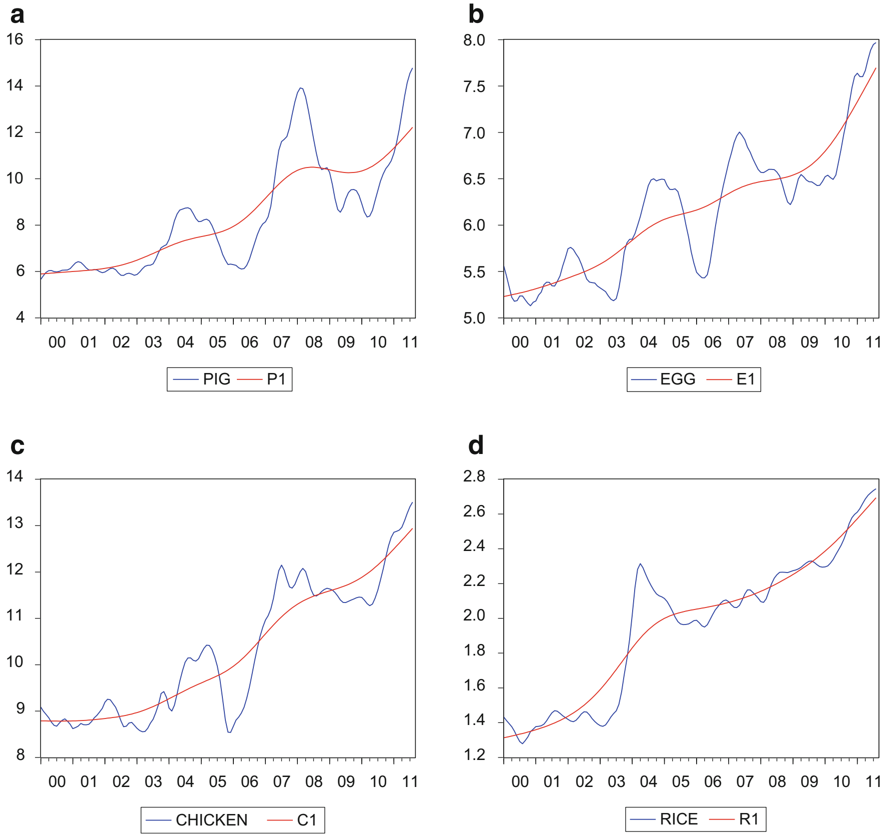

Fig. 4.2 China's major agricultural products and its trend component. (**a**) Pigs. (**b**) Eggs. (**c**) Live chickens. (**d**) Indica rice

4.3.3 Seasonal Ingredients

The seasonal ingredients pigs, eggs, live chickens and indica rice prices decomposition is shown in Fig. 4.4. The seasonal component of the 4 in the prices of agricultural products are analyzed as follows:

1. pigs: see Fig. 4.4a, the seasonal component of China's hog prices in May–June trough and a small peak in September–October, the highest peak in December–January. Description seasonal factors in May–June, 12–1 impact on the price of live pigs, 5–6 seasonal factors inhibit the upward trend of the price of live pigs in December–January season factors driving prices of live pigs.
2. eggs: see Fig. 4.4b, the price of eggs in China seasonal ingredients generally appear in the April–May troughs and peaks in September–October, Help seasonal factors, in April–May, September–October eggs Price, 4–5 seasonal factors inhibit

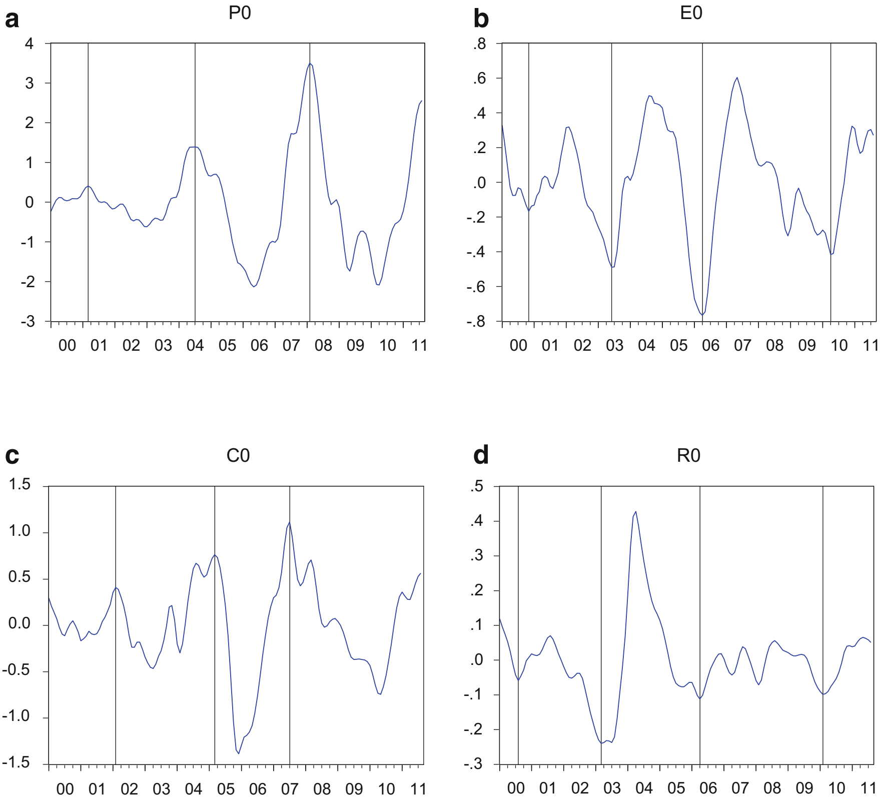

Fig. 4.3 The price cycle of pigs/eggs/live chickens and indica rice (PS: (**a**) Pigs, (**b**) eggs, (**c**) live chickens, (**d**) indica rice)

the upward trend of the price of eggs, seasonal factors driving the price of eggs rose in September to October.

3. live chickens: see Fig. 4.4c, the price of live chickens in China seasonal ingredients generally appear in the May–July troughs and peaks in September–October, Help Help seasonal factors in May–July, September–October the price of live chickens, 5–7 seasonal factors inhibit the upward trend of the price of live chickens, seasonal factors promote the live chicken prices in September–October.
4. Early Indica Rice: see Fig. 4.4d, China indica rice prices seasonal ingredients generally appear in the March–April peak, trough in July–August, Help Help seasonal factors, in March–April, July–August the price of early indica rice, March–April season factors driving the trend of indica rice prices, seasonal factors inhibit indica rice prices in July–August.

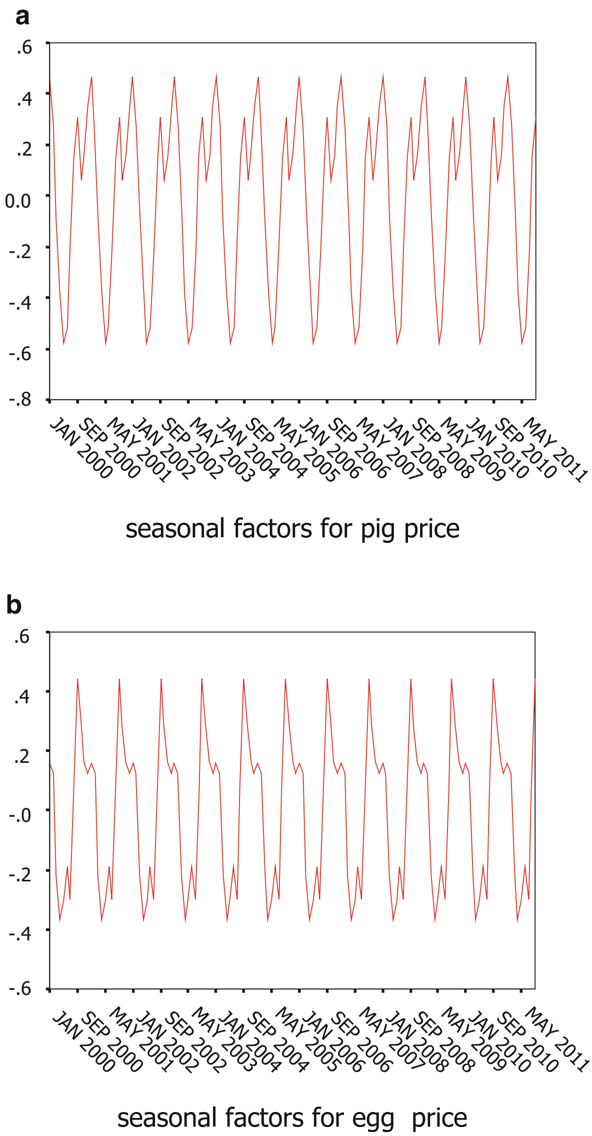

Fig. 4.4 (continued)

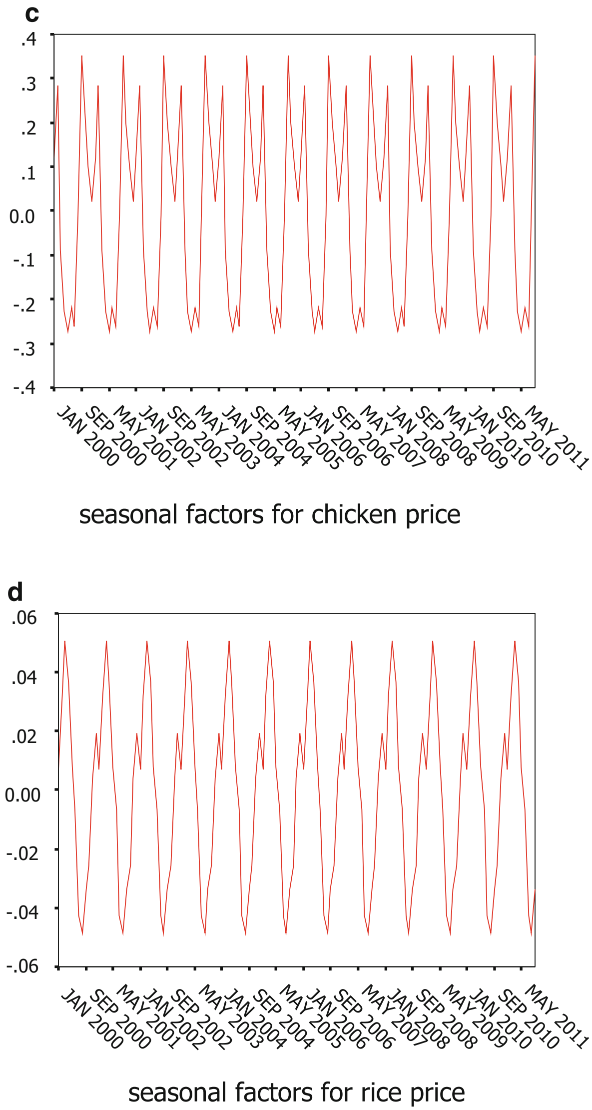

Fig. 4.4 China's major agricultural prices seasonal factors. (**a**) Pigs. (**b**) Eggs. (**c**) Live chickens. (**d**) Indica rice

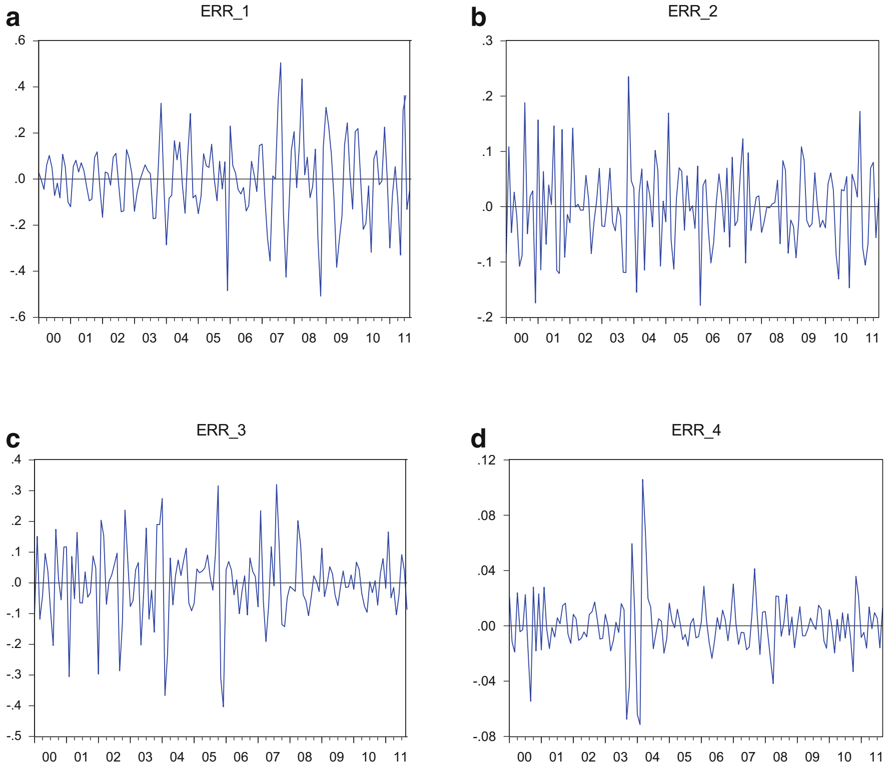

Fig. 4.5 The prices random component values of pigs/eggs/live chickens and indica rice (PS: (**a**) Pigs, (**b**) eggs, (**c**) live chickens, (**d**) indica rice)

4.3.4 Random Component

Various agricultural prices exploded view of the decomposition of the random component is shown in Fig. 4.5, and the random component and the actual price ratio is a measure of the random factor the impact of fluctuations in the prices of agricultural products.

4.4 Analysis and Conclusion

Overall, the contribution rate of the trend component pigs, eggs, live chickens and indica rice prices of agricultural products in more than 85 % of the prices of agricultural products, has an absolute leading role; composition of the rest of the cycle, the seasonal component and the random component the contribution rate of the prices of agricultural products are generally not more than 10 %, the degree of influence on the prices of agricultural products is relatively low. In comparison, the periodic component and the random component of the overall contribution rate of hog prices higher than the contribution rate of 3 Price. Periodic component impact on the price of live pigs contribution rate up to 9.4 %, eggs, live chickens and indica rice affect the contribution rate of more than 2 times; random component hog prices affect the contribution rate of 1.29 %, far higher than that of the egg, live chickens and indica rice affect the contribution rate of 0.91 %, 0.82 % and 0.71 %, respectively. The contribution rate of the random component of this study four types of agricultural prices affect the overall lower these price fluctuations of agricultural products did not appear abnormal, as a whole or in a controllable state. Among them, the random component of indica rice price contribution rate is particularly low, only 0.71 %. The following conclusions:

1. The trend component will promote long-term agricultural commodity prices remain high, pigs, eggs, live chickens and indica rice and other agricultural prices vary. With respect to livestock products, the trend component indica rice prices, the performance of the price of rice is relatively more stable and livestock, government regulation of the rice market in recent years with great results.
2. pigs, eggs, live chickens and indica rice price cycle of the same are as follows: 40–42 months, 32–47 months, 27–37 months and 30–49 months, and pigs, eggs indica rice price cycle has a tendency to increase.
3. pigs, eggs, live chickens and indica rice prices there are strong seasonal pattern, seasonal ingredients for livestock and crop products at different times. The seasonal factor greater impact in the price of live pigs, eggs and live chickens and other livestock products from May to July and September to December, and the impact on the price of early indica rice in March–April and July–August.
4. random component of pigs, eggs, live chickens and indica rice price shocks of the same, but the overall impact is small, the prices of agricultural products basically in a stable situation. Years in addition to individual components, accounting for the proportion of the entire agricultural prices low, most of the year are less than 5 %.

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Chapter 5
Research on the Optimal Combination Forecasting Model for Vegetable Price in Hainan

Lu Ye, Yuping Li, Yanqun Liu, Xiaoli Qin, and Weihong Liang

Abstract Hainan is the national people's "Vegetable Basket" in winter. It is of great significance to accurately predict vegetable market price in Hainan for farmers cultivating "vegetable garden" good and government holding "vegetable basket" steady. The theory of combination forecasting is practicable in complex economic system. In view of complexity of vegetable market system, by using the data of vegetable market price in Hainan, three models are set up separately which are Triple exponential smoothing model, simple linear regression model, and grey forecasting model. Then, an optimal combination forecasting model is constructed based on three models above. The prediction results show that the prediction accuracy of the optimal combination forecasting model is superior to the single model, and the model overcomes limitation of the single model and effectively improves the prediction results of vegetable market price.

Keywords Vegetable price • Triple exponential smoothing model • Simple linear regression model • Grey forecasting model • Optimal combination forecasting model

5.1 Introduction

Hainan province lies to the northern edge of tropic, becoming the national people's "Vegetable Basket" in winter with unique region and climate. Hainan vegetable cultivation is dominated by winter vegetable, which covers about 20 million hm^2,

Major project of science and technology of Hainan (ZDXM20110075)
Project of agro-technology extension of Ministry of Agriculture of PRC (13RZNJ-32)

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_5, © Springer-Verlag Berlin Heidelberg 2014

whose amount being transported out of Hainan Island increases year by year, and amount of fruit and vegetable out of Hainan Island is 570 million ton in 2011; perennial vegetable covers 5333 hm^2, in summer and autumn people's demand of vegetable on the island mainly depend on places out of Hainan Island. Local vegetables after 3–4 links, and vegetables bought out of the island appear in the market generally after 5–6 links, so the retail price is usually 3–5 times higher than the purchase price. Under the present situation of small production scale, scattered production link and backward circulation mode, the phenomenon of cheap vegetable hurting farmers or expensive vegetable hurting citizens repeatedly appear on account of asymmetrical production and marketing information. Vegetable growers don't have scientific planting plan and usually plant following suit, leading to high yield but no harvest. Especially in 2012, a mild winter, some vegetable prices are low even going bad in the soil with no acquisition, which seriously damages the interests of farmers. It is of great significance to predict vegetable market prices with scientific method for farmers' production decision, consumers' low economic losses and government regulation. Among methods of analysis and prediction on vegetable price, quantitative forecasting method is applied less, neural network (Luo Changshou 2011; Zhang Jinshan and Xie Xiangtian 2011), time series model (Li Ganqiong et al. 2010; Shen Chen and Mu Yueying 2011), and Markov chain are applied more prominently on vegetable price prediction research (Zhu Xiaoxia 2012). The theory of combination forecasting is practicable in complex economic system with uncompleted information. Because vegetable market system is of complexity, three forecasting models are separately selected from three kinds of forecasting methods which are time series prediction, causality prediction, and intelligent prediction, then weighted coefficients are calculated with the optimal weighting method, at last an optimal combination forecasting model is constructed based on three models above, which offers reference method for vegetable price prediction.

5.2 Prediction Methods

5.2.1 Triple Exponential Smoothing Method

Exponential smoothing method is a special weighted moving average forecasting method on the basis of moving average forecasting method, also a kind of important method of time series prediction (Li Shanshan 2012). In the method the future of phenomenon is predicted by calculating exponential smoothing values coordinated with some time series forecasting models, and exponential smoothing value in any period is the weighted average of observed value in current period and exponential smoothing value in previous period.

Triple exponential smoothing method is also Brown nonlinear exponential smoothing method. The method is another exponential smoothing on the basis of single, double exponential smoothing values, by which the parameters of the nonlinear model are estimated, so as to predict nonlinear time series. The forecasting model is set up as follows:

$$\hat{Y}_{\mathrm{t+T}} = \mathrm{a_t} + \mathrm{b_t T} + \mathrm{c_t T^2} \tag{5.1}$$

Where $\hat{Y}_{t+T}$ denotes predictive value in the period t plus T; T denotes number of periods after the period t; a_t, b_t and c_t denote smoothing coefficients.

a_t, b_t and c_t are determined by the following formulas:

$$a_t = 3S_t^{(1)} - 3S_t^{(2)} + S_t^{(3)} \tag{5.2}$$

$$\mathrm{b_t} = \frac{\alpha}{2(1-\alpha)^2}\left[(6-5\alpha)\mathrm{S_t^{(1)}} - 2(5-4\alpha)\mathrm{S_t^{(2)}} + (4-3\alpha)\mathrm{S_t^{(1)}}\right] \tag{5.3}$$

$$\mathrm{c_t} = \frac{\alpha^2}{\alpha(1-\alpha)^2}\left(\mathrm{S_t^{(1)}} - 2\mathrm{S_t^{(2)}} + \mathrm{S_t^{(3)}}\right) \tag{5.4}$$

Where α denotes weighted coefficient ($0 \le \alpha \le 1$); S_t^1 denotes single exponential smoothing value in the period t; S_t^2 denotes double exponential smoothing value in the period t; S_t^3 denotes triple exponential smoothing value in the period t.

Single, double, triple exponential smoothing value $\mathrm{S_t^{(1)}}$, $\mathrm{S_t^{(2)}}$ and $\mathrm{S_t^{(3)}}$ are determined by the following formulas:

$$\mathrm{S_t^{(1)}} = \alpha \mathrm{Y_t} + (1-\alpha)\mathrm{S_{t-1}^{(1)}} \tag{5.5}$$

$$\mathrm{S_t^{(2)}} = \alpha \mathrm{S_t^{(1)}} + (1-\alpha)\mathrm{S_{t-1}^{(2)}} \tag{5.6}$$

$$\mathrm{S_t^{(3)}} = \alpha \mathrm{S_t^{(2)}} + (1-\alpha)\mathrm{S_{t-1}^{(3)}} \tag{5.7}$$

Where y_t denotes observed value in the period t; S_{t-1}^1 denotes single exponential smoothing value in the period before the period t; S_{t-1}^2 denotes double exponential smoothing value in the period before the period t; S_{t-1}^3 denotes triple exponential smoothing value in the period before the period t.

5.2.2 *Simple Linear Regression Method*

Linear regression method is a kind of causality prediction method applied widely, also a statistical method used to handle interdependent relationship among multi-varieties. Simple linear regression method is a method that linear regression equation of independent variable x and dependent variable Y is set up to predict according to the correlation between x and Y. The forecasting model is set up as follows (Liu Xiaoxu 2009):

$$\hat{Y}_t = \mathrm{a} + \mathrm{bx_t} \tag{5.8}$$

Where x_t denotes independent variable value in the period t; $\hat{Y}_t$ denotes dependent variable value in the period t; a, b denote parameter of simple linear regression Equation.

a, b are determined by the following formulas:

$$\begin{cases} a = \dfrac{\sum_{i-1}^{n} Y_i}{n} - b\dfrac{\sum_{i-1}^{n} X_i}{n} \\ b = \dfrac{n\sum_{i-1}^{n} X_i Y_i - \sum_{i-1}^{n} X_i \sum_{i-1}^{n} Y_i}{n\sum_{i-1}^{n} X_i^2 - \left(\sum_{i-1}^{n} X_i\right)^2} \end{cases} \tag{5.9}$$

5.2.3 *Grey Forecasting Method*

Grey forecasting method obtains new ideas, new methods and new ideas about prediction from the thought of grey system modeling, correlation and residual identification. Prediction and analysis process of grey system can generally be divided into three steps: grey generating, parameter computation and accuracy test (Liu Sifeng and Xie Naiming 2008; Liu Dongjun and Zhou Zhihong 2011).

Firstly, grey generating. There is an original data sequence $x^{(0)} = (x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n))$, whose first order accumulation generated sequence is as follows:

$$x^{(1)} = \left(x^{(1)}(1), x^{(1)}(2), \ldots, x^{(1)}(n)\right) \tag{5.10}$$

Where $x^{(1)}(k)$ is computed as follows:

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), k = 1, 2, \ldots, n.$$

And then differential equation model is set up as follows:

$$\frac{dx^{(1)}}{dt} + \alpha x^{(1)} = \mu \tag{5.11}$$

Second, parameter is computed. α, μ are computed by least square method as follows:

$$\begin{bmatrix} \alpha \\ \mu \end{bmatrix} = \left(B^T B\right)^{-1} B^T Y_N \tag{5.12}$$

Where B, Y_N are computed by the following formulas:

$$B = \begin{pmatrix} -\left(x^{(1)}(1) + x^{(1)}(2)\right)/2 & 1 \\ -\left(x^{(1)}(2) + x^{(1)}(3)\right)/2 & 1 \\ \vdots & \vdots \\ -\left(x^{(1)}(n-1) + x^{(1)}(n)\right)/2 & 1 \end{pmatrix}, Y_N = \begin{pmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{pmatrix}.$$

Then, the solution of differential equation, namely the time response function is set up as follows:

$$\hat{x}^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{\mu}{\alpha}\right)e^{-\alpha k} + \frac{\mu}{\alpha}(k = 1, 2, \ldots, n) \tag{5.13}$$

The accumulative revivification of $\hat{x}^{(1)}(k+1)$, namely predictive value of original data is as follows:

$$\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k) \tag{5.14}$$

Lastly, accuracy is tested. The mean value of residual is calculated by the following formula:

$$\overline{\varepsilon}^{(0)} = \frac{1}{n}\sum_{i=1}^{n} \varepsilon^{(0)}(i) \tag{5.15}$$

Where $\varepsilon^{(0)}(i)$ is calculated as follows:

$$\varepsilon^{(0)}(i) = x^{(0)}(i) - \hat{x}^{(0)}(i), i = 1, 2, \ldots, n.$$

The residual variance is calculated as follows:

$${s_1}^2 = \frac{1}{n}\sum_{i=1}^{n}\left[\varepsilon^{(0)}(i) - \overline{\varepsilon}^{(0)}\right]^2 \tag{5.16}$$

The variance of the original data is calculated as follows:

$${s_2}^2 = \frac{1}{n}\sum_{i=1}^{n}\left[x^{(0)}(i) - \overline{x}\right]^2 \tag{5.17}$$

Where $\overline{x}$ is calculated by the following formula:

Table 5.1 The reference table for prediction grade

Precision grade	*Good (I)*	*Qualified (II)*	*Marginal (III)*	*Disqualified (IV)*
c	$c < 0.35$	$0.35 \le c < 0.50$	$0.50 \le c < 0.65$	$c \ge 0.65$
p	$p \ge 0.95$	$0.80 \le p < 0.95$	$0.70 \le p < 0.80$	$p < 0.70$

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x^{(0)}(i)$$

Mean square error ratio and small error probability are calculated as follows:

$$\begin{cases} c = s_1/s_2 \\ p = p\{\varepsilon^{(0)}(i) - \bar{\varepsilon}^{(0)} < 0.6745 s_2\} \end{cases} \tag{5.18}$$

The judgement standard is shown in Table 5.1.

5.2.4 *Optimal Combination Forecasting Method*

Combination forecasting is a method that two different forecasting methods are used on the same problem, synthetically utilizing information of each single prediction and revising system error of each single forecasting model to improve prediction accuracy. In the research, the target function Q is constructed by some optimal criterion, and minimized under constraint condition, so that the optimal weighted coefficients of combination forecasting model are obtained (Sun Nan 2004). The optimal combination forecasting model is

$$Y(t) = \omega_1 \hat{Y}(t)^{I} + \omega_2 \hat{Y}(t)^{II} + \omega_3 \hat{Y}(t)^{III} \tag{5.19}$$

Where ω_1, ω_2, ω_3 denote undetermined weighted coefficients, t denotes the number of data series.

The target function is $Q = \sum_{i=1}^{t} e(t)^2$, and programming problem becomes as follows:

$$\begin{cases} \min Q \\ \omega_1 + \omega_2 + \omega_3 = 1 \\ 0 \le \omega_1, \omega_2, \omega_3 \le 1 \end{cases} \tag{5.20}$$

Where $e(t) = \omega_1\left(Y(t) - \hat{Y}(t)^{I}\right) + \omega_2\left(Y(t) - \hat{Y}(t)^{II}\right) + \omega_3\left(Y(t) - \hat{Y}(t)^{III}\right)$.

After the optimal solution of the programming equation is obtained, the optimal combination forecasting model can be constructed.

Table 5.2 The monthly average retail price of main vegetable varieties in Hainan from March 2012 to February 2013 (unit: Yuan/0.5 kg)

Month	*Mar. 2012*	*Apr. 2012*	*May. 2012*	*Jun. 2012*	*Jul. 2012*	*Aug. 2012*	*Sep. 2012*	*Oct. 2012*	*Nov. 2012*	*Dec. 2012*	*Jan. 2013*	*Feb. 2013*
Price	2.83	2.69	3.08	3.01	2.92	3.02	2.84	2.70	2.70	2.76	2.68	2.63

5.3 Empirical Study

5.3.1 Data Source

In the research, the original data dates from Hainan province website (Price Bureau of Hainan Province 2013), on the basis of price's rapidly change and prediction's practicability, selecting month for statistical dimension, the monthly average retail price of main varieties of vegetables such as green pepper, pepper, celery, rape, cabbage, green bean, leek, tomato, white radish, carrot, eggplant, potato, and cucumber from March 2012 to February 2013 in Hainan province is shown in Table 5.2. Accurately predicting retail prices is convenient for government regulating vegetable price in time and avoiding vegetable price rising or falling too fast.

5.3.2 Simulation and Prediction

Firstly, use triple exponential smoothing method to predict by excel tool. The initial value can be taken the first value or average or weighted average of partial value, in this research, the first value is selected as the initial value. In order to make prediction more accurate, different α values are selected for trial, so as to select reasonable α value to make error less combining with specific conditions. Through constant trial, α value is determined equaling to 0.20 at last according to the principle that the average of root-mean-square error of each three set prediction is as small as possible, and the outcomes of model fitting are shown in Table 5.3.

Second, use simple linear regression method to predict by excel tool, selecting input area of Y, input area of X, and output area of the result to calculate, so that the parameter a equals to 2.98 and b equals to -0.02, and the outcomes of model fitting are shown in Table 5.4.

Then, use grey forecasting method to predict by excel tool. Data sequence $x^{(1)}$ is accumulatively generated by (5.10) on the basis of original data $x^{(0)}$, and data matrix B, Y_N are generated by $x^{(1)}$, and the parameter α and μ are calculated by (5.12) as follows:

Table 5.3 The fitting result of triple exponential smoothing model (unit: Yuan/0.5 kg)

t	Month	*Price*	$S_t^{(1)}$	$S_t^{(2)}$	$S_t^{(3)}$	a_t	b_t	c_t	*Fitting value*	*Absolute error*	*Relative error %*
0			2.83	2.83	2.83						
1	Mar. 2012	2.83	2.83	2.83	2.83	2.83	0.00	0.00	2.83	0.00	0.00 %
2	Apr. 2012	2.69	2.80	2.82	2.83	2.76	−0.02	−0.01	2.83	0.14	5.20 %
3	May. 2012	3.08	2.86	2.83	2.83	2.91	0.02	0.01	2.74	0.34	11.01 %
4	Jun. 2012	3.01	2.89	2.84	2.83	2.97	0.03	0.01	2.94	0.07	2.44 %
5	Jul. 2012	2.92	2.89	2.85	2.84	2.96	0.02	0.01	3.01	0.09	3.08 %
6	Aug. 2012	3.02	2.92	2.87	2.84	3.00	0.03	0.01	2.99	0.03	0.92 %
7	Sep. 2012	2.84	2.90	2.87	2.85	2.94	0.01	0.00	3.04	0.20	7.05 %
8	Oct. 2012	2.70	2.86	2.87	2.85	2.83	−0.02	−0.01	2.95	0.25	9.25 %
9	Nov. 2012	2.70	2.83	2.86	2.86	2.76	−0.03	−0.01	2.80	0.10	3.79 %
10	Dec. 2012	2.76	2.82	2.85	2.85	2.74	−0.03	−0.01	2.71	0.05	1.69 %
11	Jan. 2013	2.68	2.79	2.84	2.85	2.70	−0.03	−0.01	2.70	0.02	0.81 %
12	Feb. 2013	2.63	2.76	2.82	2.85	2.64	−0.04	−0.01	2.65	0.02	0.85 %

$$\begin{bmatrix} \alpha \\ \mu \end{bmatrix} = \left(\mathrm{B^T B}\right)^{-1}\mathrm{B^T Y_N} = \begin{bmatrix} 0.0109 \\ 3.0232 \end{bmatrix}$$

Grey forecasting model is set up by (5.13) as follows:

$$\hat{x}^{(1)}(\mathrm{k}+1) = -275.5368\mathrm{e}^{0.0086\mathrm{k}} + 278.3668$$

The predictive value of original data is obtained through accumulative revivification of the predicted value obtained according to grey forecasting model above by (5.14).

Mean square error ratio and small error probability are calculated through residual examination of the predicted value, and their results are as follows:

$$c = 0.0439 < 0.35, \quad p = 1 > 0.95$$

So the level of the grey forecasting model is "Good", fitting precision is very high and prediction results is more accurate. The outcomes of model fitting are shown in Table 5.5.

Lastly, use optimal weighted method to combine three forecasting models above by LINGO 9.0 software. Objective function and constraint conditions are input to dialog box "LINGO Model" to work out that the weight ω_1 of triple exponential smoothing model is 0.13, ω_2 of simple linear regression model is 0.08, ω_3 of grey forecasting model is 0.79, so as to set up combination forecasting model as follows:

$$\mathrm{Y(t)} = 0.13\hat{Y}\,\mathrm{(t)} + 0.08\hat{Y}\,\mathrm{(t)} + 0.79\hat{Y}\,\mathrm{(t)}$$

The outcomes of model fitting are shown in Table 5.6.

Table 5.4 The fitting result of simple linear regression model (unit: Yuan/0.5 kg)

Month	*Mar. 2012*	*Apr. 2012*	*May. 2012*	*Jun. 2012*	*Jul. 2012*	*Aug. 2012*	*Sep. 2012*	*Oct. 2012*	*Nov. 2012*	*Dec. 2012*	*Jan. 2013*	*Feb. 2013*
Fitting value	2.96	2.93	2.91	2.88	2.86	2.83	2.81	2.78	2.76	2.74	2.71	2.69
Absolute error	0.13	0.24	0.17	0.13	0.06	0.19	0.03	0.08	0.06	0.02	0.03	0.06
Relative error %	4.42 %	8.95 %	5.63 %	4.25 %	2.13 %	6.17 %	1.08 %	3.14 %	2.24 %	0.86 %	1.19 %	2.32 %

Table 5.5 The fitting result of grey forecasting model (unit: Yuan/0.5 kg)

Month	*Mar. 2012*	*Apr. 2012*	*May. 2012*	*Jun. 2012*	*Jul. 2012*	*Aug. 2012*	*Sep. 2012*	*Oct. 2012*	*Nov. 2012*	*Dec. 2012*	*Jan. 2013*	*Feb. 2013*
Fitting value	2.83	2.98	2.94	2.91	2.88	2.85	2.82	2.79	2.76	2.73	2.70	2.67
Absolute error	0.00	0.29	0.14	0.10	0.04	0.17	0.02	0.09	0.06	0.03	0.02	0.04
Relative error %	0.00 %	10.64 %	4.41 %	3.24 %	1.34 %	5.64 %	0.74 %	3.28 %	2.16 %	1.14 %	0.71 %	1.65 %

Table 5.6 The fitting result of optimal combination forecasting model (unit: Yuan/0.5 kg)

Month	*Mar. 2012*	*Apr. 2012*	*May. 2012*	*Jun. 2012*	*Jul. 2012*	*Aug. 2012*	*Sep. 2012*	*Oct. 2012*	*Nov. 2012*	*Dec. 2012*	*Jan. 2013*	*Feb. 2013*
Fitting value	2.84	2.95	2.91	2.91	2.90	2.87	2.85	2.81	2.76	2.73	2.70	2.67
Absolute error	0.01	0.26	0.17	0.10	0.02	0.15	0.01	0.11	0.06	0.03	0.02	0.04
Relative error %	0.35 %	9.80 %	5.37 %	3.22 %	0.83 %	5.07 %	0.25 %	4.04 %	2.38 %	1.19 %	0.76 %	1.60 %

Table 5.7 The prediction precision of three single forecasting models and the optimal combination forecasting model

Model	*Mean absolute error*	*Mean relative error*	*Root-mean-square error*	*Standard deviation error*
Triple exponential smoothing	0.1094	0.0384	0.1486	0.1050
Simple linear regression	0.1007	0.0353	0.1211	0.0701
Grey forecasting	0.0826	0.0291	0.1138	0.0818
Optimal combination forecasting	0.0824	0.0290	0.1117	0.0787

5.3.3 Evaluation and Prediction

Prediction accuracy is an important standard for evaluating prediction effect, and error is a measure of accuracy and validity of model, so that error is an important index of evaluating model. There are four common error evaluation indexes, which are mean absolute error, mean relative error, root-mean-square error and standard deviation error (Ding Yongmei 2004). The prediction accuracy of three kinds of single forecasting model and combination forecasting model are shown in Table 5.7. It can be seen that combination forecasting model is closer to the actual data, and its error is smaller than other prediction models from the following table.

The optimal combination forecasting model has minimum error, with which main vegetable varieties prices of Hainan in the next month are predicted, and the result is that the average retail price of March, April and May 2013 are 2.64 Yuan/0.5 kg, 2.60 Yuan/0.5 kg, and 2.56 Yuan/0.5 kg respectively.

5.4 Conclusion

In the research, by using the data of vegetable market price in Hainan, three models are set up separately which are Triple exponential smoothing model, simple linear regression model, and grey forecasting model. Then optimal combination forecasting model of vegetable price is constructed though calculating optimal weighted coefficients based on the three models above so as to predict vegetable price. Conclusions are as follows:

1. Triple exponential smoothing model is lack of resolving ability to turning point of vegetable prices change, accounted to that the model predicts the future according to change characteristics of vegetable prices in the past. And predictive value of the model is dispersed, predictive ability is better in short time span and need to combine with other prediction methods in long time span.
2. Simple linear regression model is a linear simulation to the whole trend of past vegetable price, whose predictive value is rather concentrated, and the model

simulates volatile data bad and need to combine with nonlinear model to improve the prediction accuracy.

3. Grey forecasting model is through generating and handling original vegetable price to find change rule, which is limited by sample size and probability distribution less and better in integrally predicting vegetable price.
4. Vegetable price fluctuation is the outcome of combined action of multiple factors, so single forecasting model is very difficult to fit price of frequent fluctuation closely. The optimal combination forecasting model can gather useful information of single model in larger limit, and think more systematic and comprehensive than single model, so the prediction accuracy is superior to single model.

Strict requirement of prediction and complexity of vegetable market system increase the difficulty of accurate prediction. The research is mainly quantitative analysis on historical vegetable prices, and doesn't bring qualitative factors which affect vegetable price rise and fall into the model (Xu Chao 2010), still needing further exploration in order to improve prediction accuracy.

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Chapter 6
Research and Design of Vegetable Price Spatial-Temporal Transmission Simulation

Fan-tao Kong, Li-yuan Xin, Dong-jie Wang, and Chao Zhang

Abstract To explore vegetable price space, time transmission mechanism and to simulate, which is important to reveal vegetable price fluctuation and slow down vegetable price ups and downs substantially. The paper takes six vegetables' price as example, and selects 108 field markets, wholesale markets and retail markets that scatter Beijing, Shandong and Hainan etc., and collects price data every day, and establishes spatial-temporal set of vegetable price. The paper using factor analysis method explores the reason, character and influencing factors of vegetable price spatial-temporal transmission, and finds mechanism and constructs network topology. The paper, using correlation test, cointegration test, partial adjustment model, Granger causality test and finite distributed lag model and etc., analyses relation, route and strength of vegetable price spatial-temporal transmission, and constructs its model. The paper develops real-time dynamic simulation and display by component technology and GIS analysis. To clarify multidimensional dynamic conduction mode of vegetable price spatial-temporal transmission by regions, markets and varieties, in order to promote vegetable produce, ensure market supply and stable vegetable price.

Project Support: "Twelfth Five-Year plan" Science and technology support program "The key technology research and demonstration of management and information service matching of agricultural production and market circulation" (Project number:2012BAH20B04), 2013 Ministry of Agriculture, Agriculture monitoring and early warning information system project.

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*, DOI 10.1007/978-3-642-54389-0_6, © Springer-Verlag Berlin Heidelberg 2014

Keywords Vegetable • Price • Spatial-temporal transmission • Simulation • Research and design

6.1 Backgrounds

Vegetables are the necessities of life, and its price directly influences the income of farmers and the consumption of residents. The supply and consumption of vegetable is an important part of people's livelihood, and its fluctuation is livelihood barometer to some extent.

Vegetable price fluctuation has become one hot topic of the society. In recent years, due to various uncertainties increasing, vegetable price ups and downs substantially (Kong et al. 2002), to farmers to sell vegetable cheaply, yet to residents to buy vegetable expensively, garlic's and ginger's price are very high, which reflect vegetable market vibrating severely. National leaders always pay attention to vegetable price. On 29th Dec, 2010, General Secretary Hu Jintao inspected vegetable produce base in Beijing Tongzhou, he said it should make every attempt to guarantee the supply of vegetables and stable the price. On 1st Oct, 2011, Premier Wen Jiabao came to Beihang community in Beijing, and asked for the information of direct sale of vegetable on weekends. On 29th JAN, 2013, Premier Wen Jiabao presided over a forum in Zhongnanhai, he and vegetable peddlers analyzed the reason of vegetable price increasing. On 4th Feb, General Secretary Xi Jinping came to Lanzhou Wuquan vegetable market in Gansu Province, and he asked whether or not vegetable price increase and how about the local vegetable produce, and he asked for the information about cabbages', potatoes', tomatoes' and onions' price.

In recent years, fluctuation frequency and range of vegetable price have been intensified in China. China vegetable market appeared "five stages" in 2012 (Kong Fan-Tao et al. 2013). Taking 28 vegetables' average price monitored by Ministry of Agriculture as example, vegetable price increased slowly from January to March, it reached 4.15 yuan/kg; it dropped quickly from April to June, it reached 2.91 yuan/kg; it rebounded slightly from July to August, it reached 3.47 yuan/kg; it dropped gradually from September to October, it reached 2.7 yuan/kg, and it felled below the level of same period in 2011, and some vegetable varieties appeared selling for difficulty; it seasonal adjusted from November to December, it reached 3.65 yuan/kg. In the matter of fluctuation range of annual vegetable price, fluctuation range of vegetable price in 2012 was much more obvious than former years, the gap between the highest price and the slowest price was 1.35 yuan/kg, and it was 1.23 yuan/kg in 2011, and it was 1.01 yuan/kg in 2010, and it was 1.01 yuan/kg in 2009 (Zhang Yu-Mei et al. 2012).

6.2 Content

6.2.1 Construct Vegetable Price Spatial-Temporal Data Set

The paper will construct vegetable price spatial-temporal data set, because there are some problems such as data can't be collected timely, the standard are unified, quality are difficult to control, data collection are low frequent and so on. Firstly, to ensure vegetable variety, dimension of space and time. On the basis of investigation, it is necessary to ensure vegetable variety, and it is from main provinces, regions and concrete market, and to ensure the time and frequency of collecting vegetable information. Secondly, ensure the samples and layout of vegetable price spatial-temporal data. Combined with the principle of statistics and GIS, to use the principle of stratified sampling, on the basis of variety, dimension of space and time, and to ensure the sampling frame, market ratio, collected content and frequency etc. Construct vegetable price spatial-temporal data set in order to reveal the variability and gradient of vegetable price. Thirdly, improve the information acquisition device. On the basis of existed device, integrate GIS, GPS and GPRS etc., and to improve the information acquisition device that is portable and on the basis of Android system.

6.2.2 Mechanism of Vegetable Price Spatial-Temporal Transmission

Vegetable fluctuates frequently in different time and space dimension. Firstly, study the reason, character and inherent rule of vegetable price spatial-temporal transmission. On the basis of realistic foundation, dynamic mechanism, key point and core mechanism of vegetable price spatial-temporal transmission, to explore the transmission mechanism. Secondly, analyze influent factors. By using the method of factor analysis, analyze the main factors, which are influent to vegetable price spatial-temporal transmission. And clear the relationship between them and price transmission. To carry out characterization analysis and situational inference of the factors, in order to describe the factors' diffusion effect and mechanism. Thirdly, construct network topological graph of vegetable price spatial-temporal transmission. On the basis of analysis of factors from production and markets, by using the theory of system science, construct network topological graph of price transmission from different regions and markets.

6.2.3 Model of Vegetable Price Spatial-Temporal Transmission

It is difficult to quantitative expression to vegetable price spatial-temporal transmission. On the basis of space and time dimension, the paper constructs model groups of vegetable price transmission. From the point of relation, route, adjustment, strength and efficiency of different vegetable varieties, the paper analyzes region transmission and sales chain transmission of vegetable price. The paper, using Correlation coefficient test, ADF unit root test, and Johansen cointegration test, studies the relation of vegetable price transmission. The paper, using Granger causality test, studies the route relationship of vegetable price transmission. The paper, using partial adjustment model, studies the adjustment of vegetable price. The paper, using error correction model and finite distributed lag model, studies the strength of vegetable price transmission. The paper, using impulse response function, studies the efficiency of vegetable price transmission. By constructing models, the paper clarifies the linkage and convergence of markets; and transmission lag and follow relationship among regions; the effects of alternative of varieties. The paper carries out comprehensive quantitative price spatial-temporal correlation features and evolution rules.

6.2.4 Simulation and Display of Vegetable Price Spatial-Temporal Transmission

Basis on the model of vegetable price spatial-temporal transmission, the paper uses Visual Basic, ArcObject and SQL Server and database management etc. The paper processes secondary development of GIS, to realize modularity of GIS of price transmission and response assessment. The paper selects Jilin, Beijing, Shandong, Hainan and so on ten provinces that are vegetable produce and market areas. Based on the main elements of space superposition map, the paper carries out case study and simulation, and to simulate vegetable price spatial-temporal transmission under different factors, and discriminate transmission route, and realize the exhibition of inquiry, forecast and early-warning of vegetable price based on ArcGIS.

China has successively promulgated a series of promotion of vegetable production, to ensure market supply and prices basically stable policy measures. Since 1988, China began to carry out the Food-Basket Project. In June 1997, the State Council promulgated the notice on strengthening the work of Food-Basket Project in the new stage. In March 2010, the general office of the State Council issued to promote a new round of Food-Basket Project construction, and the State Council organized Food-Basket Project work conference. On 18th August 2010, Premier Wen Jiabao chaired a State Council executive meeting, and studied on vegetable production and marketing problems, and determined Six Specific Measures. In 2012, the central document stressed the need to "explore the establishment of the main varieties of vegetables prices stable mechanism”. In 2013, the central document No.1 further pointed out, to “increase a new round of vegetable basket project efforts to implement the” and “regular of important agricultural products market monitoring and early warning mechanism, improve the fresh product control measures”.

It is important to simulate vegetable price spatial-temporal transmission and research its mechanism, and it has broad prospect of application. For vegetable supply and demand, selling difficulty and buying difficulty existed side by side, and its price fluctuated substantially, which not only hurt producers’ and consumers’ interest, but also it waste natural resource (Bai Bo-li and Bai Rui-Xue 2012; Cai Jiming and Su Junxia 2011). Nowadays, China are vigorously promoting the four modernizations synchronous, informatization is leading the development direction of agricultural modernization, which provides strong technical support for the agricultural modernization. Information technology taking GIS GPS GPRS as an important part; and it provides a new idea and new method to solve the problem of vegetable price spatial-temporal transmission (Xu et al. 2012). Research on the discipline of vegetable price fluctuation, and explore and simulate vegetable price spatial-temporal transmission, which are the strategic requirements of beneficial to the people’s livelihood, and which are also cross-disciplinary research among information science, economic science and geography science. Based on fully play the role of market mechanism, carry out to simulate vegetable price spatial-temporal transmission and research its mechanism, which is benefit to promote vegetable produce and to ensure market supply and price stability, and is benefit to sustained and healthy development of the national economy. So, to carry out the research has the important theory significance and the practical significance.

6.3 Design

As for vegetable variety, the paper selects Chinese cabbage, turnip, cucumber, tomatoes, beans and garlic as object of study. As for space dimension, the paper selects Jilin, Beijing, Tianjin, Hebei, Shandong, Sichuan, Hunan, Fujian, Guangdong and Hainan as region of study, and taking 108 markets as information collecting spots. As for time dimension, collecting frequency is one time one day.

6.3.1 Technology Route

Based on constructing vegetable price spatial-temporal data set, revealing the mechanism of vegetable price spatial-temporal transmission, constructing the models of vegetable price spatial-temporal transmission, simulation and display between the models and ArcGIS, the paper carries out the mechanism of vegetable price spatial-temporal transmission and simulation (Fig. 6.1).

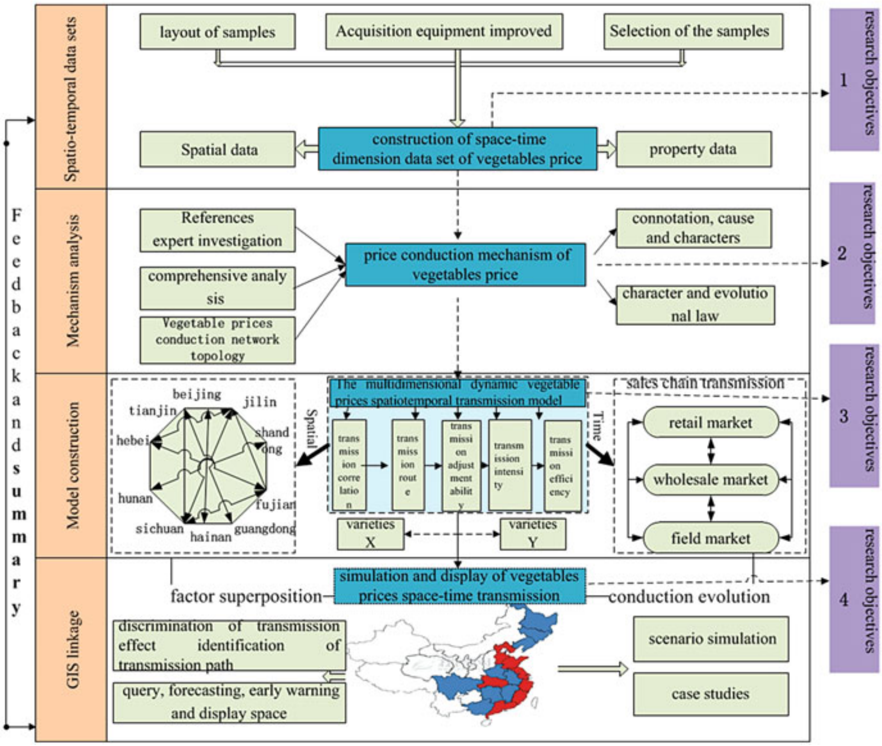

Fig. 6.1 Technology route

6.3.2 Construct Vegetable Price Spatial-Temporal Data Set

1. Layout of vegetable price spatial-temporal data

   According to the principle of statistics and GIS, the layout should cover the main produce areas and sale areas. It should reflect and represent the market situation in China. And it can meet the principle of statistical sampling. By determining the sampling frame, the paper selects the sample spots in Jilin, Beijing, Shandong, Hainan etc. they will provide data support and demonstration for the project. The content of collecting information is price, and it includes geographic information data and quality data, and it will provide basic support to construct vegetable price spatial-temporal data set.
2. Improve the information acquisition device

   On the basis of existed device, the device applies GPS positioning technology, and strengthens the real time information collection. The device integrates GIS, and optimizes the layout of the sample spots. GSM, GPRS, 3G/WiFi are compatible with the device; the paper integrates a variety of information technology. Improve the information acquisition device, and it will make the device more convenient and universal. The device embeds two industry standards of the Ministry of Agriculture, and it will realize collecting vegetable information.

6.3.3 Mechanism of Vegetable Price Spatial-Temporal Transmission

By literature review and investigation, the paper studies the reason, character and inherent rule of vegetable price spatial-temporal transmission. The paper states the basic connotation and evolution characteristics of vegetable price spatial-temporal transmission. The paper using the method of factor analysis method, analyze the main factors, which are influent to vegetable price spatial-temporal transmission. On the basis of that, combining with the situation of different vegetable produce and sale areas, and vegetable reason cycle; and the paper will give the qualitative judgment on the route and direction of vegetable price. And at last the paper construct network topological graph of vegetable price spatial-temporal transmission.

6.3.4 Model of Vegetable Price Spatial-Temporal Transmission

The relationship of vegetable price spatial-temporal transmission includes the transmission of sale chain, different regions and varieties. The relationship of vegetable price spatial-temporal transmission covers relation, route, adjustment, strength and efficiency of different vegetable varieties.

6.3.5 Simulation and Display of Vegetable Price Spatial-Temporal Transmission

The paper applies component technology to design the module. The paper uses Visual Basic to make interface and function expansion, and transfer ArcObject database, and construct the function module of vegetable price spatial-temporal transmission. The paper uses customize the dialog box and applies it in ArcGIS environment. It will modularize price transmission and effect evaluation, and it will make simulation and display of scope, speed and strength. ArcGIS can display multidimensional information, combining with autocorrelation model and semi variance model of vegetable price.

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Chapter 7
Food Consumption of Households in Poverty-Stricken Areas of West China: The Case of Shaanxi, Yunnan, and Guizhou

Fengying Nie, Jiaqi Huang, and Jieying Bi

Abstract This study on food consumption demand in poverty-stricken areas was based on the household data obtained from surveys on six poor counties of Zhen'an and Luonan of Shaanxi Province, Wuding and Huize of Yunnan Province, and Pan and Zheng'an of Guizhou Province, which sponsored by the United Nations – Spain MDG Achievement Fund Joint Programme. Own-price elasticities, cross-price elasticities, expenditure elasticities, and other factors' impacts to food consumption were estimated with an AIDS model. Wealth Index and Livelihoods clusters were creatively put into the model. Eggs and milk are own-price elastic. Foods substitution due to relative price change is small, except in the case of grain. Most of Foods are expenditure-elastic, and expenditure elasticity of fish is the highest. Household size, education years of labors, whether suffering from disasters or other shocks, economic conditions, regional differences are all more or less influence the food consumption of households.

7.1 Introduction

The primary goal of the Millennium Development Goals (MDGs) is to eliminate hunger and poverty, in which China has achieved world-renowned progress. The report of World Development Indicators (World development report 2013) released by the World Bank in April 2013 shows that in 1981, the number of China's poverty-stricken people accounted for 43 % of the world's total, while the ratio is less than 13 % in 2010. China has made significant contribution to global poverty reduction, and has played a significant role in achieving the Millennium

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_7, © Springer-Verlag Berlin Heidelberg 2014

Development Goals. However, according to the data released by the Food and Agriculture Organization of the United Nations (FAO), there were still 158 million undernourished people in China during 2010–2012 (FAOSTAT), accounting for 18.2 % of the total number of undernourished people worldwide and 11.5 % of China. Thus, in order to realize the primary goal of the Millennium Development Goals, China will need to make constant efforts. And it is very important to carry out studies on food consumption of households in China's poverty-stricken areas.

In the studies of food consumption, Chinese scholars mainly focus on analyzing food consumption data in rural or urban areas that released by the National Bureau of Statistics of China (Zhou Jinchun 2002; Zhu Xinkai 2005; Zhang Yumei 2012), whereas studies on poverty-stricken areas are relatively few. The data for this research was obtained from surveys on six poor counties of Zhen'an and Luonan of Shaanxi Province, Wuding and Huize of Yunnan Province, and Pan and Zheng'an of Guizhou Province, which sponsored by the United Nations – Spain MDG Achievement Fund Joint Programme, titled "Improving Nutrition, Food Safety and Food Security for China's Most Vulnerable Women and Children". The authentic first-hand data reflect the latest food consumption situation of households in poverty-stricken areas in west China in detail.

In this paper, the empirical analysis consists of two parts: part one is descriptive statistics that analyze quantity demanded and consumption structure for food of households in different regions; part two is by the use of Almost Ideal Demand System (AIDS) to estimate demand elasticities for food commodities to analyze how the price and expenditure as well as the characteristics of households, socio-economic factors and shocks affect households' food consumption. It should be noted that this paper bring new ideas in variables, as wealth index, livelihood clusters were used to classify households and analyze food consumption of given population.

7.2 Data and Methods

7.2.1 Data

The data sources were mentioned above, the six counties of Zhen'an and Luonan of Shaanxi Province, Wuding and Huize of Yunnan Province, and Pan and Zheng'an of Guizhou Province were selected randomly from a group which concludes the most poverty-stricken counties in China. The sample size was calculated according to the standard **c**alculation formula and then sampling was made by using a two-stage sampling method. In the first stage, 19 villages were selected based on the population of each village with a population-weighted sampling method (Probability Proportional to Size: PPS), the more a village is populated, the higher the probability of being selected. In the second stage, a random sampling method was used to select 12 households in each sample village. In this way, 228 households of 19 villages of each county, and a total of 1,368 households of 114 villages of the six counties were confirmed.

As to the survey on food consumption, a retrospective method is used. The retrospective time spectrum is a month. Sample counties are located in mountainous areas, where road infrastructure is poor and economy level of development occupies to the backward condition. Various factors caused the monotonousness of food consumption of the poverty-stricken areas' households. If retrospective spectrum is too short, zero consumption of many kinds of food of a large number of households would appear. In order to obtain comprehensive data, the past month is selected as the retrospective spectrum.

7.2.2 Methods

7.2.2.1 Model Selection

Consumer demand theory studies under a given price, income level, personal conditions (such as age, occupation, education etc.) as well as geographical conditions, how much commodity and service will be consumed (Huang Yiping and Song Ligang 2001). Among all the applications of demand analysis, the most commonly used are linear expenditure system (LES) proposed by R. Stone (1954), extended linear expenditure system (ELES) developed by C. Lluch (1973) on the basis of LES theory, and almost ideal demand system model (AIDS) by Deaton and Muellbaue (1980). Compared with the ELES model, the AIDS model has its obvious advantages. Variables in an AIDS model are relative index which, to some extent, reduce the error in data acquisition (Shenggen Fan et al. 1994; Huang Jikun 1995). Therefore, AIDS model is used in this paper to analyze consumer demand for food.

In a basic specification, the share equations assume the form (Mu Yueying 2001):

$$w_i = a_i + \sum_j r_{ij} lnp_j + b_i \ln\left(\frac{X}{P}\right) + e_i \tag{7.1}$$

Where *Wi* is the expenditure share of commodity *i*, *Pj* represents the price of commodity *j*; *X* is expenditures, and *P* stands for an overall price index, which is commonly approximated by the Stone price index:

$$lnp = \sum_j w_j lnp_j \tag{7.2}$$

The restrictions on the parameters of the AIDS equation are:

1. Adding up: $\sum_i a_i = 1, \quad \sum_i b_i = 0, \quad \sum_i r_{ij} = 0;$
2. Homogeneity: $\sum_j r_{ij} = 0;$
3. Symmetry: $r_{ij} = r_{ji}$, $i \neq j$.

The system of equations is estimated using Zellner’s ITSUR (Iterated Seemingly Unrelated Regression) (Zellner 1962).

According to the models above, expenditure elasticity (7.3) and Marshall uncompensated price elasticity (7.4) can be calculated:

$$\varepsilon_i = 1 + b_i/w_i \tag{7.3}$$

$$\delta_{ij} = -\sigma_{ij} + \frac{r_{ij}}{w_i} - \frac{\beta_i w_j}{w_i} \qquad \sigma_{ij} = 1(i = j) \quad \sigma_{ij} = 0(i \neq j) \tag{7.4}$$

7.2.2.2 Variable Selection

In this study, the system of expenditure share equations involves a total of 11 categories of food: grains, vegetables, fruits, fish, meats, eggs, dairy, beans, oil, condiments, and alcohol. The price of a certain category of food is the weighted expenditure of its subcategories (Dong GuoXin and Lu Wencong 2009). Because dependent variables are the shares of expenditure on different types of food, the error covariance matrix is singular, and one equation must be removed. So the entire AIDS model includes ten equations, the coefficients of the last equation are calculated from those of other equations.

In addition to price, there are many other factors that may affect food consumption behavior. Therefore, in accordance with sustainable livelihoods framework, such dimensions are taken into account as supply capacity, vulnerability, accessibility, and households’ characteristics to see how they affect food consumption. All the variables of each dimension that obtained from questionnaires are listed, then after analyzing and screening, variables are ultimately determined: other food consumption behaviors (buying snacks, eating outside), households’ characteristics (household size, average years of education, level of poverty, livelihood cluster), socioeconomic factors (whether they suffer from natural disasters, whether they suffer from socio-economic impact, the distance from market), and regional differences.

It should be noted that the commonly used indicator “income” is replaced by Wealth Index to measure households’ economic situation and level of poverty. Wealth Index (WI) is a composite index composed of key asset ownership variables, which covered housing and living facilities, productive assets, transport assets and household assets indicators (Nie et al. 2011). Wealth Index, compared with income, possesses strong stability, comprehensiveness, and an ability to reflect economic situation of a household objectively. It is calculated based on the assets owned by a household. Sample population is classified by using quinquesection: 20 % of the poorest populations are taken as poor households, and 20 % of secondary poverty-stricken populations are relatively poor households, etc. In addition, livelihood cluster variables such as subsidy and remittance, agricultural production replaces traditional occupational variable. In previous studies, whether a household is only engaged in farming or not was usually used by scholars as an indicator in models. However, livelihood cluster is determined by the household’s main source of income. For example, subsidiary-remittance-type households mainly rely on government subsidies or remittances sent by their relatives other than engaged in production activities. They rarely have self-produced food and can only buy food. The money they get is fixed and limited, so they are very sensitive to the changes of food prices.

7.3 Basic Situation of Food Consumption

7.3.1 Food Consumption Variety

Figure 7.1 shows the proportions of households consumed vegetables, meat, beans, eggs, fruits, dairy, and fish and shrimp. It is plain to see that households which consumed fish and shrimp in the past month account for the lowest percentage (14.7 %) followed by dairy (17.6 %), more than half of the surveyed households consumed eggs (61.0 %) and fruits (57.7 %). Households which consumed vegetables, meats, and beans occupy a high proportion. But what should be noted is that the mainly consumed meat is pork, and the proportion of households that consumed poultry is just 35.5 %, those of beef and lamb are even lower, only 8.6 and 4.3 %. And the reason for high proportion of beans is that tofu is nearly an essential homely dish. This shows that most of sample households still have a monotonous type of food consumption.

7.3.2 Food Consumption Quantity

The surveyed samples show that the intake of grains is 587.2 g per equivalent per day, accounting for 50.6 % of all consumed food, but the recommended proportion released by Chinese Dietary Guidelines (Chinese dietary guidelines 2010) is only 20 %. Their intake of fruits is 68.1 g per equivalent per day and that of fish and shrimp is only 7 g per equivalent per day, which is less than one third of China's rural average level 10 years ago. Their intake of eggs and diary is also at a very low level, while that of vegetables, meats, beans, and oil is relatively adequate.

As to the food consumption proportions, those of grains, meats, and vegetables are relatively high, while those of fish and shrimp, dairy and fruits are low. On one hand, it is because of the diet habit that has been developed for many years. On the other hand, it has something to do with income level, food source and other factors. The correlation test shows that there is a highly significant positive correlation between per capita net income and consumption per equivalent per day of fish and shrimp, dairy, and fruits.

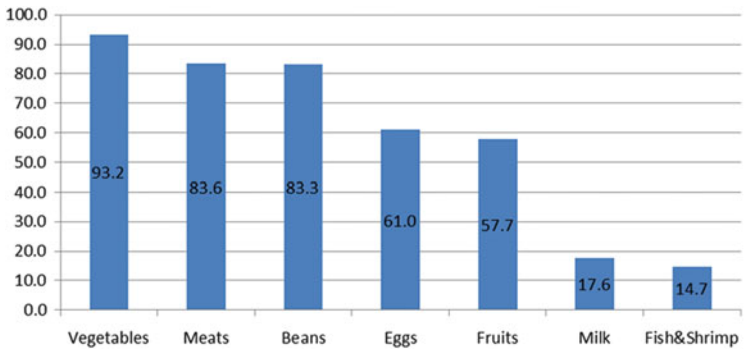

Fig. 7.1 The proportion of household consumed each foods in the past month (%)

As to each county, food consumption shows significant regional differences: the aggregate food consumption basically presents ladder form: Shaanxi is on the top, followed by Yunnan and Guizhou. Types of food consumption are also different: grains consumption of Luonan is significantly higher than that of other counties, while its livestock and poultry consumption is significantly lower. Fish and shrimp consumption of Wuding and Huize of Yunnan Province is significantly higher than that of other counties (Fig. 7.2).

7.4 Results

7.4.1 Food Expenditure Share

As seen from Table 7.1, grains accounts for the largest share (0.352) of average food expenditure of sample households, followed by meats (0.231), oil (0.145) and vegetables (0.077). Fish and shrimp, and dairy occupy particularly small shares, which is in consistent with the analysis on food consumption quantity.

7.4.2 Price Elasticity

7.4.2.1 Own-Price Elasticity

The values on the diagonal in Table 7.2 are own-price elasticities, and reflect how change in the price of a certain type of food affects its demand. The figure shows that price elasticities of all the foods are negative, indicating that sample households will decline their food consumption when prices rise. In addition, eggs, dairy, and alcohol are price-elastic, showing that sample households are very sensitive to price

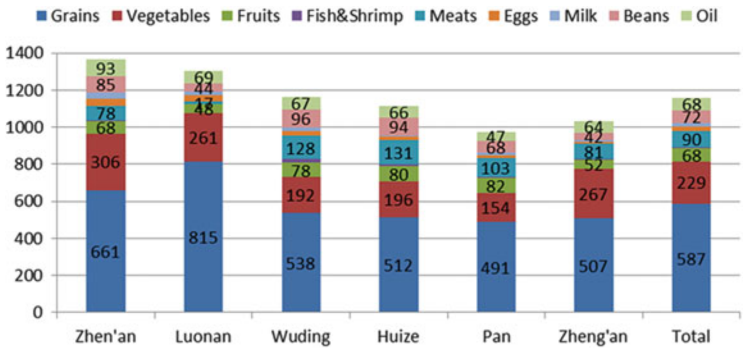

Fig. 7.2 The average consumption of each foods (g/equivalent per day)

Table 7.1 Food expenditure share

Grains	Vegetables	Fruits	Fish and shrimp	Meats	Eggs	Milk	Beans	Oil	Condiments	Alcohol
0.352	0.077	0.031	0.010	0.231	0.030	0.016	0.045	0.145	0.031	0.033

changes of those food items. Own-price elasticities of eggs and dairy are −1.058 and −2.029, which means that if their prices increase by 1 %, their consumption will be reduced by 1.058 and 2.029 %. Eggs and dairy contain high nutritional value and offer premium protein, which are particularly important for the growth and development of children. As previously mentioned, there is a serious shortage of eggs and dairy consumption in the surveyed areas. So, stabilizing the prices of eggs and dairy plays a key role in improving the level of protein intake and reducing the prevalence of children malnutrition in poverty-stricken areas of west China.

7.4.2.2 Cross-Price Elasticity

In Table 7.2, the values on the non-diagonal are cross-price elasticities of different food items, reflecting how change in the price of a certain type of food affects the demand for other food items. It is not difficult to see that change in the prices of grains significantly affect consumption of other foods. Its cross-price elasticity of demand for fruits, fish and shrimp, dairy, and alcohol is greater than 1, and that for fish and shrimp is −3.520, which means that if the price of grains increases by 1 %, fish and shrimp consumption will be reduced by 3.520 %, which further suggests it is vital to stabilize the price of grains.

Table 7.2 Estimated price elasticities

	Grains	Vegetables	Fruits	Fish and shrimp	Meats	Eggs	Milk	Beans	Oil	Condiments	Alcohol
Grains	−0.839	−0.028	−0.104	−0.092	−0.085	0.012	0.066	0.053	−0.023	−0.042	0.434
Vegetables	−0.205	−0.372	0.074	−0.012	−0.215	−0.013	0.093	0.025	−0.168	0.003	−0.079
Fruits	−1.410	0.152	−0.060	−0.090	−0.279	0.006	−0.256	0.039	−0.389	0.027	0.982
Fish and shrimp	−3.520	−0.158	−0.283	−0.040	−0.282	−0.190	0.148	0.074	−0.486	0.346	2.651
Meats	−0.439	−0.122	−0.045	−0.010	−0.603	−0.003	−0.010	−0.197	−0.091	−0.033	0.026
Eggs	−0.032	−0.054	0.010	−0.059	0.067	−1.058	−0.204	−0.121	−0.159	0.098	0.382
Milk	1.266	0.422	−0.491	0.101	−0.062	−0.387	−2.029	−0.028	−0.210	−0.086	0.304
Beans	0.236	0.020	0.030	0.023	−0.935	−0.083	−0.009	−0.391	−0.149	0.000	0.090
Oil	−0.099	−0.082	−0.067	−0.025	0.030	−0.022	−0.016	−0.028	−0.446	0.045	−0.059
Condiments	−0.420	0.036	0.051	0.128	−0.011	0.114	−0.033	0.031	0.247	−0.491	−0.150
Alcohol	4.521	−0.225	0.907	0.839	0.092	0.329	0.138	0.090	−0.425	−0.187	−7.663

Table 7.3 Estimated expenditure elasticities

Grains	Vegetables	Fruits	Fish and shrimp	Meats	Eggs	Milk	Beans	Oil	Condiments	Alcohol
0.649	0.87	1.279	1.739	1.526	1.13	1.199	1.167	0.769	0.498	0.649

7.4.3 Expenditure Elasticity

The Table 7.3 is expenditure elasticities of different foods. All the expenditure elasticities are positive, indicating that with the increase in disposable income, the demand for all types of food will increase. It can be seen that except grains, vegetables, fats and oils, and condiments, the expenditure elasticities of the other seven foods are larger than 1, and they are expenditure-elastic for demand. Expenditure on fish and shrimp are the most elastic, up to 1.739, which means that when a household's disposable income increases by 1 %, its fish and shrimp consumption will increase by 1.739 %. It is clear that enhancing the income level of rural households in poverty-stricken areas plays a vital role in improving their food consumption structure and nutrition intake.

7.4.4 Analysis on Other Variables

The estimated results of variables other than price affect food expenditure shares show that buying snacks and eating outside affect it to a small extent. Household size significantly affects consumption of other types of food than dairy and condiments. Grains and vegetables consumption will increase with the increase of household members, which is the opposite case to other foods, which have high price elasticities and high nutritional values. So, the enlargement of household negatively affects food consumption.

The labors' average years of education significantly influence the consumption shares of grains, fruits and eggs. The higher the labors' educational level, the less they consume grains, the more they consume fruits and eggs. Eggs are price-elastic and have high nutritional value which is lowly consumed in poverty-stricken areas. Households with high level educated labors are more likely have access to foods that are price-elastic. Therefore, more efforts should be made to improve education level in poverty-stricken areas in order to improve food consumption.

Natural disasters have a significant negative impact on food consumption. Those households which are affected by natural disasters consume less food. Droughts, winds and other natural disasters reduce crop yields, thus affect their food consumption. Social factors and economic factors influence the meats consumption. Households that are suffered such misfortune consume less meats. Factors like sickness of family members and high cost of living directly affect the economic situation of households, thus affect consumption of meats, whose price is relatively high. Grains and meats are the most basic and essential food, so it is very important to improve the ability of resisting natural disasters, to stabilize market prices, and to improve people's living standard in poor areas so as to enhance their anti-shocks capabilities.

The level of poverty significantly affects food consumption share, especially for the poorest households. Compared with wealthier household, poorer households' expenditure on fruits, fish and shrimp, meats, eggs and dairy, which have higher price elasticities and nutritional value, occupy a smaller share; while their expenditure on grains and vegetables, which have lower price elasticities occupy a larger share. It further shows poverty reduction work should mainly focus on helping the poorest and the most vulnerable people to avoid insufficient in food consumption and malnutrition.

Households engaged in agricultural production have passed a test of significance regarding consumption shares of grains, meats and eggs. Compared with households of other livelihoods (mainly waged households), for them, grains consumption occupies a larger share and consumptions of meats and eggs occupy a smaller share.

There are significant differences of food consumption share in different regions while the test of significance has been passed regarding consumption of grains, vegetables, fish and shrimp, and meats. Compared with Guizhou Province, Shaanxi Province's grains and vegetables consumption share is larger, while Yunnan Province's is smaller; Shaanxi's fish and shrimp, and meat consumption share is smaller, while Yunnan Province's is larger, which is consistent with the previous analysis of food consumption quantity. The result shows that Shaanxi Province's food consumption is grains-based, also Shaanxi households consume less meats, fish and shrimp which have higher price elasticity and richer protein. Shaanxi's food consumption structure is in an urgent need to be improved.

7.5 Recommendations

Given the results above, following recommendations are proposed: (1) making more efforts to alleviate poverty of poverty-stricken areas in west China and promoting poverty reduction through development-oriented way so as to effectively increase the poor households' income and improve their living standard, which will positively adjusting their food consumption structure, and improving the level of nutrition; (2) building a stable agricultural products market, tracking and monitoring food prices timely, stabilizing food prices and avoiding the prices in animal food fluctuates dramatically; (3) controlling the growth of household members so as to weak the negative impact of large household size on food consumption structure; (4) investing more in poverty-stricken areas' education in west China, and developing more incentives to better education in order to minimize drop-out rate and improve human capital; enhancing the training of labor so they can gain a stronger ability to survive, also to improve their income level and in the end to achieve the purpose of improving their food consumption situation; (5) when carrying out poverty alleviation work and food consumption improvement program, more attention should be paid to the poorest, of whom are in the worst condition of food consumption and need more help.

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Chapter 8
China's Aquatic Products Supply and Demand Situation over the Past Decade

Yumei Zhang

Abstract This paper reviews the production, consumption and trade trends of aquatic products over the past decade. Both the aquatic products demands for direct consumption and processing were increased significantly, which promoted aquatic products industry development. Although the outputs of aquatic products were kept increasing, the speed were lower, especially the outputs of natural grown aquatic products grew very slowly. Both the imports and exports of aquatic products increased a lot, while the growth rate of export was faster than that of import, as a result, trade surplus became larger. About one third of domestic production was used as direct human consumption. The processing of aquatic products increased rapidly and also accounted for about one third of total production. Both of the direct human consumption and processing consumption increased faster than the output of aquatic products over the same period. The gaps between supply and demand of aquatic products kept growing, which lead to the price of aquatic products rising. In the future, the production structure of aquatic products should be optimized and the quality should be improved to satisfy the diversity and growing demand.

Keywords Aquatic product • Production • Consumption • Trade • China

In the past decade, accompanying with China's rapid economic growth and the improvement of people's living standards, people increased their demand for protein rich aquatic products. Driven by the boosting demand, the fisheries industry

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This work was supported by the National Twelfth-Five Year Research Program of China (Grant No. 2012BAH20B04).

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_8, © Springer-Verlag Berlin Heidelberg 2014

experienced upgrading with significantly the output growth and structure optimization. Domestic and abroad aquatic products markets were very active with rising trends of prices. In 2001–2012, the national aquatic consumer price index increased by about 80 %, and the average annual growth rate was about 5 %, especially in 2010–2012, the average annual growth rate was more than 8 %, which was significantly higher than the growth rates of food price index and consumer price index. A review of China's aquatic products supply and demand situation would be helpful for understanding the future market trends, and making aquatic products development plans.

8.1 Aquatic Products Production Situation

China total output of aquatic products increased steadily year by year, from 37.06 million tons in 2000 to 56.03 million tons in 2011. While the growth rate became slowdown with annual growth rate of 3.83 % during 2000–2011, which is lower than that of 1980–1990 and 1990–2000 with 10 % and 6 %, respectively. Among them, the growth of marine products were relatively slower, increased from 22.04 million tons in 2000 to 29.08 million tons in 2011 with average annual growth rate of only 2.55 %. The output of freshwater products grew faster with average annual growth rate of 5.46 %, increased to 26.95 million tons in 2011 from 15.02 million tons in 2000, close to the outputs of marine products. The share of freshwater production increased from 40 % to almost half. Fish products are still the most important aquatic species, shellfish and shrimp followed. The outputs of fish products accounted for about 60 %, shellfish and shrimp accounted for about one quarter and 10 %, respectively (Fig. 8.1).

8.1.1 Artificially Cultured Aquatic Products Developed Faster than the Natural Grown

Over the past decade, the output of artificially cultured aquatic products increased from 22.37 million tons in 2000 to 40.23 million tons in 2011 with an average annual growth rate of 5.5 %. Its share in total aquatic products increased from 60 to 72 %. However, the natural aquatic production in recent decade was almost stagnated, the production hovered around 14.7 million tons between 2000 and 2007. While it increased fast in 2008–2011, and reached to 15.8 million tons in 2011. The average annual growth rate of natural grown fish production in 2000–2011 was only 0.66 %. Its share of total aquatic products dropped from 40 % in 2000 to 28 % in 2011. Marine natural production accounted for about 86 % of the total production of natural grown. Freshwater natural grown production accounted for about 14 % of the total aquatic products. However, the marine natural grown production grew slowly with the average annual growth rate of 0.56 % during

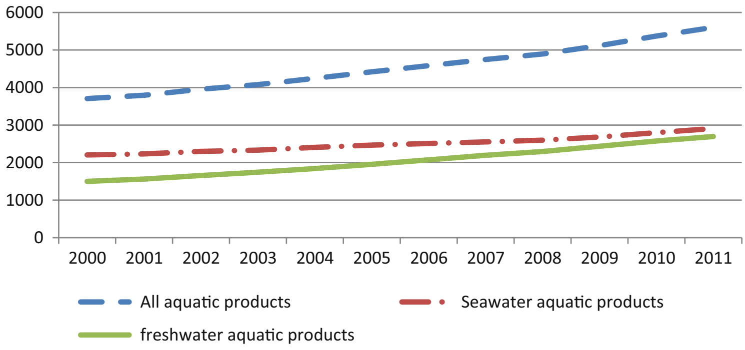

Fig. 8.1 The outputs of aquatic products. Source: National Bureau of Statistics of China (2012)

2000–2011, the natural production of freshwater aquatic products output increased slightly faster with average annual growth rate of 1.31 %. Seawater aquatic products and freshwater aquaculture output of aquatic products accounted for 40 and 60 % of the total output of artificially cultured aquatic products; and their average annual growth rates were faster than that of natural grown aquatic products with an average annual growth rate of 4.78 % and 5.96 %, respectively. The details are showed in Table 8.1.

8.1.2 Major Aquatic Products Producing Areas Concentrated

Aquatic production became more concentrated. The share of outputs of aquatic products produced by the top 11 provinces in total outputs was near to 90 %. The aquatic products from Shandong, Guangdong and Fujian ranked the top three, with more than 10 % of the total national aquatic output of aquatic products in 2011. From the geographical distribution of aquatic production, Shandong, Guangdong, Fujian and Zhejiang ranked the top fourth, slight changes in other provinces. Among them, the rapid development of aquatic products in Jiangsu, over Liaoning and ranked the fifth, Hubei became the seventh over Guangxi, Jiangxi ranked the ninth over than Hunan and Anhui, as shown in Table 8.2.

Table 8.1 The outputs of natural grown and artificially cultured aquatic products, million ton

Year	Natural grown	Artificial cultured	Seawater natural growth	Freshwater natural growth	Seawater artificial cultured	Freshwater artificial cultured
2000	14.69	22.37	12.76	1.93	9.28	13.09
2001	14.3	23.66	12.44	1.86	9.89	13.76
2002	14.33	25.22	12.38	1.95	10.6	14.62
2003	14.5	26.27	12.37	2.13	10.96	15.31
2004	14.63	27.84	12.53	2.1	11.51	16.32
2005	14.76	29.44	12.55	2.21	12.11	17.33
2006	14.66	31.18	12.45	2.2	12.64	18.54
2007	14.69	32.78	12.44	2.26	13.07	19.71
2008	14.83	34.13	12.58	2.25	13.4	20.72
2009	14.95	36.22	12.76	2.18	14.05	22.16
2010	15.44	38.29	13.15	2.29	14.82	23.47
2011	15.8	40.23	13.57	2.23	15.51	24.72
Average annual growth rate (%)	0.66	5.48	0.56	1.31	4.78	5.95
Average share (%)	33.03	66.97	85.59	14.41	40.44	59.56

Source: China Statistical Yearbook

Table 8.2 The distribution of aquatic products among provinces and its changes (million ton, %)

Province	Outputs of 2011	Outputs of 2010	Output share of 2011	Output share of 2000	Rank of 2011	Rank of 2000
Shandong	8.14	6.98	14.52	16.32	1	1
Guangdong	7.63	5.93	13.61	13.86	2	2
Fujian	6.04	5.28	10.77	12.34	3	3
Zhejiang	5.16	4.7	9.21	10.97	4	4
Jiangsu	4.76	3.09	8.49	7.22	5	6
Liaoning	4.51	3.38	8.06	7.91	6	5
Hubei	3.56	2.34	6.36	5.48	7	8
Guangxi	2.89	2.4	5.16	5.61	8	7
Jiangxi	2.17	1.27	3.88	2.97	9	11
Hunan	2	1.33	3.57	3.11	10	10
Anhui	2	1.6	3.56	3.73	11	9
Total	48.86	38.30	87.19	89.53		

Source: China Statistical Yearbook

Table 8.3 The outputs and structure of aquatic products by variety

	Shrimps, prawns and crabs	Shellfish	Others		Shrimps, prawns and crabs	Shellfish	Others
Fish	Output (million ton)			Fish	Structure (%)		
2000	22.55	3.34	9.42	60.85	9.02	25.41	1.87
2001	22.88	3.5	9.82	60.27	9.21	25.86	1.79
2002	23.65	3.75	10.21	59.79	9.49	25.82	1.97
2003	24.44	3.79	10.11	59.95	9.29	24.79	2.96
2004	25.18	4.04	10.12	59.3	9.51	23.82	4.29
2005	26.51	4.22	10.54	59.98	9.54	23.86	3.59
2006	27.15	4.67	10.98	59.22	10.19	23.95	3.63
2007	28	5.01	11.19	58.97	10.55	23.56	3.99
2008	28.63	4.99	11.23	58.48	10.19	22.93	3.29
2009	29.91	5.32	11.72	58.45	10.41	22.91	3.42
2010	31.32	5.59	12.24	58.29	10.4	22.79	3.54
2011	34.19	5.71	12.67	61.02	10.18	22.61	3.29
Annual growth rate (%)			Average share (%)				
	4.99	2.73	9.31	59.55	9.83	24.03	3.14

Source: China Statistical Yearbook

8.1.3 *Fish Was Still the Most Important Aquatic Products, the Shrimps and Crabs Increased Faster, While the Shellfish Grew Slower*

Over the past decade, the structure of all kinds of aquatic remained stable. Fish production increased steadily from 22.55 million tons in 2000 to 34.19 million tons in 2011, an increase of more than 50 % with average annual growth rate of 3.86 %. The fish production accounted for 60 % of the total aquatic products. The outputs of shrimp and crab increased relatively faster, while the shellfish grew relatively slower. The outputs of shrimp and crab increased from 334 million tons in 2000 to 571 million tons in 2011(increase of about 70 %) with the average annual growth rate is nearly 5 %. Its share in aquatic production increased from 9 % to more than 10 %. Shellfish production increased from 9.42 million tons in 2000 to 12.67 tons in 2011(only increase of 35 %), and the average annual growth rate was less than 3 %. Shellfish production accounted for 22.61 % of total aquatic products with a drop of about three percentage points from 25.41 % in 2000. Other aquatic proportion was low with less than 5 % of total outputs (see Table 8.3).

8.2 The Consumption Situation of Aquatic Products

The aquatic products are used for direct human consumption, processing, and other consumptions and wastages. The situations of each kind of consumption are described as below.

8.2.1 Direct Human Consumption

With the socio-economic development and the improvements of people's living standards, the demand for high quality protein-rich aquatic products increased steadily. Per capita fish consumption at home of rural and urban households increased from 3.82 kg and 10.34 kg in 2000 to 5.36 kg and 14.62 kg in 2011, respectively. Both of them increased approximately 40 % and the average annual growth rate was more than 3 %. While, we also found the big differences of fish consumption between urban and rural households, urban households' per capita fish consumption of was close to three times of the rural households. The total rural and urban households' consumption of aquatic products equals to the population multiplied by the per capita consumption of aquatic products. Due to the rapid development of urbanization, The growth of urban population were significantly faster than the growth rate of rural population with an annual growth rate of 7.10 % compared to 1.2 % for rural population. The total food consumption of aquatic products at home increased from 7.83 million tons in 2000 to 13.62 million tons in 2011(increase of nearly three-quarters), with an average annual growth rate of more than 5 %.

With the rapid income growth and lifestyle changes, people choose eat out more and the consumption away from home for aquatic products increased too. The statistical data from National Bureau of Statistics showed that the share of urban households' expenditure on eating out in total food expenditure increased from 14.70 % in 2000 to 21.49 % in 2011. While, there is no data about aquatic products consumption away from home. Here, we assumed that the share of aquatic products eating out consumption in total aquatic consumption was the same as the share of urban households' expenditure on eating out in total food expenditure for rural and urban households. The away from home consumption for aquatic products we calculated increased from 1.15 million tons in 2000 to nearly 3 million tons in 2011 with an average annual growth rate of 9 %, which was significantly faster than the growth of consumption at home. The urban and rural food consumption of aquatic products in total was about 16.55 million tons, and accounted for about 30 % of the output of aquatic products, 7.56 million tons more than in 2000. The average annual growth rate of 5.71 % was obviously higher than the growth rate of output of aquatic products over the same period (see Table 8.4).

Table 8.4 Direct human consumption of rural and urban households

Year	Per capita consumption of rural household (kg)	Per capita consumption if urban household	Total home consumption of rural household (million ton)	Total home consumption of urban household	Total home consumption of all households	The share of eating out (%)	Total consumption of eating out (million ton)	Total consumption of all households	The ratio of direct food consumption in total outputs (%)
2000	3.82	10.34	3.09	4.75	7.83	14.7	1.15	899	24.25
2001	3.92	11.74	3.12	5.64	8.76	15.6	1.37	1013	26.69
2002	4.12	10.33	3.22	5.19	8.41	18.2	1.53	994	25.14
2003	4.36	13.2	3.35	6.91	10.26	18.13	1.86	1213	29.75
2004	4.65	11.12	3.52	6.04	9.56	19.69	1.88	1144	26.94
2005	4.49	12.48	3.35	7.02	10.36	20.84	2.16	1253	28.34
2006	4.94	12.55	3.61	7.32	10.93	22.21	2.43	1336	29.15
2007	5.01	12.95	3.58	7.85	11.43	20.97	2.4	1384	29.15
2008	5.36	14.2	3.77	8.86	12.63	20.61	2.61	1524	31.14
2009	5.25	14.705	3.62	9.49	13.11	21.8	2.86	1597	31.21
2010	5.15	15.21	3.46	10.19	13.64	21.21	2.98	1662	30.94
2011	5.36	14.62	3.52	10.1	13.62	21.49	2.93	1655	29.5
Annual growth rate (%)	3.13	3.2	1.2	7.1	5.15	–	8.86	5.71	–

Source: China Statistical Yearbook

Note: The ratio of eating out is the share of expenditure on eating out in total food consumption expenditure of urban household

Table 8.5 Aquatic products used for processing

Year	Total aquatic products used as processing (million ton)	Total fresh water aquatic products used as processing	Total sea water aquatic products used as processing	The share of aquatic products used as processing in total outputs	The ratio of products used as processing in total freshwater aquatic products (%)	The ratio of products used as processing in total seawater outputs
2003	12.42	0.89	11.53	30.45	5.08	49.42
2004	13.82	1.38	12.45	32.55	7.47	51.77
2005	15.49	1.79	13.7	35.04	9.15	55.56
2006	16.35	2.31	14.04	35.67	11.13	55.94
2007	16.77	2.75	14.01	35.32	12.54	54.94
2008	16.37	3.23	13.14	33.45	14.07	50.58
2009	18.22	3.94	14.29	35.61	16.17	53.27
2010	17.78	4.27	13.51	33.1	16.59	48.29
	Average annual growth rate (%)			Average annual ratio (%)		
	5.27	25.19	2.29	33.90	11.53	52.47

Source: China Fishery statistics Yearbook

8.2.2 *The Processing Industry of Aquatic Products Developed Rapidly*

Nearly 10 years, processing industry of aquatic products developed rapidly. The output of aquatic products used for processing was 17.78 million tons in 2010 and accounted for about one third of total output of aquatic products. The output of aquatic products used for processing increased by 5.37 million tons than that of 2003 with an annual growth rate of 5.27 %. The rapid development of aquatic products processing industry is mainly thanks to the rapid development of freshwater processing industry. The output of freshwater aquatic products used for processing was very few, but it increased rapidly. The freshwater aquatic products used for processing was only 0.89 million tons and accounted for 5 % of total freshwater aquatic products production in 2003. Until 2010, it increased to 4.27 million tons with an increase of 3.39 million tons, and the average annual growth rate was over 25 %. The share of processing in total freshwater aquatic products production increased to 16.59 % in 2010. And the share of marine aquatic products used for processing is relatively high, accounts for about half of total output of marine aquatic products. But relative to the freshwater aquatic products, the marine aquatic products used for processing remained stable at about 14 million ton annually during 2005–2010 (see Table 8.5).

Table 8.6 Other consumption and wastages of aquatic products (million ton)

Year	Total outputs	Direct food consumption of households	Products used as processing	Net export	Other consumption and wastages	The ratio of other consumption and wastages in total outputs (%)
2003	40.77	12.13	12.42	−0.23	16.46	40.36
2004	42.47	11.44	13.82	−0.57	17.77	41.84
2005	44.2	12.53	15.49	−1.09	17.28	39.09
2006	45.84	13.36	16.35	−0.31	16.43	35.85
2007	47.48	13.84	16.77	−0.4	17.27	36.38
2008	48.96	15.24	16.37	−0.9	18.24	37.26
2009	51.16	15.97	18.22	−0.78	17.75	34.69
2010	53.73	16.62	17.78	−0.48	19.81	36.86

Source: Author calculation

8.2.3 Other Consumptions and Wastages

Other consumptions and wastage includes the consumption as feed, fry, inventory, loss and etc. Because there are no public data of aquatic products consumption and wastage, this paper roughly calculated other consumptions and wastages of aquatic products according the balance relationship between supply and demand: domestic output of aquatic products = direct human consumption + aquatic products used for processing + imports of aquatic products -exports of aquatic products + other consumptions of aquatic products and wastage. In another word, other consumptions of aquatic products and wastage = output of aquatic products – direct demand of aquatic products consumption – aquatic products used for processing – net exports of aquatic products. According to the data of the output of aquatic products, the direct human consumption of aquatic products, aquatic products used for processing and net export, we calculated the amount of other consumptions and wastage of aquatic products as shown in Table 8.6. The amount of the other consumptions and wastages was large, about 1,600 to 20 million tons, which accounted for about 35–40 % of the output of aquatic products (see Table 8.6).

8.3 Trade Situation of Aquatic Products

In 2011, China's total import and export of aquatic products was about 8.16 million tons, total imports and exports value was about 25.81 billion U.S. dollars, which increase by 13.9 and 26.7 % year on year. The export volume of aquatic products was 3.91 million tons and the exports value was 17.79 billion US $, which accounted for 29.3 % of China's total agricultural exports. In the period of 2000–2011, the average annual growth rates of China's aquatic products export volume and value were 9.81 % and 16.60 %, respectively. The aquatic products export accounted for 14.8 % of the world's total seafood exports and ranked the first top for 10 consecutive years in the world. The aquatic products of shellfish, shrimp, tilapia,

Table 8.7 The trade of aquatic products

Year	Export volume	Import volume	Export value	Import value	Net export value
	(Million ton)		(Billion USD$)		
2000	1.53	2.52	3.83	1.85	1.98
2001	1.95	2.31	4.19	1.88	2.31
2002	2.09	2.49	4.69	2.27	2.42
2003	2.1	2.33	5.49	2.48	3.01
2004	2.42	2.99	6.966	3.239	3.727
2005	2.57	3.66	7.89	4.12	3.77
2006	3.02	3.32	9.36	4.3	5.06
2007	3.06	3.46	9.74	4.72	5.02
2008	2.99	3.89	10.61	5.4	5.21
2009	2.97	3.74	10.795	5.264	5.531
2010	3.34	3.82	13.828	6.536	7.292
2011	3.91	4.25	17.79	8.02	9.77
Average growth rate (%)	9.81	5.36	16.6	15.8	15.62

Source: China Fishery statistics Yearbook. Bureau of Fisheries of Ministry of Agriculture (2011)

eel, large yellow croaker, crayfish and catfish tail were the main export products and the exports were mainly concentrated in the coastal provinces. Among them, Shandong Province was the largest aquatic products export province in China in 2011 with 4.926 billion U.S. dollars of export value, which accounted for 27.68 % of the total export value of aquatic products. Aquatic imports and imports amounted to 252 million tons and 1.85 billion U.S. dollars in 2000, increased to 4.249 million tons in 2011 and $ 8.02 billion, with an average annual growth rate of 5.36 % and 15.80 %, respectively. Most of the imports were fish meal and feed processing raw material, and some edible fish. For example, in 2011, both of the amounts of imports for domestic consumption of aquatic products and feed processing raw materials were about 1.5 million tons, each accounted for 36 % of total imports, the amount of fish meal imports was 1.21 million tons, which accounted for 28 % of total imports. In recent years, the imports of aquatic products used for domestic human consumption increased rapidly (Yu 2013). Due to the fast growth of domestic demand for high-quality aquatic products, China's imports of aquatic products for household consumption from international market increased rapidly. The imports of aquatic products for household food consumption was only 70.6 million tons, accounting for only 21 % of imports in 2006, and until to 2011, which increased 1.15 times with the average annual growth rate of 16.5 %, and its share in total imports of aquatic products increased by 15 percentage points. Although both the import and export of aquatic products increased, the exports grew faster than imports, the aquatic trade surplus increased to $ 9.77 billion in 2011 from $ 1.98 billion in 2000(Table 8.7).

8.4 The Supply and Demand Situation Analysis of Future Aquatic Products Market

Over the past decade, China's aquatic production developed rapidly, especially the rapid development of freshwater products and artificially cultured aquatic products. Aquatic structure has also been optimized with rapid growth of shrimp and crab production. The growth rate of aquatic products output tend to be slower, but it is still higher than that of population growth, aquatic products consumption per capita continues to increase. Aquatic products mainly used for the residents direct consumption and processing, accounting for about 30 % and 33 % of the total output of aquatic products, respectively. With the improvement of living standards, the direct human consumption of aquatic products increased rapidly, especially the consumption of away from home increased fast with the annual growth rate was near 10 %. In addition, aquatic products processing industry developed rapidly with the almost same growth rate with food direct consumption, ant the average annual growth rate is about 5 %, significantly faster than the outputs growth rate of aquatic products. Driven by the strong consumption of aquatic products, aquatic products prices showed a rising trend year by year. In the future, with the continuous improvement of people's living standards, the demand for aquatic products will continue to be increased. The production situation in the future, the aquatic market supply is shifted from the Marine to freshwater y resources, from natural grown to artificially culture. Therefore, it should strengthen the integrated management and development of freshwater fisheries resources, and achieve the sustainable development of freshwater fisheries resources. At the same time, strengthen research and technology extension to improve aquatic productivity to meet the needs of people (Yue et al. 2012).

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Chapter 9
Spatial-Temporal Characteristics and Outlook of Grain Consumption in China

Jianzhai Wu, Zhemin Li, Zhiqiang Li, Lei Liu, and Jiajia Liu

Abstract In the context of sustained growth of grain demand and the accelerated upgrading of diet structure, grasping the change characteristics and trend of domestic grain consumption can provide important support to ensuring food security in China. This article looks at the spatial distribution of grain consumption and its outlook in China based on the changing trend of main influence factors. Results show that domestic grain consumption have kept growing over the past 15 years in China, among which the food consumption decreased, while both industry and feed increased. As for the spatial pattern, it takes on an obvious "eastward" trend and relative equilibrium between the South and the North. It also indicates that the grain consumption, especially the feed consumption, will be kept growing driven by main influential factors, such as the increase of population, urbanizing process and the upgrading of dietary pattern. The gap between the East and the West will be reduced, and the pattern of south-north will be kept relative balance.

Keywords Grain • Consumption • Outlook • China

Grain problem is always the major strategic issue in agriculture field and even the national economic in China. Since the reform and opening-up, especially the new century, Chinese government has basically guaranteed domestic grain demand and realized the tight balance between demand and supply of domestic grain by propelling the grain production (Liu Xiaomei 2004).

In the system of grain supply-demand, demand should be the goal and direction of production and play a guidance role in the system. However, the phenomenon of production determining consumption has been commonly existed for a long time, which led to the structural imbalance of grain supply-demand. At present, in the

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_9, © Springer-Verlag Berlin Heidelberg 2014

background of the relative sufficient supply of agricultural products and rapid change of consumption structure, it is necessary to establish the modern pattern of food consumption leading production (Xu Shi-wei 2011). The rapid increasing demand results in the worry about grain security in China from both domestic and overseas in recent years and it is of great significance to conduct systematic research on the change characteristics of grain consumption.

In order to provide support for grain development policy and the grain efficient supply, we propose the systematic research of the quantitative changes and spatial distribution of grain consumption and also give an outlook based on deep analysis of main influence factors.

9.1 Data and Process

The basic data mainly are from *China Statistical Yearbook, Comprehensive Statistical Data (*1996–2011) *and Materials on 60 Years of New China (2009), China Urban Life and Price Yearbook (1996–2011), National Agricultural Products Cost-Benefit Compilation (1996–2011), China Food Industry Yearbook (1996–2011), China Agricultural Products Processing Industries Yearbook (1996–2011)* The grain production data are directly obtained from the related statistical yearbooks, while the consumption data are estimated.

Estimating grain consumption are composed of five parts, including food consumption, feed grain, industry use, seed and wastage. (1) Grain for food consumption: The rural grain for food consumption is the per capita consumption based *China Statistical Yearbook* multiply by rural population. The urban is the per capita raw grain, which is converted from per capital commodity grain based *China Urban Life and Price Yearbook*, multiply by urban population. We also take into account outside consumption relative to family consumption. (2) Feed grain: It is the unit major livestock consumption from *National Agricultural Products Cost-Benefit Compilation* multiply by the yield of livestock. The major livestocks are classified to eight sorts: pork pig, beef cattle, mutton sheep, poultry, eggs, milk, aquatic product and the livestock on hand. (3) Industry use: the different rations of input-output used to calculate the grain consumption are of alcohol (3), liquor (2.3), beer (0.172) and monosodium glutamate (24). The other industrial usage of grain are calculated by 25 % of the above (Xiao Guoan 2002). (4) Seed: It is the unit area consumption multiply by planting area. (5) Wastage: It is the annual grain production multiplied by loss coefficient, and the coefficient is from some related research (Wang Chuan and Li Zhiqiang 2007).

9.2 Scale Characteristics of Grain Consumption

9.2.1 Scale Change

The grain consumption, which was characterized by stable growth, increased by 19.38 % from 472 million tons in 1995 to 563 million tons in 2010 with the annual growth rate of 1.19 %. During 1995–2003, grain consumption experienced a process of wavelike growth with the annual growth rate of 0.56 %, and the ending consumption was 493 million tons. In this circle, the consumption peak appeared in 1996, 1999 and 2002, while the grain consumption experienced decrease in 1997, 2000, 2001 and 2003.. Grain consumption had grown rapidly by 14.16% with the annual growth rate of 1.91 % since 2004–2010. Increasing consumption of both industry and feed was the major factor that lead to the growth of grain consumption during the last 6 years (Fig. 9.1).

As for the grain categories, the three main commodities (wheat, rice and maize) consumption increased by 13.55 %, which equaled 53.27 million tons and accounted for 58 % of the total increase. In the view of consumption proportion, these three main commodities consumption decreased by 3.5 %. Among these, the proportion of wheat and rice decreased, while maize increased significantly from 20.94 to 28.09 % (Fig. 9.2).

9.2.2 Structural Change

9.2.2.1 The Grain Consumption for Food Decreased, Especially the Coarse Grain

The food consumption decreased by 10.77 % from 296 million tons in 2005 to 264 million tons in 2010. The ratio of wheat and maize consumption in total food consumption decreased by 0.22 % and 3.16 %, while the ratio of maize increased by 6.49 %. Proportion of flour and rice consumption descended, and coarse food grain ascended accordingly.

The Urban Consumption Increased Rapidly

The urban grain food consumption increased by 84 % from 50.75 million tons in 1995 to 102 million tons in 2010. As for the categories structure, the ratio of rice consumption decreased by 2.82% dramatically, while wheat and maize increased slightly.

As grain for food consumption of average per capita decreased, it is the increasing urban population from urbanization that made grain for urban food

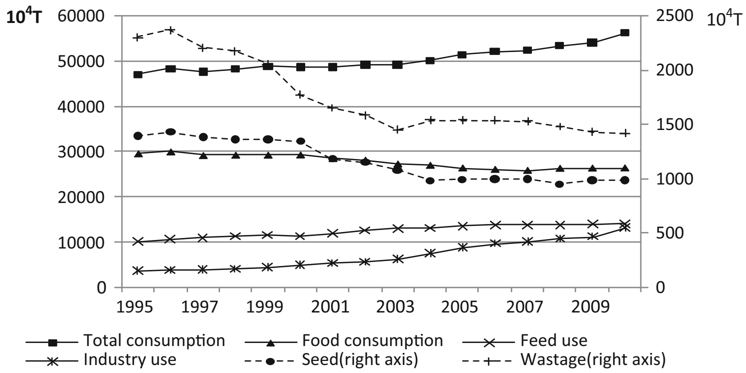

Fig. 9.1 The change trend of grain consumption in China during 1995–2010

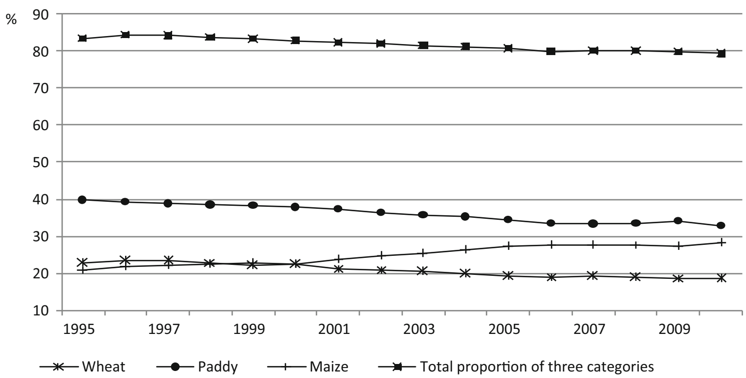

Fig. 9.2 The change trend of main commodities proportion in China during 1995–2010

consumption increased. Urban population increased by 90.42% from 352 million to 670 million during the study period (Fig. 9.3).

The Rural Consumption Decreased Significantly

The rural grain used for food decreased by 32.38 % from 235 million tons in 1995 to 163 million tons to 2010. As for the variety structure, the ratio of rice consumption increased by 2.82 %, while the ratios of wheat and maize decreased by 2.89 % and 3.38 % respectively.

The greatly decrease of food consumption of the average per capita consumption and the rural population were the main reasons that made the significantly depression of rural grain food consumption. During the research, rural per capita ration consumption decreased by 21.92 % from 279 to 216 kg. Especially, the maize's decreased by 51.63 %. Meanwhile, the rural population also significantly decreased

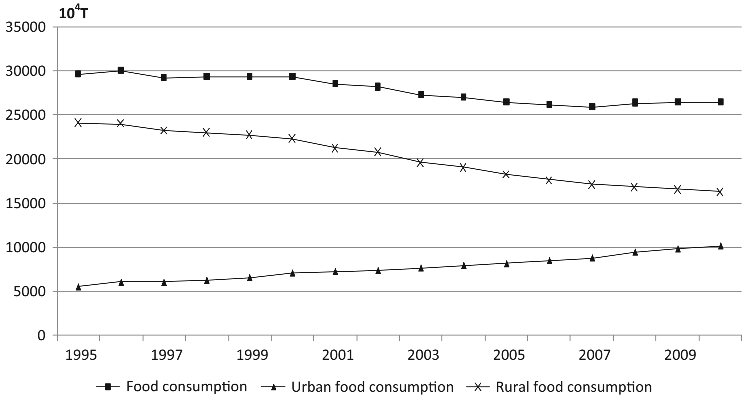

Fig. 9.3 The change trend of grain food consumption in China during 1995–2010

from 859 million in 1995 to 671 million in 2010. With the development of social economic, rural food consumption changed a lot, among which the grain direct consumption, especially the coarse consumption, decreased dramatically.

9.2.2.2 The Grain Consumption for Feed Increased, the Proportion of Maize Occupied Absolutely

The grain consumption for fodder increased by 39.32 % from 102 million tons in 1995 to 142 million tons in 2010, having a net increase of 40 million tons. With the social and economic development, the consumption structure upgrading resulted in consumption increase of meat, egg and milk. Meat, egg, and milk of the average per capita were 43.66 kg, 13.10 kg and 4.60 kg in 1995. After 12 years, the amounts of them were 59.11 kg, 20.60 kg and 27.95 kg. The increasing consumption of livestock products led the grain consumption for fodder increased substantially (Fig. 9.4).

As for the grain categories, the ratio of wheat consumption remained below 4 % before 2000, while it had increased to 8 % in recent years. The ratio of rice consumption decreased more than 3 percentage point. The maize consumption accounted for the highest proportion of total feed consumption, and the ratio beyond 65 % except the special years.

9.2.2.3 The Grain Consumption for Industry Increased Significantly

The grain consumption for industry significantly increased from 36.32 million tons in 1995 to 132 million tons in 2010 which could be classed into two stages. During 1995 to 1998, the consumption kept stable growth at 7.41 %. With the annual ratio of 10.35 %, the grain consumption for industry had increased rapidly Since 1999.

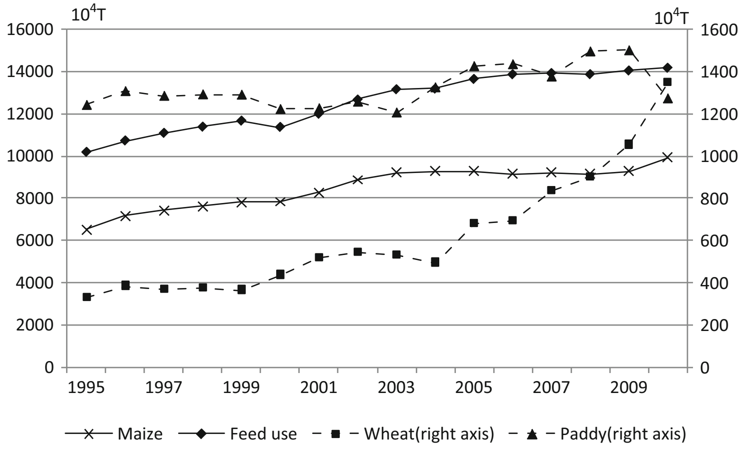

Fig. 9.4 The change trend of feed use of grain in China during 1995–2010

The increasing consumption of commodity increased the production of industrial products, especially the light industrial products. Then it resulted in the rapid increase of grain consumption. In the study period, the production of liquor, alcohol and starch increased respectively by 54 %, 300 % and 600 % during the study period. Pastry, biscuit and instant noodles also increased significantly (Fig. 9.5).

As for the varieties structure, the ratio of wheat consumption changed lightly. Nevertheless, the change in inner wheat consumption was dramatic, and the ratio picked up since the bottomed out in 2000. The ratio of rice showed a descending trend basically except 2001 and 2002. However, the ratio of maize consumption increased rapidly, and reached about 33 % in 2010.

9.2.2.4 The Consumption for Seed and Wastage Decreased

During 1995–2010, the consumption for seed dropped gradually in both the amount and proportion, which were by 29 and 1 % separately. as for wastage, they were 38 % and 2 %. These changes reflected the improvement of agricultural science and farming ability, especially the breeding technology that appeared significantly in the per unit use. During the research, the unit consumption for seed in wheat, rice and maize decreased by 8.72 %, 50.18 % and 25.31 % respectively. The improvement of the grain transportation and storage level also reduced the wastage.

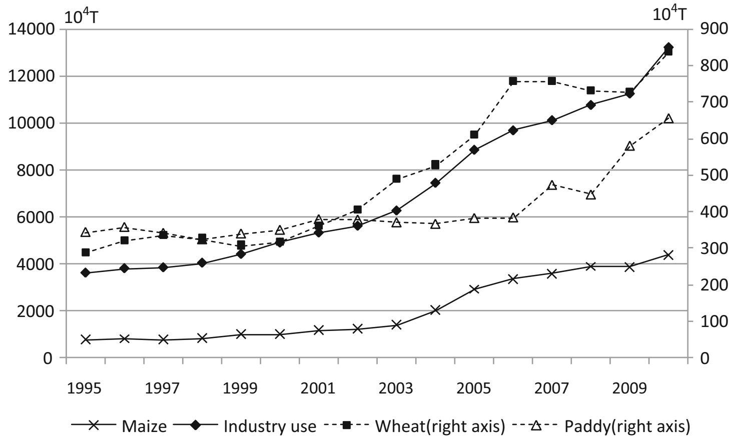

Fig. 9.5 The change trend of grain processing in China during 1995–2010

9.3 Spatial Pattern of Grain Consumption

9.3.1 Grain Consumptions Differs from Areas

According to the proportion of grain consumption (R) in 2010, we divide 31 grain production provinces into four levels: the first-grade regions (R ≥ 8 %), the second-grade regions (8 % > R ≥ 4 %), the third-grade regions 4 % > R ≥ 1 %) and the fourth-grade regions (R <1 %) (Fig. 9.6).

The first-grade regions include Shandong and Henan province. Grain consumption in Shandong added up to 58 million tons, which is the highest in China, then Henan, the amount is above 45 million tons.

The second-grade regions are composed of Sichuan, Jiangsu, Guangdong, Liaoning, Hebei, Heilongjiang, Guangxi, Jilin, Hunan and Anhui. Grain consumption in Sichuan and Jiangsu are both above 30 million tons, while the amounts were all above 20 million tons in the rest eight provinces.

The third-grade regions consist of Hubei, Yunnan, Jiangxi, Zhejiang, Inner Mongolia, Tianjin, Shanxi, Guizhou, Fujian, Gansu, Shanxi, Chongqing and Xinjiang, Grain consumption in Hubei, Yunnan, Jiangxi, Zhejiang, Inner Mongolia, Tianjin, Shaanxi, Guizhou and Fujian are all above 10 million tons, while the amounts in the rest four provinces are above 7 million tons.

The forth-grade regions are Beijing, Shanghai, Hainan, Ningxia, Tibet and Qinghai, which are either municipalities or remote provinces. Their grain consumption are all below 7 million tons, accounting for less than 1 % of the total consumption.

The grain consumption are quite close between north China and south China. The first-grade regions are mainly situated in north China, and the second-grade regions keep relative balance between north and south.

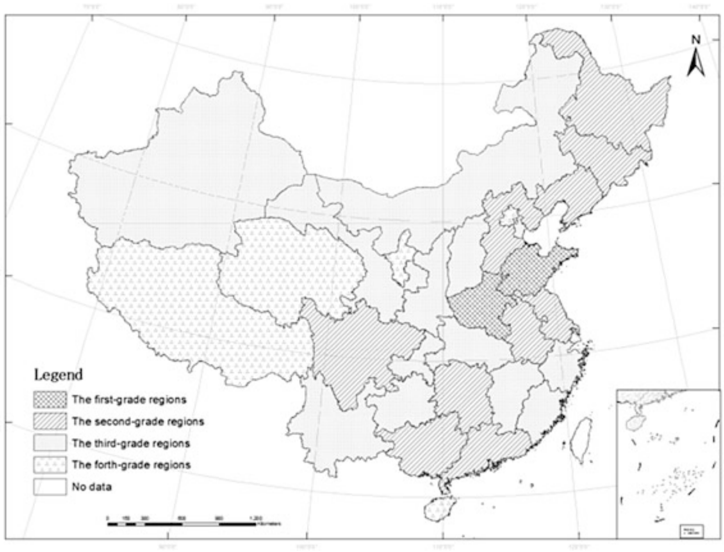

Fig. 9.6 Spatial pattern of grain consumption in China at 2010

In 2010, grain consumption in northern China was 283 million tons accounting for 50.38 % of whole country consumption, and southern China were 279 million tons and 49.62 %. The spatial pattern was most driven by population distribution, livestock production and grain processing. Eastern China with the proportion of 45.02 % contributes more than middle and western China to total grain consumption. Current population distribution and industrial production space distribution lead to the current distribution of grain consumption. Firstly, population distribution plays a key role in the distribution of grain consumption. For instance, population in eastern China accounted for 44.72 % of all in the country in 2010, while central China and western China are 33.55 %, 21.73 %. Secondly, the consumption of pork, poultry, eggs and milk is much more in the eastern China than in the western. For example, the milk production in the east accounted for above 50 %, and industrial production of the wine, beer, starch and subsidiary food lied mainly in the east, leading to the higher consumption of industrial grain in the east.

9.3.2 Changes in Spatial Pattern of Grain Consumption

From 1995 to 2010, the spatial pattern of grain consumption has changed greatly due to a series of factors.. Henan turned into first-grade from second-grade., Liaoning, Jilin, Heilongjiang and Guangxi turned into second-grade from third-grade. Shanghai decreased from third-grade into forth-grade and Hubei decreased

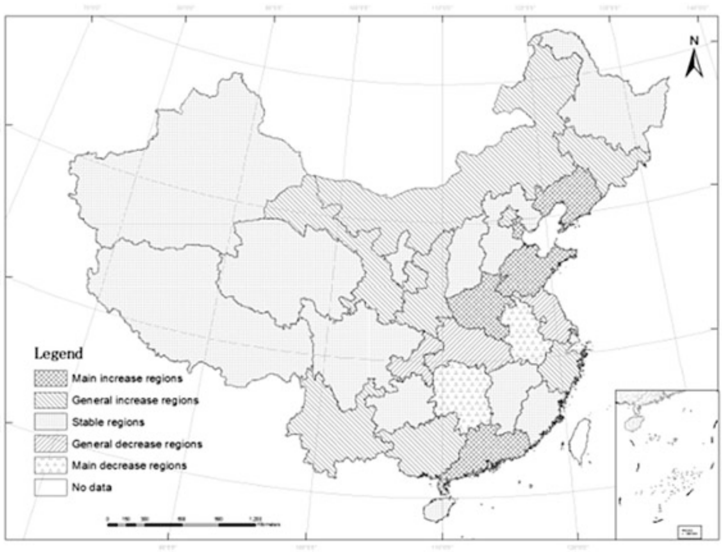

Fig. 9.7 Spatial pattern change of grain yield in China from 1995 to 2010

from second-grade into third-grade, and Tianjin was form forth-grade into third-grade.

Given increase trend of grain consumption during the research, this paper divides the 31 provinces into five change types including main increase regions, general increase regions, stable regions, general decrease regions, and main decrease regions (Fig. 9.7).

The result shows that the main increase regions are Shandong, Liaoning, Guangdong, Tianjin and Henan, arriving at 64.34 million tons totally, 15.61 million tons in Shandong and 14 million tons in Liaoning.

The general increase regions, include Guangxi, Yunnan, Jilin, Gansu, Inner Mongolia, Zhejiang, Shaanxi and Beijing, of which the grain consumptions increased by 35.14 million tons. Shanghai, Jiangxi, Guizhou, Tibet, Fujian, Qinghai, Hainan, Hebei, Xinjiang, Heilongjiang, Ningxia, Shanxi and Sichuan belong to stabile regions, and the change of consumption is little. Jiangsu Hubei and Chongqing belongs to general decrease regions.

The main decrease regions include Anhui and Hunan, decreased into 6.48 million tons, the production of Hunan decreased more.

With regard to the differences between the north and the south,, provinces with increase in grain consumption mainly situated in northeastern and northern China from 1995 to 2010. During the period, the grain consumption in northern China increased by 66.76 million tons, the proportion of which increased more than four percentage points. Viewed From the direction of east and west, the grain consumption center moved towards eastern areas, where has more concentrated population and higher level of non-farm industry development.

From 1995 to 2010, the proportion of grain consumption has improved in the east, increased by more than 6 percentage points, while central and western had decreased by 5.8 % and 0.91 %.

From 1995 to 2000, grain consumption grew slowly and fluctuated significantly, and two peaks of consumption were in the 1996 and 1999. The provinces with increasing grain consumption mainly distribute in northern China, where the processing industry of grain developed quickly; while those with decreasing grain consumption were in south China, for instance, Guizhou, Sichuan Zhejiang, Guangzhou and so on. Between 2000 and 2010, grain consumption grew significantly, especially in the northern and northeastern areas; grain consumptions in the southern regions still decreased, including Hunan and Hubei.

9.4 The Main Influence Factors and Future Trend

9.4.1 The Major Influence Factors of Grain Consumption in the Future

9.4.1.1 Changes in Quantity and Structure of Population

The population increased by 73.9 million from 2000 to 2010 in China, with the annual growth rate of 0.57 %. and it would keep on growing but at a much slower pace in the following years. According to World Bank estimates released recently, by the year 2020, the total population of China would reach 1.39 billion.

With regard to the structure of population, aging of population has been a basic consensus in the future. According to the forecast of UN, China's population, people over 65, by the year 2010, would be 169 million, making up 11.9 % of total population. Some researches found that the grain consumption of people over 65 would be obviously lower than other age groups (Morrison et al. 2011).

Despite the changes in the structure of population seems to be a release of grain consumption, the quantity was so big that the increase of population would induce enormous demand for grain and the distribution of population would pull up the proportion of grain consumption in eastern China.

9.4.1.2 Rapid Development of Urbanization

In accordance to the 6th nationwide population census in China, city population in 2012 is 710 million and urbanization rate is 52.51 %. In the next 10 years, urbanization will continually develop rapidly and the urbanization rate will rise 1 % each year. By the year 2020, urbanization rate will reach up to 60 %. What's more, urbanization rates in central and western provinces would be much quicker.

In the process of urbanization, people's grain consumption structures also change significantly. Experts estimated that for every added people in the city, the meat products would increase by 15 kg, poultry and eggs would increase by 5 kg, the milk product would increase by 12 kg, aquatic product would increase by 7 kg, which corresponding to 50 kg.

Urbanization will not only change the proportion of rural population and city population, but also influence people's lifestyles and dietary structures, consequently people's grain consumption structures. so urbanization will increase grain demand and remit the consumption differences between east and west in China.

9.4.1.3 Updating of Dietary Structure

Updating of dietary structure mainly arose from two factors—increase of income level and non-grain agricultural production. Income level was considered as the most important factors influencing the grain demands of developing countries (Kolleen 2011). Allowing for the fact that Chinese government had planned to double income by 2020, the annual growth rate of real disposable income per capita would remain about 7 %. In the following ten years demands for meat, milk and eggs will remain on a strong upward trend according to predictions of FAO. In the future, the two factors mentioned above will generate positive influence on the updating of dietary structures.

In China, overall consumption structure of urban and rural residents will close to diversity gradually, forming the replacement to grain deeply and widely. The proportion of cereal consumption declines and proportion of meat, eggs and milk is on the way up, which will result in increase of grain consumption, especially in central and western China.

9.4.1.4 Other Factors

Besides above three factors, there would be some other factors that affected grain consumption in China.

Because of good policies background, grain processing industry also developed quickly in recent years and the processing ability had been improved greatly. Processed maize is from 12.5 million tons in 2001 to 45 million tons in 2010. Processed soybean is from 18 million tons in 2001 to 55 million tons in 2010. Processing requirement continued to stimulate the demand for soybean imports to a new level. Meanwhile, biomass energy industry continues to thrive worldwide and certainly increases grain consumption. Even though Chinese government has undertaken initiatives to restrain these two industries and release pressure from grain consumption, the prospect is still unclear.

Just like the characteristics shown in soybean processing over past 10 years, both grain processing industry and biomass energy will have a positive promotion to the demand for grain in the future and probably improve the consumption proportion in the coastal areas. But this change will be modest and controllable.

9.4.2 Analysis for Grain Consumption in China in the Future

According to international experiences and relevant researches, with increase of income, food consumption per capita will gradually reach a saturation point, from which China still have some distance away. Because all kinds of factors are positive, grain consumption in China would continue to increase in the following years, but at a slower pace.

As for the structure of grain consumption, changes in population and dietary structures would be a relief for pressure from continually growing of food consumption and maintain at a relatively stable level. Since the absolute increase amount of the population, food consumption would grow in quantity, but decline to 40 % in proportion. Feed grain consumption would keep on growing and become a principal part of grain consumption and the proportion would reach above 20 %. Grain consumption for industry would grow not so quickly under the government' control and share about 20 % of total grain consumption. Grain for seed and wastage would be further reduced.

With the decrease of per capita food consumption rice and wheat demand would remain stable, while consumption of soybean and maize would increase sharply due to the development of feed and processing industry. Maize may the category with the largest gap between domestic supply and demand in China, and soybean demand would still increase with a slower speed.

With regard to the spatial pattern of grain consumption, the floating speed of population will be slowly and the improvement of urbanization and diet structure will have bigger space in the central and western China which will get more government's attention in the future.

Differences between the western and the eastern regions are expected to relieved and the pattern between the northern and the southern regions may be kept in balance relatively.

Acknowledgements This work was supported by the Key Project of National Key Technology R&D Program of China (2012BAH20B04), National Natural Science Foundation of China (41201599).

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Chapter 10
Research on Early-Warning Proposal of China Milk Market

Yun Gao and Jianjun Qin

Abstract Wide fluctuation of milk market is thresholds of income increasing of dairy farmers and it also brings negative effects on milk industry development, livestock, milk processing industry. The aims the research is to set up index system of early-warning, key warning indicators, division of alarm and alarm line, method to determine the alarm. It clarified available statistics and its characteristic and content based on China current statistics system.

Keywords Early-warning proposal • Milk market

10.1 Preface

In the processing of agricultural economic transition, China agricultural industry development is exposed to risks not only comes from agricultural production and business operation system but also external risk such as nature and environment, market and administrative intervention etc. Under the market mechanism, supply and demand, competition and price are connecting, interacting and restricting each other, to achieve efficiency of resource allocation and stimulate economic development. It also reflects on market price fluctuation of agricultural products and the relationship between supply and demand is remained dynamic balance. In the past 10 years, the average increasing rate of milk consumption of China is 14.6 % and the total consumption jumped more than ten times, while income of dairy farmers didn't increased accordingly. In the backdrop of rising price, dairy breeding profit

Sponsored by Basic Science Research Program launched by CAAS (NO. 0052013010).

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_10, © Springer-Verlag Berlin Heidelberg 2014

encountered a sharp slide unexpectedly. It is estimated that in 2004, the cost of breeding a cow in freshens period producing 18 kg milk per day, is 7,250 RMB and annual profit only about 707 RMB. On the contrary, due to fodder price increasing, farms annual losses are 1,150RMB. “Pouring the milk and selling cow” was the often case. In early half year of 2008, milk market prices are expected to rise while “melamine” event happened. And it leads to a serious blow to consumer confidence, domestic producing milk and milk powder sold badly.

Wide fluctuation of milk market is thresholds of income increasing of dairy farmers and it also brings negative effects on milk industry development, livestock, milk processing industry and routine life of customers. It is necessary to strengthen monitoring and early warning of milk market and reflected accurate market information on time, with the aims of supporting for policy -makers and parties involved in production and business operation, therefore avoiding wide fluctuation and equilibrium of supply and demand.

10.2 Early-Warning Management System and Theory

Research on economic early-warning started in the late time of nineteenth century (Zhao Ruiying and Jia Weili 2004). And then it developed to more improving early-warning systematic theory, early-warning index and variables with significant evaluating function (Yucel 2011). More information and index were put into early-warning system. The early-warning system on certain industry and economy of certain area considered the relevant industries development and global economy as well. Therefore, the research developed in the trend of synthesis and integration (Lebraty and Sfeir 2010). Since the supply chain and demand situation is complicated in China, early-warning of milk market would in line with the aim of risk early-warning management and reflect on efficiency and problems of milk market. In such a case, index of the system should typical, sensible to market fluctuation, available in statistics and all indexes are connected as a whole and its independent character. Meanwhile, there’s no threshold on exit of entry in dairy feeding and quality differences of milk, this research regards milk market as a perfect competition market. The early-warning proposal is based on milk supply chain of producing, circulating and consumption. The aims the research is to set up index system of early-warning, key warning indicators, division of alarm and alarm line, method to determine the alarm. It carried out comprehensive analysis on early-warning of milk market by system engineering method, and clarified available statistics and its characteristic and content based on China current statistics system.

10.3 Index System of Early-Warning Proposal of China Milk Market

Index system of early-warning proposal is composed by production index, stock index, trade index, price index, consumption index, processing index and some relevant index. The indicators of total production of milk, cost of feeding and profit are main index for production. The total production of milk is the basic indicator to evaluate production fluctuation. Expected dairy herds, the actual number of dairy herds, annual average milk yield, forecasted milk yield and the actual milk yield are also included in production index. Cost of feeding is calculated by direct and indirect inputs of materials, processing and labor. And the next step is to combine the cost and cash income of selling milk and feeding profit to calculate the profit of milk produce.

There are two modes of dairy feeding and milk production in China, one is based by household operation and the other mode is enterprise running. And milk production area is highly localized distributions in Hebei province and Inner Mongolia region. Especially around farms and factories locations of two major milk production enterprises “MENGNIU” and “YILI”, a large mount of dairy farm and milk industry employees distributed. Therefore, early-warning proposal input enterprise purchase milk price, average purchase milk price, processing and production capacity of enterprise, industry scale and economic benefit as enterprise related index to reflect wholesale market price and cost and benefit allocation mechanism in the procedures of production, circulation and consumption. These price indicators serve as key indicators for market price fluctuation with dairy retail price index and dairy consumption price index.

Based on agricultural products supply and demand theory, domestic consumption, trade, stock, milk and its products price are the key indicators for milk market supply and demand situation and prosperity. Estimation of domestic consumption is based by the national household per capita annual dairy consumption expenditure, annual yoghourt consumption per capita, annual milk powder consumption per capita, fresh milk and its products consumption. And input other indicators to the early-warning proposal such as production, supply, demand, trade, and technology improvement, policy trend of major trade country, staffs and employees on dairy disease epidemic prevention, dairy growth cycle, and milk production level.

10.4 Key Warning Indicators, Division of Alarm and Alarm Line

The six key warning indicators of milk market early-warning proposal are: indicator of security supply, indicator of production fluctuation, indicator of market price fluctuation, indicator of international competition, indicator of dependence on foreign trade, indicator of cost and benefit.

The steps of alarm division of key warning indicators are as follows: the first is to determine the alarm of indicators; the second step is to synthesize alarm division of various indicators to a primary alarm division. If there's only one indicator, the alarm division of this indicator is primary alarm division of key indicator. The proposal also set up supplementary indicators, but alarm division is based on key indicator. If alarm division of key indicators is uncertain, it is suggested to reference or choose that of supplementary indicators. The early-warning proposal of China milk market are divided into there status. They are normal, weak warning, middle level warning and strong warning and showed by green, blue, yellow and red respectively.

10.4.1 Indicator of Security Supply

Indicator of security supply reflects whether the situations of supply exceeding demand or that of demand exceeding supply happened and its degree. This indicator is to evaluate if demand and supply are in balance. The forecasted supply is the sum of forecasted production of this period and forecasted imported quantity. The forecasted demand is the sum of directly edible demand, forecasted demand in food processing industry and various losses. Directly edible demand calculation is based on price, income, urbanization, consumer preference and population etc. Forecasted demand in food processing industry will consider food processing technique improvement and consumer preference.

Equation: Key warning indicator:

The ratio of production to consumption = raw milk yield/milk and its products consumption $\times$ 100 %

Supplementary indicator:

Dependence on foreign trade = raw milk production/(domestic milk and its products output/conversion ratio of raw milk to all kinds of milk processing)

The supplementary indicator helps to calculate raw milk production by milk and its products output. The ratio of raw milk to all kinds of milk processing will estimated by expert.

Warning signs indicator: Warning signs indicators are milk output, milk consumed quantity, milk trade fluctuation etc.

Sources of data: Dairy Yearbook, Agricultural Statistical Yearbook and Animal husbandry Yearbook; forecasted production output and consumed quantity will be estimated by association and experts (Fig. 10.1).

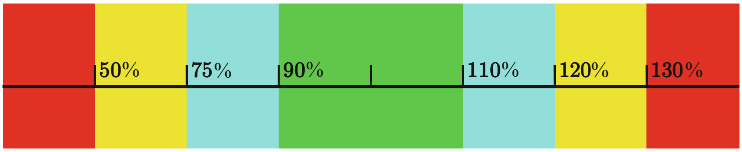

Fig. 10.1 Diagram of division of alarm and alarm line of milk security supply and demand indicator

10.4.2 Indicator of Production Fluctuation

Indicator of production fluctuation is to reflect trend and degree of production change. This indicator plays a role of judging if production change rate is in normal range. Milk supply and demand has a big elasticity, so it is easier to regulate. According to China economic development situation, supply of milk is tight of the long term. So we could identify alarm by tracing whether supply increasing rate is keep pace with that of population increasing and economy development.

Equation: Key warning indicator:

Rate of milk production change (δ) = (forecasted milk production-average milk production in the past 5 years/average milk production in the past 5 years

Supplementary indicator:

The degree of scaled dairy breeding = Herds of dairy of scaled enterprises/the sum hers of diary

Increasing rate of milk production = current milk production/average milk production in the past 5 years-1

Increasing rate of each dairy production = (current production of each dairy − production of each dairy of last year)/production of each dairy of last year $\times$ 100 %

Change rate of diary hers = current diary hers/diary hers of last year $\times$ 100 %

Warning signs indicator: Change rate of feed grain production, hers of diary in the end of year, change rate of diary hers, rate of improved variety diary, increasing rate of epidemic prevention expenditure, increasing rate of income per capita, index of raw milk price, dairy price index/raw milk price index, increasing rate of technique staff of dairy industry.

Sources of data:Forecasted milk production is estimated by analysis staff based on warning signs indicators, milk production of past 5 years quoted from Dairy Yearbook, Agricultural Statistical Yearbook and Animal husbandry Yearbook (Fig. 10.2).

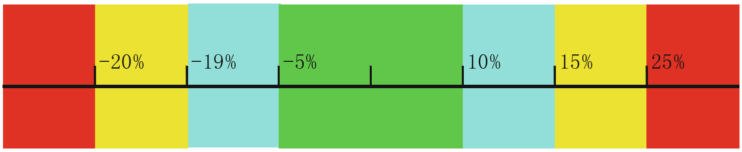

Fig. 10.2 Diagram of division of alarm and alarm line of milk production fluctuation indicator

10.4.3 Indicator of Market Price Fluctuation

Milk market price fluctuation is set up to show trend and degree of market price change and judge if fluctuations in the normal range.

Equation: Key warning indicator:

Year-on-year growth rate of milk price = (enterprise purchasing raw milk price − enterprise purchasing raw milk price of the same time of last year)/enterprise purchasing raw milk price of the same time of last year × 100 %

Supplementary indicator:

Milk price fluctuation index = enterprise purchasing raw milk price/enterprise purchasing raw milk price of the same time of last year.

Warning signs indicator: Production situation, consumption, changes of consumption structure and international trade.

Sources of data:cost of feeding reported by domestic and aboard dairy association、enterprise purchasing raw milk price, Dairy Yearbook, milk and its productions market price (Fig. 10.3).

10.4.4 Indicator of International Competition

Indicator of international competition is refers to price margin between CIF price of imported milk and that of domestic produced.

Equation:Key warning indicator:

International Competition of milk and its products = (CIF price of imported milk − domestic produced milk price)/domestic produced milk price.

Warning signs indicator: Change of producing cost of milk and its production, market circulation, supply and demand situation and policy trend of major milk producing countries.

Sources of data: Total imports value of milk and its products which are available in Customs Statistics Data and Customs Yearbook, domestic produced milk prices of the same time are available in wholesale price data issued by Ministry of Agriculture and National Development and Reform Commission (Fig. 10.4).

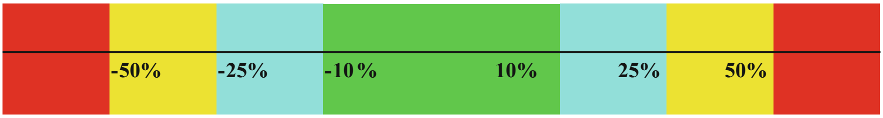

Fig. 10.3 Diagram of division of alarm and alarm line of milk price fluctuation indicator

Fig. 10.4 Diagram of division of alarm and alarm line of milk products international competition indicator

10.4.5 Indicator of Dependence on Foreign Trade

Indicator of dependence on foreign trade is the ratio of imported quantity of milk and its products to the domestic consumption. It reflected the degree of dependence on international trade and trade effect on domestic production.

Equation: Key warning indicator:
Indicator of dependence on foreign trade = annual trade value of milk market/ Domestic milk production × 100 %
Warning signs indicator: Policy change on international trade, change of cost on milk production and processing, market circulation and supply and demand situation and policy change of major producing countries.
Sources of data: Net imports value of milk and its products will be calculated based on Customs Statistics Data and the other data are provided by Dairy Yearbook and Customs Statistics Data (Fig. 10.5).

10.4.6 Indicator of Cost and Benefit

Indicator of cost and benefit reflected change of cost and profit of dairy feeding by ratio of enterprise purchasing raw milk price on fodder price of dairy.

Equation: Key warning indicator:
The ratio of enterprise purchasing raw milk price on fodder price of dairy = enterprise purchasing raw milk price/fodder price of dairy.
Supplementary indicator:
Profit of milk = net income/total cost × 100 %
Warning signs indicator: Supply and demand situation of feed grain, dairy feeding infrastructure input, risks of dairy feeding etc.

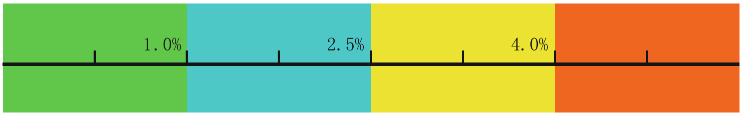

Fig. 10.5 Diagram of division of alarm and alarm line of indicator of dependence on foreign trade

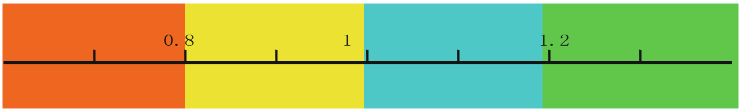

Fig. 10.6 Diagram of division of alarm and alarm line of indicator of cost and benefit (Alarm line of indicator of cost and benefit is suppose raw milk producers to decide their produce quantity under the principle of maximize profit. If market price is higher than cost, there's no alarm, If market price is higher than variable costs, it is weak alarm. If market price is less than costs, it is strong alarm)

Sources of data: Cost-benefit Yearbook, Dairy Yearbook, Agricultural Statistical Yearbook and Animal husbandry Yearbook (Fig. 10.6).

10.5 Synthetical Warning-Signal Judgment Method

It is adopted "Table Qualitative Judgments Method" to identify synthetical warning-signal after process of repeated recognition and practice. This method draws different combination of various division of alarm of six key warning indicators in one table and synthesizes warning signs indicators to a final judgment based on a certain principle. The synthetical warning-signal judgment method of milk market is as follows. In the real operation, it could be adjusted according to suggestion of experts and analysis (Table 10.1).

In the procedures of synthetical warning-signal judgment, we should Stick up for the following principles: (1) the current situation and qualitative analysis should be overall considered to determine if it is necessary to alarm; (2) the absolute number of warning indicators should be noted, such as output, price and trade. The order of magnitudes will affect alarm identification; (3) The stock and sum of the past several years should be considered. For example, if rapid decreasing or strong warning lasted for 2 years, middle level warning of the next year is equivalent to strong warning; (4) The relation of various indicators should be noted. If production decreasing sharply, imported quantity would be increased to meet demand. It is strong alarm in the view of import, but it is measurement to eliminate alarm of supply, so it is not necessary to alarm; (5) Synthetical warning-signal judgment based on independent and key warning indicators and also consider synthetical warning to judge the overall situation of milk market.

Table 10.1 Table of synthetical warning-signal judgment

Synthetical warning	Different combination of various division of alarm					
	Supply and demand	Production fluctuation	Price fluctuation	International competition	Dependence on foreign trade	Cost and benefit
	Other possibility of combination not stated in the table					

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Chapter 11
Meteorological Effects on China Expected Rapeseed Yield

Wen Yu, Yu Wang, Yunqing Liu, and Mengshuai Zhu

Abstract National rapeseed yield model is part of China Agriculture Monitoring and Early-warning System. To measure the expected yield for rapeseed in China, the authors use Fisher Integral Model and Orthogonal Polynomial stepwise regression, and get the weather-related yield coefficients for rapeseed. Then trend yield, meteorological yield and expected yield change rate are presented. The results found 2013 expected yield for rapeseed in China will increase 10.1 % than 2011 actual rapeseed yield.

Keywords Rapeseed • Yield • Fisher model • Weather • China

Sunshine, rainfall and temperatures during the growing season affected rapeseed production in China. This paper addresses the relationship between weather and rapeseed yield by developing China rapeseed yield model, which is included in China Agriculture Monitoring and Early-warning System (CAMES).

To understand weather effects on rapeseed, a background review of rapeseed distribution, growing seasons is presented. National yield model for rapeseed is then developed. Next is to forecast the rapeseed trend yield and to estimate meteorological yield. Lastly, implication for expected rapeseed yield in 2013 is presented.

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*, DOI 10.1007/978-3-642-54389-0_11, © Springer-Verlag Berlin Heidelberg 2014

Table 11.1 2011 the rapeseed area and output in some provinces of China

	Area and its rank		Production and its rank	
	(1,000 ha)	Rank	(10,000 T)	Rank
Hunan	1,167.2	1	215.3	5
Hubei	1,141.4	2	304.7	3
Sichuan	964.2	3	278.4	4
Anhui	640.4	4	213.8	6
Jiangxi	542.6	5	113.6	11
Guizhou	489	6	78.9	13
Jiangsu	441.3	7	144.1	7
Henan	383.5	8	532.4	1
Yunnan	272.9	9	60.7	17
Inner Mongolia	218.7	10	133.9	9
Total	7,347.4	–	3,306.8	–

Resource: The data is from National Bureau of Statistics of China (NBSC) and processed by the author

11.1 Background

Rapeseed almost grows in all provinces of China. But in China mainland, the rapeseed regions mainly focus on South-central, Eastern, Southwestern, and Northern China. According to the size of the rapeseed harvested acreage, 85 % of which is covered in the ten provinces, including South-central China (Hunan, Hubei, and Henan provinces), Eastern China (Anhui, Jiangxi, Jiangsu), Southwestern (Sichuan, Guizhou, Yunnan) and Inner Mongolia, Northern China (Table 11.1); and there is over 62 % of rapeseed production.

11.2 Data

The data of monthly rainfall, daily temperature and sunshine-hour for selected provinces covering a period of 33 years (1980–2013) was obtained from China Meteorological Data sharing Service Office, China National Meteorological Information Center. And the authors have calculated it into average monthly data. The weather stations were selected based on geographical location to represents the main sub regions, variation in micro climate, Daily temperature, rainfall, and sunshine duration data were downloaded from http://cdc.cma.gov.cn.

In China, there are two kind of rapeseed planting according to the planting season, which includes spring and winter rapeseed. More than 90 % of rapeseed is winter rapeseed, which is planted in the end of September or October. After seedling, it would over the winter seasons, harvesting in the end of May or June next year. The rapeseed passes the following stages: seeding, germination, seedling and winter-over, budding bolting, flowering and ripening (Table 11.2).

According to the share of rapeseed harvest acreage, the average rainfall, sunshine hours, temperatures are also calculated in Table 11.2, and similarly, the 2013

Table 11.2 Winter rapeseed growing stage and weather factor issues

Stage	Month	Average (1980–2012)			2013		
		Rainfall (mm)	Sunshine (h)	Temperature (°C)	Rainfall (mm)	Sunshine (h)	Temperature (°C)
Seeding	October	2.28	4.43	16.06	1.86	4.34	16.53
Germination	November	1.59	4.38	10.40	2.29	3.97	9.62
Seedling and wintering	December	0.83	3.98	4.95	1.62	3.30	3.94
	January	1.19	3.42	3.06	0.50	3.71	3.34
	February	1.69	3.59	5.42	1.41	3.05	6.48
Budding and bolting	March	2.47	4.00	9.54	2.43	5.08	12.22
	April	3.39	4.96	15.43			
Flowering	May	4.41	5.42	20.04			
Ripening	June	5.99	5.08	23.30			

relative data also filled in. anyway these difference will be used to explain the meteorological yield. Here, rainfall is the monthly average value, sunshine is the average daily hours, and temperature is the daily average centigrade value.

Before the harvesting, the weather data from the April to June is not available, so the authors estimate the meteorological yield for rapeseed with tree month's data default. And the authors assume that the weather character is the same as 1980–2012 average level.

11.3 Meteorological Yield Model

Trend analysis is a useful framework to forecast crop yields. Long-term trends in crop yield reflect improvements in technology (for example, new seed with high yield) as well as improvement in production practices such as pest Integrated management and precision planting. Though trend analysis could examine the crop yield, weather-related yield would make the expectation yield deviate from actual yield (Westcott and Jewison 2013).

Actual yield could be explained to trend yield and meteorological yield. The trend yield reflected the yield change by all non-natural factors such as agricultural technological progress and etc. In this research, we consider trend yield for each province as simple linear trend. All calculations are based on actual yields without any weather-adjusted trend yield from year-to-year. The trend yield is based on the simple linear trend of the provincial average yield for 1980–2011. Notice that the calculation does not include 2012, for the National Bureau of Statistics of China does not publish the information yet. The slope of trend yield indicates that the trend increase the weight per year from 1980 to 2011.

The trend yield is the overall trend of the yield curve corresponding to the yield in the case of normal years. It is different from the actual yield, the difference can be thought as the result of the weather changes. In other words, the meteorological yield reflects the weather-related yield presented in the function (11.1). Meteorological yield can be greater or less than zero. If the meteorological yield is greater than zero, which means compared with normal years, the climate benefits the yield; on the contrary, the meteorological yield is less than zero.

The Meteorological yield is a function of rainfall, sunshine and temperature. The Fisher (1925) thought that the impact of meteorological factors on yield could be denoted in the form of the integral regression. The extended Fisher integral regression model is:

$$\mathrm{My} = \alpha_0 + \sum_{\mathrm{i}} \int_0^{\tau} \mathrm{a_i(t)x_i(t)dt} \tag{11.1}$$

My – meteorological yield,
α_0 – constant,

$x_i(t)$ – meteorological factors ($i = 1{,}2$ and 3 represent rainfall, sunshine and temperature respectively),
$a_i(t)$ – regression coefficient,
t – the time of year
τ – the growth period of winter wheat (j – independent period),

Usually, we used the orthogonal polynomial to approximately express $a_i(t)$ in the following,

$$a_i(t) = \sum_j \alpha_{ij} \varphi_{ji} \tag{11.2}$$

φ_{ji} is j times polynomial, is the constant, we institute (11.2) into (11.1),

$$\begin{aligned} My &= \alpha_0 + \sum_i \int_0^\tau \left(\sum_j \alpha_{ij} \varphi_{ji} \right) x(t)dt, \\ My &= \alpha_0 + \sum_i \sum_j \alpha_{ij} \rho_{ji} \end{aligned} \tag{11.3}$$

Here, we had:

$$\rho_{ji} = \int_0^\tau x_i(t) \varphi_j dt \tag{11.3'}$$

φ_j could be derived from the Chebyshev-orthogonal polynomial in the following ($\varphi_0 = 1$).

$$\varphi_{k+1}(x) = \varphi_1(x)\varphi_k(x) - \frac{k^2\left(n^2 - k^2\right)}{4\left(4k^2 - 1\right)} \varphi_{k-1}(x) \tag{11.4}$$

Taking into account the actual production situation, we determined winter oil-seed rape growth period from October to June in most regions of China. Therefore, according to the function (11.3) obtained through the derivation, Chebyshev orthogonal table is neglected.

Following the above (11.3) is a typical multiple linear regression equation of the stepwise regression approach to solving the equations. After several rounds of comparison, the two equations can be close to our expectations.

According function (6), the significant coefficient for meteorological yield could be obtained by the following.

$$C\_my = \Sigma \alpha_{ij} * \varphi_j \tag{11.5}$$

In the function (11.5), c_my is the coefficient for meteorological yield; αij is estimated from function (11.3).

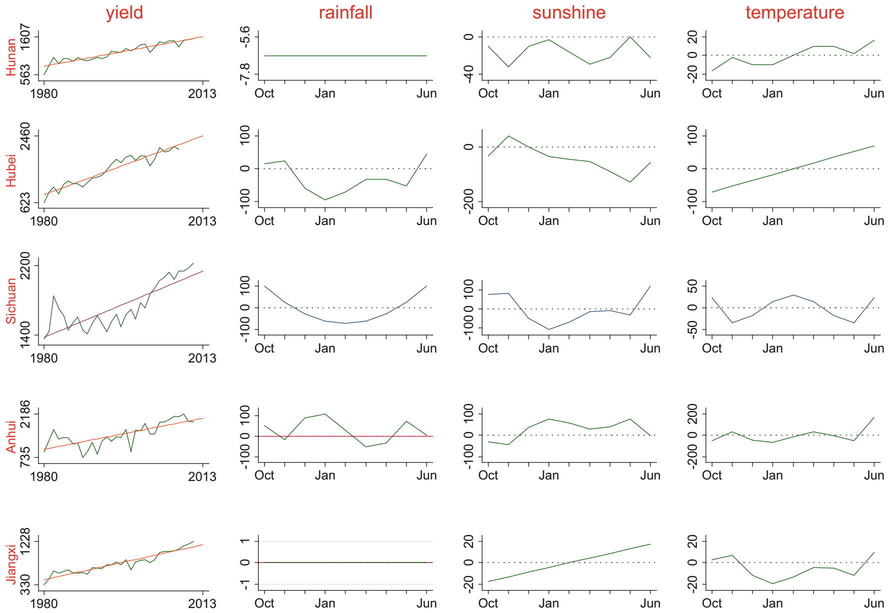

Fig. 11.1 Actual and trend yield of rapeseed and the meteorological yield coefficient in Hunan, Hubei, Sichuan, Anhui and Jiangxi

11.4 Results

For the upcoming 2013 season, the yield models can be used to provide initial forecast of expected yields.

From October to February, especially in wintering period, there is less rainfall and low temperature in Inner Mongolia. For example, Averagely in October from 1980 to 2012, it is 5.1 °C and 0.4 mm rainfall in Inner Mongolia, but in other nine Provinces, the rainfall is 1.5–3 mm, and temperature ranges 12–20 °C; From March on (after wintering period) the weather has the similar characteristics.

In 2013, the lower temperature and less sunshine period effects the rapeseed yield in Inner Mongolia; drought and less sunshine also reduce the trend yield in Henan; in Hubei, Hunan, Sichuan, the lower temperature in wintering period and less rainfall benefit in crop yield through wintering period (Figs. 11.1 and 11.2).

According to the calculation, 2013 trend yield and meteorological yield are listed in Table 11.3. Most provinces weather benefits the yield except for Jiangxi, Guizhou, Henan and Inner Mongolia. But comparing with 2011 actual yield, Sichuan and Jiangxi expected yield will be lower than 2011 actual yield for rapeseed.

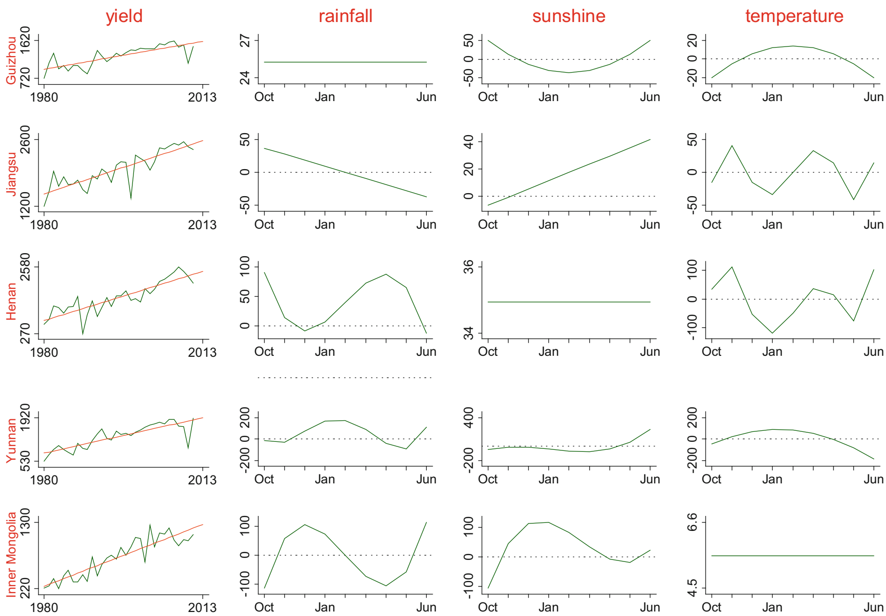

Fig. 11.2 Actual and trend yield of rapeseed and the coefficient of meteorological yield in Guizhou, Jiangsu, Henan, Yunnan and Inner Mongolia

Table 11.3 2013 trend yield, meteorological yield and yield change rate (unit: kg/ha)

Region	No. of weather stations	2011 Actual yield	2013 Trend yield	2013 Mete. yield	Change rate to 2011 (%)
Hunan	37	1,558.9	1,607.23	67.6	7.4
Hubei	35	1,930.9	2,459.51	101.6	32.6
Sichuan	52	2,223.2	2,133.25	46.6	−1.9
Anhui	25	1,917.2	2,038.82	29.7	7.9
Jiangxi	28	1,228.4	1,158.49	−22.1	−7.5
Guizhou	35	1,468.5	1,596.55	−28.6	6.8
Jiangsu	24	2,385	2,571.8	6.5	8.1
Henan	22	2,016.4	2,431.45	−77.1	16.8
Yunnan	36	1,899.7	1,911.93	7.1	1.0
Inner Mongolia	51	1,098.7	1,264.01	−58.7	9.7
Total	**833**	**1,815.0**	**1,967.8**	31.2	10.1

11.5 Conclusion

During the growing season, weather is important for rapeseed yield development. Weather adjustment in analysis of China rapeseed yield is critical for determining trend yield expectations.

National rapeseed yield model just run on each provinces respectively.

Meteorological yield coefficients are calculated according the Polynomial Integral Regression, which reflects the relationship between meteorological yield and weather characteristics difference among provinces.

The rapeseed model mean expected yield for 2013 is 1,999 kg per hectare, the trend yield is 1967.8 kg per hectare, and the weather adjusting yield is 31.2 kg per hectare.

The estimation of rapeseed yield could be examined using various measures, for example, we could use the critical weather information to regress the yield.

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Chapter 12
County-Level Catastrophic Risk Assessment of Crops Caused by Flood in Northeast China

Sijian Zhao and Qiao Zhang

Abstract **[Purpose]** County-level catastrophic risk assessment of crops in Northeast China caused by flood was performed on the combination of extreme storm precipitation and flood vulnerability function of crops under the support of historical flood-affected records of crops, time serials of annual crops' planting area, time serials of daily precipitation from weather stations and digital elevation model. **[Methods]** With Inverse Distance Weighting (IDW) method, daily precipitation for county can be interpolated by daily precipitations from its adjacent three weather stations. With bivariate regression, flood vulnerability function of crops among the variables of crops' flood-affected ratio, storm precipitation and average terrain of county was built; Using Block Maximum Method (BMM), annual extreme storm precipitations can be extracted from daily precipitation. Combined with flood vulnerability function, annual extreme flood-affected ratios of crops can be worked out. Generalized Extreme Value (GEV) distribution was applied in constructing probability density function (PDF) of extreme flood-affected ratio of crops. Based on the PDF, expectation and VaR were used to measure catastrophic risk, and then the county-level risk maps under average condition, 20-years return, 50-years return and 100-years return scenarios were generated. **[Results]** In general, the catastrophic risk of Liaoning is highest, and then Heilongjian and Jilin. In space, there exits four high-risk zones in which the first two highest locates in the east and the center of Liaoning, the third highest locates in the mid-west of Heilongjian, and the last highest locates in the center of Jilin.

Keywords Crop • Catastrophic risk • Flood • Risk assessment • Vulnerability • GEV • BMM • VaR • Northeast China

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_12, © Springer-Verlag Berlin Heidelberg 2014

12.1 Introduction

Farming is a typically risky business (Hardaker et al. 2004). Farmers are exposed to extreme weather events, such as hail, storm, drought, frost, heavy precipitation, excessive heat, which may result in potential damage to crops (Langeveld et al. 2003). China is one of the countries most affected by natural disasters in the world, and Chinese farmers are facing more catastrophic risk by natural disasters than other countries. Especially in recent 10 years, with the deepening of global climate change, China suffered from the extreme weather disasters of flood, storm, drought, freezing and so on, which caused great financial losses to Chinese farmers. According to the statistic (Zhang and Wang 2011), every year China loses 0.45 billion acres of crops affected by catastrophic disasters on average, accounting for 25 % of total crops' planting area; the annual average financial losses of crops by catastrophic disasters is about 85 billion RMB, accounting for 25 % of total financial losses of the world. Catastrophic risk of agriculture becomes more and more significant, abstracting the wide attentions of China government and farmer. In response to the severe impact of catastrophic risk, agricultural catastrophic insurance is necessary to implement for transferring and dispersing risk. One of the most crucial problems in agricultural catastrophic insurance is that catastrophic risk should be given an accurate assessment, which has been proven to be a prerequisite condition.

Generally defined, a catastrophic risk is a low-probability (rare) event leading to major and typically irreversible losses with adverse impact on business results (Chichilnisky 2000; Vose 2001). Catastrophic risk assessment is defined as the assessment on both the probability of catastrophe occurrence and the degree of damage caused by catastrophe. Extreme Value Theory (EVT) is the theory of modeling and measuring events which occur with very small probability and very large losses. EVT has been widely used in the many fields of catastrophic risk assessment, such fire (Xie Qian 2008; Ouyang Zisheng 2007), hydrological engineering (Davison and Smith 1990; Katz et al. 2002), insurance (McNeil 1996; Rootzén and Tajvidi 1995) and finance (Embrechts et al. 1999), etc. But in agriculture, EVT is used to assess catastrophic risk in recent years, such as Lie Xu et al. (2011) using Peak Over Threshold (POT) model in EVT to make a catastrophic risk assessment of wheat in Henan Province of China based on disaster-affected loss data provided by China Ministry of Civil Affairs. However, in China, there exists a serious problem to directly apply EVT in agricultural catastrophic risk assessment on small spatial scale, such as county scale, due to the insufficient of extreme disaster samples. The main reason is that the period of effectively surveying and recording disaster losses of crops on county scale is short (~30 years) since 1982. At the best, there exits ~30 samples if extreme disasters occurs annually. As we all know, at least 32 samples are sufficient to formulate a stable probability distribution.

Therefore, in order to solute the problem, a new approach was proposed in this article to assess catastrophic risk of crops caused by flood in Northeast China through the combination of extreme storm precipitation and flood vulnerability function of crops. As a result, high-risk zones in Northeast China can be identified.

12.2 Description of Study Region

Northeast China, also called as three Northeast Provinces of China, consists of three provinces of Liaoning, Jilin and Heilongjiang with 173 counties shown as Fig. 12.1. For a long time, Northeast China is one of the largest grain bases in China. Although it occupies only 8.33 % of the land area of China, it has 16.68 % of the cultivated land area of China. In 2011, Northeast China produced 2,155 billion kilograms grains including corn, soybean, rice and so on, accounting for about 20 % of national grain yields (CNIR 2012). On the other hand, Northeast China is one of the most susceptive areas to climate change in China. It has been reported that there was an increase in mean temperature of 0.34 °C per 10 years in the past five decades (Sun et al. 2006). The extreme weather disasters, especially flood catastrophes, have become more frequent with increase in climatic variability due to the trend of global warming, which make Northeast China to be one of the areas with the greatest fluctuation in grain yields in China (Cheng and Zhang 2005). In order to reduce flood-caused losses, guarantee grain yields and direct catastrophic insurance of Northeast China, it is necessary to make a flood catastrophic risk assessment for crops.

12.3 Data Preparation

In this study, four types of data were prepared, i.e. (1) historical flood-affected records of crops, (2) time serials of crops' planting area, (3) Digital Elevation Model (DEM) and (4) time serials of daily precipitation from weather station, of Northeast China.

Total 544 historical flood-affected records of crops in Northeast China from 1984 to 2012 were collected from China Meteorological Bureau, local meteorological bureaus and local agricultural bureaus. The detailed information in each record contains the counties where a flood occurred, begin and end date of flood and flood-affected area of crops (hectare).

Time serials of annual county-level crops' planting area (hectare) in Northeast China from 1981 to 2012 were obtained from the county-level rural economy statistic database of Chinese Ministry of Agriculture.

Digital Elevation Model (DEM) with 30 m spatial resolution shown as Fig. 12.2 was provided by Resource Environment Science Data Centre, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences.

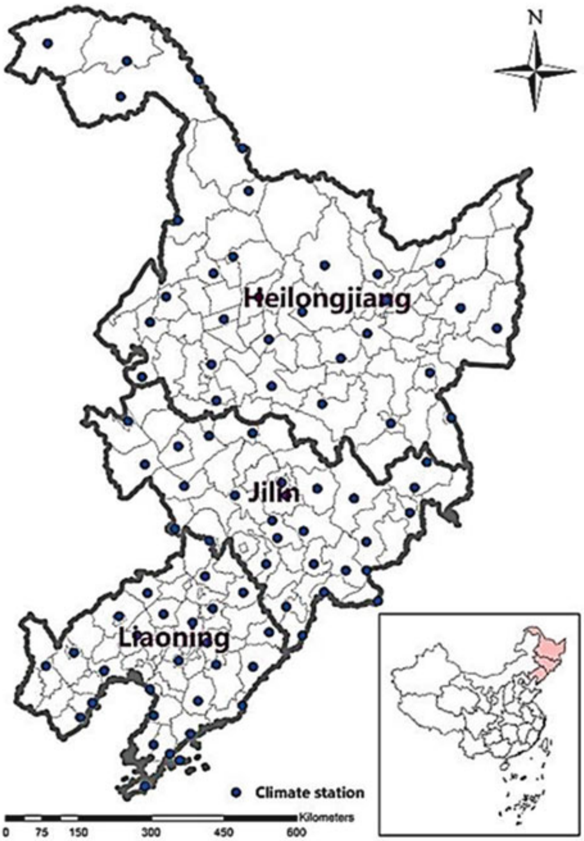

Fig. 12.1 Location of Northeast China

Time serials of daily precipitation (mm) from 86 weather stations shown as Fig. 12.1 in Northeast China from 1951 to 2012 were obtained from China Meteorological Data Sharing Service System.

12.4 Calculation of Basic Variables

12.4.1 Calculation of Disaster-Affected Rate of Crops

Given a flood in a specific year led to the flood-affected area a_c (hectare) of crops in a specific county c, and the total planting area of crops of the county in the same year is s_c (hectare), then the flood-affected ratio (FR) y_c of crops by the flood can be calculated as follows.

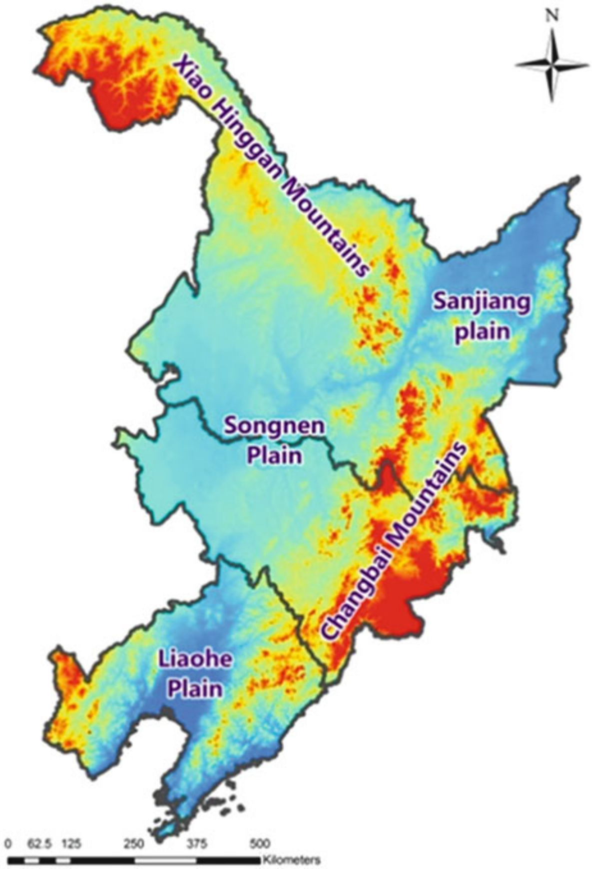

Fig. 12.2 DEM of Northeast China

$$y_c = a_c / s_c \tag{12.1}$$

FR would be a variable representing loss of crops by flood used in the following modeling.

12.4.2 Calculation of Average Elevation of County

On the basis of DEM, the average elevation $\overline{h}_c$ (m) of county c in Northeast China can be easily worked out as bellow.

$$\overline{h}_c = \sum_{i=1}^{n_c} h_i / n_c \tag{12.2}$$

where h_i refers to the elevation (m) in the i-th grid cell of this county, and n_c is the total number of grid cells. All grid cells come from DEM.

12.4.3 Interpolation of Daily Perception for County

It can be seen from Fig. 12.1 that total 86 climate stations cannot cover 173 counties of Northeast China. In other words, some counties have no climate stations, and it is unreasonable to directly use the daily precipitation of stations as the one of counties. Therefore, the inverse distance weighting (IDW) model was employed to interpolate daily precipitation for each county using the one of its nearby stations.

Given a specific county c, three closest climate stations (m_k, $k = 1, 2, 3$) to the county can be found out, and the distances of three stations (d_k, $k = 1, 2, 3$) (m) to center of county can also be calculated. Then, daily precipitation i_c (mm) of the county can be interpolated by the following IDW model (Chen et al. 2002).

$$i_c = \frac{\sum_{k=1}^{3} \left(i_k \cdot \frac{1}{d_k^2} \right)}{\sum_{k=1}^{3} \frac{1}{d_k^2}} \tag{12.3}$$

where i_k ($k = 1, 2, 3$) (mm) is the daily precipitation of three stations.

12.5 Flood Vulnerability Function of Crops

Flood vulnerability of crops refers to the extent how big a flood could harm crops, or how large crops can be affected by the impact of a flood (Zhou Yao and Wang Jingai 2012). In common, it is expressed as a function or curve of the relationship between the strength of flood and the corresponding damage of crops. In the subsequent content, flood vulnerability function of crops would be formulated.

A flood results from a storm and/or snow melting, when rivers rise and go over their banks. A storm refers to the days of heavy rain whose total precipitation exceeds a threshold, such as 100 mm in this article, shown as Fig. 12.3. To describe a storm, three meteorological variables can be used, e.g. total storm precipitation (mm), mean storm precipitation (mm), and peak storm precipitation (mm). Except heavy rain, flooding is highly correlated with terrain. As we all know, the lower the

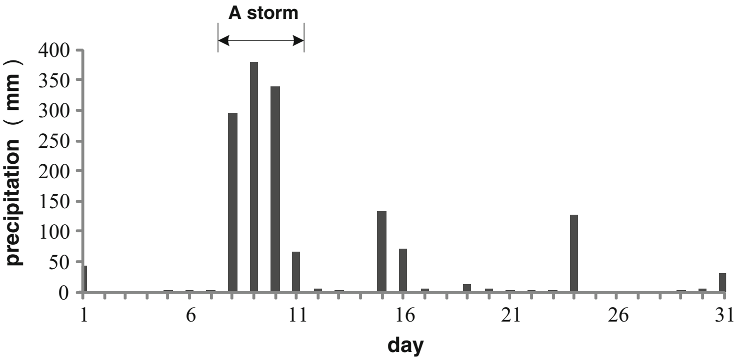

Fig. 12.3 Illustration of a storm

terrain, the easier the occurrence of flooding. Therefore, the average elevation (m) of county would be a key variable to study flood.

Using the collected historical flood-affected records of crops, the relationship among crops' FR, three meteorological variables of storm, and average elevation of county was regressive analyzed. As a result, it is found that there exists a good correlation among crops' FR, total storm precipitation and average elevation of county. Then, flood vulnerability function of crops in county c was formulated as below with bivariate regression shown as Fig. 12.4.

$$\begin{aligned} y_c &= V\left(i_{m,c}, \overline{h}_c\right) \\ &= 0.2210 - 4.1451 \times 10^{-4} \times \overline{h}_c + 9.6105 \times 10^{-5} \times i_{S,c} + 4.0680 \\ &\quad \times 10^{-8} \times \overline{h}_c \times i_{S,c} \end{aligned} \tag{12.4}$$

where y_c is crops' FR, $i_{S,c}$ is total storm precipitation (mm), and $\overline{h}_c$ is the average elevation of county (m). The correlation coefficient of bivariate regression is 0.626.

12.6 Probability Distribution of Extreme Flood-Affected Losses

12.6.1 Extreme Value Theory

Extreme value theory (EVT) or extreme value analysis is a branch of statistics dealing with maxima, minima or values above a threshold of a stochastic event. The field of EVT is pioneered by Tippett and Fisher who initially obtained three asymptotic limits describing the distributions of extremes (Fisher and Tippett 1928). Two approaches exist for practical extreme value analysis, i.e. Block

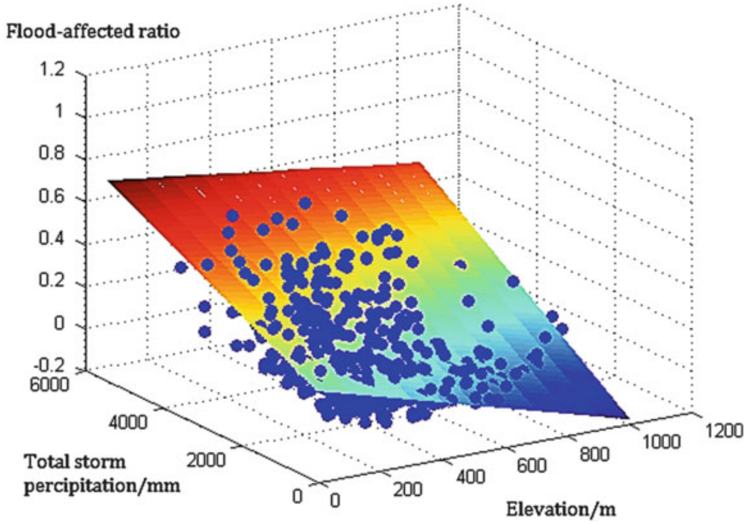

Fig. 12.4 Bivariate regressive surface of crops' flood-affected ratio

Maxima Model (BMM) and Peak Over Threshold (POT). The first method relies on deriving block maxima (minima) series as a preliminary step. In many situations it is customary and convenient to extracting the annual maxima (minima), generating an Annual Maxima Series (AMS). The second method relies on extracting, from a continuous record, the peak values reached for any period during which values exceed a certain threshold (falls below a certain threshold). Because BMM is more suitable to study the extreme events with periodicity, it is used in the following catastrophic risk modeling of flood.

12.6.2 Generation of AMS of Crops' Flood-Affected Ratio

Due to the fact that the effective period for recording FR of crops is short, the annual maxima samples of crops' FR are insufficient to perform extreme value analysis. Therefore, the annual maxima samples of FR would be expanded through the combination of annual maxima serials of total storm precipitations and flood vulnerability function of crops.

For a specific county c, the sample collection I_m of total storm precipitation in 1 year can be extracted from the interpolated daily precipitations as below.

$$I_{m,c}(t) = \{i_{m,1}, i_{m,2} \ldots, i_{m,k}\}_c, k = 1, 2, 3 \ldots, t = 1951 \sim 2012 \qquad (12.5)$$

where k is the number of storms in 1 year, and t is the year. According to the BMM, the annual maxima series of total storm precipitation I_e can be generated by extracting the annual maxima in I_m from 1951 to 2012 as following.

$$\begin{cases} I_{e,c}(t) = \{i_e(t_1), i_e(t_2), \ldots, i_e(t_l)\}_c, t = 1951 \sim 2012 \\ i_{e,c}(t_l) = \max\{I_{m,c}(t_l)\} \end{cases} \tag{12.6}$$

Combined with flood vulnerable function of crops as Eq. (12.4), the Annual Maxima Series (AMS) of FRs of crops Y_e can be generated as below.

$$\begin{cases} Y_{e,c}(t) = \{y_e(t_1), y_e(t_2), \ldots, y_e(t_l)\}_c, t = 1951 \sim 2012 \\ y_{e,c}(t_l) = V\left[i_{e,c}(t_l), \overline{h}_c\right] \end{cases} \tag{12.7}$$

There are 61 samples (1951 ~ 2012) at least in Y_e, which is enough to analysis.

12.6.3 Probability Distribution Modeling

According to the EVT, when the number of block maxima (minima) samples trends to infinity, the probability distribution of extreme values belongs to the one of *Gumbel* distribution, *Frechet* distribution and *Weibull* distribution (Fisher and Tippett 1928). Jenkinson (1955) and Gules (Coles 2001) united these three types of distribution into a single family, i.e. well-known generalized extreme value (GEV) distribution as following:

$$F(x) = P(X < x) = \begin{cases} \exp\left\{-\left[1 + \xi\left(\frac{x-\mu}{\sigma}\right)\right]^{-1/\xi}\right\}, \xi \neq 0 \\ \exp\left\{-\exp\left(-\frac{x-\mu}{\sigma}\right)\right\}, \xi = 0 \end{cases} \tag{12.8}$$

where x is the random variable, μ is the location parameter, σ is the scale parameter, and ξ is the shape parameter. When $\xi = 0$, the GEV distribution is *Type I*, i.e. *Gumbel* distribution; when $\xi > 0$, the GEV distribution is *Type II*, i.e. *Frechet* distribution; when $\xi < 0$, the GEV distribution is *Type III*, i.e. *Weibull* distribution.

Using annual maxima serials of Y_e, GEV is used to obtain the probability density function (PDF) of extreme FR of crops for each county with Maximum Likelihood Estimation (MLE) of parameters. Due to the limitation of space, it cannot be done to list all PDFs of counties in Northeast China. Only three PDFs and histograms of three counties are presented in Fig. 12.5, where the PDF of Baicheng city is *Type I* of GEV, the one of Baiquan county is *Type II* of GEV, and the one of Zhangwu county is *Type III* of GEV.

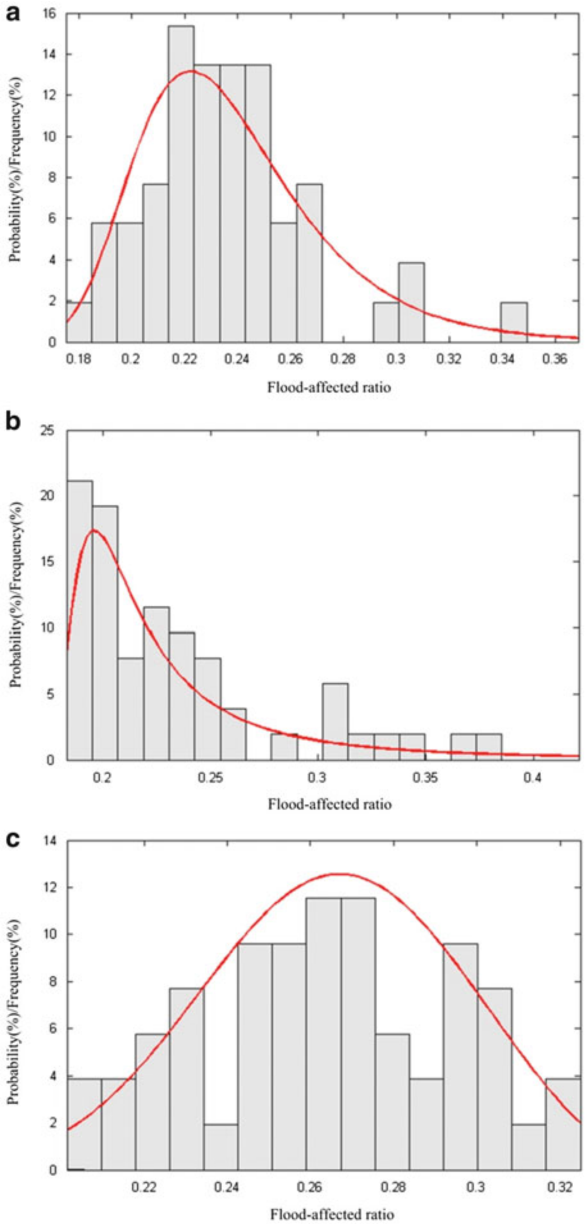

Fig. 12.5 Three types of PDFs and histograms of three counties for an example (**a**) Baicheng city (*Type I*, *Gumbel* distribution) ($\xi = -0.002$, $\sigma = 0.028$, $\mu = 0.2222$) (**b**) Baiquan county (*Type II*, *Frechet* distribution) ($\xi = 0.5584$, $\sigma = 0.0242$, $\mu = 0.2055$) (**c**) Zhangwu county (*Type III*, *Weibull* distribution) Zhangwu county (*Type III*, *Weibull* distribution) ($\xi = -0.3401$, $\sigma = 0.0313$, $\mu = 0.2549$)

12.7 Quantifical Measures of Catastropic Risk

12.7.1 Risk Measuring Models

Based on the PDF of extreme FRs of crops, the Expectation-based and VaR-based measures were used to quantify flood catastrophic risk of crops for each county in Northeast China.

1. Expectation measures the expected losses of extreme flood events expressed as below.

$$E(Y_e) = \int y_e f(y_e) dy_e \tag{12.9}$$

   where $f(y_e)$ is the PDF of extreme FR of crops. Expectation-based measure is used to obtain the average level of catastrophic risk in general.
2. VaR (Value-at-Risk) is widely used risk measure in market risk management. VaR measures the worst expected losses under normal market conditions over a specific time interval at a give confidence level. Using VaR, the risk at a specific confidence level is measured as below.

$$VaR(\alpha) = -\min\{y_e | F(y_e) \geq \alpha\} \tag{12.10}$$

   Then,

$$P(y_e > VaR) = 1 - \alpha \tag{12.11}$$

where $F(y_e)$ is the cumulative probability function (CDF) of extreme FRs of crops. In disaster study, return period T is often used to measure the frequency of disaster outbreaks. Therefore, using return period, VaR can be expressed as below.

$$P(y_e \leq VaR) = 1 - \frac{1}{T} \tag{12.12}$$

Compared with Expectation-based measure, VaR-based measure is used to obtain the worst level of catastrophic risk at a specific return period of flood events.

12.7.2 Results and Discussion

Using Expectation-based and VaR-based measure models, the expected FRs and the worst FRs under 20-years return, 50-years return and 100-years return scenarios were calculated for 172 counties of Northeast China that are presented as county-level risk maps in Fig. 12.6.

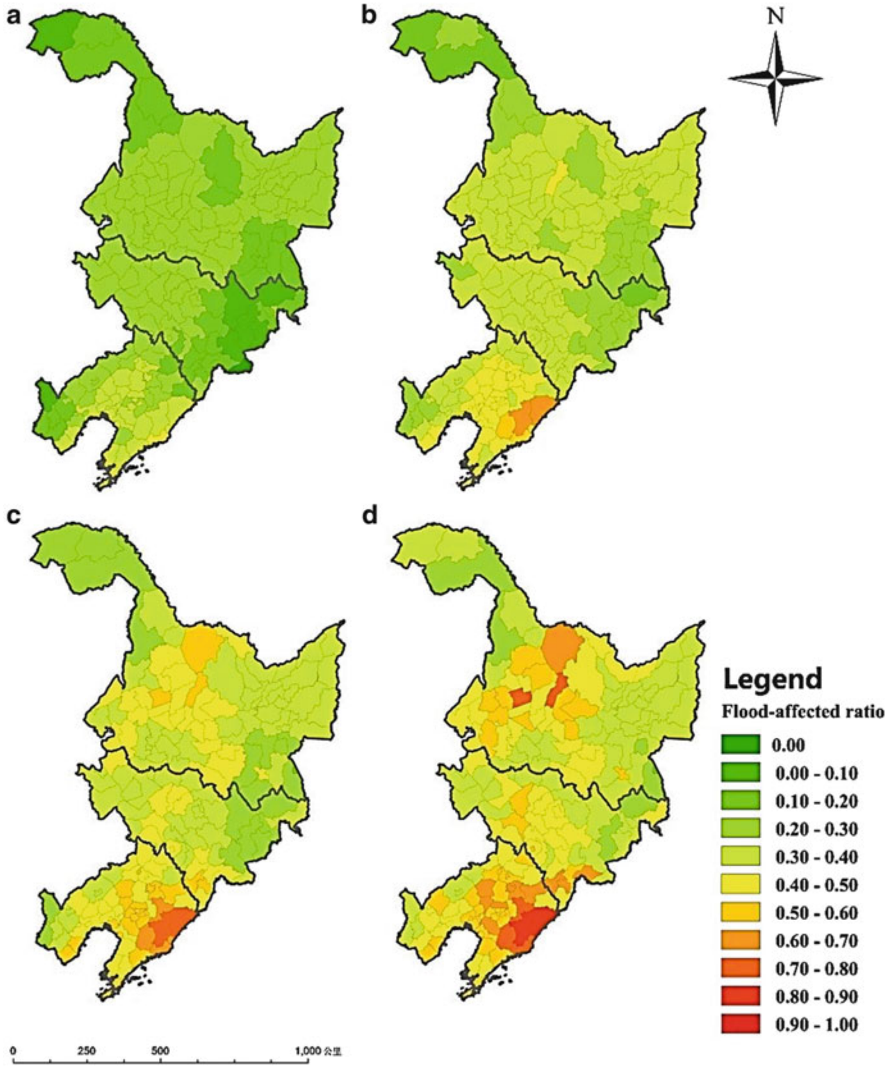

Fig. 12.6 Four types of county-level flood catastrophic risk maps of Northeast China (**a**) Expected flood-affected ratios (**b**) Worst flood-affected ratios of 20-years return (**c**) Worst flood-affected ratios of 100-years return

Three kinds of province-level statistics (mean, maxima and minima) to four types of county-level FRs were calculated and compared among three provinces as Table 12.1. From the table, it can be seen that Liaoning has largest catastrophic risk, and then Heilongjiang and Jilin. From the mean statistic to three provinces, the expected FRs are between 0.2 and 0.3, the FRs of 20-years return are between 0.3 and 0.4, the FRs of 50-years return are between 0.35 and 0.5, and the FRs of

Table 12.1 The comparison of mean, maxima and minima of four types of FRs among three provinces

	Name of province (Number of county)	Expected (order)	20-years return (order)	50-years return (order)	100-years return (order)
Mean	Heilongjiang (76)	0.2271 (2)	0.3203 (2)	0.3718 (3)	0.4170 (3)
	Jilin (48)	0.1991 (3)	0.3157 (3)	0.3743 (2)	0.4240 (2)
	Liaoning (58)	0.2851 (1)	0.4124 (1)	0.4773 (1)	0.5339 (1)
Maxima	Heilongjiang (76)	0.2927 (2)	0.4116 (2)	0.5665 (2)	0.7324 (2)
	Jilin (48)	0.2666 (3)	0.3976 (3)	0.5455 (3)	0.6874 (3)
	Liaoning (58)	0.4012 (1)	0.6485 (1)	0.7749 (1)	0.8819 (1)
Minima	Heilongjiang (76)	0.0819 (3)	0.1720 (1)	0.1863 (1)	0.1947 (1)
	Jilin (48)	0.0657 (1)	0.1942 (2)	0.2504 (2)	0.2984 (2)
	Liaoning (58)	0.0787 (2)	0.2033 (3)	0.2676 (3)	0.3109 (3)

100-years return are between 0.4 and 0.55. From the statistic of maxima, the maximum expected FR exceeds 0.4 (in Donggang city of Liaoning), the maximum FR of 20-years return exceeds 0.6 (in Fengcheng city of Liaoning), the maximum FR of 50-years return exceeds 0.7 (in Kuandian county of Liaoning), and the maximum FR of 100-years return even trends to 0.9 (in Fengcheng city of Liaoning). From the statistic of minima, the minimum expected FRs are below 0.1, the minimum FRs of 20-years return are below 0.2, the minimum FRs of 50-years return are below 0.3 and the minimum FRs of 100-years return are below 0.35.

Four high-risk zones in Northeast China were identified and traced out in Fig. 12.7. In Liaoning province, there exist 2 high-risk zones, i.e. *Zone I* and *Zone II*. *Zone I* locates in the east of Liaoning, having the first highest risk in Northeast China due to the influence of the Yellow Sea and Bohai Sea. From the statistic of mean, in *Zone I*, the expected FR is 0.2814, the FR of 20-years return is 0.4825, the FR of 50-years return is 0.5828, and the FR of 100-years return is 0.6774. The county with highest risk in *Zone I* is Fengcheng city. *Zone II* locates in the center of Liaoning, having the secondary highest risk in Northeast China with the expected FR of 0.3227, the FR of 20-years return of 0.4391, the FR of 50-years return of 0.5006 and the FR of 100-years return of 0.5536 from the statistic of mean. The county with highest risk in *Zone II* is Yingkou city. In Heilongjiang province, there exists 1 high-risk zone, i.e. *Zone III*. *Zone III* locates in the middle-west of Heilongjiang, having the third highest risk in Northeast China with the expected FR of 0.2387, the FR of 20-years return of 0.3578, the FR of 50-years return of 0.4436 and the FR of 100-years return of 0.5283 from the statistic of mean. Suileng is the county with highest risk in *Zone III*. In Jilin province, there exists 1 high-risk zone, i.e. *Zone IV*. *Zone IV* locates in the middle of Jilin, having the last highest risk in Northeast China with the expected FR of 0.2465, the FR of 20-years return of 0.3556, the FR of 50-years return of 0.4145 and the FR of 100-years return of 0.4656 from the statistic of mean. Xifeng is the county with highest risk in *Zone IV*. These four high-risk zones should be paid an attention to, and some measures, such as catastrophic insurance, to transfer and disperse risk need to be taken actively.

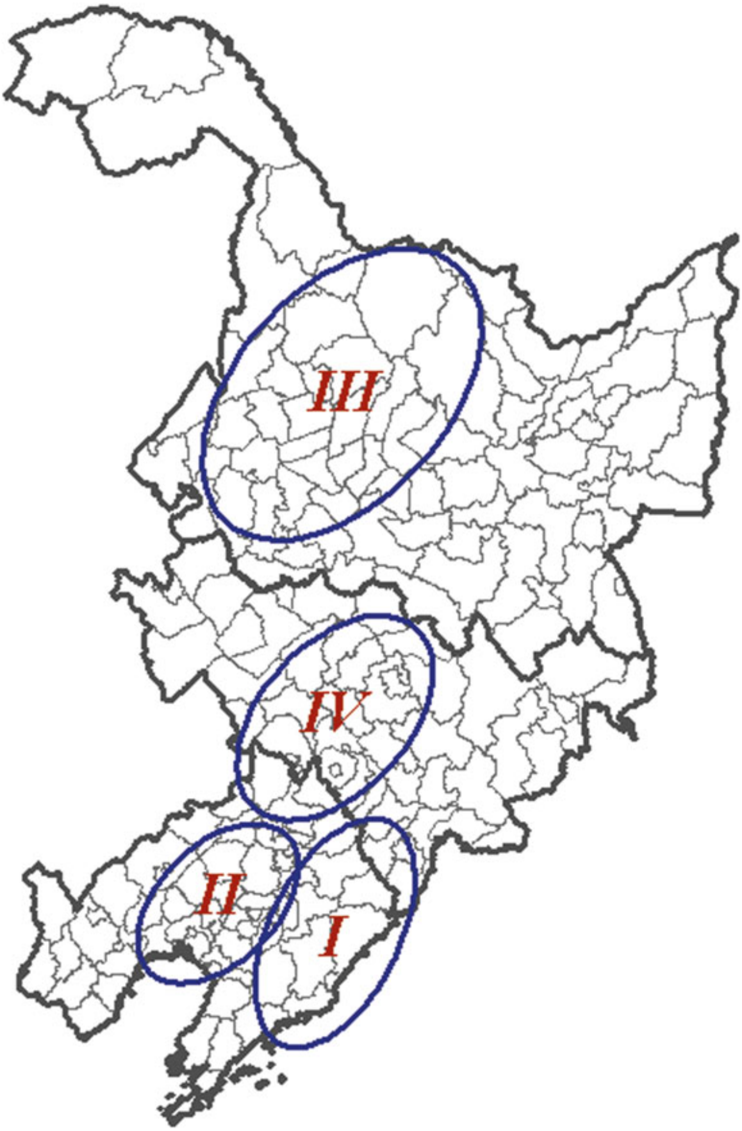

Fig. 12.7 The spatial distribution of high-risk zones in Northeast China

12.8 Summary

In order to solute the problem of the insufficient of loss samples, the county-level probability distribution model of crops' catastrophic risk assessment in Northeast China caused by flood was established indirectly on the combination of extreme storm precipitation and flood vulnerability function of crops under the support of metrological data, terrain data, flood-affected record data and crops' planting area data. Moreover, two measure models, i.e. Expectation-based and VaR-based measures, were employed to quantify catastrophic risk based on the probability distribution model. As a result, four types of county-level risk maps under the average condition, 20-years return, 50-years return and 100-years return scenarios were generated, and high-risk zones in Northeast China were identified.

On the other hand, it can be found out that the flood vulnerability model of crops is crucial in the catastrophic risk assessment. But the current regressive vulnerability function between FR of crops and precipitation, average elevation is not the best because there may be other factors to affect the extent of flooding and the losses of crops by flooding, such as density of rivers, river's depth and width, bank's height, vegetation, etc. Therefore, in the future work, the vulnerability model of flood vulnerability of crops with good fitness would be established under the consideration of more factors involved in modeling.

Acknowledgements This study was funded by Natural Science Foundation of China (40901274), Basic Scientific Research Project of Nonprofit Central Research Institutions (2013-J-014) and Key Projects in the National Science & Technology Pillar Program during the Twelfth Five-year Plan Period (2012BAH20B04), and the financial supports are gratefully acknowledged.

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Chapter 13
Study on Fluctuation Rules of Meteorological Phenomena Stress Environment in Cow Dominant Areas of China

Xiaoxia Dong, Haomiao Liu, Jianhua Zhang, Jiangpeng Guo, Ma Chong, Yanqiu Feng, and Zhiqiang Li

Abstract Climate change has become the hot topic in the world, more and more scholars started to pay attention to the impact of climate change on agricultural production. This article adopts two indicators – the temperature and humidity index (THI) and wind chill temperature (WCT) analyses the daily change characteristics of THI and WCT in 13 provinces of cow breeding dominant areas from 2000 to 2011. The study finds that climate change assaulted external stress environment on cow dominant areas, on the overall, the impact of advantages overweighed disadvantages. The number of hot stress days declined in cow dominant area of Beijing, Tianjin and Shanghai, Northeast China and Inner Mongolia area and North China, meanwhile, the number of cold stress days also decreased in Northeast China and

Supported by "Beijing Innovation Team of Technology System in Dairy Industry" and The Ministry of Agriculture Soft Subjects (Z201335) and National Natural Science Foundation of China "A study on Asymmetry of vertical price transmission in Chinese livestock industry chain" (71203221).

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_13, © Springer-Verlag Berlin Heidelberg 2014

Inner Mongolia area and Northwest China cow breeding dominant areas. In a word, external stress environment improved significantly on cow breeding.

Keywords Climate change • Stress environment • Temperature and humidity index • Wind chill temperature • Cow breeding dominant area

13.1 Introduction

Now, climate change is the biggest environmental problems that our humanity has ever faced. Although there was a dispute of future climate change trends among the scientific community, climate change already had a profound impact on the global ecosystem and human health life (Xiao Guoju et al. 2010). Climate resources are the basis resources for agricultural production. Climate change influenced agricultural production, not only related to the production and supply security, but also may affect the quality of agricultural products and food security (Pan Genxing et al. 2011a). In 2009, the Food and Agriculture Organization of the United Nations (FAO) addressed climate change as an important means to solve the world's food supply and alleviate hunger (FAO 2009). More and more attention has paid to the climate change effect on agriculture production, especially food security.

Scholars at home and abroad took widely study on climate change on crop production since the 1990s. Wolf etc. (1996) considered that the raise of rainfall and carbon dioxide could lead to higher yields of crops by wheat growth simulation model to simulate scenarios under different weather conditions. Chakraborty et al. (2000) proposed that climate change caused plant diseases and augment of crop losses. Study showed that climate change was a serious threat to agricultural development in Africa by research on agricultural risks posed by climate change. Zhang Jianping et al. (2009) predicted future climate by discharging SRES, they found that water demand on corn showed an increasing trend in three provinces of Northeast China and the highest demand increased 77.8 %. Zhao Guoliang et al. (2012) analyzed change trend and relationship between rape growth period and temperature, found that rape full growth period showed a highly significant negative correlation with average ground temperature of 5, 10, 15, 20 cm by using the temperature changes data from 1968 to 2009 as well as the rape growth periods from 1980 to 2010 in Tianshui city.

Compared to crops, domestic and foreign scholars pay less attention to the impact of climate change on livestock production. At present, the relative research around climate change on animal husbandry studied mainly through direct effect of the climate change on grassland resources change, and then affecting grassland production capacity and product quality of animal husbandry (Pan Genxing et al. 2011b). As a typical representative of livestock industry, cow breeding impact by climate change increasingly prominent. Study the impact of climate change on dairy farming is great significantly. Therefore, this article selected the cow dominant areas in China and analyzed the influence of cow breeding stress environment from climate change in nearly 10 years. The article is divided into four parts: first, general situation in research regions; second, data and method; third, cow dominant areas analysis; fourth, summary and conclusion.

13.2 General Situation in Research Regions

According to the National Cows Regional Distribution Plan (2008–2015), China's cow breeding dominant areas, including Jingjinhu area (Beijing, Tianjin and Shanghai); Northeastern China and Inner Mongolia area (Heilongjiang, Liaoning and Inner Mongolia), North China area (Hebei, Shanxi, Henan and Shandong), Northwest China area (Xinjiang, Shaanxi and Ningxia), those comprise 313 cow breeding bases in the county (mission field) in 13 provinces (cities, districts) as the national dairy production dominant areas (Fig. 13.1).

Cow breeding dominant areas hold an important position in the national dairy farming. The number of dairy herds was 1,925,000, accounting for 71.5 % of the country's total breeding stock; dairy production was 4.157 million tons, accounting for 68.9 % of the country's total output in above dominant areas in 13 provinces (cities, districts) in 1990. The concentration was more and more obvious with cow breeding development. In 2011, the number of dairy cattle herds of the dominant areas reached 12.029 million, accounting for 83.5 % of the national number of herds; milk production run up to 32.14 million tons, accounting for 87.9 % of the country's total output (see Table 13.1). Production fluctuation of cow dominant areas directly affected the national milk production. Therefore, study on climate change of cow dominant areas and its possible impact on milk production took on great significance.

13.3 Data and Method

13.3.1 Data

The data for this study were meteorological data from Chinese terrestrial climate daily data set, which included the daily average temperature, maximum temperature, minimum temperature, average relative humidity, average wind speed and precipitation. The samples covered 13 provinces (cities, districts) that were Beijing, Tianjin, Shanghai, Heilongjiang, Liaoning, Inner Mongolia, Hebei, Shanxi, Henan, Shandong, Xinjiang, Shaanxi and Ningxia, including Zhangbei, Wei County, Anyang, Xuchang, Harbin, Qiqihar, Anshan, Yingkou, Hohhot, Xilinhot, Salt Lake, Ning, Jinan, Qingdao, Taiyuan, Datong, Xi'an, Shangzhou, Baoshan, Beijing

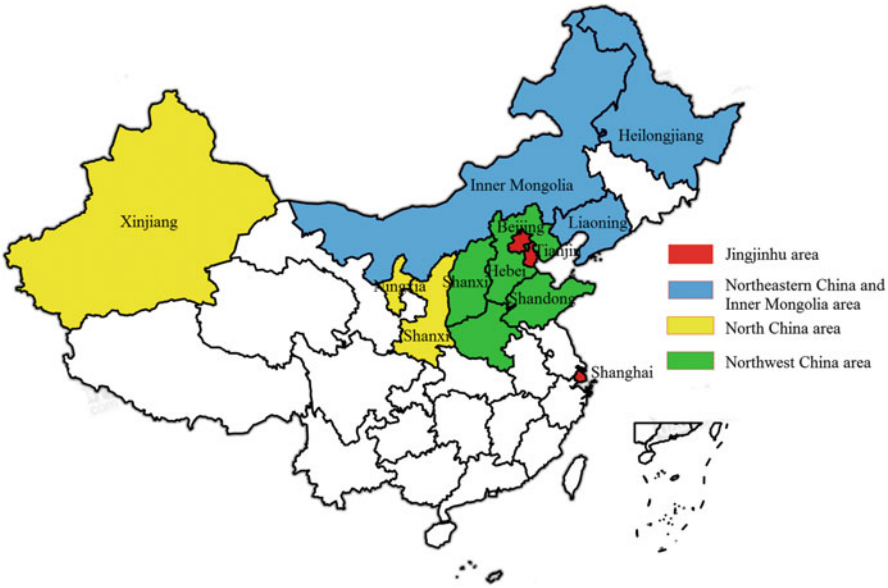

Fig. 13.1 Regional distribution of cow breeding dominant areas in China

Table 13.1 Dominant areas' position in the national dairy production (Unit: 10,000 t, 10,000 herds, %)

	Output			Number of cow herds		
	National	Dominant area	Proportion	National	Dominant area	Proportion
1990	415.7	286.4	68.9	269.1	192.5	71.5
1995	576.4	441.9	76.7	417.2	350.3	84.0
2000	827.4	640.5	77.4	488.7	414.0	84.7
2005	2,753.4	2,383.6	86.6	1,216.1	1,054.4	86.7
2010	3,575.6	3,144.3	87.9	1,420.1	1,185.0	83.4
2011	3,656.0	3,214.0	87.9	1,440.2	1,202.9	83.5

Source: China dairy industry statistical yearbooks

and other more than 200 monitoring stations. These observed samples were used from January 1, 2000 to October 31, 2011.

13.3.2 Method

Cows are warm-blooded animal; its thermoneutral zone (TNZ) is 5–25 °C. Out TNZ, stress occurs and climate conditions have a direct impact on the milk production and milk quality, even bring out disease. When the outside temperature exceeds TNZ, cows occur stress, when the temperature is higher than the upper limit value of TNZ, it reflects heat stress, on the contrary, it reflects cold stress. The study measures changes of external meteorological stress environment in the national cow dominant areas through temperature-humidity index and wind chill index.

13.3.2.1 Temperature and Humidity Index

The level of heat stress is not only associated with the outdoor temperature, but also related with the air humidity closely. In the same temperature, the greater humidity causes the greater the degree of heat stress for cow breeding. In order to represent the degree of heat stress objectively, usually use temperature and humidity index (THI) to reflect the heat stress environment. Ravagnolo et al. (2000)'s THI calculation formula was based on the impact of cow heart rate, respiration, body temperature and other physiological indicators according to the different degrees of temperature and humidity. And it was corrected in summary form the formula. The specific formula as follows:

$$THI = (1.8 \times T_{air} + 32) - (0.55 - 0.55 \times RH) \times (1.8 \times T_{air} - 26)$$

Here, THI is a temperature and humidity index, T_{air} expresses Celsius (°C) and RH shows relative humidity.

Johnson (1980, 1985), Du Preez et al. (1990) and Armstrong (1994) all found that heat stress occurred when THI was greater than 72, feed intake and milk production decreased. Comprehensive above studies, specific criteria for the classification of the degree of heat stress were as follows: $72 < THI \leq 79$ for mild heat stress; $79 < THI \leq 88$ for moderate heat stress; and $THI > 88$ for severe heat stress (see Table 13.2).

13.3.2.2 Wind Chill Index

Wind chill index (WCI) was created by Sinpal and Passel in the scientific research expedition in the Antarctic in 1941. Siple and Passel (1945) in a follow-up studies, people often lost to the heat converted into metrics wind chill temperature of cold temperature (wind chill temperature, WCT), also known as cold considerable temperature. In the late 1990s, many people began to strongly question the Siple-Passel the suitability of the method. In 1999, the U.S. National Weather Service (NWS) and the Canadian Meteorological Service Center (WSC) jointed together to re-study the WCT, and published the latest wind chill temperature formula in 2001, the specific calculated as follows:

$$WCT = 13.12 + 0.6215\,T_{air} - 11.37\,V^{0.16} + 0.3965\,T_{air}V^{0.16}$$

Here, WCT shows the cold temperature, T_{air} expresses Celsius (°C) and V means that the ground 10 m wind speed (km//h). Now, WCT is an effective and convenient

Table 13.2 The degree of stress grading of cow breeding

Heat stress		Cold stress	
THI $\leq$ 72	No	WCT > -10	No
THI>72	Happen	WCT ≤ -10	Happen
$72 <$ THI ≤ 79	Mild	$-25 <$ WCT ≤ -10	Mild
$79 <$ THI ≤ 88	Moderate	$-45 <$ WCT ≤ -25	Moderate
THI > 88	Severe	WCT ≤ -45	Severe

Source: Authors reorganized according to the literatures (Osczevski, 1995; Hu et al., 2010)

indicator of the international academic community recognized for evaluation cold environment impact on the performance of dairy cattle. Specific criteria for the classification of the degree of cold stress were as follows: $-25 <$ WCT ≤ -10 for mild cold stress, $-45 <$ WCT ≤ -25 for moderate cold stress, $-59 <$ WCT ≤ -45 for the height of cold stress and WCT ≤ -59 for extreme cold stress (see Table 13.2).

13.4 Stress Environment Change in Cow Dominant Areas About Resent 10 Years

13.4.1 Jingjinhu Area

Cow dominant areas of Beijing, Tianjin and Shanghai are located in the suburbs of big cities, which Beijing and Tianjin are behalf of north metropolitan and Shanghai is behalf of south metropolitan. Cow breeding in Shanghai dairy only had heat stress environment, while cow breeding in Beijing and Tianjin had both heat stress and cold stress environment. Analysis on change trend from heat stress environment, cow dominant of Jingjinhu area got some improvement, the days of heat stress decreased. In detail, the number of days that THI > 72 in Beijing was 127, Tianjin was 115 and Shanghai was 147 in 2011, which reduced 17, 26, and 9 days compared with 2000, respectively. Analysis on change trend from cold stress environment, dominant areas of Beijing and Tianjin showed a “U” shape and the year 2007 was the turning point in the nearly 10 years of climate change. The number of days that WCT < -10 in Beijing was 11, Tianjin was 28 in 2007, which was short 47 and 31 days compared with 2000, respectively. Cold stress days increased significantly since 2008, the days that WCT < -10 in Beijing was up to 41 and Tianjin was 56 (see Table 13.3).

Table 13.3 Stress environment change of cow breeding in Jingjinhu area from 2000 to 2011

	Beijing		Shanghai		Tianjin	
	Days		Days		Days	
Year	THI > 72	WCT ≤ −10	THI > 72	WCT ≤ −10	THI > 72	WCT ≤ −10
2000	144	58	156	1	141	59
2001	140	58	150	0	138	62
2002	135	23	155	0	130	28
2003	142	27	150	1	137	41
2004	139	28	155	2	132	39
2005	134	49	161	3	133	75
2006	143	21	162	0	137	40
2007	142	11	161	0	136	28
2008	143	34	155	1	127	49
2009	146	35	165	3	136	46
2010	134	48	138	2	120	61
2011	127	41	147	1	115	56

Source: Authors calculated according to meteorological data

13.4.2 Northeastern China and Inner Mongolia Area

Northeastern China and Inner Mongolia area is the largest cow dominant area in China. By provinces, Heilongjiang was mainly in cold stress environment for cow breeding, Liaoning and Inner Mongolia had both cold stress and heat stress environment. Impact of climate change on cow breeding had differences among the three provinces. In detail, stress environment in Heilongjiang improved markedly, that the days THI > 72 was 23 and WCT < −10 was 149, which reduced 18 and 11 days compared with 2000. Stress environment of Liaoning changed little, the number of days that THI > 72 decreased slightly in fluctuations and the days that WCT ≤ −10 had been maintained at about 100. Inner Mongolia's environment change was mainly reflected in the reduction of cold stress days, which from 160 days in 2000 to 141 days in 2011(see Table 13.4).

13.4.3 North China Area

Heat stress environmental impact was significantly greater than the cold stress in North China cow dominant area. From variation trend of heat stress environment, the days that THI > 72 declined in Henan, Hebei, Shandong and Shanxi in the past 10 years. The days that THI > 72 in the four provinces were 138, 114, 114 and 96 in 2011, which reduced 17, 17, 15 and 16 days compared with 2000, respectively. From variation trend of cold stress environment, Hebei and Shandong provinces changed, in addition to Shanxi and Henan provinces increased slightly in stability. The change presented "U" shape with volatility characteristics with 2007 as cut-off

Table 13.4 Stress environment change of cow breeding in Northeastern China and Inner Mongolia area from 2000 to 2011

	Heilongjiang		Liaoning		Inner Mongolia	
	Days		Days		Days	
Year	THI > 72	WCT ≤ −10	THI > 72	WCT ≤ −10	THI > 72	WCT ≤ −10
2000	41	160	120	109	90	160
2001	36	152	116	104	98	150
2002	21	158	113	94	78	154
2003	15	142	110	93	72	144
2004	32	145	120	90	79	151
2005	22	147	107	111	82	140
2006	21	157	126	99	81	150
2007	33	149	119	95	93	147
2008	24	134	104	97	80	137
2009	12	149	117	108	71	146
2010	25	165	113	101	96	160
2011	23	149	106	103	80	141

Source: Authors calculated according to meteorological data

point. In 2011, cold stress days in Henan, Hebei, Shandong and Shanxi provinces increased significantly which were 20, 75, 51 and 97 days, respectively, increased 16, 30, 30 and 14 days compared to 2007(see Table 13.5).

13.4.4 Northwest China Area

Climate characteristics in Northwest China cow dominant area presented outstanding performance as follows: hot in summer, little rain throughout the year and dry climate. By province, Shaanxi was influenced mainly by heat stress, while Xinjiang and Ningxia had impacted both heat and cold stress environment. The stress days in all the three provinces showed inverted “U” trend from overall change trend of heat stress environment. In detail, 2006 as a turning point for Shaanxi province, the days that THI > 72 were 127, which was the highest in nearly 12 years, and then declined year by year, falling to 111 days in 2011; 2008 as the turning point for Xinjiang and Ningxia provinces, the days that THI > 72 were 120 and 101, respectively, which reached a record high point, and then decreased significantly, falling to 107 and 92 days, respectively. Change trend of cold stress presented that the days of cold stress reduced in addition to Shaanxi province, where the days of cold stress enhanced 15 days, while the days reduced 29 and 28 in Xinjiang and Ningxia provinces. Cold stress environment changed in the opposite comparing with heat stress, cold stress days in Shaanxi and Ningxia reduced lowest in 2007, and then showed up obviously (Table 13.6).

Table 13.5 Stress environment change of cow breeding in North China area from 2000 to 2011

	Henan		Hebei		Shandong		Shanxi	
	Days		Days		Days		Days	
Year	THI > 72	WCT ≤ −10	THI > 72	WCT ≤ −10	THI > 72	WCT ≤ −10	THI > 72	WCT ≤ −10
2000	156	14	131	84	129	41	112	94
2001	153	15	130	88	130	41	111	89
2002	155	5	121	60	128	30	109	75
2003	137	13	126	69	119	45	108	84
2004	154	15	126	62	132	39	107	92
2005	144	20	121	83	133	75	116	101
2006	170	0	130	55	146	29	78	92
2007	155	4	129	45	139	21	110	83
2008	153	12	130	68	132	39	110	98
2009	157	15	133	69	136	32	102	94
2010	140	14	121	82	118	47	106	98
2011	138	20	114	75	114	51	96	97

Source: Authors calculated according to meteorological data

Table 13.6 Stress environment change of cow breeding in Northwest China area from 2000 to 2011

	Shaanxi		Xinjiang		Ningxia	
	Days		Days		Days	
Year	THI > 72	WCT ≤ −10	THI > 72	WCT ≤ −10	THI > 72	WCT ≤ −10
2000	121	39	99	142	91	128
2001	112	34	108	139	94	116
2002	124	30	104	100	94	100
2003	118	35	112	122	98	107
2004	124	36	106	102	95	107
2005	121	65	101	106	96	112
2006	127	37	110	104	90	103
2007	124	28	112	112	98	46
2008	124	57	120	104	101	96
2009	119	42	91	119	91	100
2010	119	47	97	110	97	102
2011	111	54	107	113	92	100

Source: Authors calculated according to meteorological data

13.5 Summary and Conclusion

Climate change had a certain impact on external stress environment of cow dominant areas in nearly 10 years. In general, the effect was good than harm. From heat stress environment, we got the results that external heat stress environment of cow breeding improved significantly, which was to say that all the cow dominant areas' heat stress days declined in addition to the Northwest China area, where the heat stress days showed an inverted "U" shape. From cold stress environment, we could see that cold stress days decreased in Northwest China area and Northeastern China and Inner Mongolia cow dominant areas, other dominant areas presented a "U" shape. Studies by province, stress days were fluctuated significantly whether heat stress or cold stress in all the other 11 provinces except Liaoning and Jiangxi province.

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Chapter 14
Study on Extreme Risk Measurement of Chinese Soybean Futures Market—VaR Based on GARCH Model

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Abstract Accurate risk measurement is critical to improve the level of market risk quantitative management. At present the indicator of VaR has been widely applied in the measurement of agricultural market extreme risk. However, the basic application research of VaR estimation techniques is not in-depth enough to efficiently estimate the increasingly complicated market risks. This study analyzed summary statistics for the soybean futures market price return, measured its price risk with the VaR method based on GARCH model, and discussed the impacts of residual probability distribution's assumptions of normal distribution, Student-t distribution and generalized error distribution on the accuracy of VaR estimation. The results showed that VaR based on GARCH model could better depict the distribution and volatility of soybean futures market return, and to some extent the accuracy of VaR could be improved considering residual's skewness.

Keywords Value at risk • GARCH model • Probability distribution • Soybean futures market • Price risk

14.1 Introduction

As an important part of modern financial markets, futures market plays an important role from both the perspective of risk aversion and the investment perspective. Since 2004, China government has put forward nine No. 1 Central Documents which highlighted the importance of actively developing agricultural futures market to evade risks. At present China agricultural futures market has formed the basic

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*, DOI 10.1007/978-3-642-54389-0_14,

configuration, composed of Zhengzhou Commodity Exchange (ZCE), Dalian Commodity Exchange (DCE), and Shanghai futures exchange (SFE). Nowadays there are 13 agricultural futures varieties in China. With the development of agricultural futures market and the increasing emphasis of government, some commodities such as pig, rice, egg and so on are also being prepared for listing. According to the U.S. Futures Industry Association (FIA) statistics, China's agricultural futures trading volume accounted for 58 % of that of the global agricultural futures market in 2011, which implied China has become the world's largest agricultural futures markets. What's more, the Dalian Commodity Exchange has become the world's second-largest soybean futures market following Chicago Board of Trade (CBOT) of United States.

Soybean is a variety of agricultural futures with higher degree of market orientation and relatively earlier to be introduced among China's four major grain varieties. Since joining the WTO, China's agricultural market speeds up opening up, and the soybean industry flourished while also facing huge market risk. Over the past decade, soybean imports of China increased rapidly. The quantities of soybean imports increased from 13.94 million tons in 2001 to 58.38 million tons in 2012, and China become the world's largest soybean importer. However, the global four major grain merchants which are ADM, Bunge, Cargill and Louis Dreyfus controlled 80 % supply of China's soybean imports. Wholly foreign-owned and joint venture processing among domestic oil extraction enterprises accounts for about 85 % of total domestic soybean crushed, which makes the risk of China soybean futures market is particularly prominent. In particular, the occurrence of several big risk events seriously damaged the positive functions of soybean futures market. Therefore, how to effectively identify, measure and control the risk of futures market is not only a scientific problem to be solved, but also an important and urgent task to strengthen risk quantitative management research of agricultural futures market.

Risk measurement is the key of risk quantitative management. Referring to the methodologies of market risk measurement, the indicators of market risk measurement and modeling to estimate these indicators are two important aspects of market risk measurement research. In 1952, American economist Markowitz (1952) put forward mean-variance model for portfolio and used it to measure the risk of portfolio. Therefore he was regarded as the earliest pioneer to use quantitative model to measure the market risk. Markowitz (1959) put forward the second half variance of portfolio return as risk measurement of variance model. In the middle of 1960s, Sharp (1964), Lintner (1965) and Mossin (1966), etc. put forward Capital Asset Pricing Model (CAPM) based on the theory of portfolio management, and proposed to use the beta coefficient to measure assets risk. Achaya and Pedersen (2005) decomposed the flow risk into three parts based on traditional CAPM, and constructed a four-beta model. In 1996, VaR was adopted by Bashar Agreement as a tool of financial institution risk measurement and management. The advantages of VaR are that it cannot only measure the amount of potential losses, but also assess the probability of the loss occurrence, which make VAR become the general method to measure market risk. At present, VaR has become the popular method to measuring market risk.

Extreme price movements in the financial markets are rare but important. Some important events such as economic, political and natural risk events have attracted a great deal of attention among investors, practitioners, and researchers (Liu and Hua 2012). As a result, VaR has become the standard measure of market risk in risk management. Its usefulness is widely discussed. VaR is a single estimate by which an institution's position in a risk category could decline due to general market movements during a given holding period. The measure can be used by financial institutions to assess their risks or by a regulatory committee to set margin requirements. In the former case, VaR is used to ensure that the financial institutions can still be in business after a catastrophic event. From the viewpoint of a financial institution, VaR can be defined as the maximal loss of a financial position during a given time period for a given probability. In this view, one treats VaR as a measure of loss associated with a rare (or extraordinary) event under normal market conditions. Alternatively, from the viewpoint of a regulatory committee, VaR can be defined as the minimal loss under extraordinary market circumstances. Both definitions will lead to the same VaR measure, even though the concepts appear to be different.

To measure market risk, the application of VaR methodology offers comprehensive and recapitulative advantages. It depicts market risk by means of the probability distribution of a random variable and evaluates the risk with a single real number. As a result, VaR has become an essential tool within financial markets. VaR is also applicable in agricultural markets to measure risk, and several authors have accomplished commendable research using VaR. Internationally, Manffredo and Leuthold (2001) used historical simulation method of GARCH model to calculate VaR of American beef market. Giot (2003) used VaR method to measure the risk of agricultural futures market such as coffee, cocoa, sugar, etc. Odening and MuBhoff (2002) used GARCH model to analyze the pig market risk of German. Siaplay et al. (2005) established the model of American turkey market risk measurement based on extreme theory, and analyzed its impact on food security. Zhang et al. (2007) used Monte Carlo method to measure the extreme risk of American cotton futures price volatility. In China, Zhang et al. (2010), Wang et al. (2012), etc., based on the empirical distribution of probability density distribution model, estimated VaR of grain and vegetable market including cash market and futures market. Han (2008), Liu (2011), Li and Shen (2010), Li et al. (2011, 2012), He et al. (2012), Liu and Fei (2012), etc., estimated the VaR based on GARCH model for wheat, soybeans, rapeseed oil, cotton, soybean meal, sugar and rubber futures market. However, only a few studies modeled the probability density distribution based on non-parametric kernel density method, and used it to measure the price risk of agricultural market (Li 2011; Li et al. 2012).

From the existing literatures which adopted the VaR method to measure risks in agricultural markets, it should be noted that most are solely focused on the market risk when agricultural price returns go down (i.e. downside risk). However, agricultural product, as a special commodity, has its own traits different from financial products, and so does its market risks. Specifically, its market risk has quite distinct implications for disperse market participants. For example, when agricultural market price returns slump, agricultural producers or sellers will suffer losses and vice versa. Therefore, in contrast to the risk measurement in financial markets, both the downside and upside risks have to be considered in agricultural markets. However, there are still shortcomings in existing VaR methods (such as the assumption of standard normal distribution). Hence, exploration should be conducted for appropriate VaR methods, and convincing empirical research. This work would be of great significance to identify future trends of agricultural price returns, and thus help to support the scientific decision making of those governmental departments and enterprises concerned.

Taking soybean futures price of Dalian Commodity Exchange for example, this study analyzed summary statistics for the soybean futures market price, measured its price risk with the VaR method based on GARCH model, and discussed the impacts of residual probability distribution's assumption of normal distribution, Student-t distribution and generalized error distribution on the accuracy of VaR estimation. The results showed that VaR based on GARCH model could better depict the distribution and volatility of soybean futures market returns, and to some extent the accuracy of VaR could be improved considering residual's skewness.

The remainder of the paper is set out as follows. In section of methodology, we describe our empirical framework modeling. In section of data description, we give a brief description of the data and summary statistics of variables of interest. In section of empirical analysis, we report our results. In section of conclusion, we summarize the most important conclusions of this study and illustrate the implications of the research.

14.2 Methodology

It is generally believed that the term of Value at Risk was put forward by Gul Diman. In July 1993, the International Group of 30 (G-30) used this term officially in their report of "Derivatives: Practices and Principles". In particular, the Basel Committee on Banking Supervision (1996) of the Bank for International Settlements imposes it on financial institutions such as banks and investment firms to meet capital requirements based on VaR estimates. As a result, Value at Risk has come out as a standard measurement of an institution's risk exposure and has become a standard tool to evaluate and manage financial risk.

14.2.1 The Definition of VaR and Estimation Method

Value at Risk is mainly concerned with market risk. It can be defined as the maximal loss of a position on a financial asset during a given time period for a given probability. Given a confidence level c ∈ (0, 1), the VaR of the portfolio at the confidence level c is given by the smallest number l such that the probability that the loss L exceeds l is at most 1-c. Mathematically, if L is the loss of a portfolio, then VaR_c(L) is the confidence level c quantiles, i.e.

$$\Pr\left\{ \mathrm{VaR}_{t|t-1}(\mathrm{L}) \geq l|\mathrm{I}_{t-1} \right\} = 1 - c$$

14.2.1.1 VaR Calculation Based on General Distribution

If P_0, is the initial portfolio investment, then taking R as the rate of return, the expected value of the portfolio at the end of a chosen time horizon is: $P_t = P_0(1 + R)$. Let the average return be denoted by μ, Since we are interested in the lowest portfolio value at a particular confidence level, denoted by α, we are finding the rate of return R^* resulting in this lowest portfolio value P^*: $P^* = P_0(1 + R^*)$. Gives us the estimate for the VaR relative to the mean to be written as:

$$VaR = E(P_t) - P^* = -P_0(R^* - \mu)$$

Absolute VaR can be defined as $VaR = P_0 - P^* = - P_0R^*$.

As can be seen, the calculation of VaR is equivalent to compute smallest value of assets (P^*) or the minimum returns of assets (R^*). Assume that the probability density function of the assets' future returns is $f(x)$, VaR of the assets for a given confidence level c is:

$$\int_{-\infty}^{VaR} f(x)dx = 1 - \mathrm{c}$$

14.2.1.2 VaR Calculation Under Normal Distribution

Given α is the quantile of the standard normal distribution for a given confidence level c, it can be specified:

$$-\alpha = \frac{R^* - \mu}{\sigma}$$

Therefore, the minimum returns can be written as $R^* = \mu - \alpha\sigma$. Assuming the series of returns is not related, thus relative VaR for a given holding time interval T is:

$$VaR = -P_0(R^* - \mu) = P_0\alpha\sigma\sqrt{T}$$

Based on normal distribution assumption, the critical value for a given confidence level c is the maximum possible loss of assets in the statistics. According to the theory of sampling distribution, the probability of loss over VaR will be no more than $1 - c$.

14.2.1.3 Back Testing of VaR

After the calculation of VaR, for the sake of reliability, it is necessary to backtest whether the VaR model used has adequately estimated the real extreme risk or not. To this end, the backtest method provided by Kupiec (1995) is employed here. Its main idea can be summarized as that if we assume the confidence level c, sample size T, days of failure N, then the frequency of failure can be regarded as $f = N/T$. Subsequently, Kupiec (1995) proposed the most proper likelihood ratio test with the null hypothesis $f = 1 - c$, where the statistic

$$LR = -2\ln\left[p^N(1-p)^{T-N}\right] + 2\ln\left\{[1-(N/T)]^{T-N}(N/T)^N\right\}$$

Where, p represents expected probability for a certain confidence level. The null hypothesis is $H_0 : p = N/T$ and alternative hypothesis is $H_0 : p \neq N/T$. Under the null hypothesis, $LR \sim \lambda^2(1)$, and the critical values at 95 and 99 % confidence level are 3.841 and 6.635 respectively. According to the definition of λ^2 distribution, if the value of LR is larger than the corresponding critical value, then the null hypothesis should be rejected. In other words, it can be said that the VaR model is not adequate.

14.2.2 VaR Estimation Based on GARCH Model

GARCH (p, q) is one kind of generalized autoregressive conditional heteroscedasticity models. The basic GARCH (p, q) model can be specified as:

$$\begin{aligned} r_t &= b_0 + b_1 r_{t-i} + \varepsilon_t \\ \sigma_t^2 &= \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \end{aligned}$$

Where r_t denotes the returns of soybean futures market price, ε_t denotes residual, σ_t denotes conditional standard deviation, ω denotes constant. There are also some other constraints, such as $p > 0$, $q \geq 0$, $a_0 > 0$, $\alpha_i \geq 0$ ($i = 1, 2,\ldots, q$), $\beta_j \geq 0$ ($j = 1, 2,\ldots, p$), and $\sum_{i=1}^{q}\alpha_i + \sum_{j=1}^{p}\beta_j < 1$ which reflects the duration of return volatility.

There are three kinds of assumptions for residual distribution of GARCH (p,q) model, i.e. normal distribution, student t distribution and GED distribution. Generally, normal distribution is unable to depict the fatter tail characteristics of market returns series. However, it could better reflect the characteristics of agricultural market price volatility based on the assumption of student t distribution and GED distribution.

For the parametric method, VaR can be calculated according to the below equation

$$VaR_t = p_{t-1}\sigma_t z_c$$

Where P_{t-1} is the market price prior to present, σ_t is the standard deviation which can be calculated based on GARCH model.

14.3 Description of Data

Data used in this study are soybean futures daily price of Dalian Commodity Exchange (DEC) and the sample period spans from 4 January, 2000 to 31 August, 2011 giving a total 1349 trading days. For price series of soybean futures market denoted by P_t, the daily returns are defined as:

$$\text{RSB} = \ln\left({}^{P_t}/{}_{P_{t-1}}\right)$$

Where P_t represents the trade price of soybean futures market at the period of t. In this study, the time series of soybean daily returns was denoted by RSB.

We check the summary statistics of DEC soybean daily returns during the sample period, and results are shown in Table 14.1. Generally, the means and variances of the returns are in the neighborhood respectively. Meanwhile, compared with the standard normal distribution with skewness 0 and kurtosis 3, the skewness of daily returns here is negative (i.e. left skewed) while kurtosis is far larger than 3, hence we may deduce that the return has aleptokurtic distribution with a fat left tail. In other words, returns here do not follow the standard normal distribution. Verification is from the results of Jarque Bera (JB) test.

In order to check the autocorrelation of the series, Ljung Box (LB) test confirms it that the series *RSB* has significant autocorrelation. In addition, the return series is stationary series by means of ADF unit root test, which reject the null hypothesis at 5 % significance level (Table 14.2).

Whereas the return series *RSB* has significant volatility clustering, therefore, the ARCH LM test is carried out for the residual series. The result shows that there is high-order ARCH effect, so a GARCH model needs to be adopted. According to the requirements that the AIC value should be relatively small, and model coefficients must be significant and positive, the GARCH (1,1) model is the best when comparison was made among GARCH (1, 1), GARCH (2, 1), GARCH (1, 2) and GARCH (2, 2) models.

Table 14.1 Summary statistics for DEC soybean market daily returns

Series	Mean	Median	Max	Min	Std. Dev	Skewness	Kurtosis	Jarque-Bera
RSB	0.04 %	0.07 %	8.23 %	−18.15 %	0.014778	−1.480	23.146	23306.5

Table 14.2 Augmented Dickey-Fuller statistics for series *RSB*

variable	t-statistic	Critical value (5 %)	(C,T,K)	Conclusion
RSB	−39.645	−1.941	(0,0,0)	Stationary

Notes: (C,T,K) represents the test type. Where C means intercept, T means trend and K means lag length. The lag length selection is determined according to the requirements of AIC value

14.4 Empirical Analysis

In this study, GARCH (1,1) model was employed for DEC soybean daily return series with three different residual assumptions, i.e. normal distribution (N), t distribution (T) and generalized error distribution (GED). Parameter estimation results of GARCH (1,1) model are shown in Table 14.3. All the parameters are significant at 95 % confidence level.

The calculation of VaR employed parametric method, i.e. $VaR_t = RSB_{t-1}\alpha\sigma_t\sqrt{T}$. Where RSB_{t-1} implies the asset price at the period of $t - 1$, σ_t can be obtained from conditional heteroscedasticity model, α represents quantile with certain distribution, and T means the holding time of asset. Since the daily VaR was calculated in this study, so the value of T is 1. The downside and upside VaRs can be obtained based on normal distribution (N), t distribution (T) and generalized error distribution (GED), and are shown in Figs. 14.1, 14.2 and 14.3 respectively at 95 and 99 % confidence level.

Table 14.4 gives the backtesting results using the likelihood ratio method on VaR of DEC soybean futures market. The results in the Table 14.4 shows that both the LR statistics of downside VaR based on normal distribution and GED distribution assumptions are less than their corresponding critical values at the confidence of 95 %, only with the exception of downside VaR based on t distribution assumption because of higher estimation. However, it was shown that only the LR statistics of upside VaR based on GED distribution assumption is less than the critical value. In other words, it will overestimate the market risk when we use GARCH model based on normal and t distribution assumptions to calculate VaR.

14.5 Conclusion

It is generally believed that the distribution of agricultural futures market daily returns exhibit fatter tails than normal distribution. In addition, the returns are often characterized by a number of stylized "facts" such as volatility clustering and volatility asymmetry. In this study, we compared the performance of VaR models

Table 14.3 Parameters for GARCH (1,1) model of DEC soybean series *RSB*

Distribution	ω	α	β	d	0.95th	0.99th
N	$3.70e^{-6}$	0.082524	0.905659		1.645	1.96
T	$3.64e^{-6}$	0.080711	0.909083	3.688654	2.185	3.928
GED	$3.43e^{-6}$	0.071987	0.911252	1.057920	1.635	2.729

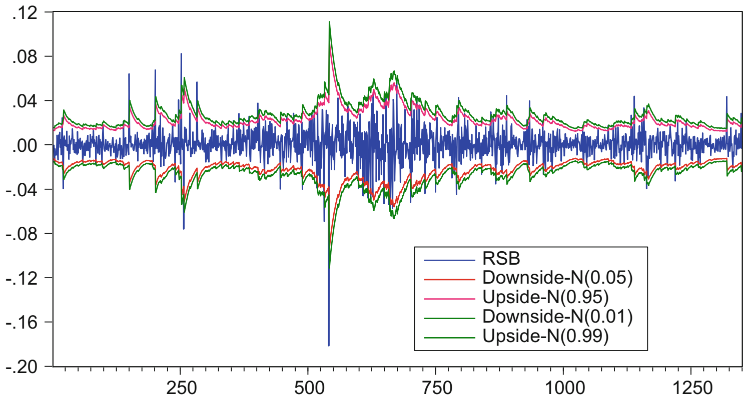

Fig. 14.1 Upside and downside VaRs of RSB based on GARCH model with normal distribution assumption at the 95 and 99 % confidence level

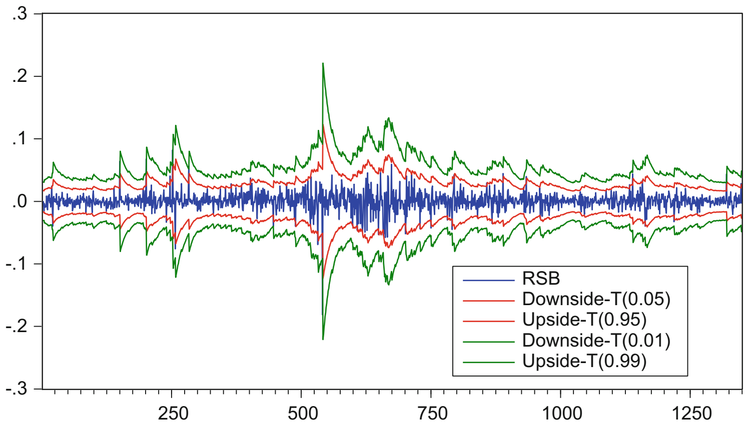

Fig. 14.2 Upside and downside VaRs of RSB based on GARCH model with Student-t distribution assumption at the 95 and 99 % confidence level

with different residual distribution assumptions (i.e., Normal distribution, Student-t distribution and GED distribution) at the 95 and 99 % confidence level respectively. According to the discussion above, it may be safely drawn the following conclusions:

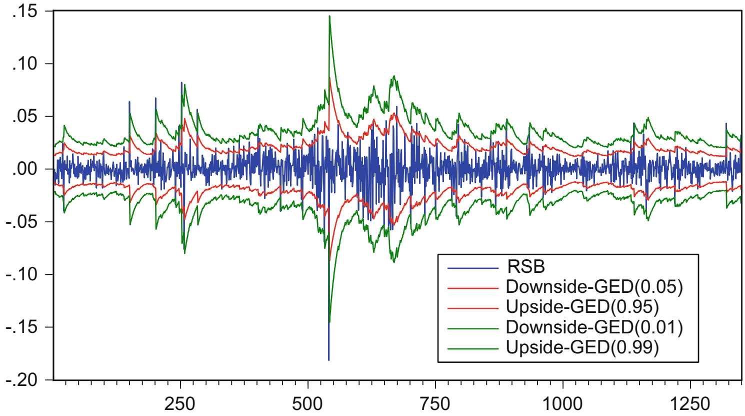

Fig. 14.3 Upside and downside VaRs of RSB based on GARCH model with GED assumption at the 95 and 99 % confidence level

Table 14.4 Testing results of VaR on soybean futures market returns

Distribution (%)		Failure times Downside	Failure times Upside	Rate of failure (%) Downside	Rate of failure (%) Upside	*LR* statistic Downside	*LR* statistic Upside	*VaR* 样本总数
95	N	57	50	4.225	3.706	1.795	5.200	1,349
	T	23	25	1.705	1.853	40.933	36.665	1,349
	GED	60	55	4.448	4.077	0.898	2.575	1,349
99	N	34	35	2.520	2.595	22.157	24.066	1,349
	T	2	5	0.148	0.371	15.443	7.109	1,349
	GED	15	13	1.112	0.964	0.165	0.018	1,349

Notes: $\chi^2_{0.95}(1) = 3.841$ $\chi^2_{0.99}(1) = 6.635$

1. At the 95 and 99 % confidence level, the VaR based on GARCH model can accurately measure the upside risk and downside risk. However, it is easier at the 99 % confidence level to overestimate the market risk with the same model.
2. We find that at the 95 and 99 % confidence level, both the upside risk and downside VaRs based on GARCH model with GED assumption, which is not uncommonly used, proves to be more robust and accurate than that based on the assumptions of standard normal distribution and Student-t distribution. However, the VaR model with Student-t assumption is the most unsatisfactory and easy to overestimate market risk.
3. It has obvious advantages for GARCH model to portray the dynamic changes of high frequency time series.

Overall, our findings have implications for investors, financial institutions, and futures exchanges. For example, conservative investors may prefer to choose the Student-t distribution with the 99 % confidence level to evaluate their investment risk. For futures exchanges, they can apply the GARCH model to compute the optimal margin levels. Finally, since the GARCH model with Student-t distribution is more conservative, it may provide significant value for exchanges and regulators when the market faces turmoil and becomes more volatile.

Acknowledgements The authors gratefully acknowledge the financial support from the Project of National Key Technology R&D Program of China (grant No. 2012BAH20B04) and the National Natural Science Foundation of China (grant No.71203221).

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Chapter 15
Prediction of Pork Prices Based on SVM

Jian-Hua Zhang, Zhe-Min Li, Fan-Tao Kong, Xiao-Xia Dong, Wei Chen, and Sheng-Wei Wang

Abstract In order to predict pork prices accurately, a pork price forecast model based on support vector machine (SVM) is proposed. Data of 229 nationwide weekly average retail pork prices from January 1, 2008 to July 1, 2012 is selected as samples to train and test SVM. The experiment results show that the relative error is kept in the range between −0.04 and 0.04, the mean squared error is 0.00157 and correlation coefficient is 99.5196 %. This method can also provide a reference for predicting other agricultural prices.

Keywords Pork price • Support vector machine • Prediction

15.1 Introduction

Pork has the largest share of consumption of meat in China. Pork price fluctuations do not only affect economic development and the overall price situation, but are also closely related to people's daily lives (Li et al. 2012). Sharp fluctuations in pork prices may cause unrest, is not conducive to the harmonious development of society (Xu et al. 2012, 2013). The pork price problem has aroused great attention and extensive research. How to accurately predict the prices of pork in terms of the direction and extent of changes is particularly important.

In recent years, a variety of intelligent prediction methods have been applied to the prices of pork, such as gray systems, neural networks, and time series analysis. For example, Ma Xiongwei (2008) combines gray prediction theory and neural network to establish a model for short-term predicting pork price. However,

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_15, © Springer-Verlag Berlin Heidelberg 2014

prediction precision of this model needs further verification. Ping Ping et al. (2010) devises a method of forecast combining two models which divides the forecast into two elements including factors and results by using regression based on grey systems, artificial neural networks, and time series. This model can predict the recent prices of pork in the province of Jilin. Li Zhemin et al. (2013) puts forward a chaotic neural network model based on genetic algorithm for short-term prediction of pork prices. The experiment results show that the model has high prediction precision and good fitting effect therefore has an important reference and practical significance for the short-term price forecasting of the pork market.

In summary, most pork price forecasting methods use neural networks and obtain relatively good results through experiments. However, neural networks require large sample sizes. Their training speeds are slow and they are prone to the "over fitting" phenomenon. The Support Vector Machine method is established by the structure of VC dimension in statistical learning theory and the principle of risk minimization, and it is suitable for small sample sizes, nonlinear and high dimensional pattern recognition. Moreover, it overcomes neural networks' disadvantages very well. Therefore, we use support vector machine regression prediction model to forecast short-term pork prices for further improving the pork price forecast prediction accuracy and generalization ability.

15.2 Materials and Method

15.2.1 Data Selection and Processing

According to the characteristics of support vector machine, 229 nationwide weekly average retail pork (streaky pork) price data from January 1, 2008 to July 1, 2012 released by Xinhua News Agency is selected as the samples. In the samples, 228 data points from the first week of January, 2008 to the first week of June, 2012 are regarded as training samples in the support vector machine. The next week of training data are regarded as test samples to make comparison with the forecasting results of the model.

In order to avoid causing a huge prediction error due to large differences in the magnitude of the input data, it is necessary to normalize the data before training. The data normalization formula is as follows:

$$f(x) = \frac{x - x_{min}}{x_{max} - x_{min}} \tag{15.1}$$

15.2.2 Support Vector Machine

SVM is put forward by Vapnik on the basis of small-sample statistical learning theory, which is used primarily to study small samples under statistical learning rules, and is commonly adopted in pattern classification and nonlinear regression (Vapnik 2000 and Kim 2003).

The sample data set is given as $v = \{(x_i, y_i) | i = 1, 2, \ldots, n\}$, where $x_i \in R^n$ represents the input variables and $x_i \in R^n$ denotes the output variables.

The SVM algorithm seeks one misalignment mapping from the input space to output space $\varnothing$. Through this mapping, data x is mapped to a feature space, Γ and linear regression is carried out in the feature space with the following function:

$$f(x) = [\omega \times \varphi(x)] + b \tag{15.2}$$

$$\phi : R^m \rightarrow \Gamma \tag{15.3}$$

In (15.2), b is a threshold value. According to statistical learning theory, SVM determines the regression function through objective function minimization:

$$\min\left\{\frac{1}{2}\|\omega\|^2 + C\sum\nolimits_{i=1}^{n}\left(\xi_i^* + \xi_i\right)\right\} \tag{15.4}$$

where C is a weight parameter for balancing the complex items of the model and training error, which is also called the penalty factor, and ξ_i^* and ξ_i are the relaxation factors. ξ_i^* is expressed as follows:

$$\xi_i^* = \begin{cases} 0, |f(x) - y_i| \leq \varepsilon \\ |f(x) - y_i| - \varepsilon, |f(x) - y_i| > \varepsilon \end{cases} \tag{15.5}$$

By solving the dual problem in (15.2), lag range factors α_i, a_i^* can be obtained, so that the regression equation coefficient is:

$$\omega = \sum\nolimits_{i=1}^{n}\left(\alpha_i - \alpha_i^*\right)X_i \tag{15.6}$$

The SVM regression equation is as follows:

$$\mathrm{f(x)} = \sum\nolimits_{i-1}^{n}\left(\alpha_i - \alpha_i^*\right)K(X_i, X) + b \tag{15.7}$$

where $K(X_i, X)$ is the SVM kernel function. Possible kernel function types include linear kernels, polynomial kernels, RBF kernels and radial basis functions. In this paper, RBF is selected as the kernel function in the model:

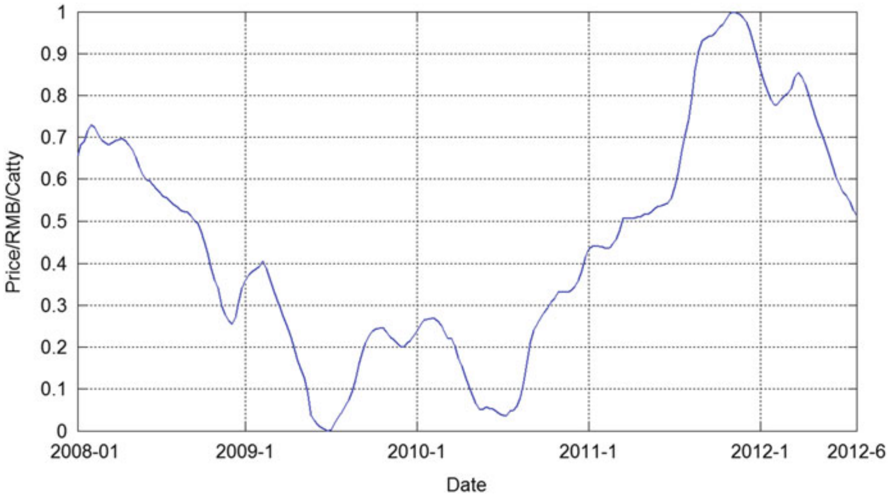

Fig. 15.1 Normalized data

$$K(X_i, X) = exp\left(-\|y_i - x_i\|^2/2\sigma^2\right), \sigma > 0 \tag{15.8}$$

15.3 Experiment Results

15.3.1 Data Normalization

Support vector machine is applied for experiments of training and forecast of pork prices. To obtain better convergence results, we normalize the training data to an interval [0, 1]. The figure of normalized data is shown in Fig. 15.1.

15.3.2 Determination of Parameters and Prediction

The experiment process is coded with Matlab R2012 and the LibSVM 3.17 toolbox developed by Chih-Chung Chang and Chih-Jen Lin. The pork price prediction test is divided into two parts. The first part is to determine the parameters of the support vector machine, and the other part is to model training and testing.

Support vector model has two main parameters respectively c and g, whose values need to be determined before training and testing. We select a value roughly at first. An optimal parameter value is determined through continuous tests. In this model, we set $c = -1$ and $g = 1.624$.

The above optimal parameters c and g is used to train SVM. Afterwards, regression and test for the original data can be done. The prediction results are

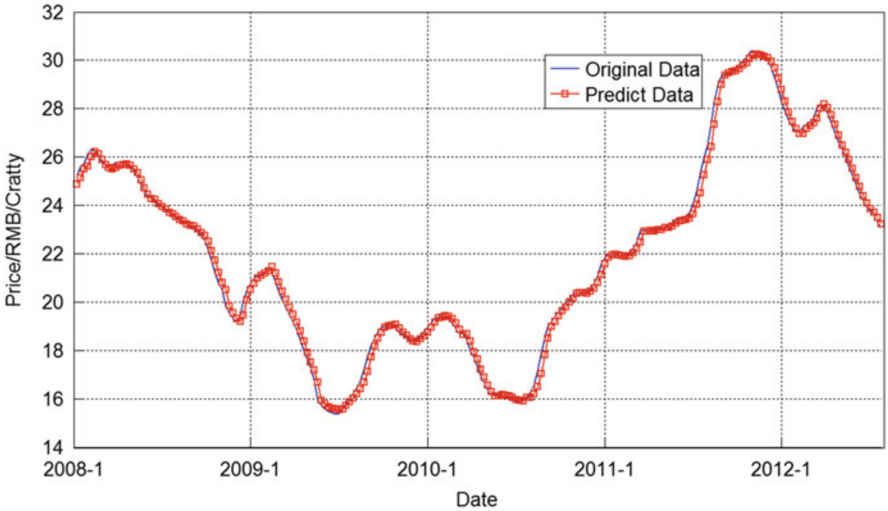

Fig. 15.2 Prediction results of pork prices

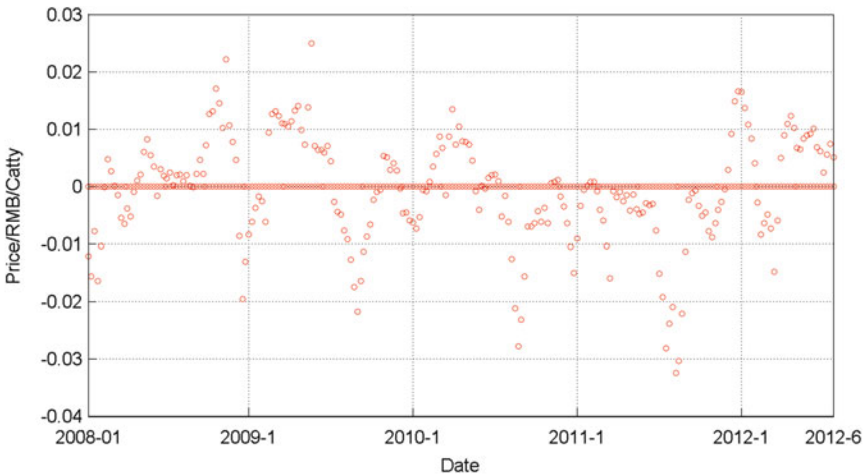

Fig. 15.3 Relative errors between the original and predicted data

shown in Fig. 15.2 and the relative errors between the original and predicted data is shown in Fig. 15.3. From Fig. 15.2, we can see that the predicted data and the real data are basically consistent and prediction is a relatively smooth curve. There is a considerable part of overlapping. Meanwhile, it can be seen from Fig. 15.3 that the relative error is kept in [−0.04, 0.04], which shows that the error is kept in a relatively small range. Moreover, the mean squared error is 0.00157, and correlation coefficient is 99.5196 %.

The experiment results show that the proposed model based on support vector machines can accurately predict the prices of pork.

15.4 Conclusion

For the characteristics of pork price changes, support vector machine is used to predict the prices. The experiment results show that the relative error is kept in the range between −0.04 and 0.04, the mean squared error is 0.00157 and correlation coefficient is 99.5196 %. Therefore, this method can predict pork prices and has high accuracy.

Acknowledgements The 948 program of MoA (No.2012-Z1) Special program, This work is supported by the Key Technologies R&D Program of China during the 12th Five-Year Plan period (2012BAH20B04), and National Natural Science Foundation of China (No. 61003263).

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Chapter 16
Study on Optimal Risk Sharing Issue for Chinese Crop Insurance: A Case Study from Government Perspective

Ke Wang, Ran Huo, Qiao Zhang, and Xianhua Zhou

Abstract Agricultural insurance in China has in recent years been skyrocketing. However, the catastrophic risk management system is relatively lagging behind in China hence affecting the sustainable development of Chinese agricultural insurance program. Chinese government especially provincial governments are trying to develop a mechanism to stabilize crop insurance program by sharing some risk with insurer when CAT events happen. But the critical issue which is to layer the risk responsibility between insurer and local government is still unsolved. Therefore, this paper aims to provide a quantitative methodology of estimating the optimal risk sharing ratio between insurer and provincial government from the government perspective adopting the approaches in actuarial sciences, such as Copula, Monte Carlo and stochastic. After a robust empirical study, it is found that the optimal risk sharing ratio is 210 % in the case of taking account of non-accumulative loss ratio and 130 % in the case of taking account of accumulative loss ratio of insurer. It is believed that this paper has significant implications for China to set up crop reinsurance system because we proposed a suitable methodology to identify the responsibility of government and insurers in crop insurance.

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_16, © Springer-Verlag Berlin Heidelberg 2014

Keywords Crop Insurance • CAT risk • Reinsurance • Risk sharing • Government perspective • China

16.1 Introduction

Since the central government began to provide premium subsidy in 2007, Chinese agriculture insurance has witness a rapid growth. The premium of Chinese agricultural insurance rose to 24.06 billion CNY (appropriately $4 billion) in 2012 from 5.2 billion CNY in 2007 and 11.1 billion CNY in 2008 in which China rank to the second world largest agricultural insurance market following the American agricultural insurance market.[1] However, in contrast with the fast development of agricultural insurance, agricultural catastrophic risk management system is relatively lagging behind in China. Because of the systemic features of agricultural risk, the agri. catastrophic (CAT) risk management system such as agri. reinsurance is extremely needed to be developed for diversifying the risk of agri. insurance otherwise the insurers cannot afford the high indemnity and will be doomed to bankrupt (Miranda and Glauber 1997; Turvey et al. 1999; Xie 2003; Feng 2004; Deng 2008; Xu 2008).

Learning experience in developed countries such as United States and Canada where governments plays a dominant role in developing a sound agri. CAT risk management system, Chinese government also plans to contribute more on the developing of agri. insurance risk diversification mechanism including crop reinsurance for decreasing insurers' risk exposures, and to prompt the development of Chinese crop insurance program. Similar with Canada, the provincial governments instead of central government play the vital role in decreasing insurer's risk exposures, mainly by the way of excluding the payout obligations of insurers when the loss ratio (Indemnity/Premium) of crop insurance at the year when the loss ratio goes beyond a given threshold (above 100 % of course). In Beijing, the Beijing municipality stipulates that crop insurance companies only need to pay up to 1.6 times of its premium income and the government as a reinsurer will take the rest risk when CAT events occur, and Henan government increase the trigger of its payout responsibility to 200 % at that year. In practice of China's agri. insurance, however, the responsibility boundary (e.g. 160 % in Beijing and 200 % in Henan) between insurers and government in terms of indemnity are determined based on empirical judgment and negations. Does it make sense? How the appropriate responsibility of crop insurance indemnity between insurers and government should be set? Unfortunately, there is no robust and quantitative approach to address these important and critical questions for China to develop appropriate and sound agri. insurance risk diversification mechanism.

In our opinion, the above questions are similar to the determination of optimal stop-loss ratio in Chinese agricultural insurance programs. Optimal reinsurance

[1] 2010 Asia-Pacific international symposium on agricultural insurance and reinsurance.

strategy has always been an interesting topic for economists and actuaries. Many studies was done to discuss the optimal reinsurance strategies in layer reinsurance and stop loss reinsurance under the criterion of the minimum of Value at risk (VaR) or conditional tail expectation (CTE) (Cai and Tan 2007; Cai et al 2008; Porth et al. 2013; Hi and Tan 2011). Some scholars also investigated the optimal reinsurance behaviors in the context of SRA reinsurance policy (Coble et al. 2007; Pai and Boyd 2010). Most of these studies, however, rest on the standpoint of insurance companies. Notable exceptions are Hayes et al. (2003) and Mason et al. (2003) who estimated the probability density function (pdf) of FCIC reinsurance exposures that ceded by crop insurance companies though the Stand Reinsurance Agreement (SRA). Although from the view of government, their studies pay little attention to the indemnity boundary between FCIC and insurer. In China, most studies on crop reinsurance are to conduct the qualitative discussion on how to establish agriculture reinsurance system (Tuo and Wang 2010; Xie 2003; Liu 2006; Long et al. 2007; Zhao 2007). An exception is Gao et al. (2009) who tried to find out the appropriate threshold in the indemnity sharing of Beijing's crop insurance by policy simulation, but their study were criticized because their conclusion are made using the short period and inconsistent of crop insurance loss ratio data (Indemnity/premium). This paper will be the first one to conduct quantitative investigation on the optimal risk sharing issues between insurer and Chinese's government from government perspective adopting the approaches in actuarial sciences, such as Copula, Monte Carlo and stochastic. It is believed that this paper has significant implications for China to set up agri. CAT risk diversification mechanism because we proposed a suitable methodology to identify the responsibility of government and insurers in crop insurance program.

The rest of this paper is organized as follows. The second part is the brief introduction of current agri. insurance policies and agri. CAT risk sharing policy in selected provinces of China. Following this, the model and studying approach of this paper are discussed. Then, the sample data simulation and empirical results are demonstrated in the fourth section. And finally, the discussion and conclusion are presented in the fifth section.

16.2 Policies of Chinese Agriculture Insurance and CAT Risk Management

In 2007, the premium subsidy policy of agricultural insurance began to pilot in China. Before that year, the scale of agricultural insurance industry was very small and the indemnity ratio was as high as more than 1, which was part of the reason that the market was contracted. However, as the implementation of the premium subsidy policy, the insurance market in China started to skyrocket and rank to the second largest agricultural insurance market in the world (Fig. 16.1).

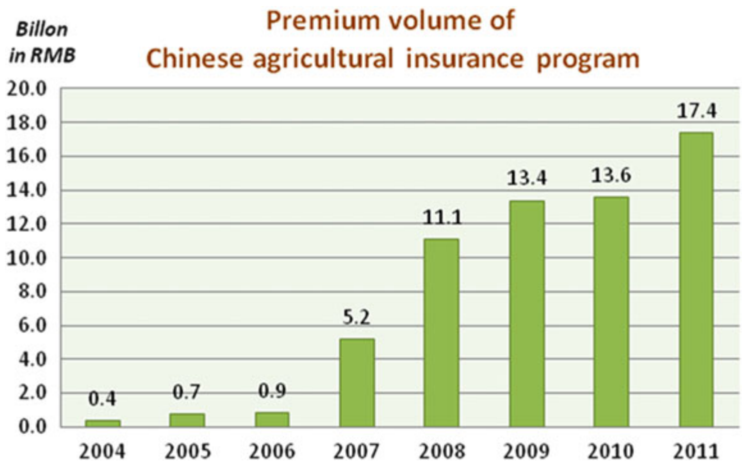

Fig. 16.1 Chinese agricultural insurance premium soars after 2007 (Source: China Insurance Regulatory Commission (CIRC))

As mentioned above, the agricultural risk involves frequent catastrophic events, thus catastrophic risk management is indispensable for the sustainable development of the agricultural insurance system. In addition, the government needs to participate in the agricultural risk sharing system and play a leading role in the system according to the historical evolvement of catastrophic management system in the developed countries. In China, provincial governments are exploring the construction of the risk sharing system. Some provincial governments have introduced risk sharing policies to undertake part of liability when the catastrophe strikes and the indemnity goes beyond the solvency of the agricultural insurance companies. The forerunners include Beijing, Henan, Zhejiang and Jiangsu. In Beijing, the municipal government undertakes the remaining liability if the ratio of loss to premium (indemnity/premium) of the agricultural insurance exceeds 160 % in the year when the catastrophe occurs. In addition, the municipal government purchases reinsurance in private reinsurance market to cover the indemnity risk between 160 and 300 %, and establishes reserve fund against the risk over 300 %. In Henan, the government caps the ratio of loss to premium of crop insurance at 300 %. If the loss ratio exceeds 300 %, the actual indemnity will be curtailed pro rata. In the interval between 200 and 300 %, the Henan provincial government and insurer will bear 50 % of the indemnity respectively. In Zhejiang province, the risk sharing arrangement is more complicated. Government and insurer will bear 50 % respectively if insurer's ratio of loss to premium is between 200 and 300 %, and bear the indemnity by a ratio of 1–2 when insurer's ratio of loss to premium is from 300 to 500 %. Different from the three provinces above, Jiangsu government participates into insurance operation directly and shares 50 % of premium and indemnity of crop insurance. Table 16.1 summarizes the risk sharing polices in sample provinces of China.

Table 16.1 Risk sharing arrangement in four provinces of China

	Provinces			
Indemnity (%)	Henan	Zhejiang	Beijing	Jiangsu
Above 500	–	–	Gov	Gov:Insurer = 1:1
30–500	–	Gov:Insurer = 1:2		
200–300	Gov:Insurer = 1:1	Gov:Insurer = 1:1		
160–200	Insurer	Insurer		
100–160			Insurer	
0–100				

Note: Insurer represents agricultural insurance companies; *Gov* represents government

16.3 Methodology

It can be seen from Table 16.1 that although the risk sharing policies in four provinces are different, one thing is in common, that is the provincial government shares part of the risks faced by the crop insurance company, and the arrangement is similar to stop-loss reinsurance. Therefore, here in this paper we hypothesize that the relation of the government and the crop insurance company is similar as the relation of insurer and reinsurer. The crop insurance company pays the government an outlay as reinsurance premium or a sum of money for catastrophic reserve fund, and when the indemnity is over a threshold, the government undertakes the part of indemnity. For the simplicity, a hypothesized company, JLCI,[2] was established to run the corn and soybean insurance business in five counties of Jilin.

Under above assumption, the final problem of this paper is to estimate the optimal risk sharing ratio between Jilin government and JLCI. The detailed method to achieve our goals is consisted of three steps: (a) Estimating the potential indemnity of the crop insurance. (b) Estimating the loss of the crop company and the government. (c) Estimating the optimal risk sharing ratio using stochastic simulation technology from government's perspective.

16.3.1 Estimating the Potential Indemnity of the Crop Insurance Program

Because of the short experience of agri. insurance program in China, the actual data sets of loss cost ratio (LCR, indemnity/Liability) coming from insurer are not available. Thereby, the simulation indemnity that calculated from yield historical data are used in this paper. The steps that estimate indemnity data from yield data are shown as following Table 16.2.

[2] In fact, there is more than one agricultural insurance company to undertake the crop insurance business in Jilin although more than 90 % market are taken by Anhua Agricultural Insurance Co.

Table 16.2 Steps of data processing to estimate crop insurance indemnity

Step	Description
1.	Detrend the yield data for each crop and each county
2.	Simulate the correlation of five counties yield of each crop using copula method
3.	Generate the simulated yield using Monte Carlo Simulation
4.	Estimate the crop insurance indemnity for each crop and each county

In the first step, we detrend the yield data using linear moving average method (LMA), and then we can calculate the loss for each crop and each county.

The second step is to simulate the correlation of five counties yield using Copula method for each crop. Because of the significant spatial correlation the crop risk presents, the correlation of yield in five counties must be taken into account when conducting Monte Carlo simulation. As the advantage of copula to establish multivariable distribution, it is adopted in this paper to estimate the correlation of five counties for each crop.

In the third step, given that the period span of the data is not long enough, we use Monte Carlo Simulation to expand the sample capacity. We generate 1,000 random yields by using Monte Carlo Simulation.

The fourth step is to estimate the possible crop insurance indemnity and loss ratio for each crop and each county according to the practical crop insurance policy in Jilin. We take the planting acreage of the year 2008 as the acreage of simulated yield. As stipulated by the current crop policy, we set the price of the crop that the ensured values per hectare are: for corn 3,000 RMB, for soybean 2,500 RMB.

The yield data is transferred as indemnity data by using the following formula:

$$indm_i = P_i * S_i * max\left(0, \overline{EY_i} - AY_i\right) \tag{16.1}$$

Where i represents the county of i; P represents the ensured value per hectare of each crop (corn 3,000 RMB, soybean 2,500 RMB). S_i is the planting acreage of the crop in the county i (the planting acreage in 2008). $\overline{EY_i}$ stands for the ensured yield level, and it is computed by the linear moving average of 11 years. AY_i represents the actual yield (the 1,000 simulated yield). Therefore, the gross indemnity is:

$$indm = \sum indm_i = \sum P_i * S_i * max\left(0, \overline{EY_i} - AY_i\right) \tag{16.2}$$

16.3.2 Estimating the Loss of the Insurer Company and the Government

After the four steps above, we can obtain the simulated indemnity of JLCI. In this paper, we assume the Jilin province government undertakes the remaining indemnity of the crop insurance over the risk sharing ratio that is similar to stop-loss reinsurance. The government acts as the last reinsurer although it can purchase reinsurance and use other tools to manage the risk it undertakes. Therefore, the risks that the agricultural insurance company and the government bear are:

$$insurer : Loss_{insurer} = \begin{cases} Indm + R(D) & if\ Indm \le D \\ D + R(D) & if\ Indm > D \end{cases} \tag{16.3}$$

$$government : Loss_{gov} = \begin{cases} 0 & if\ Indm \le D \\ Indm - D & if\ Indm > D \end{cases} \tag{16.4}$$

Where D is the optimal retention of risk to the agricultural insurance company JLCI. $R(D)$ is the reinsurance premium.

According to the risk the JLCI and the government sector undertake, the premium of both sides is calculated as:

$$\begin{aligned} insurer : prem_{Insurer} &= \sum prem_i \\ &= \sum P_i * S_i * (1+\theta)\int_0^{c*\overline{EY_i}} (\overline{EY_i} - AY_i)\_f(y_i)dy_i \end{aligned} \tag{16.5}$$

$$\begin{aligned} government : prem_{gov} &= R(D) = \sum R(D)_i \\ &= \sum P_i * S_i * (1+\rho)\int_D^{c*\overline{EY_i}} (\overline{EY_i} - AY_i)_{+}f(y_i)dy_i \end{aligned} \tag{16.6}$$

Where, c represents the coverage ratio. θ and ρ represent loading factor.

$\sum P_i * A_i * \overline{EY_i}$ is the liability of the company in the county of i. It is customary to model loss cost (indemnity) to the liability exposure i.e. the loss cost ratio. Then, as usual, we define loss of ratio (LCR) as the Indm/Liability. Thus, the LCR of the insurer is calculated as

$$LCR_{insurer} = \frac{loss}{liability} = \begin{cases} \dfrac{Indm + prem_{gov}}{\sum P_i * S_i * \overline{EY_i}} & if\ Indm < D \\ \dfrac{D + prem_{gov}}{\sum P_i * S_i * \overline{EY_i}} & if\ Indm > D \end{cases} \tag{16.7}$$

Then in order to model the optimal risk sharing ratio (the ratio of loss to premium, represented by RLP), we need to calculate the optimal retention ratio (D/liability) first, we rewrite D to the liability as

$$\frac{D}{liability} = \frac{\overline{RLP} * prem}{\sum P_i * A_i * \overline{EY_i}} = \frac{\frac{Indm}{prem} * prem}{\sum P_i * A_i * \overline{EY_i}} = \overline{LCR} \tag{16.8}$$

$$\overline{RLP} = \frac{Liability}{prem} * \overline{LCR} \tag{16.9}$$

Similarly, $prem_{insurer}$ and $prem_{gov}$ is also rewritten as

$$\begin{aligned}\frac{prem_{insurer}}{liability} &= \frac{(1+\theta)\int_0^c (c-lcr_i)_- * f(lcr_i)dlcr_i}{\sum P_i * A_i * \overline{EY_i}} \\ &= (1+\theta)\sum W_i * \int_0^c (c-lcr_i)_+ * f(lcr_i)dlcr_i\end{aligned} \tag{16.10}$$

$$\begin{aligned}\frac{prem_{gov}}{liability} &= \frac{(1+\theta)\int_{\overline{LCR}}^c (c-lcr_i)_+ * f(lcr_i)dlcr_i}{\sum P_i * A_i * \overline{EY_i}} \\ &= (1+\rho)\sum W_i * \int_{\overline{LCR}}^c (c-lcr_i)_+ * f(lcr_i)dlcr_i\end{aligned} \tag{16.11}$$

Where $\frac{1}{\sum P_{i*A_i*\overline{EY_i}}}$ is shorted by $W_{i.}$

16.3.3 Estimating the Optimal Risk Sharing Ratio Between JLCI and Government

Since in this paper we intend to estimate the optimal risk sharing ratio from the government perspective, we need to examine the goal of the government to share the agricultural risk. The government, as the regulator of the agricultural insurance industry, aims to ensure the stable operation of the agricultural insurance company and the indemnity of the policy holders (farmers) when catastrophe occurs. Therefore part of the objective of the government can be described as to make the volatility (variance or standard deviation) of the loss cost of agricultural insurance company to be as "small" as possible. Moreover, the government, as a risk sharing part, also needs to avoid moral hazard of the risk cedant to make sure the risk sharing arrangement is constructed in a prudent and effective way. Thus, in the determining the risk sharing ratio model, the general ratio of loss to premium needs to be taken into consideration to constrain the company's behavior so as to avoid the insurance company transfer most of risk to the government sector. In this paper, we assume the usual ratio of loss to premium is 80 %. Thus, the government also intends to make the ratio of loss to premium of JLCIT to be as close to 80 % as possible. Based on the two criteria, we can describe the government objective as

$$abs\left(sd(lcr) * mean\left(\left(\frac{lcr}{prem_{insurer} - prem_{gov}}\right) - \widetilde{RLP}\right)\right) \tag{16.12}$$

Where $sd(lcr)$ is the standard deviation of the loss cost assuming the liability is 1. $\widetilde{RLP}$ is the usual ratio of loss to premium and $\widetilde{RLP} = 80\%$. To avoid moral hazard of the insurance company, the government may request the RLP of insurance company to operate up to this level and not to exceed it. Then, the mean of $\frac{lcr}{prem_{insurer} - prem_{gov}} - \widetilde{RLP}$ is better to be close to 0. abs means absolute value. The optimal risk sharing ratio is the attachment point that minimizes the function above (objective of the government).

16.4 Result

16.4.1 Data

County-level data of sowing area and yield from 1980 to 2008 in Dehui, Jiutai, Yushu, Dunhua and Nongan (five counties of Jilin) were collected in this paper. The data are coming from Chinese County Statistic Database, MOA China.

16.4.2 The Payout Performance of Insurer and Government Under Alternative Scenarios

Following the method and steps mentioned above, we have calculated the simulated LCR for corn and soybean, JLCI and Jilin government. After that, in the assumption of (1) both the premium and reinsurance premium are ratemaking according to actuarial principals, (2) the loading factors of both insurer and reinsurer are set as 0.2, the payout performance of insurer and government can be simulated under given risk sharing ratio which has been presented in Fig. 16.2

16.4.3 The Optimal Risk Sharing Ratio Between Insurer and Government

With the help of MATLAB, we program the government objective function (Eq. 16.12) and then trying to calibrate the optimal risk sharing ratio between JLCI and government of Jilin using stochastic simulation. Two types of scenario are considered, the first one is the objective of Gov. is to stabilize the JLCI's loss ratio in each year, that is to say on accumulative loss ratio are considered; another

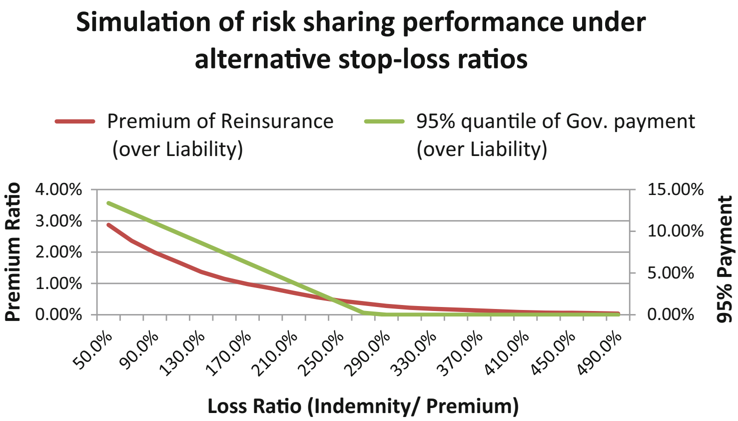

Fig. 16.2 Payout performance of insurer JLCI and Gov. of Jilin

one is opposite that only accumulative loss ratio of insurer are considered by government. The optimal risk sharing ratio between two agencies under the two scenarios are shown as below (Figs. 16.3 and 16.4).

As shown in Table 16.3, the optimal risk sharing ratio between insurer and government is about 210 % (indemnity/premium) in case of scenario a, and the optimal risk sharing ratio in scenario b is near to 130 %. But the government may bear huge risk when layer the agri. insurance indemnity as that ratio because the 95 % quantile of Gov. payment will up to 3.8 and 2.6 % of liability in scenario a and scenario b, respectively.

16.5 Conclusion and Discussion

Learning experience in developed countries such as United States and Canada, China is developing an agri. insurance risk diversification mechanism to decreasing insurers' risk exposures, and to prompt the development of Chinese crop insurance program. This paper proposal the relationship between insurer and provincial government can be treated as insurer and reinsurer, and develop a quantitative method based on actuarial principal to estimate the optimal risk sharing ratio among them. Through the hypothesis study, we conclude that:

(a) In the case of non-accumulative RLP, the optimal risk sharing ratio is 210 %, which means the maximal indemnity of the crop insurance company is 210 % of the premium at a year when the catastrophe occurs, and the government pays the rest indemnity over the 210 % of the premium.
(b) In the case of accumulative RLP, the optimal risk sharing ratio is 130 %, which means the maximal indemnity of the crop insurance company is130% of the

Fig. 16.3 The optimal risk sharing ratio between insurer and Gov. (Scenario a)

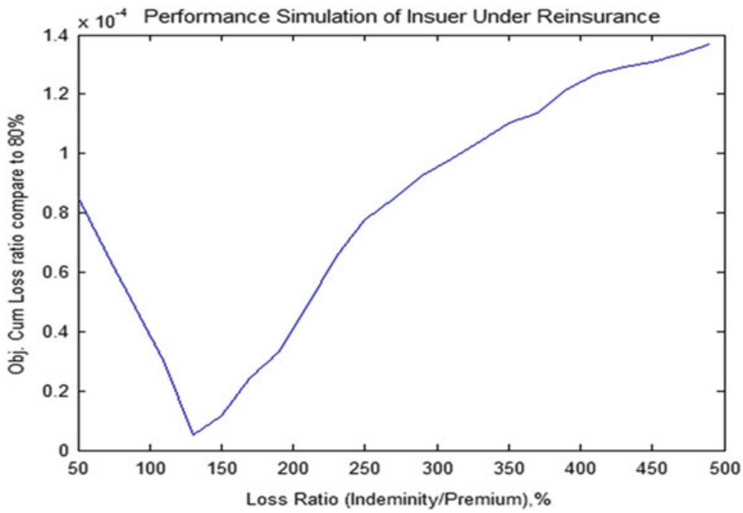

Fig. 16.4 The optimal risk sharing ratio between insurer and Gov. (Scenario b)

Table 16.3 Simulation of risk sharing behavior between JLCI and Gov. of Jilin

	Optimal risk sharing ratio (%)	Premium ratio of crop insurance (%)	Prem of Reinsurance (over Liability) (%)	95 % quantile of Gov payment (over Liability) (%)
Scenario a	210	5.97	0.70	3.82
Scenario b	130	5.97	0.56	2.62

premium at a year when the catastrophe occurs, and the government pays the rest indemnity over the 130 % of the premium.

However, after estimating the optimal risk sharing ratio between the government sector and the crop insurance company, there are still some points to be clarified. First, the government is assumed to undertake the rest of risk and indemnity responsibility over the optimal risk sharing point. However, in practice, it is very necessary for the government to consider its potential indemnity responsibility in order to avoid subjecting itself into "indemnity trap". It can use multiple risk management tools like purchasing private reinsurance or catastrophic reserve fund to deal with the potential indemnity responsibility and it also can cap the maximal indemnity even though in this paper we assume there no ceiling in the loss and indemnity. Furthermore, the central government can establish a lay of risk sharing system so that the provincial government can transfer part of its risk to the central government. Second, as we know, like reinsurance, the insurance company needs to pay for the risk it transfers determined by the risk the insurance company cedes. This outlay is huge enough to influence the behavior of the insurance company. In this paper, we do not constrain the risk transferring premium of the insurance company. However, in practice, this constraint needs to be considered. Third, the results of this paper cannot be applied in practice directly because of the data and the assumptions are simplified. However, the methodology of the paper is feasible in determining the optimal risk sharing ratio for provincial government.

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Chapter 17
Evaluating Catastrophe Risk of Cold Damage for Crop Production at the Provincial Scale in China

Lei Xu, Qiao Zhang, and Xi Zhang

Abstract This study presents a methodology for risk assessment of cold damage catastrophe to crop production at the provincial scale in China based on Block maxima model (BMM). The assessment method of cold damage catastrophe risk combine crop loss collection, Monte Carlo simulation, generalized extreme value distribution (GEV) fitting, and risk calculation. It is shown that the Type III Extreme distribution (Weibull) has a weighted advantage of modeling cold damage catastrophe risk for crop production. The impact of cold damage catastrophe to crop production in China was relatively serious, and very high or high risk of cold damage catastrophe mainly concentrates on the southwest and northwest regions as well as the middle and lower reaches of Yangtze River in China. Given the scenario of suffering once-in-a-century cold damage, the crop-production loss ratios for 30 provinces in China vary from 5 to 10 %, which represents a high probability of occurrence; and the probability of 5–10 % reduction of crop output actually exceeds 70 % especially for Inner Mongolia, Hunan, Jiangsu, and Hubei provinces. The results obtained in this study can provide multifaceted information about cold damage catastrophe risk that can help to guide management of cold damage catastrophe.

Keywords Risk assessment • Cold damage catastrophe • Block maxima model (BMM) • Provincial scale • China

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_17, © Springer-Verlag Berlin Heidelberg 2014

17.1 Introduction

As one of the most significant stress factors in crop production, cold damage receives more attention owing to its unique characteristics, that is, the high frequency of occurrence, and the consequence, which can lead to obvious yield reduction even complete crop failure. China is a major agriculture country with large exposure areas and easily affected by cold damage. During the decade from 2002 to 2012, extreme cold damage or cold damage catastrophe occurred with an increasing occurrence and magnitude tendency under global climate change, which has made an adverse impact on china's crop production. In response to the potential impact of uncertain cold damage catastrophe, assessing cold damage catastrophe risk has therefore been correspondingly put on the agenda urgently. Consequently, it is important to quantitatively depict the relationships between crop production and cold damage catastrophe, and to comprehensively calculate the probabilities of the various degrees of loss caused by cold damage catastrophe for crop production in China. Risk assessment of cold damage catastrophe has been proven to the basis for making strategies to mitigate cold damage and reducing the losses to a minimum, and adjust the medium and long-term distribution of agricultural activities so as to adapt to environmental changes.

While many studies have been performed in the field of cold damage risk assessment, only a few analyses have started to incorporate effects of cold damage catastrophe risk. Meanwhile the methods or models of cold damage catastrophe risk assessment have mainly been undertaken from three different angles based on risk loss, risk factors or risk indicators system, and risk mechanisms (Lei Xu 2012). However, these methods were almost invariably equivalent to the approaches for assessing common risk of cold damage disaster, which may have some obvious defects. In general, different risks show various levels of complexities and uncertainties, if all the risks are assessed and managed in the traditional reductive methods indiscriminately, it will not only lead to low efficiency, but even worse, may get the totally wrong results (Yuehong Zhang et al. 2008).

Aiming to provide an effective quantitative method of cold damage catastrophe risk assessment for cold damage catastrophe management, this paper focuses on crop loss data owing to cold damage and introduces extreme value theory (EVT) for cold damage catastrophe risk modeling instead of parametric and nonparametric methods in the traditional sense. Generally, there are two principal approaches in modeling extreme values: block maxima model (BMM) and peak over threshold (POT) model. BMM method focuses on the statistical behavior of the largest or smallest value in a sequence of independent random variables, which follows a Generalized Extreme Value (GEV) distribution. POT method models all large or small observations that exceed (fall below) a high (low) threshold, which follows a Generalized Pareto Distribution (GPD) (Lei Xu et al. 2011). There's no doubt that the BMM and POT models can provide two effective approaches to evaluate agricultural catastrophe risks owing to extreme events. Theoretically, sufficient sample observation satisfying certain conditions is prerequisite for using BMM method. In respect of applying POT model, the determination of threshold is a trade-off between bias and variance: a threshold that is exceedingly low is likely to violate the asymptotic basis of the model and lead to a bias, while a threshold that is exceedingly high will generate few observations left to estimate the parameters of tail distribution function and cause high variance (Coles 2001). To avoid the dilemma or subjective factors of threshold determination in the POT model, this paper developed the assessment models of cold damage catastrophe based on the improved BMM method. On this basis, this paper conducted quantitative assessment of cold damage catastrophe risk for crop production at the provincial scale in China using the method proposed.

17.2 Methodology and Data

17.2.1 Cold Damage Catastrophe Risk Definition

According to prior studies, the concept of risk is defined and understood in different ways. This paper quoted the definition of scene as saying that risk is a scene in the future associated with some adverse incidents (Chongfu Huang and Da Ruan 2008). From this definition, risk can be expressed as a triple-elements set, which includes the scenario, the probability of scenario and the consequences of scenario. In terms of agricultural catastrophe, there is also no general agreement on a standard definition. It can be the most commonly described as extreme natural disasters characterized by low probability but high consequence. We grasped the coherent attributes of agricultural catastrophe and expounded the concept as once-in-a-century disaster. Therefore the concept of cold damage catastrophe risk in this paper is defined as the scenario under which crop is susceptible to once-in-a-century cold damage disaster. The connotation and core of assessing cold damage catastrophe risk is fully analogous to modeling the probability distribution of crop loss (Goodwin and Mahul 2004) and calculating the probabilities of the various degrees of loss for crop production in question, given the scenario of once-in-a-century cold damage disaster.

17.2.2 Methodology

This paper developed the methodology of cold damage catastrophe risk assessment, which can be shown as the standard process of crop loss collection, Monte Carlo simulation, generalized extreme value distribution (GEV) fitting, and risk calculation. As the premise and foundation of modeling cold damage catastrophe risk, cold damage disaster loss data must be collected first. In China, the Ministry of Civil Affairs is in charge of monitoring and recording data related to cold damage disasters. Data reported by the Ministry of Civil Affairs provide three indicators (hectares covered by cold damage disaster, hectares affected by cold damage disaster, and hectares destroyed by cold damage disaster) that are useful for assessing crop loss risk. Hectares of all crops covered by, affected by, and destroyed by specific natural disasters (such as cold damage, flood, drought, and typhoon, and so on) are officially defined as the quantity of hectares with 10–100 %, 30–100 %, and 80–100 % of production loss separately. Therefore, we can estimate total loss ratio of all crops for cold damage disaster using these three indicators. The basic model can be shown as follows:

$$G(y_i) = \{[(A_1 - A_2) \times C_1 + (A_2 - A_3) \times C_2 + A_3 \times C_3] \times p\}/[A_0 \times p] \quad (17.1)$$

Where $G(y_i)$ represents total crop loss ratio due to cold damage disaster for specific province in year i; A_1, A_2, and A_3 are hectares covered by, affected by, and destroyed by cold damage disasters for specific province in year i, respectively. For accurate description of crop loss, this paper takes the difference between $(A_1 - A_2)$ and $(A_2 - A_3)$ as the definition of slightly influenced and severely influenced hectares of all crops due to cold damage disaster. Thus slightly influenced, severely influenced and destroyed hectares can be explained as the quantity of hectares with 10–30 %, 30–80 %, and over 80 % production loss, respectively; C_1, C_2, and C_3 are average loss ratio of crop in slightly influenced, severely influenced, and destroyed hectares, respectively; and p and A_0, denote crop yield per hectare and total sown hectares of all crops in year i, respectively. For simplicity, it is assumed that cold damage can result in the same damage probability to different crops in a region. According to such model, data on hectares of all crops covered by, affected by, and destroyed by cold damage disaster can be easily converted into crop loss ratio, which demonstrates the crop loss due to cold damage disaster. In other words, the problem of agricultural disaster loss data can be easily resolved; series of crop loss caused by cold damage disaster (CDL) are collected and presented here.

As mentioned above, we will model the risk of cold damage catastrophe based on extreme value theory (EVT). Assuming $G(y_i)$ ($i = 1, 2...n$) is independent and continuous observation that denotes crop loss caused by cold damage for specific province in year i, this paper breaks up the sequence into blocks of size 100 (with 100 reasonably large), and extracts only the maximum observation x_j ($j = 1, 2...k$) from each block. According to the definition of agricultural catastrophe risk, x_j indicates the maximum loss of crop production caused by cold damage disaster within 100 years in a specific province, which is the degree of damage the cold damage catastrophe disaster. Hence we can capture the cold damage catastrophe loss, which located in the tail of distribution curve of crop loss caused by cold damage disaster. According to the connotation of block maxima model (BMM) based on the extreme value theory, X_j ($x_1, x_2...x_k$) is normalized to obtain a non-degenerated limiting distribution, known as the generalized extreme value distribution (GEV), with cumulative density function:

$$F(x;\mu,\sigma,k) = \exp\left\{-\left(1+k\frac{x-\mu}{\sigma}\right)^{-1/k}\right\} \tag{17.2}$$

Where *F(x)* is the cumulative density function of generalized extreme value distribution (GEV), the function involve a single shape parameter (K) and optional location (μ) and scale parameter (σ), respectively. The function of GEV has a very simple closed form expression, although it can be seen as comprising a family of three distributions. In the extreme value theory (EVT), determination of shape parameter K is crucial, which governs the tail behavior of the distribution. Defined by $K=0, K>0,$ *and* $K<0$ correspondingly, the sub-family of generalized extreme value distribution (GEV) fall into three camps, officially called the Type I Extreme distribution (Gumbel), the Type II Extreme distribution (Frechet), and the Type III Extreme distribution (Weibull), respectively. Then, the log-likelihood for the GEV parameters is given by the followed equation:

$$l(\mu,\sigma,k) = -n\log\sigma - (1+1/k)\sum_{i}^{n}\log\left[1+k\frac{x_i-\mu}{\sigma}\right] - \sum_{i=1}^{n}\left[1+k\frac{x_i-\mu}{\sigma}\right]^{-1/k} \tag{17.3}$$

The maximization of this equation with respect to the parameter vector (μ, σ, K) leads to the maximum likelihood estimate (MLE) with respect to the entire GEV family (Gumbel 1958). After modeling crop loss caused by cold damage catastrophe, this paper used approaches similar to Deng et al.'s (2002) to quantify agricultural catastrophe risk for cold damage at the provincial scale in China. This paper assesses the catastrophe risk of cold damage for crop producers and calculates the probability of catastrophe risk under different loss degrees (x) using basic statistics formulae as followed:

$$\begin{cases} p(x \le x_1) = F(x_1;\mu,\sigma,k) \\ p(x \ge x_1) = 1 - F(x_1;\mu,\sigma,k) \\ p(x_1 \le x \le x_2) = F(x_2;\mu,\sigma,k) - F(x_1;\mu,\sigma,k) \end{cases} \tag{17.4}$$

17.2.3 Data and Monte Carlo Simulation

This paper assessed the risk of cold damage catastrophe for crop producers at the provincial scale in China, following the above process and approach. The data of loss spanned the period of 1978–2011, with a total of 34 sets of data samples obtained from the database of Planting Network (www.zzys.gov.cn). Based on the suggestion of specialists, this paper sets median value as the average loss ratio of slightly influenced (10–30 % production loss), severely influenced (30–80 % production loss), and destroyed (over 80 % production loss) of all crops. This indicates that the values of C_1, C_2, and C_3 are 0.20, 0.55, and 0.90, respectively. The time series of crop loss due to cold damage disaster (CDL) for 30 provinces in China was then calculated using Eq. (17.1).

To overcome the obstacle of data insufficiency, this paper attempts to expand sample size through Monte Carlo simulation. Based on the optimal probability distribution of crop loss data fitting for 30 provinces in China, this paper sampled 10,000 random simulation observations from the each given probability distribution for 30 provinces in China, respectively, which represent the disaster loss of crop production in 10,000 years, and established 30 new samples. We set $k = 100$ in this paper according to the size criteria of block. After breaking up each sequence into blocks of size 100 and extracting the maximum value of simulation observation in each segment, this paper get 100 data of catastrophe loss due to cold damage for each province in China. In other words, the problem of cold damage catastrophe loss data can be easily resolved, and time series of catastrophe loss caused by cold damage (CCL) for 30 provinces in China were presented here.

17.3 Results and Discussion

17.3.1 Modeling the Distribution of Cold Damage Catastrophe Risk

R statistical software was used to fit probability distribution of cold damage catastrophe loss based on the time series of catastrophe loss owing to cold damage (CCL) for 30 provinces in China. According to the principles of the BMM method, parameters of GEV were estimated by using the MLE approach. Parameter values of GEV distribution of crop loss caused by cold damage catastrophe for 30 provinces in China were shown in Table 17.1.

From Table 17.1, it can be seen that GEV distributions of crop loss caused by cold damage catastrophe for 26 provinces in China have negative shape parameter (K), which obeys a type of the Type III Extreme distribution, or Weibull distribution. Table 17.2 also shows that the model of cold damage catastrophe risk for Heilongjiang, Gansu, Qinghai, and Xinjiang obeys the Type II Extreme distribution, or Frechet distribution since the shape parameter (K) of GEV distribution are positive. The results of modeling the distribution of cold damage catastrophe risk are similar to the conclusion of Hao (2005), which means that the appropriate distribution of extreme cold damage differs across regions and the Weibull distributions fit overall the best in the majority of regions. It is generally true that the Type III Extreme distribution (Weibull) is optimal to simulate the risks of cold damage disaster in most regions for crop production because it has a weighted advantage of modeling cold damage catastrophe risk.

Table 17.1 GEV distribution of crop loss caused by cold damage catastrophe for 30 provinces in China

Provinces	Parameter values	Provinces	Parameter values
Beijing	$k = -0.1637$ $\sigma = 0.0012$ $\mu = 0.0083$	Hubei	$k = -0.1602$ $\sigma = 0.0066$ $\mu = 0.0519$
Tianjin	$k = -0.0784$ $\sigma = 0.0016$ $\mu = 0.0100$	Hunan	$k = -0.1013$ $\sigma = 0.0069$ $\mu = 0.0534$
Hebei	$k = -0.0980$ $\sigma = 0.0018$ $\mu = 0.0164$	Guangdong	$k = -0.0552$ $\sigma = 0.0049$ $\mu = 0.0385$
Shanxi	$k = -0.1067$ $\sigma = 0.0072$ $\mu = 0.0557$	Guangxi	$k = -0.0893$ $\sigma = 0.0043$ $\mu = 0.0307$
Inner Mongolia	$k = -0.0544$ $\sigma = 0.0067$ $\mu = 0.0560$	Hainan	$k = -0.1504$ $\sigma = 0.0063$ $\mu = 0.0533$
Liaoning	$k = -0.1349$ $\sigma = 0.0035$ $\mu = 0.0288$	Chongqing	$k = -0.1349$ $\sigma = 0.003$ $\mu = 0.0271$
Jilin	$k = -0.0896$ $\sigma = 0.0044$ $\mu = 0.0339$	Sichuan	$k = -0.1494$ $\sigma = 0.0012$ $\mu = 0.0120$
Heilongjiang	$k = 0.0207$ $\sigma = 0.0040$ $\mu = 0.0347$	Guizhou	$k = -0.0641$ $\sigma = 0.0062$ $\mu = 0.0461$
Jiangsu	$k = -0.1829$ $\sigma = 0.0074$ $\mu = 0.0525$	Yunnan	$k = -0.1303$ $\sigma = 0.0062$ $\mu = 0.0505$
Zhejiang	$k = -0.0750$ $\sigma = 0.0045$ $\mu = 0.0347$	Xizang	$k = -0.0500$ $\sigma = 0.0111$ $\mu = 0.0787$
Anhui	$k = -0.0950$ $\sigma = 0.0059$ $\mu = 0.0469$	Shannxi	$k = -0.0780$ $\sigma = 0.0053$ $\mu = 0.0397$
Fujian	$k = -0.1792$ $\sigma = 0.0049$ $\mu = 0.0375$	Gansu	$k = 0.0066$ $\sigma = 0.0056$ $\mu = 0.0588$
Jiangxi	$k = -0.1153$ $\sigma = 0.0059$ $\mu = 0.0419$	Qinghai	$k = 0.0186$ $\sigma = 0.0057$ $\mu = 0.0450$
Shandong	$k = -0.1584$ $\sigma = 0.0028$ $\mu = 0.0203$	Ningxia	$k = -0.1231$ $\sigma = 0.0117$ $\mu = 0.0840$
Henan	$k = -0.0618$ $\sigma = 0.0018$ $\mu = 0.0162$	Xinjiang	$k = 0.0157$ $\sigma = 0.0049$ $\mu = 0.0433$

Table 17.2 Summary of cold damage catastrophe risk for 30 provinces in China

Provinces	Probability of cold damage catastrophe loss ratios (x)			Mean (%)
	$1\% < x \leq 5\%$	$5\% < x \leq 10\%$	$>10\%$	
Beijing	17.310 %	0.000 %	0.000 %	0.035
Tianjin	63.683 %	0.000 %	0.000 %	0.127
Hebei	100.000 %	0.000 %	0.000 %	0.200
Shanxi	11.830 %	88.166 %	0.005 %	0.288
Inner Mongolia	9.335 %	90.635 %	0.031 %	0.291
Liaoning	100.000 %	0.000 %	0.000 %	0.200
Jilin	98.787 %	1.213 %	0.000 %	0.201
Heilongjiang	97.446 %	2.554 %	0.000 %	0.203
Jiangsu	25.165 %	74.835 %	0.000 %	0.275
Zhejiang	98.005 %	1.995 %	0.000 %	0.202
Anhui	44.145 %	55.855 %	0.000 %	0.256
Fujian	96.745 %	3.255 %	0.000 %	0.203
Jiangxi	79.719 %	20.281 %	0.000 %	0.220
Shandong	100.000 %	0.000 %	0.000 %	0.200
Henan	100.000 %	0.000 %	0.000 %	0.200
Hubei	26.361 %	73.639 %	0.000 %	0.274
Hunan	19.795 %	80.204 %	0.001 %	0.280
Guangdong	92.269 %	7.731 %	0.000 %	0.208
Guangxi	99.702 %	0.298 %	0.000 %	0.200
Hainan	19.306 %	80.694 %	0.000 %	0.281
Chongqing	0.000 %	100.000 %	0.000 %	0.300
Sichuan	98.698 %	0.000 %	0.000 %	0.197
Guizhou	58.999 %	41.001 %	0.000 %	0.241
Yunnan	34.087 %	65.913 %	0.000 %	0.266
Xizang	0.001 %	87.493 %	12.506 %	0.325
Shannxi	88.717 %	11.283 %	0.000 %	0.211
Gansu	0.733 %	99.193 %	0.000 %	0.299
Qinghai	65.699 %	34.286 %	0.015 %	0.234
Ningxia	0.001 %	79.744 %	20.255 %	0.341
Xinjiang	77.385 %	22.613 %	0.002 %	0.223

Notes: Probability of various loss ratios, Mean risk = **0.2*p(1 % < x ≤ 5 %) + 0.3*p(5 % < x ≤ 10 %) + 0.5*p(>10%)**

17.3.2 Calculating Cold Damage Catastrophe Risk

Based on the GEV distribution of crop loss caused by cold damage catastrophe for 30 provinces in China, we use Matlab software to calculate the probability of cold damage catastrophe risk. As shown in Table 17.2, the risk of cold damage catastrophe for crop production at the provincial scale in China was relatively serious. Given the scenario of suffering once-in-a-century cold damage, the crop-production loss ratios for 30 provinces in China fall into the interval mostly from 5 to 10 %, which represents a high probability of occurrence, while most provinces whose cold damage catastrophe loss falling into extreme interval ($x > 10\ \%$) had a very small probability to witness the extreme cold damage catastrophe except for Ningxia and Xizang. In addition, it must be pointed out that China's crop production is relatively so concentrated that the production of 13 grain major-producing provinces (include Liaoning, Jilin, Heilongjiang, Inner Mongolia, Hebei, Henan, Hubei, Hunan, Shandong, Jiangsu, Anhui, Jiangxi and Sichuan) accounts for over 70 % of the total grain output, which occupies about 80 % of the national commodity grain. When the extreme cold damage occurs, in terms of Inner Mongolia, Hunan, Jiangsu, and Hubei, the probability of 5–10 % reduction of crop output is actually more than 70 %. This undoubtedly may post a serious challenge to China's food security.

The cold damage catastrophe risk for 30 provinces were divided into four grades according to the mean of classification statistics (very high: 0.300–0.341; high: 0.256–0.299; medium: 0.200–0.241; and low: 0.035–0.197). As shown in Fig. 17.1, the provinces with very high or high risk of cold damage catastrophe mainly occur in the southwest and northwest regions as well as the middle and lower reaches of Yangtze River in China. The provinces with medium or low risk of cold damage catastrophe are mainly located in the central and eastern part of China. Ningxia, Xizang, Chongqing, Gansu, Inner Mongolia, Shanxi, Hainan, Hunan, Jiangsu, Hubei, Yunnan, and Anhui confront relatively high risk of cold damage catastrophe. More attention should be paid to the provinces with high cold damage catastrophe risk and large areas of crops-Chongqing, Inner Mongolia, Hunan, Jiangsu, Hubei, and Anhui. Compared with the above provinces, Ningxia, Xizang, Gansu, Shanxi, Hainan, and Yunnan only have relatively small sown areas, but these provinces are also in the geographic position of high cold damage catastrophe, so they should not be ignored. In contrast, the medium risk regions of cold damage catastrophe include Guizhou, Qinghai, Xinjiang, Jiangxi, Shannxi, Guangdong, Heilongjiang, Fujian, Zhejiang, Jilin, Hebei, Liaoning, Shandong, Henan, and Guangxi while Beijing, Tianjin and Sichuan face the lowest risk of cold damage catastrophe for crop production.

17.4 Conclusions

This paper developed the quantitative methodology of cold damage catastrophe risk assessment, which can be shown as the process of crop loss collection, Monte Carlo simulation, generalized extreme value distribution (GEV) fitting, and risk calculation. Data on crop loss were collected based on hectares covered by cold damage disaster, hectares affected by cold damage disaster, and hectares destroyed by cold damage disaster using the standard equation. Monte Carlo simulation based on appropriate distribution was used to expand sample size to overcome the insufficiency of crop loss data. Block maxima model (BMM) approach based on the extreme value theory was for modeling the generalized extreme value distribution (GEV) of cold damage catastrophe loss, and then cold damage catastrophe risk at the provincial scale in China was calculated. Catastrophe risk of cold damage to grain production in China was relatively serious. Given the scenario of suffering

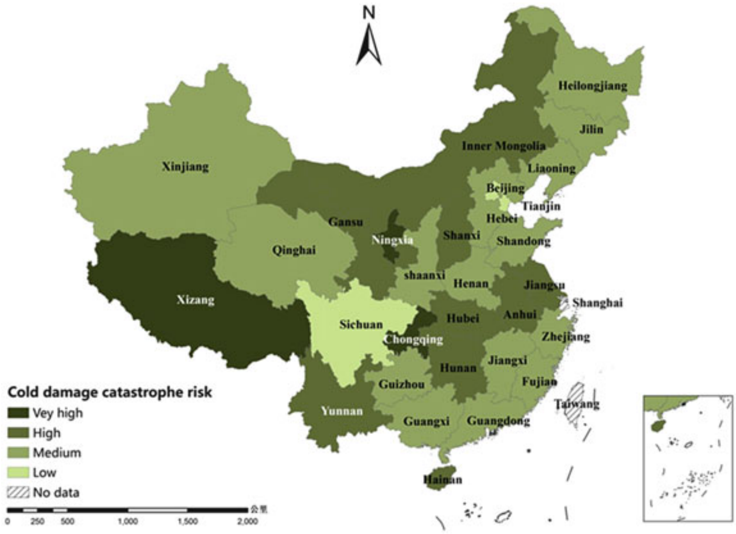

Fig. 17.1 Risk zoning of cold damage catastrophe in China

once-in-a-century cold damage, the grain-production loss ratios for 30 provinces in China varied from 5 to 10 % which is a high probability of occurrence. Very high or high risk of cold damage catastrophe is mainly located in the southwest and northwest regions as well as the middle and lower reaches of Yangtze River in China. Risk assessment of cold damage catastrophe can provide multifaceted information about cold damage catastrophe risk that can help to guide management of cold damage catastrophe.

Acknowledgments This work was jointly funded by National Natural Science Foundation of China (Grant No. 41201551) and support program of National Science and technology in China (Grant No. 2012BAH20B04-2).

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Chapter 18
Rice Yield of Rural Household of Niger State of Nigeria

Abdul-Gafar Ahmed, Wen Yu, and Xihai Zhao

Abstract Rice yield per hectare in Nigeria compared to her neighboring countries is low, given the ecological and economic advantages. Nigeria's rice yield should be seen in line with other developing countries such as Egypt and China. Based on a recent survey carried out 2012/2013, a sample size of 164 farm household was selected in Niger State, using an econometric analysis of Cobb-Douglas production function this paper examines factors that contribute significantly to the rice yield in rural household. The explanatory variable labor is categorized into seven stages of rice growth cycle to capture the essential labor usage. The result of the analysis reveals following significant factors; pesticide, fertilizer and irrigation having coefficient of 0.03, 0.05 and 0.15 respectively. Labor used during seedling relates positive while the number of labor used during tillering stage shows otherwise. Negatively related to yield also include flood and outside job. A trained, older farmer with farmer whose major crop is rice depicts a positive relationship with yield. These findings have useful information to investment priorities on how to stimulate rice production explained by yield.

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_18, © Springer-Verlag Berlin Heidelberg 2014

Keywords Rice yield • Production function • Ruralhouse hold • Niger State • Nigeria

18.1 Introduction

“Rice is the staple food for more than three billion people who eat it every day, rich in nutrients and contains a number of vitamins and minerals. It is an excellent source of complex carbohydrates—the best source of energy” (IRRI 2012). Beside the health advantage, Ojehomon et al. (2009) reported rice as a source of employment and income to many farmers and other agents in the production channels.

Rice consumption is growing and becoming increasingly important in Africa, especially in Nigeria, the Africa’s largest rice consumer and 11th in the world (USDA 2012). Rice production–consumption gap has been relatively increasing since 1970s with consumption overlapping production thereby stimulating rice importation. Majority of rice farmers are rural farmers, improving their yield will go a long way substitute importation to domestic production and/or exportation. As suggested by Zhang and Whitney (2011), to offset the need for rice importation Nigeria rice yield need to be improved.

The theoretical framework used in this paper explains the theory of production. Production is an act or process of creating value on goods and services which are useful to economic agents. Efficient production includes maximum utilization of available resources (input) to produce the utmost output (Varian 1999). Production function assists in a long way to reduce waste and maximizes output. According to Koutsoyiannis (2003), “production function is a purely technical relation which connects factor input and output”.

Higher yield can be explained in two major folds; promoting higher standard of living of the rural household via increase in income and ensuring self-sufficiency in rice production for the nation. This paper contributes to literature of rice production analysis in the following ways: provision of an update of rice yield and factors that influences yield by using 2012/2013 survey data; factor labor was categorized according to the stages of rice paddy growth cycle to provide efficient information on labor usage. This paper intend to analyze the main factors that influences rice yield in the rural household using Cobb-Douglas production function and provide any policy recommendation base on the findings.

18.2 Description of Study Area

Niger State as the case study of this paper is chosen base on her ecological advantage of rice farming system (rain-fed upland and rain-fed lowland and irrigation), the natural water availability and her role as one of the top rice producer in the country. Niger State lies in the Guinea Savanna vegetation zone in the north central part of Nigeria on latitude 80° to 11°:30′ North and Longitude 03° 30′ to 07° 40′ East. The state is about 10 % of the total land area in the country covering 76,463.903 km^2 with 85 % arable land and favorable climate with; abundant sunshine; average monthly temperature range from 23 to 37 °C; and an annual rainfall between 1,100 and 1,600 mm providing a wide variety of agricultural resources. Majority of the populace (85 %) in the state are farmers (Niger state facts and figures, 2012). The major crops grown include rice, maize, sugar cane, millet, melon, yam, groundnut, sorghum and cowpea (NSADP 1994).

18.3 Methodology

18.3.1 Model Specification

Both descriptive and statistical analysis was employed to analyze the result of the cross-sectional data (survey). An econometric estimation of the rural household rice paddy production function was carried out to determine major factors that influences yield.

Cobb-Douglas Production Function:

$$Y = A \cdot X_i^{\beta 1} \cdot X_i^{\beta 2} \tag{18.1}$$

Equivalently as:

$$\ln Y = \ln A + \beta 1 \ln X_1 + \beta 2 \ln X_2 \tag{18.2}$$

Where $A > 0$, β1 and $\beta 2 > 0$ (Elasticity output with respect to inputs; X_1, X_2)

Econometric estimation of Cobb-Douglas production function, Eqs. (18.1 and 18.2) will become:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_t t \tag{18.3}$$

The parameter β_0 represent the constant, the coefficients to be estimated are "β_1, β_2, β_3..., β_7" are the elasticity output with respect to inputs $X_1, X_2, X_3 \ldots, X_7$ (Wooldridge 2009). The sum of βi gives the degree of homogeneity or returns to scale. The Cobb-Douglas production function includes some restrictive properties upon production structure such as a fixed RTS value and an elasticity of substitution equating to unity.

Huge problem arises in regression when the independent variables are highly correlated. This paper detects highly powered collinearity among the independent variable using Variance Inflation Factors (VIF < 10 for each variable) Chatterjee and Hadi (2006). Stepwise (sw) regression was employed at pr(0.15) specifying the significance level for removal of independent variable from the model; terms with $p \geq pr(\#)$ are eligible for removal. Stepwise estimation was used because it's easy to explain, easy to compute/use when there are many independent variables also it allow many optional command apart from regression. The Interaction expansion "xi" used in the model (see Sect. 18.3.4) slots in dummy variables for difference groups (local government: id 1–5), an interaction terms for group membership with other independent variables. It select a base group (id 1)then identify what effects, if any, differ significantly from other groups.

18.3.2 Data Description

Primary data were collected with the aid of structured questionnaire. Random selection of the five local governments of Niger State of Nigeria has been done base on the share of land size, rice cropped area and on the share of rice production to the state; the selected local government area include Borgu, Bosso, Katcha, Lavun and Wushishi. Two villages have been selected in Borgu and Lavun local government base on their large land area and rice-favored ecological (water body). The rice output and land area differs in different location and with different farmers. The households in the survey area are chosen after knowing "$k = N/n$" that is the sampling interval then a random number (starting point) is chosen to avoid biasness. A total of 164 household were surveyed and interviewed. More so, in cases where applicable information is unavailable an alternative sources of secondary data such as the use of National Bureau of Statistic (NBS), Food and Agricultural Organization (FAO), International Food Policy Research Institute (IFPRI), United State Department of Agriculture (USDA), Central Bank of Nigeria (CBN), World Bank, and Research Institutes and Government Parastatal (Table 18.1).

The dependent variable is expressed as yield (output kg per hectare). The explanatory variable "labor" was divided into seven groups in relation to production stages including land preparation–planting, germination–transplanting, seedling, tillering, booting–flowering, grain filling–ripening and harvesting each is the summation of both household labor and labor hired. The natural logarithm of each labor per hectare is taken and used in model. Rice production in the surveyed are is mostly labor intensive, the study tend to investigate the use of labor during these seven stages of production noticing which stage is more sensitive to yield.

18.3.3 Estimation

The result of the estimated production function is shown in Table 18.2. The coefficient of the independent variables (X1–Xi) in the production function is the direct elasticity of each variable. The coefficient of dummy variables in the regression model of logarithm dependent variable is the percentage effect on the

Table 18.1 Variable used in the analysis

Variable	Definition	Mean	Min	Max
Output				
lny	Natural log of yield in kg	7.839	6.620	8.627
Input				
lnfert	Natural log of fertilizer kg per hectare	3.642	−3.178	6.620
lnpst	Natural log of pesticides liters per hectare	0.479	−3.738	3.114
lnhrb	Natural log of herbicides liters per hectare	2.252	−2.996	3.481
lnlab_lpp	Natural log labor/ha during land preparation & planting	2.399	1.157	3.689
lnlab_tr	Natural log of labor/ha during transplanting	1.301	−2.303	3.624
lnlab_sdl	Natural log of labor/ha during seedling	1.648	−2.303	3.555
lnlab_tibr	Natural log of labor/ha Tiller & branch	1.514	−2.303	3.555
lnlab_flo	Natural log of labor/ha during flowering	1.221	−2.303	3.114
lnlab_grfi	Natural log of labor/ha: grouting & filling	−0.771	−2.303	2.890
lnlab_hv	Natural log of labor/ha during harvest	2.609	−2.303	3.912
irrig	Dummy = 1, if irrigation is used	0.049	0	1
share	Share of lowland to yield	0.64	0	1
tentyp	Dummy = 1, if land is hired	0.44	0	1
seedx	Dummy = 1, if obtained seed from extension officer	0.20	0	1
Household characteristics				
dumage	Dummy = 1, if age $\geq$44	0.51	0	1
lneduc	Natural log of the years of education	0.331	−2.303	2.773
outsid_jb	Dummy = 1, if farmer has other jobs	0.68	0	1
Agr_Org	Dummy = 1, if belong to farmers organization	0.79	0	1
trained	Dummy = 1, if household head received training	0.51	0	1
majo_crp	Dummy = 1, if rice is the major crop planted	0.59	0	1
liv_stk	Dummy = 1, if farmer own livestock	0.72	0	1
lnodacrp	Natural log of other crop area	1.21	0.1	5
Weather				
flood	Dummy = 1, if experienced flood	0.28	0	1

Source: Authors' calculation from 2012/2013 survey data

dependent variable. In the model, the variable input; fertilizer, pesticide, irrigation appear to have significant impact on yield with an elasticity of 0.03, 0.05, 0.15 respectively. The number of labor used during seedling, and tillering stage has regression coefficients which were significant at 10 and 1 % respectively. Seed gotten from extension offices/officers on the other hand was significant on stepwise (backward selection) regression at probability for removal [pr(0.25)] this is because there was very little number of observations with such seed in the surveyed area. The above input variables have positive relationship with yield except for the number of labor used during tiller/branching stage. Farmers in the surveyed area operate a labor intensive farming system throughout the stages; there exist a unique characteristic of some farmers overusing household labor on small plot of land during some of the stages of the growth cycle. This suggests that in the survey area, a 1 % reduction in the number of labor used during tiller/branch stage will explain a 4.4 % increase in yield.

Table 18.2 Result of the stepwise regression

lny	Coef.	*t*		
lnfert	0.032	3.37**		
_Iid_3	−0.231	−3.22**		
dumage	0.070	1.54		
lnlab_sdl	0.108	4.44***		
irrig	0.151	1.47		
flood	−0.107	−2.09*		
majo_crp	0.120	2.31*		
outsid_jb	−0.099	−2.02*	Number of obs	164
trained	0.142	3**	F(12, 151)	9.67
lnpst	0.052	3.88***	Prob > F	000
lnlab_tibr	−0.044	−1.87*	R-squared	0.4345
_Iid_2	0.190	2.83**	Adj R-squared	0.3895
_cons	7.503	98.92***	Root MSE	0.27528

Source: Authors' calculation from 2012/2013 survey data
Note: Absolute value of t-statistics in parentheses—(*) statistically significant at 10 %; (**) statistically significant at 5 %; (***) statistically significant at 1 %

On the aspect of household demography, the farmers with other jobs other than farming pay less attention to the production of rice, this is a common trait to farmers in Bosso local government because of their nearness to the city. At significant level of 10 %, the more likely a farmer has another job or work outside the less (expected at 10 %) the yield. On the contrary, household with rice as the major crop, yield is expected to be increased by a 12 % at 10 % significant level. The existence of training either from the extension officer or farmers association is another importance factor that influences the level of yield (0.14 elasticity and at significant level of 5 %).

Ceteris paribus, older the farmers are expected to have more experience to maintaining and increasing the level of their yield (elasticity of 0.07). Weather as a factor represented by flood experience during production has a great impact on the reduction of yield with elasticity of −0.11 at 10 % statistical significance. In 2012/2013, severe flooding sharply reduced Nigeria's rice area (USDA 2013) this explains the height of the significance of flooding in the surveyed area.

18.3.4 The Model

xi: swreglnylnfert share dumagelneducirrig flood majo_crpoutsid_jb trained lnpstseedxlnhrbtentyplnlab_trlnlab_sdllnlab_tibrlnlab_flolnlab_grfi i.id, pr(.15)

18.4 Conclusion and Recommendation

The study shows that a 1 % increase in pesticide, yield is expected to increase to about 5.2 %. The use of pesticide help to reduce insect and other related pest but an excessive usage could also harm the environment and human. Distribution and control of pesticide will go a long way to offer an efficient production system. Policy makers should take advantage of the countries membership with FAO to ensure that pesticide and other related chemicals are properly tested and older hazardous products are taken off the market then educate farmers on farming with less or no use of pesticide. In south Asia, many farmers have learned how to control pest and other related constraints managing the natural predators in the field. In Bolivia and Paraguay, old hazardous pesticides are taken off the market FA0 (2013).

Cost and access to fertilizer has been one of the major constraints faced by farmers for decades (Longtau 2003; Ogundele and Okoruwa 2006). During the survey farmers bitterly complained on the availability and high cost of fertilizer. One common cause of this is "politicizing fertilizer" in local dialect referred to as "*tahkinsiyasa*": here small group of people with control over the distribution of subsidized fertilizer acquire but sell these fertilizer to another private retailer who then resell to farmers at higher price. The period at which these illicit exchanges take place coincides with the period of crop needing fertilizer. According to the farmers another aspect of politicizing fertilizer includes uneven distributing fertilizer; farmers or non-farmer belonging to a leading political party in the area have larger share of the subsidized fertilizer not comparative to owning a farm or size of farm. In the model, the impact of fertilizer to yield was highly significant at 5 %. To curb this problem, a different channel of distributing fertilizer should be adopted for example using the nearest agricultural institute such as the river basins.

In most less develop and developing countries investment on R&D of agricultural by the government has not been adequate but recently there are series of increased investment on agricultural R&D. As cited in Bingxin Yu and Shenggen Fan (2011), "past experience has shown high returns on investing on agricultural R&D (Fan et al. 2003; Nin Pratt et al. 2009)". The benefits of R&D can only be confirmed if there is an effective and efficient extension services. This paper finds that the existence of training either through the extension officers or farmers' association considerably increases yield by 14 % stressing the importance of extension.

According to Akpokodje et al. (2001), the continuously inconsistency and short term policies has negatively affect the rice economy. In view of the 2012 presidential initiative on Agricultural Transformation Action Plan, the rice sector will be treated more seriously with increase in investment on planting area, organizing farmers in categories, restructuring the distribution of inputs and research (USDA 2011). Increase in land area to resolve production and consumption gap can have a strong impact but could also be a short-term solution (Bingxin Yu and Shenggen Fan 2011) this suggest that providing higher yield via improved seed and better hybrids, regulating the flow of input via extension and training will go a long way curbing these problems. Challenges of external shocks such as flood, low rainfall could be reduced by providing an early warning system and/or compensation scheme to the farmers adversely affected.

These findings have useful information to investment priorities on how to stimulate rice production explained by yield. Moreover, the issue of electricity, rural roads transparent market system, mill factories sequencing to mention few, needs to be provided to lubricate the speed of the rice sector.

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Chapter 19
Empirical Analysis on the Economies of Scale of Natural Rubber Production: Based on the Panel Data of 86 Rubber Farms of HSF Between 1998 and 2007

Nengrui Xu, Na Qi, and Junli Li

Abstract Based on the panel data of 86 rubber farms of HSF (Hainan State Farm) between 1998 and 2007, the number of rubber trees being tapped and annual output of tapping workers as variables were chosen in this paper, and the non-linear regression was applied to analyze natural rubber's production scale, then two conclusions were drawn: (1) There was nonlinear economies of scale in natural rubber production of Hainan State Farms;(2) In theory, the optimal scale of rubber farm of HSF was 2322.2hm2.

Keywords Farm size • Natural rubber production • State-owned natural rubber farms • Non-linear regression

19.1 Introduction

Does agricultural production have the economies of scale? This has been a controversial issue for decades in economic development fields. Literature mainly focuses on three perspectives:

First, agricultural production has no economies of scale, and small farms are more efficient than large farms. This idea first appeared in the late 1960s of last century, Sen (1962) observed a negative relationship between farm size and land productivity when they were analyzing Indian farms' management data. Srinivasan (1972) provided a research on India's agricultural production, thought, due to the different needs of irrigation facilities caused by market irrationality and differences in land quality, small farms were more willing to increase input on per hectare of land than large farms, therefore small farms get more unit output. Bardhan (1973) used the output equation through controlling the variable of irrigation, and found that small farms are more efficient than large farms in technical control. Yotopoulos

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_19, © Springer-Verlag Berlin Heidelberg 2014

and Lau (1973) found that small farms are more efficient than large farms in economical efficiency. Sen (1975) once again used the data of a single village, and pointed that farm size often plays a negative role in production efficiency. S. Bhalla (1979) found that even after controlling the variables of land quality and irrigation, farm size and output efficiency continue to show a negative relationship. The World Bank's comparative study on small farms and large farms in Kenya found that the output per hectare of farm above 0.5 ha is 19 times of that of farm above 8 ha, and the former's labor amount were also 30 times of the latter (World Bank 1983). Carter (1984) did an empirical analysis of farmers' agricultural production, and proved a negative relation between farm size and productivity. Giovanni Andrea Cornia (1985) analyzed the relationship between various input factors, land productivity, labor output efficiency and farms of different sizes based on FAO's relevant data of 15 developing countries, and found a strong negative relationship between farm size and output of factors input. Robert McC Netting (1993)'s study also showed that in India, the income of per hectare land of farm below 2 ha is more than double of that of farm above 10 ha. M Ahmad and SK Quresh (1999) applied rural financial census data of Punjab region in northwest India, which also showed a negative relationship between farm size and output efficiency.

Secondly, agricultural production has economies of scale. Up to 1970–1980s of last century, many Asian countries were developing rapidly toward internationalization, small farms are considered as a major obstacle in the developing process, whereas, and international development requires rural labor to be transferred to urban areas, which conflicts with small farms' labor-intensiveness. Graham Dyer (1991) reflected the relationship between agricultural scale and output efficiency based on the survey data of Egyptian countryside areas, and concluded that agricultural production requires a certain scale. Andrew Dorward (1991) applied the survey data of small family agricultural production of African Malawi in 1980s, found farm size and output efficiency (from the perspective of labor and land) are positively correlated. K Hadri and J Whittaker (1999) used stochastic frontier production function to apply the panel data of 35 farms in southwestern Britain from 1986 to 1991, and suggested positive relations between farm size and technical efficiency, technical efficiency and the use of chemical fertilizers and pesticides. However, farm size and the use of chemical fertilizers and pesticides have no strong relevance. Ana R. Riost and Gerald E. Shively (2005) studied the effectiveness of small coffee farms in Vietnam through the application of two-step method on farm census data of 2004, suggested that small farms' effectiveness are inferior to that of large farms.

Thirdly, agricultural production's economies of scale is variable. Having studied the 30 years' data of Japan's agriculture production, Yujiro Hayami and Toshihiko Kawagoe (1989) thinks that when the economy comes to a stage of rapid development, agricultural production's economies of scale is pretty obvious. RF Townsendt and JF Kirsten et al. (1998a, b) used DEA (data envelopment analysis) to analyze the survey data of grape wine production areas of South African's west coast, which suggests the negative relationship between farm size and land productivity efficiency, and output efficiency of total input factors is weak, and the relationships between different regions are inconsistent. JJ Assunçãot and M Ghatak (2003) thought that the negative relationship between farm size and output efficiency is caused by imperfect credit market and the heterogeneous agricultural production techniques, unless farmers' ability difference could be controlled during the application of econometric methods, or else there would be a possibility that the negative relation could be exaggerated.

From the above brief review of related literature, It can be seen that the debate on agricultural production's economies of scale is not ended. However, the basic trend is bright and clear. With the in-depth study and improvement of quantitative analysis techniques, scholars begin to treat the problem with more and more precision, and start to study on agricultural production's economies of scale by phase and object. After all, agricultural production and industrial production is completely different, hence, the ideas and methods for studying the relationship between farm size and output efficiency is certainly not appropriate for agricultural production study, and the conclusion would also be ambiguous. For example, the relationship between short-term and long-term crop in production scale and efficiency are certainly different, if applied the same way on the two objects, then the conclusion may be seemingly reasonable, but if we probe into the problem, it would not only looks like ridiculous, but also it would lead to terrible results if it is taken as a reference for policy making.

This study chooses rubber Farm of Hainan State Farms as the object, which has the following advantages: (1) Rubber farms generally take large scale cultivation of natural rubber as their single production, which makes the research objectives tangible and comparable; (2) Natural rubber production typically depends on the input of land and labor, therefore the relationship between production scale (land input) and output efficiency (labor output efficiency) is very clear; (3) Management techniques in various Hainan state-owned rubber farms are almost the same, since all of them belong to state-owned farm system, thus, excellent management reform and innovation usually would be implemented in all of them; (4) State-owned rubber farms have detailed statistical data, which facilities this empirical study; (5) Natural rubber is a typical long-term crop, its growth period reaches as long as 7–8 years, and production period reaches as long as 30 years, which facilitate time series analysis; (6) The disturbance of differences in labor productivity on this research could be weakened, as for farm workers have gone through strict technical training to get post permit which only allows for tapping work, and which is completely different from rural farmers, so farmers' ability difference could be well-controlled; (7) Long-term average cost and marginal cost of rubber farms of Hainan State Farms are almost the same; (8) The specialized resources that rubber farm of Hainan State Farms owned (the land for natural rubber plantation and tapping workers) can not be used for other purposes.

This study chooses the panel data of natural rubber production of 86 rubber farms of Hainan State Farms between 1998 and 2007, the indicators that represent output efficiency (Y) include: per capita output (annual average output of per tapping worker), average production of per plant (annual average production of per plant), the indicators that represent farm size (X) include: total farm population, tapping areas of rubber plantation.

19.2 Model Assumption and Research Methods

19.2.1 Model Assumption

Assume rubber farm applies Cobb-Douglas production techniques, then have the following production function:

$$Y_{it} = A_{it} f(K_{it}, L_{it}, F_{it}) \tag{19.1}$$

R. H. Coase talked about the size of the firm in his article "The Nature of The Firm", he thinks market cost, organizing cost of different entrepreneurs and products that firm produced, will affect the size of the firm (Coase 1937). Therefore, for farm size, the input of capital (K), labor (L) and land (F) can be regarded as a function of production scale (S), that is:

$$S_{it} = f(K_{it}, L_{it}, F_{it})$$

Therefore, Function (19.1) could also be

$$Y_{it} = A_{it} f(S_{it}) \tag{19.2}$$

Based on the above analysis, this paper proposes an assumption on rubber production's economies of scale:

Rubber production's scale efficiency changes non-linearly, that is, there is nonlinear relationship between farm size and output efficiency; moreover, under certain production technology conditions, farms have the boundary of an optimal size. The assumption will use the production data of 86 rubber farms of Hainan State Farms between 1958 and 2007 for testing.

19.2.2 Research Methods: Optimization of Nonlinear Regression Method

For the relationship between output efficiency (Y) and farm size (S), this study adopts the method of nonlinear regression to analyze. Nonlinear regression does linear transformation on 11 possible curves (see Table 19.1). And then estimates the coefficients of each equation after transformation. Again optimize the estimated results, and optimization methods are: first, remove those whose F test values are

Table 19.1 Ten curve models and their linear transformation

NO.	Mathematical models	Transformation method	After transformation
1	$Y = aX^b$	$Y2 = \log(Y), X2 = log(X)$	$Y2 = c + bX2$
2	$Y = ae^{bx}$	$Y2 = log(Y)$	$Y2 = c + bX$
3	$Y = aXe^{bx}$	$Y3 = \log(Y/X)$	$Y3 = c + bX$
4	$Y = a\exp(b/X)$	$Y2 = \log(Y), X3 = 1/X$	$Y2 = c + bX3$
5	$Y = a\exp(bX^2)$	$Y2 = log(y), X4 = X^2$	$Y2 = c + bX4$
6	$Y = a + blog(X)$	$X2 = \log(X)$	$Y = c + bX2$
7	$Y = a + b/X$	$X3 = 1/X$	$Y = c + bX3$
8	$Y = 1/(a + bX)$	$Y4 = 1/Y$	$Y4 = c + bX$
9	$Y = X/(a + bX)$	$Y4 = 1/Y, X3 = 1/X$	$Y4 = c + bX3$
10	$Y = 1/(a + be^{-x})$	$Y4 = 1/Y, X5 = e^{-X}$	$Y4 = c + bX5$
11	$Y = a + bX$		$Y = a + bX$

non-significant, then remove those whose T test values are not significant, finally make a comprehensive comparison on P (F), $Adj - R^2$, $Adj - R^2$, D-W, S.D and AIC, and choose the most appropriate equation as analysis model.

19.3 Empirical Analysis

19.3.1 Relationship Fitting Between the Average Output per Plant (Y) and the Total Population (X)

First, we use the annual average output per plant of rubber being tapped to represent production efficiency, total farm population to represent farm size, and run a relationship fitting between the two. Use Eview6.0 data to do non-linear regression on 860 pairs of data. Estimation results are in Table 19.2.

From the comparison of estimated results in Table 19.2, we know that Eq. 19.3 is the optimal one as final analysis model.

After selecting Eq. 19.3, in order to examine the causal relationship between Log (Y/X) and X data sets, we run Granger Causality Test, and Table 19.3 lists the test results that whose lag period is 2. Results show that under at least 99.999 % confidence interval, X is the reason of Log (Y/X).

In order to examine the stationarity of Log (Y/X) data sets, we run a unit root test. The results obtained are shown in Table 19.4, and the results show that Log (Y/X) data are stationary.

Again, run the same unit root test on X data, the results of that are in Table 19.5, which shows X data is stable. Thus, least squares regression on Log (Y/X) and X data is feasible.

Therefore, the relationship between production scale represented by total population and output efficiency represented by output per plant of rubber farms of Hainan State Farms can be expressed through Eq. 19.3:

Table 19.2 Estimated results of ten curve models' linear transformation

Model	Constant (C)	Scale (X)	F value	$Adj-R^2$	D-W	S.D	AIC
1	4.1163***	−0.00753	0.000	0.0317	0.76	0.302	0.414
2	3.494***	−5.16E-06***	0.001	0.0124	0.73	0.307	0.434
3	−4.506***	−0.0001***	0.000	0.6819	0.75	0.836	1.336
4	3.389***	313.02***	0.000	0.027	0.77	0.302	0.418
5	3.452***	−5.05E-11	0.276	0.0001	0.72	0.302	0.446
6	52.95***	−2.296	0.000	0.041	0.74	8.122	6.987
7	30.859***	9167.28***	0.000	0.033	0.75	8.122	6.996
8	0.0366***	−3.09E-08	0.951	−0.0011	1.11	0.101	−1.736
9	0.0388***	−14.023	0.441	−0.0006	1.11	0.101	−1.736
10	14.055	−14.01	0.506	−0.0006	1.11	0.101	−1.736
11	34.0626***	−0.000165***	0.000	0.018	0.71	8.122	7.011

Table 19.3 Granger Causality Test on Log (Y/X) and X

Null hypothesis:	Obs	F-statistic	Prob.
X does not Granger Cause Log (Y/X)	688	10.4235	3.E-05
Log (Y/X) does not Granger Cause X		2.82907	0.0598

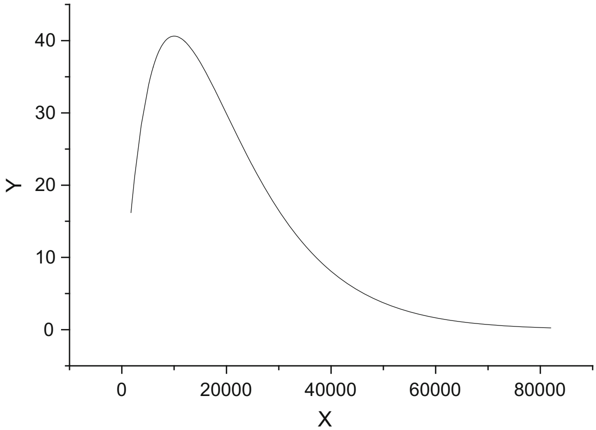
Table 19.4 The results of unit root test on Log (Y/X) data sets

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	−10.4979	0.0000	86	688
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	−2.65296	0.0040	86	688
ADF – Fisher Chi-square	207.270	0.0343	86	688
PP – Fisher Chi-square	370.625	0.0000	86	774

Table 19.5 The results of unit root test on X data sets

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	−13.4002	0.0000	86	688
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	−3.85461	0.0001	86	688
ADF – Fisher Chi-square	240.082	0.0005	86	688
PP – Fisher Chi-square	490.001	0.0000	86	774

Fig. 19.1 A curve graph within in the data X and Y



$$\mathrm{Log}(\mathrm{Y}/\mathrm{X}) = -4.506 - 0.0001\mathrm{X} \tag{19.3}$$

Then make a arrangement on Function (19.3), we have

$$\mathrm{Y} = \mathrm{X}e^{(-4.506-0.0001\mathrm{X})} \tag{19.4}$$

The model (19.4) within in the data X (farm's total population) and Y (average output per plant) actual numerical range, a curve graph was drawn in origin6.0, then we have Fig. 19.1,

From Fig. 19.1, we can see that the whole curve is a peak-shaped curve, which indicates that with the expansion of the farm population, output efficiency of per plant increases at first, but starts to decline after reaching a peak, and the peak value is around 10,000 people. It can be seen that rubber production's economies of scale measured by total farm population is nonlinear, and then assumption 1 was tested at this point of view.

19.3.2 Relationship Fitting Between Output per Capita (Y) and (X)

We use annual average output per capital to represent output efficiency, tapping area of rubber tree to represent farm size, and run a relationship fitting between the two. Use Eview6.0 data to run non-linear regression on 860 pairs of data. Estimation results are in Table 19.6.

From the comparison of estimation results in Table 19.6, we can see Eq. 19.3 still is the optimal one.

After deciding on model 19.3, we run Granger Causality Test again in order to examine the causal relationship between Log (Y/X) and X data sets. Table 19.7 lists the test results whose lag period is 2. The results show that the two interact as both

Table 19.6 Estimation results of non-linear regression on 860 pairs of data

No.	Constant (C)	Scale (X)	F value	$Adj-R^2$	D-W	S.D	AIC
1	0.528**	0.0578**	0.012	0.006	0.646	0.381	0.902
2	1.978**	0.127	0.152	0.001	1.37	1.457	3.593
3	−8.099***	−3.8E-05***	0.000	0.592	0.575	0.651	1.084
4	10171***	−1139.6***	0.000	0.021	0.626	0.381	0.888
5	10113***	7.64E-12	0.52	−0.000	0.643	0.381	0.909
6	10978**	0.127	0.152	0.001	1.372	1.458	3.593
7	3.407***	−0.2921.4**	0.003	0.009	1.382	1.458	3.586
8	0.407***	−8.27E-07	0.707	−.001	1.103	1.014	2.869
9	0.363***	384.9	0.583	−0.001	1.103	1.014	2.869
10	−384.46	384.9	0.584	−0.001	1.103	1.014	2.869
11	3.246***	1.16E-06	0.714	−0.001	1.37	1.458	3.595

Table 19.7 Granger Causality Test between Log (Y/X) and X

Null hypothesis:	Obs	F-statistic	Prob.
X does not Granger Cause Log (Y/X)	688	24.4676	5.E-11
Log (Y/X) does not Granger Cause X		5.63629	0.0037

cause and effect under 99 % confidence interval, and X is the reason of Log (Y/X) in a greater extent.

In order to investigate the stationary of Log (Y/X) data sets, we run a unit root test. The results obtained are shown in Table 19.8, the results show that Log (Y/X) data are stationary.

Again, run the same unit root test on X data, the results of that are in Table 19.9, which shows X data is stable. Thus, least squares regression on Log (Y/X) and X data is feasible.

Therefore, the relationship between production scale represented by tapping area and output efficiency represented by average output per capital of Hainan State Farms can be expressed through Eq. 19.3:

$$\mathrm{Log}(Y/X) = -8.099 - 0.0000038X \tag{19.6}$$

then make a arrangement on Function (19.3), we have

$$Y = Xe^{(-8.099-0.0000038x)} \tag{19.7}$$

Basing on the model (19.7), it is clearly indicate the relationship between X and Y is nonlinear. And we can calculated the economies of scale is about 2322.2hm2. It can be seen that rubber production scale is non-linear from this perspective, therefore assumption 1 is re-verified.

Table 19.8 The results of unit root test on Log (X/Y) data sets

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	−5.71301	0.0000	86	688
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	−0.98822	0.1615	86	688
ADF – Fisher Chi-square	179.804	0.3262	86	688
PP – Fisher Chi-square	240.730	0.0004	86	774

Table 19.9 The results of unit root test on X data sets

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process				
Levin, Lin & Chu t*	−4.23936	0.0000	86	688
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	2.10241	0.9822	86	688
ADF – Fisher Chi-square	169.683	0.5357	86	688
PP – Fisher Chi-square	313.663	0.0000	86	774

19.4 Conclusion and Discussion

19.4.1 Conclusion

1. rubber production's economies of scale are dynamic. Some scholars suggest that economies of scale will have a fixed parameter. The dynamic benefits of economies of scale in agricultural production will vary with different crops, different regions, different management methods, different production techniques, and the results of empirical study strongly support the view that agricultural production has to enhance scientific management.
2. In general, there is huge relationship between firm size and its production method, the dependence level before and after production process, the level of production factors being separated, if the production method is relatively simple, dependence level before and after production process is low, and production factors are easy to separate, then the scope of a firm's reasonable size is large; on the contrary, the firm's reasonable size is small. Rubber farms meet the former industrial requirements, and the quantitative analysis also shows rubber production's economies of scale of Hainan State Farms is nonlinear, that is, the size of rubber farms are not the bigger, the better, nor "small is perfect" (Fan and Chan-Kang 2005), but which

has a optimum point of its production scale, or can be called a boundary point of rubber farm size and output efficiency, the output efficiency of labor increases with the expansion of production scale before the optimum point, and it decreases with the expansion of production scale after the optimum point. This conclusion is similar to the conclusion of Steven M. Helfand and Edward S. Levine's research in 2004, but actually which is contrary, they believe that efficiency increases at first then decreases with the expansion of farm size. There are two possible reasons why the conclusions are different: first, research objects are different, and second, study methods are different.

19.4.2 Discussion

So far, this paper is only a basic research, and there are some fields for in-depth study in the future:

First, different variables can be selected under the same research methods. For example, production scale of rubber farms can be replaced by farm workers numbers, farm land area, and the production efficiency may also be represented by annual output per unit area, or annual output of per rubber tree. Different variables selection means that the focuses of researches are different. Natural rubber is a resource-constraint industry, as for rubber trees originating from Amazon River Basin under equator's rainy climate, which require higher level of growth conditions, now only South China regions (Hainan, southern Yunnan, south-west of Guangdong) have the necessary conditions that natural rubber required. Therefore, in terms of relative labor input, land – as the production factor is more and more scarce, and fully exploiting land output has more and more practical significance.

Secondly, the comparative study of private rubber farms can be made. Form the perspective of natural rubber's production technology, private rubber farms lag far behind state-owned rubber farms, which is partly because rubber planting in China has high technological requirements, and partly because state farms have specialized research institutes and training mechanisms. But from the perspective of farms' overall economic efficiency, there are indications that large state-owned farms are inferior to small private farms, which needs further in-depth investigation and analysis.

Acknowledgments This research is supported by the earmarked fund for China Agriculture Research System (CARS-34).

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Chapter 20
Research on Economic Effect of Grain Consumption Expenditure in Urban and Rural China

Yu Wang, Jianzhai Wu, and Xihai Zhao

Abstract **[Purpose]** Based on the influence of economic growth on urban and rural residents' grain consumption, this paper aimed at measuring the grain consumption of rural and urban residents in China. **[Methods]** This paper adopted co-integration model, error correction model and Granger causality test to reveal the long-term dynamic equilibrium relationship and short-term dynamic relationship between the economic growth and rural or urban residents' grain consumption expenditure, which would help convert perceptual knowledge to rational knowledge. **[Conclusions]** (a) Rural or urban residents' expenditures on grain demonstrated strong correlation with the economic growth. (b) In the short term, when the short-term fluctuations deviate from the long-term equilibrium, they would return to equilibrium with the adjustments of 0.3782 and 0.7652 respectively. (c) Economic growth is the cause of increases of rural and urban residents' expenditures on grain, while the increases of rural or urban expenditures on grain are not the cause of economic growth.

Keywords Expenditure on grain • Co-integration model • Error correction model • Granger causality test • Comparison between rural and urban

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_20, © Springer-Verlag Berlin Heidelberg 2014

20.1 Introduction

Grain has always been the first problem faced by human (Gerbens-Leenes PW and Nonhebel S, 2002). Since the reform and opening-up, the sustained growth of income has promoted the increases of grain consumption expenditure, and the acceleration of industrialization and urbanization help improve the grain consumption structures. Grain demand demonstrates the characters as follows: the consumption type has changed from daily consume to production consume; urban or rural grain demands differ from each other because of different living and eating habits, different income levels and so on. Grasping the character and development trend of grain consumption totally, we can make sure the equilibrium of grain supply and demand, guarantee food security and put the way to the theory basis of relevant policy.

In the past few years, studying on the grain consumption level mainly focused on the amount of grain demand, and mostly according to the population, income, nutrition, urbanization rate or some other factors, except economic growth factor. For example, some scholars have conducted researches on rural residents' grain consumption (Huang Ji Kun, 1995; Qin Fu and Chen Xiu-Feng, 2007; Wu La-Ping and Zhang Rui-Juan, 2011; Yu Aizhi and Liang Shiying, 2010; Chen Dongdong, 2010), and national grain consumption (Shiwei Xu, 2001; Zhang Yumei et al., 2012; Wang Yu, 2012).

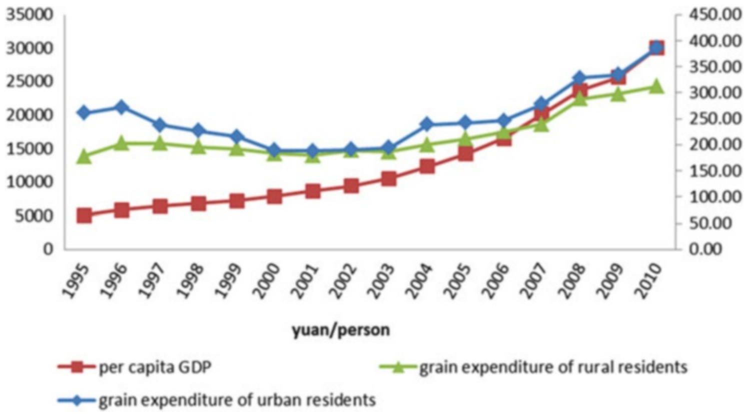
Therefore, based on the influence of economic growth on urban and rural residents' grain consumption, this paper aimed at measuring the grain consumption of rural and urban residents in China. This paper adopted co-integration model, error correction model and Granger causality test to reveal the long-term dynamic equilibrium relation and short-term dynamic relationship between the economic growth and rural or urban residents' grain consumption expenditure, which would help convert perceptual knowledge to rational knowledge.

20.2 Theoretical Basis

20.2.1 Data

This paper used per capita GDP (Y) to reflect China's economic growth, rural residents' per capita grain consumption expenditure (X) and urban residents per capita grain consumption expenditure (X') to reflect the urban and rural grain consumption level. As is shown in Graph 20.1, the trend of per capita GDP, the rural and urban residents' per capita grain consumption expenditure from 1995 to 2012, data is taken from *China Rural Statistical Yearbook (1996–2011)* and *China Statistical Yearbook (1996–2011).*

In order to eliminate the heteroscedasticity of the time series, this paper converted the original data to logarithmic form and used software of EViews6.0 to making each period difference of LNX, LNX′ and LNY (Yi Danhui, 2008).



Graph 20.1 Trend of per capita GDP, the rural and urban residents' per capita grain consumption expenditure from 1995 to 2012

$$\text{GENR LNY} = \text{LOG}(\text{Y});$$
$$\text{GENR LNX} = \text{LOG}(\text{X});$$
$$\text{Series } \Delta\text{LNY} = \text{LN}(\text{Y}) - \text{LN}(\text{Y}(-1)), \text{Series } \Delta\text{LNX} = \text{LN}(\text{X}) - \text{LN}(\text{X}(-1)).$$

20.2.2 Methodology

This paper adopted co-integration model, error correction model and Granger causality test to reveal the long-term dynamic equilibrium relation and short-term dynamic relationship between the economic growth and rural or urban residents' grain consumption expenditure, which would help convert perceptual knowledge to rational knowledge (Liu Meng, 2011; He Xian ping et al. 2009; Gao Tiemei, 2006; Li Guozhu and Liu Dezhi, 2010; Ma Wei, 2004; Ma Jingshui and Ma Shuqing, 2001; He Juxiang and Wang Taoyang, 2011; Zhang Mingxiang, 2007).

20.2.2.1 Co-integration Model

This paper used the co-integration model to research on the long-term relationship between economic growth and rural or urban residents' expenditures on grain consumption. Theoretical basis of co-integration is that if two or more time series variables are not stationary, while their linear combination is stationary, then these variables have co-integration relationship, which is also called as long-term equilibrium relationship.

In order to apply co-integration model to study relationship between economic growth and rural or urban residents' expenditures on grain, first of all, it's necessary to carry on the unit root test to examine whether the time series variables are stationary or not. If the variables are not stationary, then the co-integration test would result in false regression and false conclusion consequently. The paper adopted ADF method to test the variables' stability, in other words, conducted the following regression:

$$\Delta y_t = \beta_0 + \beta_1 * t + \beta_2 * y * t - 1 + \sum_{i=1}^{m} \beta_{3i} * \Delta y_{t-i} + \beta_t \quad (20.1)$$

In the formula (20.1), β_0 is constant term, t is the time trend part, m is lagged order.

$H_0 : \beta_2 = 0, H_1 : \beta_2 < 0$, If the null hypothesis H_0 is accepted, then we deem that the series y_t has unit root and the variables are un-stationary; conversely, unit root doesn't exist and the variables are stationary. If the sequence is un-stationary, it's necessary to test stationary of the first-order difference of the sequence. If the first-order (second-order) difference of the variable is stationary, the variable could be regarded as integrated of order one (two). The stationary of the first-order (second-order) difference of the variables are the premise of co-integration relationship.

In addition, co-integration test could examine the existence of co-integration relationship between economic growth and rural or urban residents' expenditures on grain, and determine whether the set of the linear regression equation is reasonable or not. This paper adopted the AEG co-integration test to examine the stationary of the sequences, co-integration relationship between the dependent variable and independent variables of the regression equation, and the accuracy of model specification.

Details steps of AEG co-integration test as follows:

Assume y_1, $y_2 \ldots y_k$ are all integrated of one-order, and establish the regression equation as follows:

$$y_{1t} = \beta_2 y_{2t} + \beta_3 y_{3t} + \ldots + \beta_k y_{kt} + u_t, t = 1, 2, \ldots, T \quad (20.2)$$

The residual sequence produced by the model is as below:

$$\hat{u}_t = y_{1t} - \hat{\beta}_2 y_{2t} - \hat{\beta}_3 y_{3t} - \ldots - \hat{\beta}_k y_{kt} \quad (20.3)$$

Conducting the EG or AEG test to examine the stationary of the sequence.

If the residual sequence is stationary, then we can make sure that the variables (y_1, $y_2, y_3, \ldots, y_k$) in the regression equation have co-integration relationship, the co-integration vector is $\left(\hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3, \ldots, \hat{\beta}_k\right)'$, $\hat{\beta}_1 = 1$. Otherwise the variables (y_1, $y_2, y_3, \ldots, y_k$) don't have co-integration relationship.

20.2.2.2 Error Correction Model

This paper used the error correction model (ECM) to study the short-term relationship between the economic growth and rural or urban residents' expenditures on grain. Rather than separately using the origin variables or the first order (or second order) difference of the origin variables, the ECM combines them together and fully makes use of the supplied information. The form of ECM is described as below:

$$\Delta Y_t = \alpha ecm_{t-1} + \sum_{i=1}^{p-1} {}_i\Delta y_{t-i} + \varepsilon_t \tag{20.4}$$

In the formula (20.4), each equation is an ECM. ecm_{t-1} is error correction vector, the coefficient α reflects the speeds of adjustment to equilibrium when the variables deviate from the long-term equilibrium.

20.2.2.3 Granger Causality Test

After researching on the long-term dynamic equilibrium relation and short-term dynamic relationship between the economic growth and rural or urban residents' grain consumption expenditure, this paper conducted Granger causality test, aiming at examine the casual relationship between economic growth and rural or urban residents' expenditures on grain, and determining origin specification and economic sense of the model.

Whether the economic growth rate *X* is the reason which causes the change of rural and urban residents' expenditures (*Y*) on grain, the procedure of Granger causality test is as follows:

1. Null Hypothesis: X does not the Granger cause of Y.
2. Regress *Y* on the lagging value of *X* and *Y*, and establish the following regression model (without restrictive condition):

$$Y_t = \sum_{i=1}^{m} a_i * y_{t-1} + \sum_{i=1}^{m} b_i * x_{t-1} + u_i \tag{20.5}$$

3. Regress *Y* on the lagging value of *Y*, and establish the following regression model (with restrictive conditions):

$$Y_t = \sum_{i=1}^{m} a_i * y_{t-1} + u_i \tag{20.6}$$

4. Calculate F-statistic and examine whether the regression coefficients $b_1, b_2, \ldots, b_m$ are all significant zero. If so, refuse the null hypothesis; In other words, X is the granger cause of Y, it has the causal relationship between X and Y.

20.3 Empirical Analysis

20.3.1 Test of Series Stationary

With the help of EViews6.0, we conducted ADF test to examine the stationary of LNY, LNX, LNX′, ΔLNY, ΔLNX and ΔLNX′. From the Table 20.1 as below, we

Table 20.1 Stationary test of variables

Area	Variable	Test type (c, t, k)	ADF test value	Critical value (5 %)	Critical value (1 %)	P value	Result
Rural	LNY	(c,t,4)	−0.4257	−2.981	−3.7115	0.8905	Un-stationary
	LNX	(c,t,0)	−1.1928	−2.964	−3.6702	0.6643	Un-stationary
	ΔLNY	(c,t,3)	−3.479	−2.981	−3.7115	0.017	Stationary
	ΔLNX	(c,t,0)	−5.9081	−2.9678	−3.6793	0	Stationary
	Δ^2LNY	(c,t,3)	−3.871	−2.9862	−3.7241	0.0071	Stationary
	Δ^2LNX	(c,t,3)	−6.2197	−2.9862	−3.7241	0	Stationary
Urban	LNY	(c,t,3)	−3.8322	−3.8753	−4.9922	0.0534	Un-stationary
	LNX’	(c,t,0)	−0.6599	−3.7597	−4.7284	0.9569	Un-stationary
	ΔLNY	(c,t,3)	−0.5989	−3.9334	−5.1249	0.9532	Un-stationary
	ΔLNX’	(c,t,0)	−4.8072	−3.7912	−4.8072	0.0099	Stationary
	Δ^2LNY	(c,0,2)	−2.421	−1.9778	−2.7922	0.021	Stationary
	Δ^2LNX′	(c,0,1)	−4.8815	−1.974	−2.7719	0.0002	Stationary

Note: (c, t, k) respectively stand for the orders of intercepts, time trends and lags in the equation for ADF test. 0 stands for equation without intercept and time trend. The lags stand for white noises

can identify that the ADF test values of LNY, LNX and ΔLNY are all more than the critical values 5 %, indicating the time series LNY, LNX and ΔLNY can’t refuse the unit roots hypothesis and LNY, LNX and ΔLNY are not stationary at the level of 5 %. The ADF test values of ΔLNX, Δ^2LNY 和 Δ^2LNX are all less than the critical values 1 %, indicating that they refuse unit roots hypothesis and ΔLNX, Δ^2LNY 和 Δ^2LNX are all stationary at the level of 1 %. The ADF test values of LNY, LNX′ 和ΔLNY are all more than the critical values 5 %, indicating that LNY, LNX′ 和ΔLNY can’t refuse unit roots hypothesis and LNY, LNX′ 和ΔLNY are not stationary at the level of 5 %. The ADF test values of ΔLNX′, Δ^2LNY 和 Δ^2LNX′ are all less than the critical values 1 %, indicating that they refuse unit roots hypothesis and ΔLNX′, Δ^2LNY 和 Δ^2LNX′ are all stationary.

20.3.2 Long-Term Equilibrium Relationship

(First-order) Second-order difference sequence rejected the unit root hypothesis, indicating that the time series X and Y may have some stationary linear combination, which reflects the long-term stability proportional relationship between variables, namely co-integration relationship.

Co-integration test between variables can be made in two ways: One is the Engle-Granger two-step test method for testing the co-integration between two variables. The other is the Johansen test method for testing the co-integration between multiple variables. We use the Engle-Granger two-step test method to test the co-integration, because this paper studies on the relationship between China’s economic growth and urban or rural residents.

Table 20.2 Unit root test of series e_t

Statistical test of ADF		−3.339264
Test threshold:	1 % level	−3.689194
	5 % level	−2.971853

20.3.2.1 Countryside

Assuming co-integrated relationship between LNY and LNX, we use EViews 6.0 to get the estimating equation.

$$\begin{aligned} \mathrm{LN}\hat{\mathrm{Y}} = \ & 1.5099 + 1.4479\mathrm{LNX} \\ & (4.6841) \quad (21.1871) \end{aligned} \tag{20.7}$$

All of the regression coefficients have passed t-test. $\hat{R}^2 \approx 0.94, DW \approx 0.48$. $e_t = \Delta\,\mathrm{LNY} - \Delta\,\mathrm{LN}\hat{\mathrm{Y}}$, e_t is the random distracter, we make unit root test to e_t, seeing that the test statistic of −0.6455 is greater than the 5 % significance thresholds of −2.9862, e_t can't refuse the unit root test, e_t is non-stationary series.

Assuming co-integrated relationship between △LNY and △LNX, we use EViews 6.0 to get the estimating equation.

$$\begin{aligned} \Delta\,\mathrm{LN}\hat{\mathrm{Y}} = \ & 0.1257 + 0.1541\,\Delta\,\mathrm{LNX} \\ & (10.6269) \quad (2.4548) \end{aligned} \tag{20.8}$$

All of the regression coefficients have passed t-test. $\hat{R}^2 \approx 0.18, DW \approx 0.89$ $e_t = \Delta\,\mathrm{LNY} - \Delta\,\mathrm{LN}\hat{\mathrm{Y}}$, e_t is random distracter, we make unit root test to e_t,. We can see from the Table 20.2, the test statistic of −3.3393 is smaller than 5 % significance thresholds of −2.9719, e_t refuse the unit root test, e_t is stationary series.

From the Table 20.2, we can get there is a stationary linear combination between LNY and LNX, namely there is a long-term equilibrium relationship between economic growth level and the grain consumption expenditure on rural residents.

20.3.2.2 Urban

Assuming co-integrated relationship between LNY and LNX', we use EViews 6.0 to get the estimating equation.

$$\begin{aligned} \Delta\,\mathrm{LN}\hat{\mathrm{Y}} = \ & 0.1104 + 0.3236\,\Delta\,\mathrm{LNX}' \\ & (13.3011) \quad (3.8744) \end{aligned} \tag{20.9}$$

All of the regression coefficients have passed t-test. $\hat{R}^2 \approx 0.54, DW \approx 1.58$ $e_t = \Delta\,\mathrm{LNY} - \Delta\,\mathrm{LN}\hat{\mathrm{Y}}$, e_t is random distracter, we make unit root test to e_t.

We can see from the Table 20.3, the test statistic of −3.0536 is smaller than 1 % significance thresholds of −2.7406, e_t refuse the unit root test, e_t is stationary series.

From the Table 20.3, we can get there is a stationary linear combination between LNY and LNX', namely there is a long-term equilibrium relationship between economic growth level and the grain consumption expenditure on urban residents.

Table 20.3 Unit root test of series e_t

Statistical test of ADF		−3.053570
Test threshold:	1 % level	−2.740613
	5 % level	−1.968430

20.3.3 Short-Term Dynamic Relationship

According to Granger theorem, variables with co-integrated relationship have expression form the error correction model. Therefore, based on co-integration, we can further build the error correction model including the error correction variable, studying on the short-term dynamics and the co-integration characteristics of model. According to the co-integration test, in spite of the existence of co-integration relationship between the variables, regression coefficient is significant, and DW values are nearby 2, $\hat{R}^2$ is significantly smaller, the fitting effect should be improved. Therefore, we make a regression between LNY and LNX again, adding the lagged variable, and establish the error correction model of single equation. We use EViews6.0 to establish the correction model as follows.

20.3.3.1 Countryside

First-Order Error Correction Model

$$\begin{array}{l} \mathrm{LNY_t} = \underset{(-0.0818)}{0.1330} + \underset{(0.0691)}{0.1691\mathrm{LNX_t}} + \underset{(0.0364)}{0.9810\mathrm{LNY_{t-1}}} - \underset{(0.0727)}{0.1374\mathrm{LNX_{t-1}}} + \mathrm{u_t} \end{array} \tag{20.10}$$

$\hat{\mathrm{R}}^2$ is closed to 1, the result is very well. DW = 0.91, which is not nearby 2, autocorrelation exist in residuals, all the coefficients of the equation have pass the t-test expect the constant term.

Second-Order Error Correction Model

Considering the co-integration between ΔLNY and ΔLNX, first-order error correction model has autocorrelation, so we use the second-order error correction model, using EViews6.0 to establish the following second-order error correction model.

$$\begin{aligned} \mathrm{LNY_t} = & \underset{(0.0757)}{0.0895} + \underset{(0.0629)}{0.0717\mathrm{LNX_t}} + \underset{(0.1798)}{1.6218\mathrm{LNY_{t-1}}} - \underset{(0.0728)}{0.1362\mathrm{LNX_{t-1}}} \\ & \underset{(0.1756)}{-0.6218\mathrm{LNY_{t-2}}} - \underset{(0.0655)}{0.0604\mathrm{LNX_{t-2}}} + \mathrm{u_t} \end{aligned} \tag{20.11}$$

$\hat{R}^2$ is closed to 1, the result is very well, DW = 1.54, which is nearby 2, autocorrelation doesn't exist in residuals, all the coefficients of the equation have passed the t-test besides the constant term, LNX and LNX (−2).

We can get the second-order lag error correction model, after the appropriate identical deformation of the formula (20.11):

$$\begin{aligned}\Delta\,\mathrm{LNY_t} &= 0.0717\,\Delta\,\mathrm{LNX_t} + 0.6218\,\Delta\,\mathrm{LNY_{t-1}} + 0.0604\,\Delta\,\mathrm{LNX_{t-1}} \\ &\quad - 0.3782(\mathrm{LNY_{t-1}} + 0.3302\mathrm{LNX_{t-1}} - 0.2366) + \mathrm{u_t} \qquad (20.12)\end{aligned}$$

In the formula (20.12): $\mathrm{LNY_{t-1}} + 0.3302\mathrm{LNX_{t-1}} - 0.236$ is called as error correction term ecm. From formula (20.12), we can see if $\mathrm{LNY_{t-1}}$ is greater than its long-term equilibrium of $0.2366 - 0.3302\mathrm{LNX_{t-1}}$, ecm is positive, $\triangle$Y will decrease; if $\mathrm{LNY_{t-1}}$ is less than its long-term equilibrium of $0.2366 - 0.3302\mathrm{LNX_{t-1}}$, ecm is negative, $\triangle$Y will increase. This fits the reverse correction mechanism, reflecting the control of long-term non-equilibrium error on Y.

The size of the error correction coefficient reflects the readjustment degree for its deviation from the long-run equilibrium. From the estimates coefficient −0.3782, we can see when the short-term fluctuations deviate from the long-term equilibrium, the adjustment will be −0.3782 to pull the non-equilibrium back to a balanced state. It means that the previous year's non-equilibrium error rate is 37.82 %, which makes a direction correction for $\triangle$LNY on this year.

20.3.3.2 Urban Residents

$$\begin{aligned}\mathrm{LNY_t} = &-0.0020 + 0.3225\mathrm{LN}X'_t + 0.9984\mathrm{LNY_{t-1}} - 0.2994\mathrm{LN}X'_{t-1} + \mathrm{u_t} \\ &(-0.0073)\ \ (2.6656)\qquad\ (36.6269)\qquad\ (-2.5455)\end{aligned} \qquad (20.13)$$

$\hat{R}^2$ is closed to 1, the result is very well, DW = 1.57, which is nearby 2, autocorrelation doesn't exist in residuals, all the coefficients of the equation have passed the t-test expect the constant term.

We can get the one-order lag error correction model after the appropriate identical deformation of the formula (20.13) :

$$\begin{aligned}\Delta\,\mathrm{LNY_t} &= 0.2601\,\Delta\,\mathrm{LN}X'_t \\ &\quad - 0.7652\left(\mathrm{LNY_{t-1}} - 0.3236\mathrm{LN}X'_{t-1} - 0.1104\right) + \mathrm{u_t} \qquad (20.14)\end{aligned}$$

In the formula (20.14): $\mathrm{LNY_{t-1}} - 0.3236\mathrm{LN}X'_{t-1} - 0.1104$ is called as error correction term ecm. From formula (20.14), we can see if $\mathrm{LNY_{t-1}}$ is greater than its long-term equilibrium of $0.3236LNX'_{t-1} + 0.1104$, ecm is positive, △Y will decrease; if LNY_{t-1} is less than its long-term equilibrium of $0.3236LNX'_{t-1} + 0.1104$, ecm is negative, △Y will increase. This fits the reverse correction mechanism, reflecting the control of the long-term non-equilibrium error on Y.

The size of the error correction coefficient reflects the readjustment degree for its deviation from the long-run equilibrium. From the estimates coefficient −0.7652, we can see when the short-term fluctuations deviate from the long-term equilibrium, the adjustment will be −0.7652 to pull the non-equilibrium back to a balanced state. It means that the previous year's non-equilibrium error rate is 76.52 %, which makes a direction correction for △LNY on this year.

20.3.3.3 Causality Test

There is co-integrated relationship between LNY and LNX, when we make the analysis of Granger causality between variables, we need to analyze interaction effect between △ LNY and △ LNX by Granger-causality test method. Test results are shown in Table 20.4.

From Table 20.4, we find the null hypothesis of "LNY is not Granger reason of LNX " is refused at the significance level of 1 % in China's urban areas. The null hypothesis of "LNX' is not Granger reason of LNY" is not refused; the null hypothesis of "LNY is not Granger reason of LNX " is refused at the significance level of 10 % in China's rural areas. The null hypothesis of "LNX' is not Granger reason of LNY" is not refused; This shows that there is unidirectional Granger causality between LNY and LNX, namely China's economic growth affects the growth of grain consumption expenditure of urban and rural residents, economic growth is the Granger reason of grain consumption expenditure of urban and rural residents, and grain consumption expenditure of urban and rural residents is not Granger reason of economic growth.

20.4 Conclusions and Recommendations

20.4.1 Conclusions

We can get the following conclusions by analysis above:

We can see from the analysis of economic effect of grain consumption in rural area: (1) There is a strong correlation between grain consumption expenditure of rural residents and economic growth. Although their growth is respectively non-stationary, there are significant long-term stable equilibrium relationship between LNY and LNX. (2) In the short term, when the short-term fluctuations deviate from the long-term equilibrium, the adjustment will be 0.3782 to pull the non-equilibrium back to a balanced state. (3) China's economic growth is the

Table 20.4 Granger causality test for each variable

Null hypothesis		Lag order	F-statistics	P-value	Result
Urban	LNX′ is not Granger reason of LNY	2	1.26218	0.32871	Not refuse
	LNY is not Granger reason of LNX′	2	9.05453	0.00700	Refuse
Rural	LNX is not Granger reason of LNY	2	1.12489	0.34122	Not refuse
	LNY is not Granger reason of LNX	2	3.05398	0.06582	Refuse

reason of grain consumption expenditure of rural residents, we can see that China's economic growth plays an important role in the grain consumption growth of rural residents; while grain consumption growth of rural residents is not the cause of economic growth.

We can see from the analysis of economic effect of grain consumption in urban area: (1) There is a strong correlation between grain consumption expenditure of urban residents and economic growth. Although their growth is respectively non-stationary, there are significant long-term stable equilibrium relationship between LNY and LNX. (2) In the short term, when the short-term fluctuations deviate from the long-term equilibrium, the adjustment will be 0.7652 to pull the non-equilibrium back to a balanced state. (3) China's economic growth is the reason of grain consumption expenditure of urban residents, we can see that China's economic growth plays an important role in the grain consumption growth of urban residents; while food consumption growth of urban residents is not the cause of economic growth.

20.4.2 Recommendations

Since economic growth is reason of grain consumption expenditure in urban and rural areas, we can promote the grain consumption increase in urban and rural, enrich the diversity of grain consumption via the steady economic growth. This will not only improve the nutritional and dietary structure in urban and rural, but further improve the living situation of urban and rural and enhance the quality of life of urban and rural residents.

In addition, since grain consumption growth of urban residents is not the cause of economic growth, which has a great relationship with the current status of the consumption structure of urban residents, spending such as housing, medical care, transportation, education and non-grain categories is far more than grain consumption expenditure, the proportion (grain consumption in the total consumption) is very small, in order to improve the economic growth via the grain consumption increase of urban residents, we should change the current grain consumption patterns and institutions of urban residents, accelerate the development of grain processing industry, establish high-nutrition, high-quality, high-value commercial grain products, and improve the demand cognitive of grain consumption diversity in urban. Since grain consumption growth of rural residents is not the cause of economic growth, which has a great relationship with the current status of the consumption structure of rural residents, in order to improve the economic growth via the grain consumption increase of rural residents, we should change the current grain consumption patterns and institutions of rural residents, speed up the process of urbanization, and improve the demand cognitive of grain consumption diversity in rural.

Acknowledgements The authors gratefully acknowledge the financial support from the Key Technologies R&D Program of China during the 12th Five-Year Plan Period (2012BAH20B04).

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Chapter 21
The Outputs and International Competitiveness of Livestock Products in the BRICS: A Comparative Analysis

Ge Yu, Chao Zhang, Zhe-min Li, Xiao-xia Dong, Chen-zhuo Xu, and Lei Liu

Abstract For the past few years, the outputs and trade volumes of livestock products in the BRICS had been kept on growing. Based on the comparative analysis of the BRICS' livestock production, this paper made use of Revealed Comparative Advantage Index (RCA) and Trade Special Coefficient (TC) to measure the comparative advantage and trade competition advantage of livestock products in the BRICS. The results showed that BRICS' livestock outputs and trade volumes increased and their trade statuses gradually changed. Brazil and India had been operating well as exporters, while Russia and China run more obvious trade deficits. The BRICS had strong comparative advantages and competitiveness in HS02 (meat and edible offal) and HS16 (meat, fish and other aquatic invertebrates products); while their advantages in HS05 (other animal products) and HS51 (animal furs) were relatively weak.

Keywords The BRICS • Livestock products • Comparative advantage • Trade competitiveness

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Project Support: Project of Foreign Economic Cooperation Center (the Agriculture Department Information Communication Design for the BRICS; Research on Analysis and Dissemination of the BRICS' Agricultural information)

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_21,

21.1 Introduction

The BRICS, as the world's largest emerging economies, have taken a certain share in the international trade of agricultural products, and have made great contributions to economic growth of the world. The BRICS have reflected different types of international competitiveness, which are complementary to each other (Hongfen Lv and Cen Yu 2012; Bi Tang 2012; Jingyun Wu 2011; Baichuan and Jiguang 2011; Chunlin Cai 2008). Especially in recent years, benefited from significant economic growth and continuous improvement of people's living standard, Livestock husbandry in the BRICS has been developing fast with extended trade shares and more important roles in agriculture and international agricultural transaction. Therefore, how to promote international transaction and realize mutual advantages and exchange of needed goods on the base of actual production between the BRICS has become a hot spot of current studies.

From the available literature, studies on livestock trade between the BRICS have got plenty of achievements. It has been widely received that comparative advantages of livestock products in India and China were not so obvious (Zhizhi Si and Suomiao Mu 2012; Jingrong Tan 2004), while comparative advantage of Brazil was quite stronger than China (Xuezhong Liu 2008). Thus, based on the analysis of the BRICS' livestock production status and aimed at the trade of livestock products, this paper tried to explore the comparative advantages in livestock products transaction, replenish the research content of livestock products in the BRICS, provides theoretical reference and stimulate healthy and rapid development of livestock trade between the BRICS.

21.2 Comparative Analysis of Livestock Production in the BRICS

The BRICS, locate in North America, Asia, Europe and Africa, are all main grain production countries. In recent years, with economic growth, improvement of people's living standard and expansion of international trade, Livestock husbandries in the BRICS also have developed greatly, with increasingly significant roles and extensive production scale, and the structures of livestock products also began to optimize. The livestock products mentioned in this paper include live animals and other edible inedible animal products provided by wild and feed animals, of which the specific scopes refer to the HS classification system.

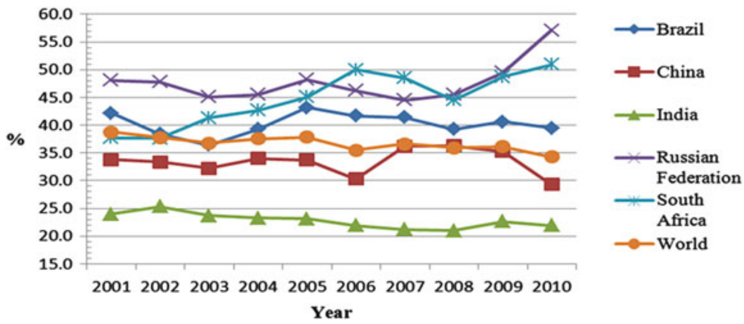

Fig. 21.1 The shares of livestock husbandry in agricultural output value, 2001–2010 (Data source: http://www.fao.org)

21.2.1 The Shares of Livestock Husbandry in Agricultural Output Value Differed from Each Other

In recent years, the shares of livestock husbandry in agricultural output value in the BRICS fluctuated constantly, with different performance in various countries. Specifically, the shares of animal husbandries in agricultural output value in Russia, Brazil and South Africa were high and presented a rising trend (see Fig. 21.1).

Russia' share of livestock husbandry in agricultural output value has always been high, remaining above 45 %; it went up significantly from 2007, and by the year 2010, it increased to 57.1 %. The share in South Africa has increased from 37.7 % in 2001 to 50.9 % in 2010, about a growth of 13 % in 10 years. Brazil went along with world's share of livestock husbandry in agricultural output value, which increased at first and then gradually went down. The share in China went up moderately except the decreases in 2006 and 2010, and has increased from 30.3 % in 2006 to 36.2 %, reaching the world's average level. In India it has been under the world's average level and presented a decreasing trend.

21.2.2 The Outputs of Livestock Products in the BRICS Grew with Years

Owing to urbanization and industrialization, people's food structures have been gradually changing. demands of meat, eggs, milk and other livestock Products were increasing. Coupled with the growing of the world's population and the melioration of planting technology, livestock husbandry in the BRICS have developed a lot, and the outputs of livestock products generally presented a rising trend. In 2011, the output of main livestock products in the BRICS was 383.149 million tons, about 112.074 million tons more than that in 2001, which was 270.075 million tons.

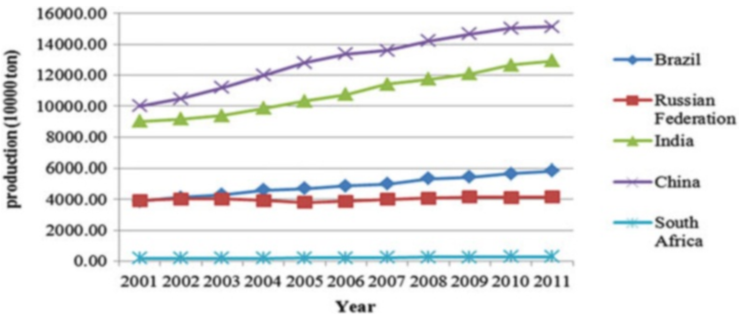

Fig. 21.2 The output of main livestock products in the BRICS, 2001–2010 (Data source: http://www.fao.org)

Among the BRICS, the largest growth appeared in China, which was about 51.29 million tons. The second was India, about 39.08 million tons, while South Africa was the last, only about 1.05 million tons growth (see Fig. 21.2).

21.2.3 *Obvious Changes in Livestock Products Structure*

Since 2001, the structures of livestock products have significantly changed, especially for meat products; the proportion of red meat fallen, poultry proportion went up. Dairy and eggs also altered. Among the BRICS, the change of meat structure in India was the most evident. Pork and beef proportions respectively decreased from 10.3 %, 49.7 % in 2001 to 5.3 %, 41.6 % in 2010, reducing by 5.1 %, 8.1 %. Correspondingly poultry proportion increased from 21.3 % in 2001 to 36 % in 2011, rising by 14.7 %. The next was Brazil; pork and beef proportions respectively decreased by 3 %, 4.9 %, and poultry proportion increased by 8.2 %. Meanwhile, poultry proportion in Russia rose by 19.2 % from 2001 to 2010. The same change happened in China, but not so significant as Brazil, India and Russia.

21.3 Analysis on Trade Differences of Livestock Products in the BRICS

Because of economy integration, trade liberalization, and improvement of traffic transport technology such as long distance cold-chain transportation and mass rapid transportation, livestock products trade in the BRICS also developed a lot and trade patterns consequently changed.

Chart 21.1 Trade volumes of livestock products in the BRICS, 2001–2010 (Unit: billion dollars)

	Brazil		China		Russian Federation		India		South Africa	
	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import
2001	30.01	3.21	26.52	27.51	2.30	22.81	3.81	2.04	2.46	1.72
2002	32.98	4.24	25.63	28.35	1.81	28.68	3.93	2.50	3.08	1.66
2003	43.32	2.60	26.99	33.15	2.01	29.67	4.36	2.67	3.33	2.53
2004	64.89	2.54	31.75	40.28	2.28	31.61	6.01	2.69	3.48	3.43
2005	84.69	3.17	35.77	42.13	2.88	42.01	8.95	2.98	3.02	4.43
2006	89.68	3.39	37.08	45.26	3.75	58.07	9.61	3.28	3.39	4.89
2007	119.82	4.07	30.12	64.41	4.26	68.70	11.95	3.91	4.31	6.10
2008	156.62	5.96	31.08	76.90	5.30	94.38	17.12	4.08	4.46	5.38
2009	126.10	6.15	27.72	65.58	4.06	82.48	14.40	3.60	4.70	4.69
2010	146.92	7.34	34.17	95.78	2.45	85.35	21.11	6.24	5.62	6.10
2011	166.21	11.44	41.86	133.48	2.93	93.20	31.30	7.11	6.50	8.30
2012	167.24	11.99	–	–	6.56	117.97	35.95	5.83	6.48	9.31

Data source: http://comtrade.un.org

21.3.1 Trade Volume of Livestock Products in the BRICS Kept on Growing Rapidly, Trade Balance Changed Obviously

From the year 2001, trade volume of livestock products in the BRICS kept on growing. In 2001, trade volume of livestock products in the BRICS was $12.239 billion, while in 2010 the number was $50.233 billion, 3.1 times more than in 2001. The growth of trade volume in China and Brazil were strong, respectively increased by $12.131 billion, $14.443 billion from 2001 to 2011, and reached $17.534 billion, $17.765 billion in 2011. Considering the average growth rate from 2001 to 2011, India ranked first, got 18.7 %; Brazil ranked second, reached 16.5 %. China ranked last (see Chart 21.1).

The chart above showed that the changes of trade balances differ from each other in the BRICS. In 2001, Russia's trade deficit of livestock products was $2.051 billion, while Brazil's trade surplus of livestock products was $2.68 billion. In 2006, Russia's trade deficit extended to $5.432 billion, and Brazil's trade surplus rose to $8.629 billion; India's trade surplus also presented a rising trend during the same period. In 2011, the trade surpluses of Brazil and India continued to expand, while the trade deficits of Russia and China became intensified, which respectively reached $9.027 billion and $9.162 billion in 2011. From 2001 to 2011, the trade balances of livestock products in the BRICS assumed significant polarization. Brazil and India have maintained growing trade surpluses, While the trade deficits of livestock products in Russia and China have been much more obvious, Only South Africa managed to keep a slight balance.

21.3.2 The Trade Comparative Advantages of Livestock Products Were Apparently Different and Largely Complementary in the BRICS

Comparative advantages are the important trade foundation between two sides, particularly in the livestock products field. Locating in different areas, The BRICS have various climatic conditions, different human resources, and diverse cultural inheritances, resulted in different comparative advantages and comparative advantages of livestock products.

21.3.2.1 Analysis on Revealed Comparative Advantages (RCA)

Revealed comparative advantage (RCA) index was put forward by American economist Balassa in 1965, and then widely used. RCA index adopted historical data to measure the ratio between the export share of certain goods in a country and in the whole world. In country i, the RCA index of product k could be calculated by the formula below.

$$\mathrm{RCA}_{ij}^{x} = \frac{X_{iw}^{k}/X_{iw}^{t}}{X_{ww}^{k}/X_{ww}^{t}}$$

$X_{\mathrm{iw}}^{\mathrm{k}}$ means export volume of product k in country i; $X_{\mathrm{iw}}^{\mathrm{t}}$ stands for the total export volume in country i; $X_{\mathrm{ww}}^{\mathrm{k}}$ and $X_{\mathrm{ww}}^{\mathrm{t}}$ severally shows the export volume of product k and total products in the world. Generally speaking, if $\mathrm{RCA} > 2.5$, product k in country i has very strong comparative advantage; if $1.25 \le \mathrm{RCA} \le 2.5$, the comparative advantage of product k is relatively strong; if $0.8 \le \mathrm{RCA} \le 1.25$, it means moderate comparative advantage; If $\mathrm{RCA} < 0.8$, the comparative advantage is weak (Balassa 1965).

Chart 21.2 below showed that in the BRICS, Brazil's livestock products had the strongest comparative advantage. China's livestock products ranked second, and among the six kinds of livestock products, the RCA indexes of three kinds were all above 1 in 2001, 2006 and 2011. India and South Africa respectively had two products, one product that maintained strong or moderate comparative advantages. Comparative advantage of Russia was weak, whose RCA indexes were all below 1, yet the highest index is 0.6. This was closely relate to cold climate, less developed agriculture, dependence on food imports, and relatively less livestock exports in Russia.

Considering different countries and varieties, Brazil had comparative advantages on HS02 (Meat and edible meat offal), HS05 (Products of other animal origin), HS15 (15Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes), and HS16 (Fish and crustaceans, molluscs and other aquatic invertebrates). The RCA indexes of HS02 and HS05

Chart 21.2 Revealed comparative advantages of livestock products in the BRICS

	Brazil			Russian Federation			India			China			South Africa		
HS code	2001	2006	2011	2001	2006	2011	2001	2006	2011	2001	2006	2011	2001	2006	2011
HS 01 Live animal	0.06	0.52	1.12	0.02	0.01	0.01	0.04	0.07	0.03	0.87	0.28	0.17	0.31	0.19	0.20
HS 02 Meat and edible meat offal	6.34	9.15	5.44	0.01	0.00	0.00	0.91	0.98	0.90	0.46	0.13	0.06	0.36	0.20	0.07
HS 04 Dairy produce; birds' eggs; natural honey; other edible products of animal origin	0.15	0.34	0.16	0.16	0.15	0.03	0.33	0.39	0.10	0.14	0.08	0.04	0.24	0.15	0.14
HS 05 Products of other animal origin	2.63	3.10	2.76	0.24	0.16	0.09	1.72	0.77	0.88	4.53	2.34	1.32	0.62	0.75	0.27
HS 16 Fish and crustaceans, molluscs and other aquatic invertebrates	2.28	3.60	1.79	0.28	0.15	0.04	0.04	0.71	0.15	2.94	2.33	1.12	0.24	0.26	0.21
HS 51 Wool and other animal wool	0.22	0.16	0.12	0.10	0.06	0.02	0.56	0.62	0.53	2.11	1.79	1.15	2.90	3.52	3.18

Data source: http://comtrade.un.org

were above 2.5 during the observation period, and particularly the former reached 9.15, which showed strong comparative advantages. HS15 and HS16 implied relatively strong comparative advantages in 2001 but fell down in 2011 with the RCA indexes decreased to 1.11 and 1.79 severally; For China, HS05, HS16 and HS51 had comparative advantages. In 2001 and 2006, the competitive advantage of HS05 and HS16 remained strong, then dropped in 2011 with the RCA indexes fell to 1.32 and 1.12. India had a slight comparative advantage on HS02. HS51 in South Africa showed extremely strong comparative advantage during the observation period, the RCA indexes were 2.90, 3.52 and 3.18 respectively.

To conclude, HS02, HS05, HS16 and HS51 in the BRICS demonstrated strong comparative advantages, while HS01 and HS04 not.

21.3.2.2 Analysis on Trade Competitive Index

The RCA index could demonstrate comparative advantages. However, it was hard to show the whole trade competitive advantage of livestock products. This paper adopted TC index to analysis trade competitive advantages. Trade Competitive index (TC index) is an efficient tool to measure international competitiveness of certain industry, and it represents the ratio of the net balance to the total volume of trade. The TC index could be calculated by the formula below.

$$\mathrm{TC}_i = \frac{X_{it} - M_{it}}{X_{it} + M_{it}}$$

In the formula, X_{it} and M_{it} severally represents the import and export of country i or industry i during period t. TC index synthetically considers the import and export factors, reflects whether a country or a product has competitive advantages in the international market compared with other countries or other similar products. Generally known, if $\mathrm{TC} > 0$, the productivity of the products in the country is above the internationally level, and the bigger the TC index is, the more advantages the country has, and vice versa. From Chart 21.3 below, it implied that competitiveness of Brazil' livestock products was the first, China ranked second, and then South Africa, while Russia' livestock products showed distinct competitive disadvantages.

Considering different countries and varieties, it was easy to identify that Brazil had competitive advantages on HS02, HS16 and HS51. During the observation period, the TC indexes of HS02 and HS16 were both above 0.9, which indicated strong competitive advantages. TC indexes of HS02 in India during the observation period were all almost 1.0, which indicated a big export share and strong competitive advantages, Competitive advantages of HS01, HS05 and HS04 were distinct before 2006 but continued to weaken in the past few years, in 2011 the TC indexes of HS01 and HS04 were 0.17 and 0.10 severally, in addition, HS51 also had obvious competitive disadvantage. China had evident advantages on HS01, HS05 and HS16. The TC indexes of HS16 during the observation period were respectively

Chart 21.3 Trade competitive indexes of livestock products in the BRICS

	Brazil			Russian Federation			India			China			South Africa		
HS 编码	2001	2006	2011	2001	2006	2011	2001	2006	2011	2001	2006	2011	2001	2006	2011
HS 01 Live animal	−0.61	0.92	0.94	−0.71	−0.97	−0.98	0.75	0.51	0.17	0.82	0.68	0.2	0.29	−0.39	−0.04
HS 02 Meat and edible meat offal	0.95	0.98	0.96	−1	−1	−0.99	1	1	1	0.17	0.04	−0.52	−0.07	−0.67	−0.79
HS 04 Dairy produce; birds' eggs; natural honey; other edible products of animal origin	−0.62	0.06	−0.38	−0.67	−0.68	−0.9	0.83	0.78	0.1	−0.07	−0.3	−0.68	0.03	−0.36	−0.17
HS 05 Products of other animal origin	0.25	0.43	0.45	0	0.05	−0.66	0.6	0.49	0.67	0.62	0.7	0.65	−0.47	−0.56	−0.7
HS 16 Fish and crustaceans, molluscs and other aquatic invertebrates	0.99	1	1	−0.54	−0.25	−0.8	0.06	0.45	−0.24	0.98	0.99	0.99	0.63	0.27	0.58
HS 51 Wool and other animal wool	0.72	0.65	0.83	−0.74	0.11	0.28	−0.99	−0.99	−0.95	−0.96	−0.9	−0.92	0.75	0.8	0.93

Data source: http://comtrade.un.org

0.98, 0.99 and 0.99, showing extremely strong competitive advantages, and so did HS05, while the competitiveness of HS01 continued to decline year by year and only 0.20 in 2011. Generally said, competitive advantages of China's livestock products presented a weakening trend. HS16 and HS51 in South Africa showed relatively strong competitive advantages, and appeared a strengthening trend. Russia's livestock products had apparent competitive disadvantages during the observation period, especially for the HS01 and HS02.

In closing, HS02 and HS16 in the BRICS showed extremely strong competitive advantages; HS01 and HS05 had relatively strong competitive advantages; and for HS04 the BRICS also maintained some advantages.

21.4 Conclusions

With the development of economy and the adjustment of agricultural structure, livestock production and trade volumes in BRICS have risen sharply, while polarization have come along at the same time. Brazil and India have always been main exporters with rapid increasing trade surpluses; while the deficits of China and Russia were much more obvious, and South Africa managed to keep the slight balance. Based on the results of Revealed Comparative Advantage index and Trade Competitive index analysis, HS02 and HS16 in the BRICS possessed relatively strong comparative advantages and competitiveness and had a great export volume, while HS05 and HS51 possessed comparative advantages and relatively weak competitiveness.

Compared with the other four BRICS countries, China had plenty of advantages in production and trade of livestock products, but presented a distinct weakening trend. In recent years, outputs and trade volumes of China' livestock products kept increasing, even faced with the global financial crisis, the trade volume and growth rate stood the first among the BRICS. However, there were still some shortcomings. Firstly, the optimization speed of livestock husbandry was slow. From 2001 to 2011, the ratios of livestock husbandry output value to total agricultural output value were under the world's average level, and the gap with the other BRICS countries increased year by year. Secondly, development of livestock products trade structure was not stable, the export proportion of hi-tech and high value-added livestock products was declined. According to the RCA (revealed comparative advantages) indexes of China' livestock products in 2001, 2006 and 2011, export proportions of high value-added products (HS05 and HS16) presented a descending trend. Thus, the government should carry on implementing the "applying high technology to promote animal husbandry" strategy (Hongbin Guo 2008), optimizing the industry structure, combining the brand advantages of livestock products with technology integration (Shuangying Jia 2010), absorbing advanced experience of developed countries, and seeking new growth pole of foreign trade.

Generally, livestock husbandry in the BRICS had made modest progresses in recent years, but compared with western developed countries there was still a considerable distance. The existing pattern of livestock products trade was quite dependent on the developed countries like Europe and American. The BRICS need to keep a close eye on the developments of international economics, absorb the experience of developed countries, strive to occupy a seat in the international economy, give respective potentials to full play, and promote the mutual development of foreign transactions.

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Chapter 22
Study on the Evaluation Indexes for Asparagus Industrial Global Competitiveness

Hou Yuan-yuan and Liu Hai-qing

Abstract On the basis of the previous studies on international competitiveness conducted by the International Institute For Management Development & International Competitiveness Research Group of Renmin University of China, the present study proposed a system of evaluation indexes for international competitiveness of asparagus industry. International competitiveness was evaluated from two aspects of competitiveness assets and process in asparagus industry. It was classified into eight levels for competitiveness involving in environment, factors, industry scale, industry structure, enterprises, products, exports and power of science and technology. Using analytic hierarchy process to reflect a weight of relative importance ranking among elements in each level. The study would promote the development of asparagus industry towards healthy and rapid direction, and also may provide the basis of decision making for the local administration of asparagus cultivation.

Keywords Asparagus industry • International competitiveness • Index system • AHP

Asparagus, an important economical crop with its rich vitamins, trace elements and antioxidants, has been considered as ‘king of vegetables’. Asparagus production in China originated at the end of the Qing Dynasty and comprehensively cultivated since 1970s. The main growing areas are distributed in some provinces including

Fund Project:1. Public service sectors (agriculture) special research “The research about asparagus industry technology and pilot demonstration”(201003074-11-4).2. Central nonprofit research institutes Fundamental Research Funds (Tropical Crops Germplasm Resources Institute, Chinese Academy of Tropical Agricultural Sciences) Research about supply mechanisms of winter vegetables based on Supply Chain in Hainan Province”(1630032013023).

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_22,

Shandong, Fujian, Guangdong, Guangxi, Yunnan, Shanxi, and Hebei etc. According to statistics data from the Food and Agriculture Organization of the United Nations (FAO) in 2010, Asparagus production areas in China has been expanded to 1.152 million hectares, and the output reached to 6.969 million tons. China has become the world's biggest asparagus producing country. At the same time, however, the asparagus yield level was only 6.0468 t/ha based on data from Food and Agriculture Organization of the United Nations (FAO) in 2010, which was far below the 20.7895 t/ha yield of Iran ranking first in the world.

Asparagus has become China's largest single processing varieties of vegetable trade; the volume of trade was accounted for 50 % of the total asparagus trade in the world. Asparagus products on the international market mainly included fresh-preserved, cold-stored, canned and other non-frozen asparagus.

According to the statistics of China Customs Information, the total export volume of China's asparagus products was 62.271 thousand tons in 2011 and exports values reached to $ 137 million, in which the amounts and values of canned asparagus exports accounted for 99.87 and 99.86 % of total asparagus products amounts and values, respectively. The export price of canned asparagus price was $ 2.7/kg in 2007 but decreased to $ 2.19/kg in 2011, indicating that the asparagus market potential would be huge in China. However, because of the international financial crisis and the impact of RMB appreciation, asparagus industry in China has encountered a greater impact involving in increase of production costs and continuous decrease of export products price, resulting in a weakened competitiveness in the international market of asparagus in China.

Although asparagus industry has achieved great progress in China, but there still are many problems. To enhance the international competitiveness of China's asparagus industry, it is required to figure out the advantages and disadvantages of the asparagus industry in China, which was the purpose of this study to establish the comprehensive evaluation index system of asparagus industry competitive.

22.1 The Principle of the Evaluation Index System

Each particular industry has specific industry characteristics and market characteristics, evaluation of specific industrial competitiveness must have a specific evaluation index system (Chen Shaoke and Lu Yuexiang 2012). In the process of the selection for indicators, in order to make the selected indicators are scientific, authentic and typical, it should follow certain selection principles.

Firstly, building the evaluation index system must follow scientific principles, to ensure scientific properties of the indicators selection, evaluation method and results. Secondly, the accessibility of data should be taken into account. If the majority of indexes are not available, this evaluation system would be no sense. Thirdly, when establishing evaluation system of industrial competitiveness, it is necessary to give full consideration for the dynamic development of the industry, as well as evaluation index made should reflect the characteristics of dynamic changes in the industry and development trend of competitiveness in the future. Fourthly, a qualitative indicator is also essential in the evaluation index system except for quantitative index. Lack of qualitative indicators may make the evaluation index system losing its integrity, and thus affect the effectiveness and credibility of the evaluation.

22.2 Construction of the Evaluation Index System About Asparagus Industry Competitiveness in China

From the point of view of competitiveness research, the industry may be referred to the collection of enterprises which directly produce competitive commodities or service (Jin Bei 1997). Porter's competitiveness theory has suggested that industrial competitiveness is the product of the industrial competitiveness assets and industrial competitiveness process (Porter 2002). According to the purposes and principles of the asparagus competitiveness evaluation index in combination with the IMD index system in the development report of China's international competitiveness (internationally competitive research team, Renmin University of China) (Research Center about Competitiveness and evaluation of Renmin University of China 2001) and the research report about the international competitiveness made by International Institute for Management Development, Lausanne (Swiss International Institute for Management Development (IMD) 2002), to construct the asparagus industry competitiveness index system. Using analytic hierarchy process (AHP), quantitatively describe the importance of comparison between each level elements. Moreover, using mathematical methods reflect the weight of the relative importance in each level element.

Firstly, establishing judgment matrix: $A = (a_{ij})_{n \times m}$

Afterwards, establishing $c_{ij} = \frac{1}{n}\sum_{n}^{k=1} \lg\left(\frac{a_{ik}}{a_{jk}}\right)(i, j = 1, 2, \cdots, n)$

And then establishing $A^* : a_{ij}^* = 10^{c_{ij}}(i, j = 1, 2, \cdots, n)$

Get the weight of the formula $W_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}^*}(i, j = 1, 2, \cdots, n)$

$$w_i = \frac{W_i}{\sum_{i=1}^{n} W_i}$$

The following table is the asparagus industry competitiveness evaluation index system and its weight coefficient: (Table 22.1).

Evaluation index system for asparagus industry competitiveness can be classified into four different levels; there are two indicators in the first level, eight indicators in the secondary level, 22 indicators in the third levels, and a total of 86 specific indicators.

The first group of indicators was the environmental indicators in asparagus industry, reflecting that the economy, politics, finance, support of the industrial environment for the asparagus industry in every asparagus producing country. In domestic economic environmental indicators, the gross domestic product (GDP),

Table 22.1 Evaluation indexes and weight coefficient for asparagus industrial competitiveness

First class indexes	Second class indexes	Third class indexes	Forth class indexes
1. Industrial competitiveness assets 0.2501	1.1 Environmental competitiveness 0.0833	1.1.1 Domestic economic environment 0.03902	1.1.1.1 GDP 0.01424
			1.1.1.2 The per capita GDP 0.00633
			1.1.1.3 The actual total retail sales of consumer goods 0.00223
			1.1.1.4 Real GDP growth 0.01051
			1.1.1.5 The rate of inflation 0.00369
			1.1.1.6 individual final consumption expenditure 0.00089
			1.1.1.7 Government final consumption expenditure 0.00113
		1.1.2 Domestic political environment 0.01203	1.1.2.1 Government debt percentage of GDP 0.00051
			1.1.2.2 Government expenditure to GDP 0.00036
			1.1.2.3 Legal system 0.00329
			1.1.2.4 Transparency of government work 0.00192
			1.1.2.5 Government decision-making 0.00595
		1.1.3 Domestic financial environment 0.02191	1.1.3.1 Rate of the actual saving growth 0.01753
			1.1.3.2 Short-term real interest rates 0.00438
		1.1.4 Industry environment 0.00660	1.1.4.1 Total industrial output value 0.00173
			1.1.4.2 The average size of industrial enterprises 0.00042
			1.1.4.3 Per capita profits of industrial enterprises 0.00024
			1.1.4.4 Agricultural product processing industry 0.00331
			1.1.4.5 Social services 0.00090
		1.1.5 Government support 0.00370	1.1.5.1 Government policies 0.00189
			1.1.5.2 Information technology service platform 0.00017
			1.1.5.3 Venture capital 0.00037
			1.1.5.4 Government subsidies 0.00127

	1.2 Elements of competitiveness 0.1667	1.2.1 Natural resources 0.06826	1.2.1.1 Land area 0.00798
			1.2.1.2 Crop acreage 0.01364
			1.2.1.3 Asparagus acreage 0.04664
		1.2.2 Capital supply 0.01388	1.2.2.1 Year-end balance of loans from financial institutions 0.00925
			1.2.2.2 Actual foreign direct investment 0.00463
		1.2.3 Infrastructure 0.01109	1.2.3.1 Railway mileage per square kilometer 0.00608
			1.2.3.2 Highway mileage per square kilometer 0.00348
			1.2.3.3 Cargo per capita 0.00133
		1.2.4 Human resources 0.02415	1.2.4.1 Population 0.00615
			1.2.4.2 The number of employees at the end of the year 0.01020
			1.2.4.3 Personnel Policy 0.00220
			1.2.4.4 Personnel Skill 0.00362
			1.2.4.5 Flow of talent 0.00130
			1.2.4.6 Talent attractiveness 0.00068
		1.2.5 Scientific and technological 0.04948	1.2.5.1 R & D share GDP 0.01789
			1.2.5.2 Per capita research and development expenditure 0.00820
			1.2.5.3 Growth rate of R & D spending 0.01420
			1.2.5.4 Technology development and application 0.00167
			1.2.5.5 Corporate investment in technology 0.00475
			1.2.5.6 Researchers engaged in research and development 0.00277
2. Industrial competitiveness process 0.7499	2.1 The scale of the industry competitiveness0.0256	2.1.1 Economic benefits 0.01707	2.1.1.1 The Proportion of asparagus sales on local GDP 0.00921
			2.1.1.2 Asparagus sales revenue 0.00279
			2.1.1.3 Per capita local asparagus industry sales revenue 0.00507
		2.1.2 Social benefits 0.00853	2.1.2.1 Number of employees 0.00569
			2.1.2.2 Contributed Tax of per capita 0.00284

(continued)

Table 22.1 (continued)

First class indexes	Second class indexes	Third class indexes	Forth class indexes
	2.2 Competitiveness of the industrial structure 0.0716	2.2.1 The growth rate of industry 0.04773	2.2.1.1 The actual growth of agriculture 0.01325
			2.2.1.2 The actual growth of industry 0.00765
			2.2.1.3 The actual growth of the service sector 0.00455
			2.2.1.4 Agricultural productivity 0.02228
		2.2.2 Industrial structure 0.02386	2.2.2.1 Primary, secondary and tertiary industrial structure of the export 0.01591
			2.2.2.2 Primary, secondary and tertiary industrial structure of the import 0.00795
	2.3 The competitiveness of enterprises 0.1249	2.3.1 Production capacity competitiveness 0.08326	2.3.1.1 Yield of asparagus 0.05551
			2.3.1.2 Agricultural labor productivity 0.02775
		2.3.2 Business operating costs and profit margins 0.04164	2.3.2.1 Labor costs 0.00649
			2.3.2.2 Infrastructure costs 0.00287
			2.3.2.3 Tax costs 0.00196
			2.3.2.4 The asparagus enterprise productivity 0.01619
			2.3.2.5 The asparagus industry average profit margin 0.00983
			2.3.2.6 Asparagus industry advertising spending 0.00430
	2.4 Product competitiveness 0.1651	2.4.1 Price competitiveness 0.04126	2.4.1.1 Asparagus production costs 0.01031
			2.4.1.2 Asparagus Price 0.03095
		2.4.2 Quality competitiveness 0.12381	2.4.2.1 Asparagus quality 0.03095
			2.4.2.2 Food security 0.09286
	2.5 Outbound competitiveness 0.321	2.5.1 Industry absorptive capacity 0.107	2.5.1.1 Foreign direct investment 0.01753
			2.5.1.2 Asparagus industry imports 0.00684
			2.5.1.3 Asparagus industry's dependence on foreign trade 0.02655
			2.5.1.4 Domestic market share 0.03894
			2.5.1.5 Difficulty of foreign technology 0.00475
			2.5.1.6 The average annual growth rate about the value of imports of asparagus 0.01239

		2.5.2 Industrial output capacity 0.21395	2.5.2.1 Asparagus exports 0.00790
			2.5.2.2 The Proportion of asparagus export on sales revenue 0.00578
			2.5.2.3 The asparagus enterprises output investment 0.00417
			2.5.2. Asparagus industry international market share 0.01608
			2.5.2.5 Asparagus relative export advantage index 0.05300
			2.5.2.6 Asparagus export concentration 0.02915
			2.5.2.7 The asparagus trade balance percentage of GDP 0.01335
			2.5.2.8 Revealed comparative advantage 0.05065
			2.5.2.9 Trade competitiveness index 0.03387
	2.6 Scientific and technological competitiveness 0.0417	2.6.1 Innovation capability of enterprises 0.03128	2.6.1.1 The asparagus business R & D Input and Output Efficiency 0.02346
			2.6.1.2 Asparagus research and development capabilities 0.00782
		2.6.2 Technological innovations 0.01043	2.6.2.1 Software works 0.00309
			2.6.2.2 Intellectual property rights 0.00171
			2.6.2.3 Talent innovation ability 0.00563

GDP per capita and real GDP growth reflect an aggregative indicator of a country's economic development, and inflation rate reflects the macro-economic operation status; final individual consumption expenditure, government consumption expenditure and actual total retail sales of consumption goods constitute the total domestic consumption demands. The five indicators in domestic political environment may evaluate government behavior impacting how much extent for industry. In indicators of the domestic financial environment, the growth rate of actual savings may reflect the growth of the reproduction funding sources; short-term real interest rate is directly related to economic development. In indicators of the related industries environment, the industrial output value, the average size of industrial enterprises, and per capita profits of industrial enterprises reflect the industrialization level of a country. In indicators of the government support, the four indicators reflect the extent of government involvement in the economy (Industrial development research group of the Institute of Macroeconomic Research Institute of the State Planning Commission 2001).

The second group of indicators was the advantage of asparagus industry factor. The indicators were set on basis of five aspects including natural resources, the capital supply, infrastructure, human resources and industrial technology strength, which reflects a country's land cultivation, capital supply, transport capacity, support of human to the industry, the national attitude towards talent, industry investment in science and technology funds, the technical cooperation between enterprises in the industry, and the capacity of transforming technological achievements into the ability of the scientific and technological strength.

The third group of indicators was the measurements of the asparagus industry competitiveness, in which the economic benefits of the asparagus industry can be reflected from the sales revenue, the sales revenue accounted for the proportion of local GDP, and per capita sales revenue. On the other hand, the social benefits can be reflected by the numbers of employees and their tax amounts per capita.

The fourth group of indicators was the measurements for competitiveness of the industrial structure. The growth rate of primary, secondary and tertiary industries independently reflects the development of the industry, agricultural productivity reflects the efficiency of agricultural production and exports and imports in the primary, secondary and tertiary industrial structure reflects an optimization of industrial structure.

The fifth group of indicators was the competitiveness of enterprises, which was reflected from two aspects involving in productive capacity of enterprises and operating costs.

The sixth group of indicators reflected the competitive capacity of between enterprises products, which was divided into two aspects of price and quality. Among them, asparagus production cost and the sale price can reflect product prices and profit margins and asparagus quality and food safety can reflect the quality of the products.

The seventh group of indicators was the outgoing competitiveness index which can reflect a direct competition in asparagus international market. It is divided into the industry absorption ability and industrial output ability. In absorption ability, a direct foreign investment performs the capability of a country's capital input; the asparagus industry's imports value can be able to demonstrate the growth of the asparagus industry resources; the domestic market share reflects the competitiveness of asparagus industry in the domestic market as compared to imported products; dependence of foreign trade indicates that the degree of association with abroad in the asparagus industry; the difficulty in introduction of technology from abroad reflects the barriers for foreign technology coming into the domestic market. In the ability of industrial output, exports value and international market share reflected the asparagus industry's export ability; exports value that accounted for the proportion of sales revenue reflected a status of asparagus export in the industry; the indices of relative export advantage and degree of export concentration were the aggregative indicators, reflecting the industry's export competitiveness capacity; the trade surplus can bring an increase in foreign exchange reserves, thereby enhancing the external debt payment and import capacities; the concentration degree of asparagus export, revealed comparative advantage can measure industrial competitiveness of a country in the international market.

The eighth group of indicators mainly reflected a contribution of science and technology in the competitiveness. It was divided into the two aspects including enterprise innovation ability and technical innovations. Industrial technology development capabilities can be transformed directly into production capacity so as to improve the competitiveness of products, and technological innovations can reflect the ability about transformation of scientific achievements to productive forces.

22.3 Summary

The indicators system in this study includes the status, development and evaluation indicators. Evaluation of asparagus industry international competitiveness was performed according to the competitive environment of the industry, competitive factors, industrial scale, industrial structure, enterprise, the products, contribution of science and technology and the outgoing competitiveness. These indicators were not only the basis of the evaluation for the status of the international competitiveness of asparagus industry, but also the focal point for enhancing the international competitiveness of asparagus industry. The asparagus industry in China should be rationally distributed depending on competitiveness evaluation index system, and should also make the key points stand out and exploit the superiority into full play, so as to effectively improve the international competitiveness of China's asparagus industry.

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Chapter 23
Industrial Agglomeration in China's Agricultural Product Processing Industry

Guixia Qian, Di Wu, Yonghong Hao, and Yuehong Pan

Abstract Industrial agglomeration is the inevitable outcome of the economic development process. The agricultural product processing industry is a basic industry of the national economy and an important pillar industry for safeguarding the people's livelihood. It mainly covers 12 sub-industries: food processing, food manufacturing, beverage manufacturing, tobacco industry, textiles, etc. in China. The primary objective of this paper is to ascertain the existence of industrial agglomeration in agricultural product processing industry of China, and to examine the extent to which these have contributed to productivity growth in China. We use the Ellison-Glaeser index (EG index) to analyze the concentration level of China's agricultural product processing industry in 2000–2009. The analysis is conducted from six regions and five sub-industries. Based on this, we then use GIS technology to analyze the spatial distribution characteristics and change. Finally, we interpret the agglomeration trend and the reasons of China's agricultural product processing. Results show that in five sub-industries of China's agricultural product processing industry, food, tobacco industry and wood, furniture industry had higher industrial agglomeration, the distribution of textiles, clothing and leather industry is relatively even, and paper-making, printing and rubber products processing industry had no industrial agglomeration. From 2007 to 2009, food, tobacco; textile, clothing, leather; wood, furniture; paper, printing; and rubber products processing industry tended to be lower industrial agglomeration and even no industrial agglomeration. Industrial agglomeration closely relates to the natural capacity and localization shows a growth trend. Based on these results, some policy recommendations are put

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_23,

forward. These findings may help for the development of the agricultural product processing industry in China and even other developing countries.

Keywords China • Industrial agglomeration • EG index • Agricultural product processing industry

23.1 Introduction

Agricultural products processing industry is an important industry concerning the people's livelihood, but also an important source of economic growth. In recent years, the agricultural product processing industry sustained rapid growth in China. There are 67,000 agricultural products processing enterprises, whose annual sales income is more than 5 million yuan. Their output value is 3.6 trillion yuan. In all industrial sections, the output value of agricultural product processing industry accounted for 25 % of the total output value of all industrial sections. Since 2006, the average annual growth rate of industrial output value of the agricultural products processing industry is 6 %. However, some problems still limits the further development of the agricultural products processing industry in China such as the small scale of processing enterprises, unreasonable distribution of enterprises, and geographically scattered industrial layout, which result in the cost increasing and resources wasting.

Since Marshall (1920), economists have recognized the propensity for industries to agglomerate across space. Spatial clustering results in increased returns and growth, as a consequence of localized economies of scale. Industrial agglomeration plays an important impact on the regional and industrial layout. The importance of agglomeration varies across industries, whence different industries have been found to exhibit surprisingly different levels of agglomeration (Ellison and Glaeser 1997). With the economic development, industrial agglomeration has appeared in the agricultural industry. The United States, Netherlands and other countries have good examples in the agricultural clusters. Therefore, the agricultural industry in the transition from traditional agriculture to modern agriculture in China is gathering more and more concern from scholars. Tan Mingjie and Li Binglong (2010) studied the agglomeration of livestock and poultry industry in China. Xingming Hu (2012) analyzed the agglomeration status of the sericulture industry in China at the provincial level by using the location quotient index and industrial agglomeration index. The existing research concentrate on the theory of cluster and empirical studies are limited, especially on China's agricultural product processing industry. Whether has the agro-processing industry in China industrial agglomeration? What is the status of the distribution of industrial agglomeration? Whether has the change occurred? How to strengthen the agglomeration of the agro-processing industry? In order to solve these problems, we use panel data at the provincial level to describe industrial agglomeration of agricultural products processing industry in China in this paper by using Ellison-Glaeser index. The data include the employment

12 sub-industries of the agricultural products processing industry in China at the provincial level from 2001 to 2010. The research results may provide the academic support in making some policies to accelerate the agglomeration of agricultural products processing industry in China.

23.2 Method and Data

23.2.1 Method: Ellison-Glaeser Index (EG Index)

Ellison and Glaeser (1997) treated agglomeration as the combined effect of natural advantage and industry spillovers. In this model, N firms sequentially choose amongst M locations. An individual firm must choose whether to follow the prior firm's decision or to choose a location randomly by throwing a dart at a map. From this model, Ellison and Glaeser (1997) derive the EG index. The EG index method to eliminate the market concentration degree in order to eliminate the difference of enterprises' scale of industrial agglomeration effect, thereby can more accurately measure the concentration degree of industry distribution. This study uses EG index to the analysis of Chinese agricultural product processing industry agglomeration level.

$$\gamma_\ell^{EG} = \frac{\sum_{i=1}^{M} (s_i - x_i)^2 - \left(1 - \sum_{i=1}^{M} x_i^2\right) \sum_{j=1}^{N} z_j^2}{\left(1 - \sum_{i=1}^{M} x_i^2\right)\left(1 - \sum_{j=1}^{N} z_i^2\right)}$$

Where S_i is the share of industry t's employment in area i, χ_i is the share of total employment in area i, and the $\{z_i\}$ are the sizes of the plants of j of industry t. Defining for an industry t the Gini index $G_t = \sum_{i=1}^{M} (s_i - \chi_i)^2$ and the Herfindahl (1959) index $H_t = \sum_{j=1}^{N} z_j^2$, we obtain the more commonly-used expression

$$\gamma_\ell^{EG} \frac{G_\ell - \left(1 - \sum_{i=1}^{M} x_i^2\right) H_\ell}{\left(1 - \sum_{i=1}^{M} x_i^2\right)(1 - H_\ell)} = \frac{G_\ell / \left(1 - \sum_{i=1}^{M} x_i^2\right) - H_\ell}{1 - H_\ell}$$

23.2.2 Data

The agricultural products processing industry includes 12 sub-industries. In this paper, we combined 12 sub-industries into 5 sub-industries: food, beverages, tobacco processing; textile, apparel and leather; timber and wood products (including furniture manufacturing); processing of paper and paper products, printing and publishing; and rubber products processing.

In this paper, we analyzed the agglomeration of seven regions in China: Northeast (Liaoning, Jilin, Heilongjiang), North China (Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia), East China (Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong), South China (Guangdong, Guangxi, Hainan), Central China (Henan, Hunan, Hubei), Southwest (Chongqing, Sichuan, Guizhou, Yunnan, Tibet) and Northwest (Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang).

The data come from the RESSET/DB database from 2000 to 2009. They are the employees of all listed companies of food and beverage; textile, clothing, fur; wood, furniture; paper making and printing; and rubber products processing industry.

23.3 The Present Situation of Agricultural Product Processing Industry

From the number of employees of the agricultural product processing industry, the food, and tobacco listed companies were distributed in seven regions of the Northeast, North China, East China, South China, Central China, Southwest and Northwest from 2000 to 2009. Listed companies in China's textile, clothing and leather industry were distributed in six regions of Northeast, North China, East China, South China, Central China and Northwest from, 2000–2005 and in 2009 and were distributed in seven regions of Northeast China, North China, East China, South China, Central China, Northwest and Southwest from 2006 to 2008. The listed companies of rubber products processing industry were distributed in four regions of Northeast, North China, East China and Southwest in 2000 and 2001 and distributed in five regions of Northeast, North China, East China, Central China and Southwest in 2002, 2003, 2005 and 2006. In 2004 they were distributed in Northeast, North China, East China, South China, Central China and Southwest and in 2007 were distributed in Northeast, East China, Central China, Southwest and Northwest. In 2008 and 2009 they were concentrated in the Northeast, East China, Central China and Southwest.

The food, tobacco industry is concentrated in the East China, North China and Southwest (Fig. 23.1). They are mainly distributed in Shandong, Anhui and Shanghai of East China, Beijing, Hebei and Inner Mongolia of North China, and Sichuan, Guizhou of Southwest.

The textile, clothing, leather industry is concentrated in the East China and North China (Fig. 23.2). They are mainly distributed in Zhejiang, Jiangsu, Shandong of East China and Inner Mongolia, Hebei of North China.

The wood, furniture industry is distributed in the Northeast and East China (Fig. 23.3). They are mainly distributed in Jilin of Northeast and Jiangsu of East China.

The paper-making, printing industry is distributed in the East China and Northeast (Fig. 23.4). They are concentrated in Shandong, Fujian, Zhejiang, Jiangsu of East China and are more evenly distributed in three provinces of Northeast.

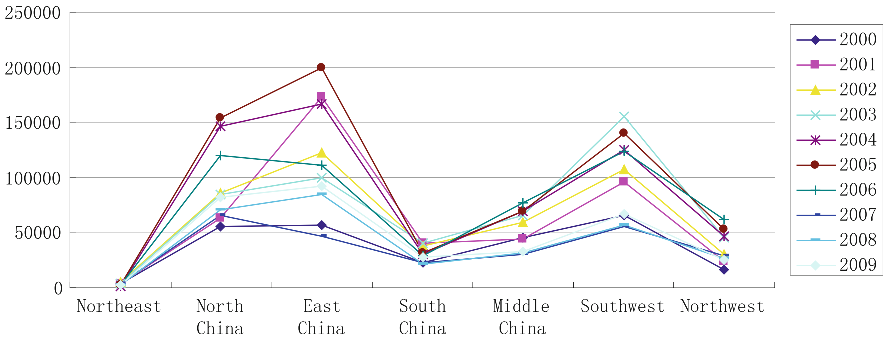

Fig. 23.1 The distribution of food, tobacco industry in 2000–2009 (Data source: RESSET/DB database)

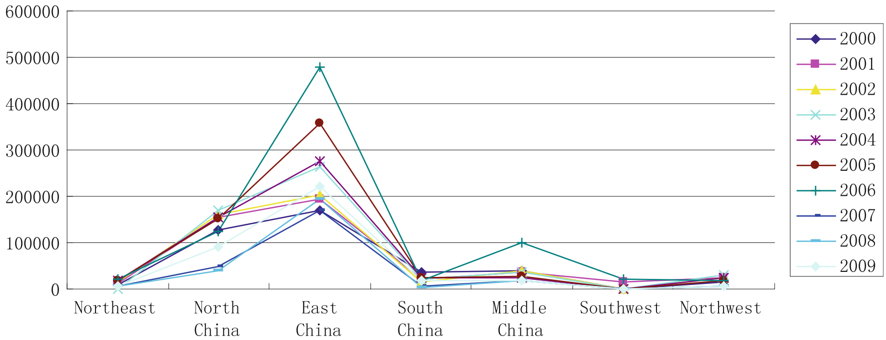

Fig. 23.2 The distribution of textile, clothing, leather industry in 2000–2009 (Data source: RESSET/DB database)

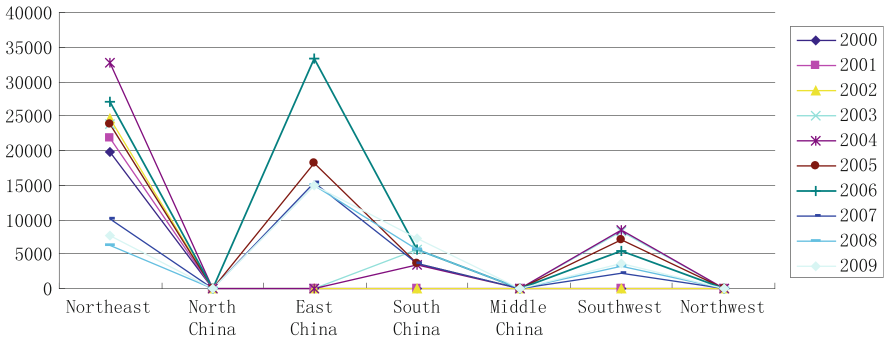

Fig. 23.3 The distribution of wood, furniture industry in 2000–2009 (Data source: RESSET/DB database)

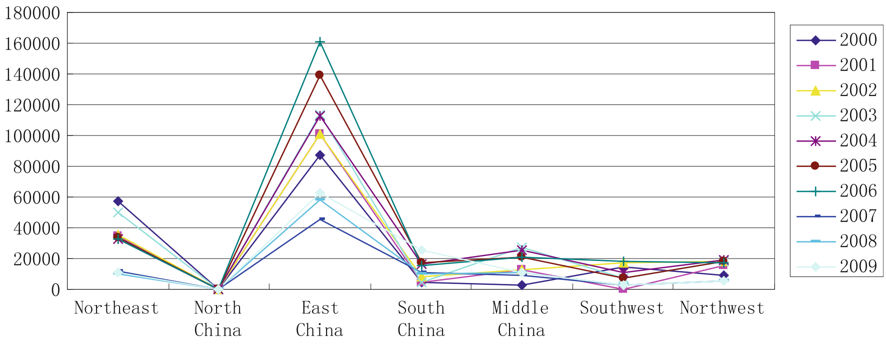

Fig 23.4 The distribution of paper-making, printing industry in 2000–2009 (Data source: RESSET/DB database)

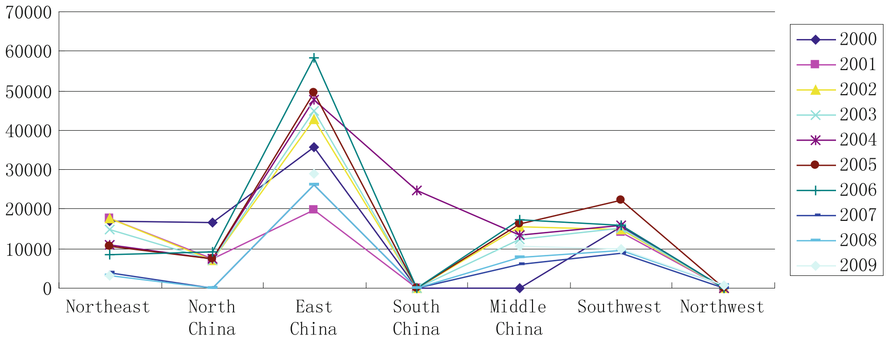

Fig 23.5 The distribution of rubber products processing industry in 2000–2009 (Data source: RESSET/DB database)

Rubber products processing industry in China is mainly distributed in the East China, Northeast and Southwest region (Fig. 23.5). They are concentrated in Shanghai, Shandong of East China, distributed in Heilongjiang in the northeast region, and Guizhou in the southwest region.

23.4 Results

23.4.1 HHI

From the HHI, the degree of concentration is higher for listed companies of the wood and furniture industry than that of the other sub-industries. This shows that industrial clustering for China's agricultural product processing industry is not high and there is no monopoly (Table 23.1).

Table 23.1 HHI of five sub-industries in China in 2000–2009

Year	Food, tobacco	Textile, clothing, and leather	Wood and furniture	Paper making and printing	Rubber products processing
2000	0.0118	0.0218	0.2211	0.0153	0.0639
2001	0.0139	0.0185	0.2282	0.0189	0.0630
2002	0.0080	0.0181	0.2126	0.0201	0.0389
2003	0.0090	0.0138	0.1232	0.0176	0.0424
2004	0.0116	0.0136	0.1497	0.0195	0.0289
2005	0.0115	0.0116	0.0702	0.0211	0.0510
2006	0.0107	0.0088	0.0638	0.0158	0.0395
2007	0.0309	0.0293	0.1880	0.0381	0.0565
2008	0.0419	0.0576	0.1540	0.0603	0.2142
2009	0.0365	0.0559	0.1355	0.0514	0.0939

Data source: Calculated according to the data from RESSET/DB database

Table 23.2 Gini coefficient of five sub-industries in China in 2000–2009

Year	Food, tobacco	Textile, clothing, and leather	Wood and furniture	Paper making and printing	Rubber products processing
2000	0.0898	0.0560	0.2687	0.0436	0.0374
2001	0.0216	0.0289	0.8506	0.0487	0.0792
2002	0.0354	0.0301	0.8455	0.0332	0.0355
2003	0.0705	0.0370	0.3211	0.0532	0.0305
2004	0.0329	0.0269	0.4524	0.0252	0.0431
2005	0.0429	0.0241	0.1718	0.0304	0.0320
2006	0.1042	0.0258	0.1091	0.0245	0.0098
2007	0.0976	0.0590	0.0765	0.0236	0.0287
2008	0.0700	0.0541	0.0467	0.0203	0.0192
2009	0.0530	0.0342	0.0559	0.0290	0.0292

Data source: Calculated according to the data from RESSET/DB database

23.4.2 Spatial Gini Coefficient

From the spatial Gini coefficient, industrial agglomeration for wood and furniture industry is relatively high from 2000 to 2004, but from 2005 the agglomeration level began declining Spatial Gini coefficient of the other four sub-industries over the years have maintained between 0 and 0.1, which shows the degree of industrial agglomeration of listed companies in China's agricultural product processing industry is not high (Table 23.2).

23.4.3 EG Index

Table 23.3 lists the EG index of each sub-industry of agricultural product processing industry in China from 2000 to 2009. The EG index of food, tobacco industry is 0.1045, 0.0151, 0.0381, 0.0820, 0.0320, 0.0485, 0.1366, 0.1049, 0.0621,

Table 23.3 EG index of five sub-industries in China in 2000–2009

Year	Food, tobacco	Textile, clothing, and leather	Wood and furniture	Paper making and printing	Rubber products processing
2000	0.1045	0.0511	–	0.0381	−0.0179
2001	0.0151	0.0203	–	0.0427	0.0434
2002	0.0381	0.0210	–	0.0210	0.0069
2003	0.0820	0.0326	0.2359	0.0486	−0.0039
2004	0.0320	0.0215	0.3670	0.0122	0.0283
2005	0.0485	0.0215	0.1653	0.0194	−0.0073
2006	0.1366	0.0275	0.0863	0.0178	−0.0269
2007	0.1049	0.0524	−0.1105	−0.0076	−0.0205
2008	0.0621	0.0220	−0.1058	−0.0339	−0.2385
2009	0.0387	−0.0088	−0.0721	−0.0137	−0.0614

Data source: Calculated according to the data from RESSET/DB database

and 0.0387 in 2000–2009, which shows that the food, the tobacco industry has no industrial agglomeration. In 2001, 2002, 2004, 2005 and 2009, the distribution is relatively even and in 2000, 2003, 2006, 2007 and 2008, its agglomeration is higher.

EG index of China's textile, clothing and leather industry is 0.0511, 0.0203, 0.0210, 0.0326, 0.0215, 0.0215, 0.0275, 0.0524, 0.0220 and −0.0088 in 2000–2009, which shows that the textile, clothing and leather industry has no industrial agglomeration in 2009. In 2001–2006 and 2008 the regional distribution is relatively uniform and its agglomeration is higher in 2000 and 2007.

EG index for China's timber and furniture industry 0.2359, 0.3670, 0.1653, 0.0863, −0.1105, −0.1058, −0.0721 in 2003–2009, which shows that it had no industrial agglomeration from 2007 to 2009. From 2003 to 2006, industrial agglomeration became higher.

EG index of China's paper-making, printing industry, 0.0381, 0.0427, 0.0210, 0.0486, 0.0122, 0.0194, 0.0178, −0.0076, −0.0339, −0.0137 in 2000–2009, which shows that China's paper-making, printing industry had no industrial agglomeration from 2004 to 2009. In 2000–2003, the distribution is relatively uniform.

EG index of rubber products processing industry in China is −0.0179, 0.0434, 0.0069, −0.0039, −0.0073, 0.0283, −0.0269, −0.0205, −0.2385 and −0.0614 from 2000 to 2009, respectively, which shows that rubber products processing industry in China had no industrial agglomeration in 2000, 2002, 2003, 2005 and 2009 and the distribution was more uniform in 2001 and 2004.

23.5 Conclusion and Policy Recommendations

In five sub-industries of China's agricultural product processing industry, food, tobacco industry and wood, furniture industry had higher industrial agglomeration, the distribution of textiles, clothing and leather industry is relatively even, and paper-making, printing and rubber products processing industry had no industrial agglomeration. From 2007 to 2009, food, tobacco; textile, clothing, leather; wood, furniture; paper, printing; and rubber products processing industry tended to be lower industrial agglomeration and even no industrial agglomeration. Although the situation of industrial agglomeration is still not optimistic, the effort in improving the healthy development is necessary. Based on the results, we put forward three suggestions:

23.5.1 Develop the Industrial Agglomeration Development Planning for the Industry with Lower Agglomeration

In the planning of the development of industrial clusters, it is necessary to consider the characteristics of resource endowments and industrial development prospects, but also to consider the region's ability to gather resources and potential for technological innovation, specialization and collaboration to enhance cluster enterprises, cultivating a sound industrial network system, establishing the effective information communication and coordination mechanism between enterprises.

23.5.2 Nurture Industrial Clusters to Promote Industrial Agglomeration

Based on the natural, geographical and resource advantages, the industrial base and support conditions, some regional industrial clusters in key areas should be quickly formed with high technology, the vitality of modern industrial organization and modern management level, and with strong market competitiveness, which can promote the rational development of industrial agglomeration and realize the returns to scale.

23.5.3 Government's Guidance and Coordination to Promote the Overall Progress of the Agricultural Products Processing Industry

The development of the agricultural products processing industry requires the coordination from raw material production to processing and marketing. Effective measures should be taken to break the boundaries of departments and regions and the coordination organization should be established to strengthen the leadership of the agro-processing technology innovation.

Acknowledgements We thank Prof. Yong Jiang for his valuable comments and suggestions. This research was supported by two grants from the National Natural Science Foundation of China (71163026, 70963007) and also supported by Program for Changjiang Scholars and Innovative Research Team in University (IRT1258).

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Chapter 24
Influence and Evaluation on Human Settlement Environment After Rural Homestead Consolidation in China: Evidence from the Typical Villages in Jiangsu Province

Xiaoyan Yi, Yinjun Chen, Linna Fang, and Shidong Liu

Abstract In China, rural "hollowing" has become increasingly evident. With increasing vs. decreasing land-use policy, local government promote rural land consolidation by merging villages and remediation hollow village, making the inaccessible and poor environment farmers improved. In this paper, authors analyzed 158 farmers satisfaction degree of human living environment to evaluate the influence of rural homestead consolidation through typical seven villages investigation in Jiangsu Province. The results show that the farmers of human living environment totally satisfactory accounted for 47 % of the general satisfaction accounted for 32, 21 % dissatisfied, overall satisfaction with a mean of 2.70, the satisfaction index was 58.86. At the same time, survey found that farmers housing quality, drainage and sewerage, their children to school, and the spirit of entertainment and are not satisfied, because this project belong to the government action, the lack of effective communication with farmers and participation rights. Finally, the authors propose to fully consider the needs and wishes of the farmers, giving farmers the right to participate, and supervise the quality of human settlement construction policy recommendations.

Keywords Human settlement environment • Rural homestead consolidation • Influence and evaluation • Farmers satisfaction degree • Jiangsu Province in China

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*, DOI 10.1007/978-3-642-54389-0_24,

24.1 Introduction

There are about more than 657 million farmers live dispersed on 164,000 km^2 of rural residential land and 214 m^2 per capita in China (Chang et al. 2009). With the rapid development of industrialization and urbanization, the rural population continued to decline and resulted the phenomenon of ‘village hollowing’ and wasted land resources. Under the dual pressure to protect arable land, security and development, the government has adopted by increasing vs. decreasing land-use policy to guide farmers live together on the rural homestead consolidation.

The farmers live together is the inevitable trend of the socio-economic development is also an urgent requirement for intensive development in China rural. On the one hand, the population concentrated in some central villages and towns are able to use small amount of funds to renovate the rural infrastructure and public service facilities, to improve the living conditions and environment. On the other hand, it is possible to reduce the size of rural settlements area, conservation of land resources. Human settlement environment is the integrated of the physical and non-physical environment, including living conditions, infrastructure and public service facilities, but also soft environment, such as life comfort, convenient level of exchange of information, the level of economic development, and social services. With the in-depth development of the rural homestead consolidation, farmers from live dispersed transition to live together, farmers have not only limited to meet the basic needs for survival, quality of life for the pursuit of higher quality, hope of a city life. Rural living environment is an important symbol of the quality of farmers life, improve rural living environment quality can promote positive interaction between the rural living environment and society, economy, resources and environment.

Jiangsu Province is one of the economically developed eastern coastal provinces in China, people will be less rapid urbanization. Rural construction land accounts for more than half of the province’s total construction land, rural homestead exceeded a serious problem, generally extensive inefficient, tapping the potential of saving space. According to land use change survey in Jiangsu Province, there are 933,098.87 ha rural residential land, accounting for 9.07 % of the total land area, accounting for 50.95 % of the construction land by the end of 2005. At the same period, rural population are 5,063.25 million, per capita rural residential land 184.29 m^2, higher than 150 m^2 (the national standards) 34.29 m^2. In order to coordinate urban and rural development, the Department of Land and Resources implemented the projection of boundless expanse of fertile land in September 2008 (Pašakarnis and Maliene 2010). The initiative designed to implement the increasing vs. decreasing land-use policy as the carrier, through the relocation of villages and comprehensive achievement goals of agricultural land concentrated living gathering, intensive land use.

Ecological Environment Effects of Land Consolidation has attracted the attention of domestic and foreign scholars. Giedrius Paššakarnis et al. (2010) studied the situation of first agricultural land consolidation implementation in Lithuania’s, focused on how to expand the farm property and create convenient road network, emphasized the program of agricultural land consolidation to increase agricultural production and production conditions most likely to have a negative impact on the environment (Kuo-Liang Lin 2010). Kuo-Liang Lin (2010) pointed out that in Taiwan, there is no rational planning, large land readjustment harmful to the environment, especially in terms of the ecology, this case, the implementation of land readjustment is entirely for the benefit of mankind, with the passage of time, in order to more space for development, decades old trees were cut down, the other green space is occupied (Li et al. 2008). Zhao Hua (2003) studied the ecological and environmental effects from the ecological characteristics, function indicators and the social and political environment indicators (Miao et al. 2011). Xun Wen (2005) studied the environmental impact of land consolidation from two aspects of the natural environment and ecological economic environment (Wang Ya-wen et al. 2011). Zhang Zheng-feng et al. (2007) generalized impact factors the land consolidation ecological environment including the characteristics of the land consolidation project, the structure changes of land use types and the pattern changes in land landscape (Xun and Liu 2005). The influence and evaluation on rural human settlement environment after rural homestead consolidation has not been systematically studied. In this paper, authors will analyze the influence mechanism of rural living environment after rural land consolidation project, evaluate farmers satisfaction degree of living environment combing the typical village in Jiangsu Province.

24.2 China's Rural Homestead Consolidation

In China, the rural landscape has a new look after the reform and development and rural construction land was growing. However there are some new issues behind the rural living environment, such as confusion layout, rural roads row growth serpentine, new buildings lack of planning in the construction, resulting in a large number of idle abandoned homestead village, forming 'hollowed villages'. In addition, planning and regulatory work to keep the law covering the housing has failed to effectively curb.

Many local governments are actively carry out rural land consolidation replacement by increasing vs. decreasing land-use policy. Through the rural settlements consolidation, it can coordinate location within the various elements of the relationship with the external environment, rational allocate natural, economic and social resources, all-round improve in the rural residential environment, create a new agricultural settlements landscape, achieve the effect of 'clean and tidy village'. Implementation of the land consolidation replacement is a effective way to change the rural homestead scattered, small natural villages, new house village, and public facilities supporting. Though homestead consolidation replacement, merging villages, remediating hollow village, relocating the village of the mountains, it can the inaccessible, harsh environment farmers move into the concentrated, facilities, and the environmentally superior market town, the center of the village, effective reduce infrastructure costs and improve public facilities shared, so that more of the farmers enjoy the achievements of new rural construction.

24.3 Region and Data

Our research group investigated seven typical villages in Jiangsu Province in July 2012, there were ZhaoZhuang, LuoGang and Zu Yao villages in Sihong country, DingZhuang and TaiFeng villages in Gaoyou coutry, XiQuan and XiGang villages in Nanjing Jiangning County. Where in Zhao and Luo village are the Housing Pilot Village in Jiangsu Province, to live together the community some cottages and apartments built in accordance with the planning, hardware infrastructure and facilities is in progress, some roads have not hardened, brook drainage in progress, there is also the house quality and infrastructure problem. Zu Yao village is in accordance with unified planning, transformation in the original homestead on farmers to buy a new home with a certain difference, the more perfect the basic infrastructure and public services, clinics, schools, activities nearby, but there are still some of the public facilities quality and drainage pollution problem. Ding and Tai Village are the Housing Pilot Village in Jiangsu Province, farmers concentrated residential apartment, infrastructure and public services supporting the basic sound, but there is the problem of housing quality and inadequate drainage facilities. Xi Quan and Xi Gang are two better villages in living environment, community greening, health and so good, while still in their houses part of the vegetable farmers claimed and name tag, a public basketball field or elderly activity center.

The data of this study from the survey on farmers after lived together in new community. Seven villages farmers were visited and we get 158 valid questionnaires including living conditions, infrastructure and public services. The samples are not only wider but also have good representation, from regional distribution, conducted a survey of the southern, central and northern Jiangsu, from economic development level, the economic development of villages and under-developed villages carried out the survey, from the land consolidation process and human living environment, have completed earlier, the presence of facilities, there are ongoing to be perfected village. There are 43.7 % male, 44.9 % of 20–50 young farmers, 34.8 % of junior high school and higher education in samples. They can accurate understanding the meaning of the questions and answers.

24.4 Method and Evaluation

In order to facilitate the statistical analysis, the attitude measurement activities easy, clear and unambiguous satisfaction survey must be qualitative into quantitative evaluation. In this paper, the fuzzy comprehensive evaluation method will be adopted. The method is simple mathematical model, multi-factor, multi-level complex problems better judge, other branches of mathematics and models difficult to replace. Farmers 'satisfaction in the environment by a variety of factors, it can use this method to evaluate the farmers' satisfaction with the living environment, a comprehensive evaluation of the satisfaction of the new rural construction Human Settlement, so that the results of the evaluation more objective and scientific. The basic principle is divided into the following five steps:

(a) Establish Evaluation factors U and Level V; (b) Build evaluation matrix R; weight set A, (c) Set weights; (d) Fuzzy Comprehensive Evaluate $B = A * R$; (e) Process evaluation index.

Usually the maximum degree of its processing to get the final evaluation results. In order to make full use of the information brought by the B, the various levels of evaluation parameters and evaluation results B into account, makes the evaluation results more realistic.

Located with respect to the parameters specified in column vector of each grade:

$$c = (c_1, c_2 \ldots c_n)T$$

c_n is a number of the total number of T ratio.

Rural living environment satisfaction, the calculated mean $E = B * C$

$$\text{Overall Satisfaction Index CSI} = (E - \min E)/(\max E - \min E) \times 100$$

Firstly, established evaluation factors and level. According to the meaning of the rural living environment, rural living environment mainly related to the hardware environment such as the living conditions, infrastructure and public service facilities. We established human settlements environment satisfaction index system including the house size, house quality, road hardening, community green, community lighting, waste disposal, water supply and drinking, drainage and sewerage, community clinics, schools, community security, leisure and entertainment 20 indicators. In order to facilitate the farmers to answer each indicator is divided into five levels. 1 means 'very satisfied', 2 means 'satisfied',3 means 'general', 4 means 'unsatisfactory' and 5 means 'very dissatisfied'.

Secondly, set weights. In this paper, the importance of each factor on the basis of information and household interviews, experts on the evaluation index system to rate the importance of each factor, and ultimately determine the factors affecting farmers satisfaction weighting factor (Table 24.1). House quality, road hardening, waste disposal, water supply and drinking, community clinics, schools, nursery given weight coefficient of 0.06 in the first place, which reflects the rural areas go to school difficult, difficult medical, communication difficult, poor health, poor quality of house" and other issues; house size, community greening, community lighting, drainage and sewerage, entertainment plaza, community security given weight coefficient of 0.05; supermarket, county fair given weight coefficient of 0.04; activities room, noise pollution, air quality given weight of 0.03, ranks last.

Table 24.1 Evaluation results of human settlement environment satisfaction

		Human settlement environment satisfaction						
Factors	Weights	Very dissatisfied	Dissatisfied	General	Satisfied	Very satisfied	Mean	CSI
House size	0.05	0.01	0.07	0.49	0.41	0.02	2.69	
House quality	0.06	0.14	0.32	0.29	0.23	0.02	3.33	
Road hardening	0.06	0.02	0.10	0.27	0.52	0.09	2.41	
Community greening	0.05	0.03	0.32	0.27	0.35	0.03	2.94	
Community lighting	0.05	0.02	0.21	0.26	0.44	0.07	2.66	
Waste disposal	0.06	0.00	0.06	0.16	0.62	0.16	2.12	
Water supply and drinking	0.06	0.00	0.01	0.24	0.47	0.28	1.96	
Drainage and sewerage	0.05	0.14	0.32	0.30	0.23	0.01	3.37	
Noise pollution	0.03	0.01	0.21	0.22	0.53	0.03	2.66	
Air quality	0.03	0.00	0.09	0.16	0.68	0.07	2.27	
Clinics	0.06	0.03	0.35	0.26	0.33	0.03	3.00	
Schools	0.06	0.08	0.38	0.49	0.05	0.00	3.48	
Nursery	0.06	0.00	0.00	0.12	0.49	0.39	1.73	
Entertainment plaza	0.05	0.02	0.46	0.30	0.13	0.09	3.20	
Activity room	0.03	0.09	0.34	0.41	0.16	0.00	3.37	
Supermarket	0.04	0.02	0.21	0.26	0.45	0.06	2.68	
County fair	0.04	0.01	0.16	0.28	0.46	0.09	2.56	
Community security	0.05	0.01	0.13	0.34	0.49	0.03	2.60	
Total satisfaction		0.01	0.20	0.32	0.44	0.03	2.70	58.86

Thirdly, comprehensive fuzzy evaluation. We use the fuzzy comprehensive evaluation method to obtain the satisfaction of the farmers living environment. Table 24.1 shows that the farmers of rural living environment totally dissatisfied accounted for 21 % of the general satisfaction accounted for 32, 47 % satisfactory, overall satisfaction with a mean of 2.70, the satisfaction index was 58.86. Thus, at present, the farmers of rural living environment satisfaction in the general level. From the mean satisfaction point of view of the various factors, the farmers' water supply and drinking (1.96), the nursery (1.73), waste disposal (2.12), the road hardening (2.41) and air quality (2.27) compare satisfaction, the satisfaction mean of 2.5; house size, community greening, community lighting, noise pollution, community clinics, supermarkets, county fair and community security, the mean satisfaction 2.5–3.0; house quality (3.33), drainage and sewerage (3.37), school (3.48), entertainment plaza (3.20), and activity room (3.37) is not satisfied, the mean satisfaction 3.0.

24.5 Conclusions and Recommendations

The farmers live in community living environment in rural homestead finishing satisfaction evaluation is useful to explore the process of urban and rural areas to achieve the degree of the side reflect local strengths and weaknesses of the implementation of the ‘hooks’ policy, as a government evaluation ‘hook’ an effective way of working. Articles by Jiangsu Province, seven villages in 158 household survey found that farmers new home housing quality, drainage and sewerage, their children to school, and the spirit of entertainment and are not satisfied, because this project belong to the government action, the lack of effective communication with farmers and participation rights, even in the house demolition comments, but live together community building farmers do not have the right to participate. To improve rural residents’ living environment satisfaction the fundamental way is to ensure effective communication between the farmers and the government, from the following aspects:

First of all, take full account of the diversification of farmers, individual needs and willingness to pay farmers new homes designed to meet the different preferences. For example, for the poor economic conditions of the farmers, affordable housing, consider the construction of multi-storey multi-family buildings; better economic conditions of the farmers, while comfortable housing, you can consider villas built similar group.

Secondly, give farmers the right to participate. On the one hand, establish supervision mechanism by the farmers on behalf of the construction process, through effective communication with the government, to fight for their tangible improvement of living environment; On the other hand, farmers representatives should advocate that the government establish ‘first payout’ system. If construction not quality and quantity, pursue the responsibility of the government departments responsible for the construction by the government to investigate the responsibility of the relevant construction unit, to avoid disadvantaged farmers pit and happiness.

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Chapter 25
SWOT Analysis on Industrial Development of Beijing Edible Fungi

Zhongwei He, Yongfei Zhao, and Fang Liu

Abstract At present industry of Beijing edible fungi already had certain dimensions and achieved a better economic effectiveness. In order to analyze industry of Beijing edible fungi, this paper uses the SWOT model puts forward suggestions on the development of Beijing in the edible fungus industry.

Keywords Edible fungi industry • SW O T • Beijing

25.1 Status and Characteristics of the Edible Fungus Industry Development in Beijing

Beijing is located in the north of the North China Plain, with the excellent geographical environment and developed transportation. With mountains on three sides—the western, northern, and northeastern, mountain climate and abundant forest vegetation is the important natural resources of development of edible fungi industry in Beijing. Due to valuing and vigorous supporting from Beijing agriculture bureau, Beijing Rural Work Committee and Beijing development and Reform Commission and other relevant government departments, edible fungi industry in Beijing, from production and processing to waste recycling (including production used with agricultural waste that regard as raw material), all is the high level of technology. Industrial development framework of edible fungi in Beijing

Supported by Program for New Century Excellent Talents in University (NCET-10-009), Study on Beijing fresh agricultural products price formation and its regulation mechanisms (SZ201110020010) and Funding Project for Academic Human Resources Development in Institutions of Higher Learning Under the Jurisdiction of Beijing Municipality.

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*, DOI 10.1007/978-3-642-54389-0_25,

Table 25.1 Beijing edible fungi for export

Year	2005	2006	2007	2008	2009	2010
Total exports (Ton)	1,512	1,423	0	150	1,200	1,500
Foreign exchange value (Million dollars)	172	94	0	32	420	500

Data sources: Beijing Association of edible fungi

has been basically formed (Beijing Agricultural Bureau 2008). The production of edible fungi in Beijing is characterized by its diversification and top-quality. In addition to local sales, the major of edible fungus products sold out to nationwide in major city through Beijing major wholesale markets, and exported to Malaysia, Singapore, Thailand and other international high-end markets. See Table 25.1 for export. In 2009 Fangshan farming service center registered “Edible Fungi Industry of Fangshan District” trademark and the production of edible fungi for export all used “Fangshan of” trademark. 2010 first edible fungi theme park of Beijing was built in Fangshan. 2011 the Demonstration Garden of Edible Fungus Varieties was built in Tong Zhou District of Beijing and put it into use. The 18th Congress of the International Society for Mushroom Science has been held ceremoniously in Beijing this year.

After 40 years of operations and government supporting, industry of Beijing edible fungi development has presented favorable trend. Industrial dimensions of Beijing edible fungi have expanded ceaselessly. To begin with, edible fungi leading enterprises in Beijing has a rapid development.2005, there are three leading enterprises of edible fungi in Beijing including Beijing Grenada Tope agricultural development limited company, Dragon Lake Temple ear post fungus stick production factory, Beijing longevity health agricultural development limited company. 2011 the number of edible fungi leading enterprises in Beijing increased to 11. See Fig. 25.1.

Moreover, the number of edible fungi production base is increasing. And in 2011, there is six edible fungi production base in Beijing. See Fig. 25.2.

Additionally, recent year the number of Edible fungi cooperatives is increasing. By 2011, seven main edible fungi cooperatives in Beijing involved in supporting the development of the edible fungi industry. See Fig. 25.3.

At the same time, yield of Edible fungi in Beijing significantly increases. 2005 the output is 3624 t and by 2011 Beijing edible fungi production reached 158,240 t. See Fig. 25.4.

Beijing edible fungi industry developed rapidly and made a better economic benefit. See Table 25.2. From 2005 to 2011 the gross value of edible fungi in Beijing has a net increase of 994.77 million Yuan. In 2011 the gross value of edible fungi in Beijing is 1.22308 billion Yuan. Beijing edible fungi industry has solved the problem of rural employment for more than 10,000 people and become the important source of income in rural areas.

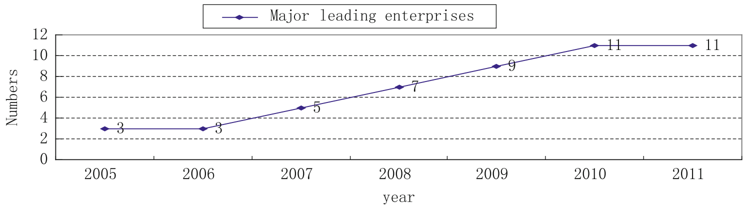

Fig. 25.1 The number of changes of edible fungus leading enterprises in Beijing (Data sources: Beijing Association of edible fungi)

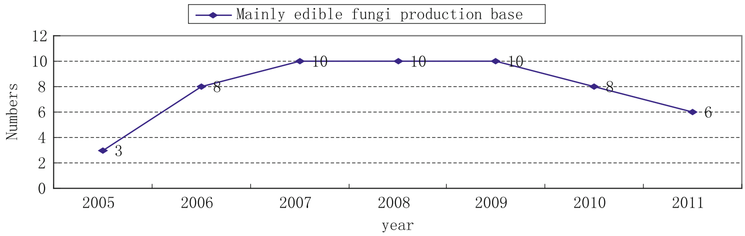

Fig. 25.2 The number of changes of edible fungus production base in Beijing (Data sources: Beijing Association of edible fungi)

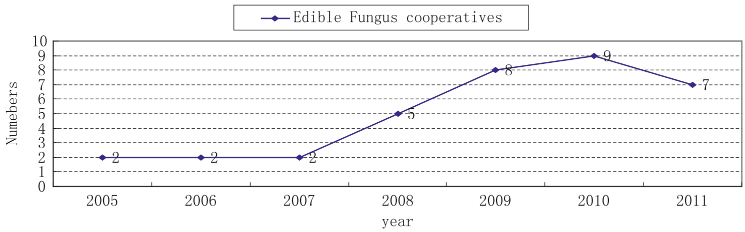

Fig. 25.3 The number of changes of edible fungus cooperatives in Beijing (Data sources: Beijing Association of edible fungi)

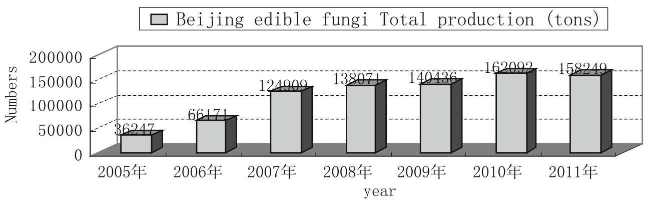

Fig. 25.4 Beijing edible fungi total production (Data sources: Beijing Association of edible fungi)

Table 25.2 Beijing edible fungi output value

Year	2005	2006	2007	2008	2009	2010	2011
Beijing edible fungi output value (10,000 Yuan)	23,831	42,356	63,689	73,193	98,263	124,457	122,308

Data sources: Beijing Association of edible fungi

25.2 SWOT Strategic Analysis in Beijing Edible Fungi Industry Development

Industrial strategy is an organic combination which mainly refers to how to organize their own strengths, weaknesses, and how to deal with problems between the macro environment opportunities and threats. SWOT analysis is a research method that is to take a comprehensive consideration which include industrial internal environment formed by advantage (strength), inferior position (weakness) and by the external environment brings opportunity, threat and other aspects, in order to find the core competitiveness of the industry. To summary Beijing advantages and disadvantages with edible fungus industry internal resource condition and in the light of potential opportunities and threats from the industry environment of Beijing edible fungi industry and exterior macroscopically environment, analyze as follow:

25.2.1 Analysis of Advantage and Disadvantage in Beijing Edible Fungi Industrial Development

25.2.1.1 Advantage Analysis

Location Advantages

Beijing climate resources are more abundant. Beijing is located at 39.8° north latitude, 116.5° east longitude, 54 m above sea level in the transition zone of the mountain and plains. Sixty-two percent is mountain and the plain is about 38 %. Plain area surrounded by mountains on three sides, forming the natural boundary of the Piedmont mountain climate. Beijing's climate is typical of the warm temperate semi-humid continental monsoon climate zone with four distinct seasons. Hot and rainy summer, the hottest is July. Cold and dry winter, the coldest is December. The average annual temperature is 14 °C, January −7 °C to −4 °C, July 25 °C to 26 °C. In Annual frost-free period of 180–200 days, western mountainous is shorter. It is one of maximum rainfall for the North China region which the annual average rainfall is 483.9 mm. Very uneven seasonal distribution of precipitation, 80 % of the annual rainfall concentrated in summer 6, 7, 8 months. Piedmont is the rainy area, the annual rainfall of 650–750 mm; mountain and plains of southern area is drier, the annual rainfall of 400–500 mm. The annual average temperature of plain areas is 11 °C–13 °C; period of annual frost-free is about 190–200 days; ≥10 °C accumulated temperature is about 4,200 °C. According to the climatic conditions in Beijing, the average temperature of summer is around 25°. The three sides in Beijing mountainous undergrowth produce high temperature edible fungi, such as Ganodorma lucidum, Coprinus, Agarics, Straw mushroom; winter and other seasons can produce low temperature edible fungi in facility greenhouse, Bailing mushrooms, Mushroom, Oyster mushrooms.

Forest Resources

Beijing is northwest tall, southeast low. The western, northern and northeastern are the endless mountains. Mountainous areas account for 62 % of the total area of whole town. Forest land area is 673,411.8 ha, of which mountain forest area is 538,729.4 ha. Edible fungi production under forest can take full advantage of forest resources of the mountainous areas and suburban counties in Beijing, as shown in Table 25.3.

Raw Material Resources of Edible Fungi Production

According to Beijing in 2005–2011 crop cultivation, many counties such as Fang Shan, Tong Zhou, Da Xing annually produce a large amount of branches and leaves of fruit tree, wheat straw, corn Stover, corn cob, sweet potato vine, soybean straw, cottonseed husk, peanut vine and other agricultural wastes. That can be used as an important raw material resource of edible mushroom production, as shown in Table 25.4.

Abundant Population Resources

In 2011 Beijing total output value is 1.62519 trillion Yuan and the total agricultural output value is 13.63 billion Yuan, accounting for 0.83 % of the total output value of Beijing area. As shown in Table 25.5, in 2011 population of Beijing resident is 2018.6 million, census register population is 1277.9 million, agricultural population is 264.2 million and 59.1 million were agricultural workers. The rich resources of the population can provide sufficient labor for the Beijing edible fungi industry. With the pursuit of healthy living and multiple functions of edible fungi including nutrition and health care and others, the abundant resources of population has also created a huge consumer market of edible fungi.

Table 25.3 Beijing forest conditions

Year	Forest area (Hectares)	Forest coverage (%)	Forest volume (10,000 m^3)	Afforestation area (hectares)
2006	626,006.3	35.9	1,295.3	12,770
2007	636,565.7	36.5	1,368.9	10,738
2008	641,368.3	36.5	1,394.4	9,122
2009	658,914.1	36.7	1,406.2	10,153
2010	666,050.7	37	1,435.4	7,765
2011	673,411.8	37.6	1,468.7	6,510

Data sources: Beijing Statistical Yearbook

Developed and Convenient Transportation

The rapid economic development in Beijing leads traffic in all directions. There is totally 381 blocks overpass in the city and the highway mileage reach over 20.6 thousand kilometers. Rail transit line is 228 km long. Beijing city road network structure parallel along the longitude and latitude and form a rectangular ring-shaped distribution. Many highways pass through Beijing, such as Beijing-Tibet, Beijing-Harbin, Beijing-Shenyang, Beijing-Tianjin-Tanggu, Beijing-Shijiazhuang, Beijing-Chengde and so on. Beijing-Tianjin intercity high-speed railway, Beijing-Harbin railway, Beijing-Taiyuan Railway, Beijing-Baotou railway, Beijing-Chengde railway, Beijing-Liaotong railway, Beijing-Shanghai high-speed railway, Beijing-Qinhuangdao railway, Beijing-Shanghai Railway, Beijing-Kowloon railway, Beijing-Guangzhou railway and many other rail lines gathered in Beijing, the total railway mileage add up to 962 km. Capital International Airport in Shunyi District is Asia's largest international airport and it is largest airport in the country. Now it already has more than 200 international and domestic routes, leading to the most cities and areas at home and abroad.

The Scientific and Technical Resources

In 2011 Beijing main varieties of edible fungi have ostreatus, lentinus edodes, flammulina, agaricus bisporus, straw mushroom, pleurotus eryngii, tea mushroom, coprinus, agaric, pleurotus, maitake, ganoderma lucidum, including new edible fungi species, as shown in Table 25.6. There are many scientific research institutions in Beijing, such as the Chinese Academy of Agricultural Sciences, China Agricultural University, Beijing Academy of Agriculture and Forestry, Beijing Agricultural College, Beijing Agricultural Vocational College and other scientific research institution. To increase production of new upscale fungi can rely on Beijing's strong research capabilities in technology and technical innovation. To promote and enhance edible fungi production technology can rely on Beijing Agricultural Bureau, Beijing Municipal Rural Work Committee, agricultural technology extension stations and the relevant government departments through

Table 25.4 Beijing crop cultivation

Item	2005		2006		2007		2008		2009		2010		2011	
	Planting area (hectares)	Total yield (tons)	Planting area (hectares)	Total yield (tons)	Planting area (hectares)	Total yield (tons)	Planting area (hectares)	Total yield (tons)	Planting area (hectares)	Total yield (tons)	Planting area (hectares)	Total yield (tons)	Planting area (hectares)	Total yield (tons)
Rice	760.3	4,553.0	687.2	4,278.0	519.7	3,192.0	444.3	2,989.0	378.1	2371.8	299.1	1892.3	230.7	1507.3
Wheat	53,339.7	267,368.0	63,067.7	300,076.0	41,339.7	203,850.0	63,891.9	327,392.0	60,455.1	309,545.1	61,566.1	283835.3	58104.3	283702.8
Corn	119,710.1	625,824.0	135,832.9	729,076.0	138,992.7	765,447.0	146,187.3	879,667.0	150,760.5	897,597.7	149,750.7	841674.0	140506.7	903402.1
Batatas	3,312.0	20,996.0	4,000.5	25,841.0	4,302.5	28,545.0	3,082.1	18,781.0	2,748.9	16,620.0	2,417.3	13554.0	2351.4	12838.4
Soybean	10,945.3	22,826.0	11,865.7	24,871.0	8,816.0	14,516.0	9,351.1	19,114.0	8,351.3	14,923.5	6,408.5	10711.2	5372.3	10798.7
Cotton	1,832.5	2,069.0	2,104.5	2,239.0	1,682.9	1,990.0	1,200.4	1,357.0	604.0	766.9	397.8	460.4	440.7	515.1
Peanut	8,347.5	24,605.0	7,018.7	21,442.0	6,919.0	21,689.0	6,903.2	21,253.0	5,814.9	17,737.8	5,389.2	15527.9	4881.1	13922.2

Data sources: Beijing Statistical Yearbook

Table 25.5 2011 Beijing population crop cultivation

Region	Resident population (million people)	Household population (million people)	Agricultural population (million people)	Agricultural workers (million people)
The city	2018.6	1,277.9	264.2	59.1

Data sources: Beijing Statistical Yearbook

Table 25.6 2011 Beijing new production fungi

New Fungi	Coprinus	Nebrodensis	Eryngii	Agrocybe	Pleurotus	Grifola frondosa	Ganodorma lucidum	Others
yield (Tons)	822	4,904	8,321	2,635	270	1,392	19	6,427

Data sources: The Chinese edible fungi business Network edible fungi market editorial department

developing exhibition agriculture and other forms and researching new varieties of edible fungi.

Financial Advantage

Beijing financial strength is strong, as shown in Table 25.7. The edible fungi industry is an important part of Beijing's urban modern agriculture. Local government attaches great importance to edible fungi production and processing enterprises. According to development ideas of edible fungi industry of "government guidance and market operation, advance steadily, rich farmer", Fang Shan District insist that exploiting and integration of edible fungi industry resources to build an industrial pattern including three industrial zone which is a mountain edible fungi features cultivation industry and Jing Zhang Highway edible fungi industrial zone, high-speed Beijing-Shijiazhuang green forest edible fungi industrial zone, and promote edible fungi industry optimization and upgrading. In order to meet the Eighteenth International Edible Fungus Conference, Tong Zhou district actively construct one mushroom professional, modern and comprehensive demonstration park which is efficient cultivation of conventional varieties of edible fungi, and it set new varieties, new technology demonstrations and science promotion in one. The park covers an area of 910 acres, including cultivation under forest area 200 acres, factory production area of 130 acres, varieties and planting mode display area of 130 acres, 450 acres of cultivation area of agricultural facilities. In 2011 Tong Zhou district edible fungi production is 35,000 t. The region has formed three plates which are edible fungi cultivation under forest, facilities cultivation and factory production.

Table 25.7 2011 Beijing financial income

Year	2006	2007	2008	2009	2010	2011
Financial income (billion)	1,235.78	1,882.04	2,282.04	2,678.77	3,810.91	4,359.10

Data sources: Beijing Municipal Bureau of Finance

Industry Is Relatively Concentrated

It is an important an important symbol to measure of the industrial strength that scale of the industry and degree of industrial concentration. At present industry of Beijing edible fungi is mainly distributed in three counties of Fangshan, Tong Zhou, and Daxing. The industry is relatively concentrated, which will help to achieve economies of scale.

25.2.1.2 Disadvantage Analysis

Lack of Unified Planning and System Organization and Management

Currently, each area county edible fungus industry fights the enemy separately. Fangshan county, Tong Zhou county, Daxing county, Huairou and other counties all has their edible fungi industrial development plan for the area, but the overall in Beijing is lack of an organized, systematic planning and supporting policy to guide the development of the edible fungi industry. Macro guidance from government on the development of edible fungi industry is insufficient, without further specific establishing detailed division to promote industrial development. Edible fungi industry exist bull management phenomenon and the urgent need to improve the degree of organization. Production standards are different and it failed to establish the perfect edible fungi standardized production system. Quality management system, market supervision and services are urgent to improve.

Supporting Funding and Propaganda Is Inadequate

Although Beijing financial strength is solid but it is less than other industries to support the development of edible fungi industry and capital investment. Supporting the work of the development of edible fungi industry is not established. And technical services (promotion of technology, technical training, technical guidance), research and development platform of edible fungi species is still not sound. Those limit the development of edible fungi industry in Beijing.

An edible fungus market is broad, edible fungus of Beijing brand effect has not been formed. Beijing edible fungi brand visibility is not enough, the urgent need to integrate upstream resources. In order to realize the industrial cluster effect and enlarge the scale of production, we can amalgamate some enterprise which has certain strength. Meanwhile, we can build brand promotion strategy of edible fungus industry to enlarge conduct propaganda and to increase the additional value of brand.

Factory Production Needed to Upgrade, Variety Is Not Quite Rich

Factory operation is an effective way of edible fungi industry development (Sun Jianhua 2009). Beijing edible fungus varieties are still not rich enough (see Table 25.8). High-grade fungi production still cannot satisfy market demand; deep processing products are still relatively scarce. The production of high-grade edible fungi, edible fungi condiment, health care products, pharmaceutical products, cans needs deep-processing enterprises. In three models of production of Beijing edible fungi, factory production needs to improve. Fang Shan edible fungus production industrialized rate increased year by year.2011 Fang Shan District edible fungus industrialized rate is 25 %, as shown in Fig. 25.5.

Lack of Edible Fungi Modern Production Professional Knowledge Staff

In the development process of Beijing edible fungi industry, the personnel of factory production who control professional knowledge is comparative short. Institutions that professionally train modern production methods of edible fungi and organization and management of knowledge are few. Training efforts can not meet an urgent need for the development of edible fungi industry. Therefore, to promote the healthy development of edible fungi industry, it is necessary to train and establish one team of modern professional knowledge personnel who control edible fungi management, research, production, sales, and logistics.

25.2.2 Opportunity Analysis for Development of Beijing Edible Fungi Industry

25.2.2.1 Transformation of Economic Development Mode in China

China's National Economic and Social Development Twelfth Five-Year Plan clearly adhere to "the strategic adjustment of the economic structure as the main direction to accelerate the transformation of economic development and adhere to scientific and technological progress and innovation as an important support to accelerate the transformation of economic development mode." In the long run, the change in the pattern of economic development will be more emphasis on the technical, institutional innovation and circular economy development. Bio-engineering and other high-tech as the guide will drive the industrial revolution of the edible fungi industry structure of revolutionary change. Ordinary edible fungi

Table 25.8 2011 Beijing mainly the production of edible fungi (2005–2011)

Year	2005	2006	2007	2008	2009	2010	2011
Shiitake yield (Tons)	3,365	11,707	32,141	38,917	42,671	65,016	45,293
Ostreatus yield (Tons)	16,129	23,804	32,609	33,579	48,064	47,428	52,334
Bisporus yield (Tons)	1,019	7,144	11,319	11,262	3,676	1,910	3,586
Volvacea yield (Tons)	889	1,033	1,592	707	890	589	303
Flammulina yield (Tons)	6,782	6,719	9,403	10,007	15,186	17,274	18,035
Agaric yield (Tons)	469	6,750	22,058	22,177	4,867	5,091	1,877

Data sources: Beijing Association of edible fungi

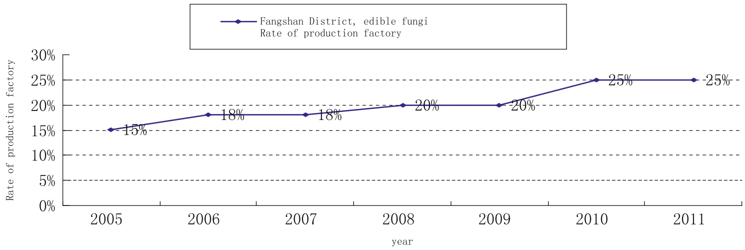

Fig. 25.5 Fang Shan District, edible fungi rate of production factory (Data sources: Beijing Association of edible fungi)

and high-grade edible fungi demand will increase. Treasure edible mushroom cultivation and development will be more attention, the overall mushroom industry in China will get a good development.

25.2.2.2 The Impact of Green, Safe, Healthy Food Concept

With the upgrading of the level of economic development in China, green, safe, healthy food concept is taking root. Our residents on diet and nutrition requirements are undergoing profound changes. The pattern of one meat, one vegetable, one edible fungus, has been formed.

Edible fungi are of high nutrition and health care products, in Western countries it is referred to as "the pinnacle of plant foods" (Guo Zhongli and Da xing 2009). Edible mushroom (fresh products) containing protein content of 15–40 %, more than 20 kinds of amino acids, including essential but our body itself can not synthesize lysine eight kinds. Compared with meat, edible fungi vitamin B1, vitamin B12, vitamin C, vitamin D is rich. Agarics fungi contain special substances that are anti-radiation and can exclude human body dust. And it is beneficial to human metabolism and expels toxins. Edible fungus containing a lot of care and disease-resistant material can play a role in lowering cholesterol, lowering blood pressure, and anti-cancer, anti-aging, beauty. At the same time it's able to effectively stimulate the formation of antibodies and significantly enhanced immune function. Edible fungi is a recognized green food, prospects of industrial development is very broad.

25.2.2.3 National Policy Support the Development of Edible Fungi Industry

Edible the industries set of economic, social, and ecological value as a whole and China attaches great importance to the development of the mushroom industry. In 1986, China's fresh edible fungi production reached 585,000 t, accounting for 26.8 % of world production. In 1990, the output exceeded 100 million tons of edible fungus, later with annual 18–20 % growth rate. In 1994, China's edible fungus production account for 50 % of the total output of world edible fungi, marking our country has become big country of world edible fungi industry. In 2000, total output of our country edible fungi located in sixth after grain, cotton, oil, and fruit, vegetable. Edible fungi industry in the promoting adjustment of agricultural structure, increasing farmers' income, expanding re-employment, increasing exports play an important role. In the main edible fungi producing areas, it has become a pillar industry of agriculture and rural economy. The Ministry of agriculture in our country vegetable development overall planning is presented that in the next 2 or 3 years we should vigorously develop the pollution-free vegetables and edible fungus production.

25.2.3 Threat Analysis for Development of Beijing Edible Fungi Industry

25.2.3.1 The Developed Countries Continue to Improve the Agricultural Food Hygiene Standards

Edible fungi production in China accounted for 70 % of world production. China has become the world's largest mushroom production and trading country. But in aspects of the agro-ecological environmental protection, production techniques, as well as food security system, there are still significant gaps between China and developed countries. The developed countries represented by The United States, European Union, Japan continue to improve the agricultural food hygiene standards and quality inspection standards, export of edible fungi frequently encountered "green barriers" in developed countries. Edible fungus products conformity assessment procedures are complex and volatile and test items are numerous. A higher market threshold, to a certain extent, is not conducive to the development of edible fungi in Beijing mountain area (Xiong Zhaojun et al. 2011).

25.2.3.2 Edible Fungi Industry Market Exists Information Asymmetry

Edible fungus market information detection and information processing capacity still lags behind, authoritative information release system of edible fungus market with has not been fully established. The producers in edible fungi market are mostly smaller scale of production and industrial organization is not sound enough. Factory production of edible fungi, the industry standardized production systems are still inadequate. Enterprise that is factory production of edible fungi, industry standard production system is still not perfect. Market information asymmetry lead to overall core competitiveness and risk-resisting ability of edible fungi industry is weak in China.

25.2.3.3 Vicious Competitive Pressures from Domestic Provinces of Edible Fungus Production Enterprise

Heilongjiang, Jilin, Shandong, Shanxi, Hebei, Hubei, Jiangxi, Fujian, Sichuan, Guangdong, Guangxi province all are big provinces of edible production. Domestic competition in edible fungi industry enterprises is growing, competitors often use price-cutting strategy that lead to vicious competition and industry profit decreasing. At the same time, mass edible fungus production from neighboring Beijing province, to a certain extent, will squeeze Beijing edible fungi market space. It will cause strong competition pressure to Beijing edible Fungi enterprises. In order to get a good development of Beijing edible industry, it is necessary to play Beijing's geographical advantages and scientific advantages, take "high, fine, sharp" market route and produce high-grade edible fungi. At the same time, constantly introducing new edible fungi production technology, play a "leading, demonstration, drive" role to the whole country's edible fungi industry.

25.3 Development Measures for Edible Fungi Industry

25.3.1 Scientific Planning and Policy Guidance for the Development of Edible Industry

To establish the "Beijing edible fungi industry development plan" and to build perfect Beijing edible fungi market management of special regulations and standards, we can give priority support for edible fungi market in accordance with the "Beijing edible fungi industry development plan". At the same time, it is necessary to increase capital investment of Beijing edible fungi industry and integrate Beijing advantage resource, accelerating edible fungi market of infrastructure construction, the trading system and logistics system construction, especially the construction of information publishing system.

25.3.2 Improving the Edible Fungi Industry Standard System

The perfect edible fungi industry standardization system and improving the system of quality standards is an important measure to enhance the competitiveness of edible fungi industry and to improve basic conditions to protect the quality of edible fungi products. Learning the agricultural products of food hygiene standards and quality inspection standards from Europe and the United States, Japan and other developed countries, we can improve Beijing edible fungi production standard system and strengthen quality supervision of edible fungus market. In order to promote edible fungi industry scale, intensive industrialization, healthy and sustainable development, it is important to actively build edible fungi standardized production base, encourage the edible fungus enterprises to upgrade standards and support leading enterprises striving for national famous brand.

25.3.3 Increasing Efforts of Research and Development to New Varieties of High-Grade Edible Fungi

Along with the development of edible fungus industry competition is becoming increasingly fierce, Beijing edible industry should fungi actively introduce, digest, absorb domestic and foreign advanced technology of edible fungi production. Beijing edible fungus enterprises and major research institutions should encourage conducting independent innovation and constantly developing new varieties to meet market demand for high-grade edible fungi. Through policies encouraging and financial supporting, actively guide edible fungi industry constantly upgrading and enhancing the level of industrial production.

25.3.4 Strengthen Industry of Beijing Edible Fungi Talent Team Construction

The edible fungi industrial talent support is the key to development of edible fungi industry. Therefore, the increase of talent team construction is vital, and to cultivate a group of personnel strength who is skilled, operated, management for edible fungi industry development and can take great advice from a professional point of view. To a certain extent Beijing edible fungi industry market management, R & D, sales, logistics and other series of the root of the problem will be solved.

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Chapter 26
Analysis on the Technology Application of Traceability Management for Agro-product Quality and Safety in China

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Abstract Traceability management has evolved as a whole chain controlling system for agro-product quality and safety in recent years. Information technology has played a key role in agro-product traceability management. This paper analyzed current status in technology application for agro-product traceability and highlighted problems in practice. Fundamental strategy and relevant policy suggestions to establish framework of traceability management platform for agro-product quality and safety have been put forward in this paper.

Keywords Agricultural products • Quality safety • Traceability • Policies

26.1 Introduction

As a new term in food safety risk management, "traceability" was first proposed at the CAC (Codex Alimentarius Commission) Intergovernmental Task Force Meeting on Biotechnology and Food. It aims to track the flow direction of food, call back the problematic food and eliminate the harm thereof according the information that must be recorded on all the links, once any food safety problem is discovered (Moe 1998). In the 1990s, to respond to the crisis of mad cow disease, the EU set up the mark tracing system for cows and beef and released the 178/2002/EC basic law on food safety. The law required that from 2005, all the food marketed within the EU

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_26,

could be tracked and traced, or it would not be allowed to sell on the market. It also stipulated the mandatory establishment of the traceability system at the different stages of production, processing and circulation of food, feed, livestock used for manufacturing food, and the goods related to the manufacturing of food and feed (Schwagele 2005). Soon afterwards, the United States, Japan and Canada successively introduced this mode of management, which was then popularized to the quality safety management of bulk agricultural products such as poultry, fish and vegetables (Smith et al. 2005). Since its implementation of the "Pollution-Free Food Action Program", China has step by step carried out the nationwide experimental exploration into the traceability management for agro-product quality and safety. Particularly, since 2007, the No.1 document of the CPC Central Committee has, for consecutive many years, put forward the definite requirements for the construction of the quality safety traceability system. As the government departments at all levels attach great importance to this, the experimental construction of such systems has been carried out in various projects in different areas, and that has greatly facilitated the innovation on the regulatory mode for agro-product quality and safety. Such traceability management for quality and safety has already evolved into a new regulatory mode for quality safety of modern agricultural products integrating standardized production, normalized control, brand-based marketing and IT-based services (Golan et al. 2004).

26.2 The Technology Application of Traceability Management for Agro-product Quality and Safety

In recent years, with the rapid development of modern agriculture and the overall reinforcement of supervision over agro-product quality and safety, the legal system, standards and technical support for the traceability management for quality and safety have become increasingly sound. Overall, China's traceability management for quality and safety has manifested such features as being driven by many departments, various modes and multiple channels. In terms of the surface, it has witnessed the situation of widespread development and application; but in terms of the level, it remains at the stage of preliminary development.

26.2.1 Legal System Gradually Established

The *Law on Agro-product quality and safety* released in 2006 and the *Food Safety Law* promulgated in 2009 have provided the fundamental legal basis for the core aspects of traceability management for quality and safety, such as management of main responsibilities, archives and packing marks. Meanwhile, such documents as the *Special Provisions of the State Council on Strengthening Quality Safety*

Supervision and Management of Food and Other Goods and the *Decision of the State Council on Strengthening the Work of Food Safety* issued by the State Council and such regulations as the *Measures for Management of Livestock and Poultry Marks and Breeding Archives* and the *Measures for Packing Marks and Management of Agricultural Products* formulated the Ministry of Agriculture have made definite stipulations on the overall arrangements and key operation links concerning the construction of the quality safety traceability system. Furthermore, the local governments have also actively released the documents of regulations on traceability management. For example, the *Regulations of Hangzhou Municipality on Supervision and Management of Pesticide Residue in Vegetables* confirms the "traceability code" management mechanism for vegetables; and the *Regulations of Beijing Municipality on Food Safety* proposes the full-process management, requiring that permit should be obtained before food can be transported out of the place of origin or admitted in the selling place, its quality should be traceable and its risk be controllable.

26.2.2 Standards and Norms Successively Released

The Ministry of Agriculture has formulated the *General Rules of Operating Procedures for Quality Safety Traceability of Agricultural Products*, *the Guidelines for Traceability Codes of Agricultural Products* and the industrial standards for domestic animal meat, fruit, tea and grain, all of which provide the standard instructions for the main aspects of quality safety traceability, such as terms and definitions, implementation of system, information management, operation and self-inspection of system, and handling of quality safety problems. The Ministry of Commerce has formulated eight technical norms including the *Basic Requirements for Meat Circulation Traceability System*, the *Basic Requirements for Vegetable Circulation Traceability System*, the *Coding Rules for Meat and Vegetable Circulation Traceability System* and the *Technical Requirements for the Management Platform for Meat and Vegetable Circulation Traceability System*, all of which have further standardized the local construction of the meat and vegetable circulation traceability systems and accomplished the interconnection among cities to ensure the integrity of such systems nationwide.

26.2.3 Experimental and Demonstration Effect Being Remarkable

At the central level, the Ministry of Agriculture, which is the competent authority for agro-product quality and safety, actively takes various channels to carry on the construction of the quality safety traceability system and currently, it has carried out the experimental traceability management in four sectors, namely, planting, livestock, aquaculture and agricultural reclamation. The Ministry of Commerce starts with the circulation links to push ahead the construction of the nationwide meat and vegetable circulation traceability system; the State Administration for the Quality Supervision, Inspection and Quarantine brings into play its advantages in quality management and familiarity with EAN-UCC system and encourages the quality standard research departments of some provinces and municipalities to actively carry on the construction of the quality safety traceability system. At the local level, most of the provinces and municipalities have respectively developed their unique traceability management for quality and safety system in light of their actual conditions in quality safety management. For example, the Agricultural Bureau of Beijing and the Department of Agriculture of Hebei Province jointly launched the "experimental work concerning the quality safety traceability system for Beijing-bound vegetable products" in 2004; Nanjing launched the quality IC card management system by using the quality safety website for agricultural products as the regulatory platform; and the Municipal Government of Hangzhou proceeded with vegetables and live pigs to launch the construction of the platform for traceability management for quality and safety "from farmland to dinner table".

26.2.4 Technical Application Being Relatively Mature

The traceability management for agro-product quality and safety mainly relates to the key technologies such as product identification and coding, information collection and transmission, and data analysis. In recent years, China has constantly achieved innovative development through experimental projects. For example, in building the animal marking and epidemic disease traceability system, China developed the two-dimension code traceability ear tag, mobile smart recognizer, software for printing electric bills, central database and data analysis software by referring to the foreign advanced experience and in light of its actual work in epidemic prevention. Through the optimization and improvement of equipment and database software, these technologies have been actually popularized and applied. The State Food and Drug Administration (SFDA) set up the quality safety supervision system for medicine, applied and popularized the barcode technology to the fields of pharmaceutical production and circulation, and used the electronic supervision codes to conduct the full-process supervision over the production, delivery and marketing of medicine so as to ensure its quality safety. In building the nationwide meat and vegetable circulation traceability system, the Ministry of Commerce encouraged the pilot cities to use such technologies as RFID and barcode on the basis of the IC card technology and in light of the actual developments of packing, mode of circulation and IT level of operators in different areas, so as to explore more advanced mode of traceability technology, gradually segment the traceability unit and improve the actual precision of traceability.

26.3 Prominent Problems Existing in Traceability Management for Agro-product Quality and Safety

Although the construction of the traceability management for agro-product quality and safety has already become the main task of the agricultural departments at all levels in transforming the mode of supervision, upgrading the supervision capability and carrying out local responsibilities and they have achieved certain results in the experimental exploration, China remains at the preliminary stage in institutional, mechanism, team and capability building thereof. Particularly, the following aspects seriously hinder the smooth progress in the construction of the traceability management for agro-product quality and safety.

26.3.1 Lack of Top-Level Design

As most of the currently existing traceability management systems and standards are independently developed by different departments and regions and the state has not laid down the unified standards for developing such systems or put forward the definite requirements for carrying out the traceability management of agricultural products, this has not only resulted in the participants' unclear understanding and lack of impetus but also led to the remarkable differences among different regions and departments in such aspects as traceability mode, concept and system design. Meanwhile, the lack of top-level design and unified technical standards has brought about the different requirements for such links as platform framework, traceability code, information collection, data exchange and inquiry mode of various traceability systems; resulted in the difficulty that the participants have to face different standards and meeting the requirements of different traceability systems; and also shaped the information islands in industries and regions, all of which have impacted the functions and actual effect of traceability management. Therefore, currently it is urgently needed to accelerate the formulation of management systems and technical standards according to the requirements of "unified coding rules, unified collection index, unified transmission format, unified interface norm and unified workflows" so as to guide different regions to carry on the traceability management work in a standardized and orderly manner.

26.3.2 Lack of Departmental Coordination

In China's experimental construction of the traceability management for agro-product quality and safety, vertically the central government and the local governments at all levels boost it simultaneously; and horizontally the departments of agriculture, quality inspection, industrial and commercial administration, food and drug administration and commerce unfold the work respectively from the perspective of their own functions in section-based supervision, trade management and industrial development. In the process of such multilevel implementation by different departments on their own, due to the lack of communication and coordination between the central and local governments and between the departments, the traceability management of the production is difficult to effectively link with the marking inspection on the market and with the information input during the circulation, so it is impossible to accomplish the full-process traceability from farmland to dinner table, which also drastically reduces the actual effect of the traceability management of the production.

26.3.3 Lack of Resources Sharing

Currently, the local or individual experiments in agricultural industry alone are hard to meet diversified demands due to the high construction costs and small number of audience. Besides, as the management departments lack the mechanism for information integration and sharing, the quality safety information, which is a resource of public attribute, is isolated and possessed by the departments and the efficiency of such resource is greatly weakened. The lack of the standards for technical operation, the differences in traceability concept based on section supervision and the blocked communication channels for promoting traceability management—all these result in the wide differences in the definition, storage and information transmission of the traceability systems constructed and operated by the governmental departments at all levels and make it impossible to realize the seamless connection among such systems and difficult to carry on the in-depth integration, fusion and comprehensive utilization of information resources.

26.3.4 Lack of Impetus for Implementation

In participating in traceability management, the production subjects need to expend the costs of manpower and material resources. After the products are launched into the market, on the one hand, the market lacks the requirements for access to traceability management; on the other hand, the consumers don’t know much about traceability management or get much involved in it. In the process of marketing, the production subjects are not only hard to get the economic benefits from traceability management, but there may also appear such strange cycle of “bad money expelling good money”, which, to a certain extent, affects the enthusiasm of the subjects for participation in the traceability system and goes against the continuous operation of the traceability system.

26.4 Basic Thinking of Strengthening Traceability Management for Agro-product Quality and Safety

To intensify the full-process traceability management by means of IT is the inevitable course for China to drive its quality safety management of agricultural products to a new level during the new period and under the new situation; and it is also a significant fundamental project for promoting the development of China's modern agriculture and upgrading the capability of ensuring the agro-product quality and safety (Alfaro and Rábade 2009). Considering that China's agricultural products are characteristic of being fresh and live and feature regional differences and that different provinces differ from each other in the modes used for traceability management for quality and safety, in the types of information collected and also in the traceability technologies applied thereof, with a view to making full use of the existing conditions and reinforcing the integration of resources, emphasis should be laid on the following aspects on the principle of "scientific layout, step-by-step construction, implementing system and ensuring operation":

26.4.1 Overall Planning

It is generally considered that traceability management will be based on the purpose of ensuring consumption safety and serving the industries, follow the basic requirements for tracing the responsible subjects, take the product marking, animal ear tag or quality conformity certificate as traceability carriers and use the IT-based methods to select a number of large and medium-sized cities and main producing areas of agricultural products for experiments. Priority will be given to incorporating the agricultural product manufacturing enterprises and farmers' professional cooperative economic organizations into the scope of traceability management and setting up the national platform for quality traceability information on agricultural products to realize the information sharing, so as to provide technical services for agricultural producers and operators and the wholesale market and provide technical support for coordinated supervision by the governmental departments.

26.4.2 Perfecting the System

Efforts should be made to further implement the *Law on Agro-product quality and safety* and the *Food Safety Law*, release the *Management Measures for Conformity Certificates on Agro-product quality and safety* and the *Measures for Quality Traceability Management of Agricultural Products*, specify the duties of traceability management, define the responsibilities and obligations of the participating subjects, reinforce the auditing of traceability information, lay down relevant punitive measures for the provision of false information and severely crack down the acts of breaching promises to ensure the accuracy and reliability of traceability information. And based on the building of the systems for standardized production of agricultural products, production archives and records, packing marks and market access, the traceability system should be continuously perfected (Gamberi and Manzini 2007).

26.4.3 Setting up the Platform

On the principle of overall planning, unified standards, compatible sharing and step-by-step implementation and based on the traceability requirements for different production links and different categories of agricultural products, efforts should be made to organize and formulate the implementation guide, technical requirements and operating norms for the quality traceability information platform, construct the national platform for quality traceability information management, instruct the provinces to establish the quality traceability data center and the county-level quality traceability management stations and set up the traceability service outlets at the designated wholesale markets to realize the flexible collection, classified management and nationwide sharing of production archives and information and focus on meeting such regulatory needs as quality safety traceability, warning and callback of agricultural products (Bechini et al. 2008).

26.4.4 Innovating on Mechanism

By relying on the regulatory and testing organizations at all levels for agro-product quality and safety and taking agricultural enterprises and cooperatives as the main objects, efforts should be made to gradually carry out the marking of agricultural products launched in the market, the recording of production process and the IT-based traceability management. The agricultural departments at the county level shall be responsible for the registration management and information auditing of the production and operation subjects within their jurisdiction; the agricultural departments at the provincial level shall be responsible for the summarizing and management of the production archives and information on agricultural products all over the province; and the national platform for quality traceability information management shall be responsible for traceability inquiry and data exchange services and for summarizing, analyzing and evaluating the quality traceability information on agricultural products.

26.4.5 Expanding the Experimental Scope

In terms of regions, efforts should be made to center on the development layout of the products for the "vegetable basket" project, start with the areas with the most favorable conditions, give priority to selecting the main producing areas and large and medium-sized cities that are valued by the government and have the foundation of traceability management, and focus the traceability management on one or several predominant products. In terms of the operation subjects, efforts should be made to select a number of farmers' professional cooperatives, leading enterprises in agricultural industrialization, "three-garden and two-farm" bases, and certificate-winning units of "three products and one standard" to first make demonstration and guide and bring along the other enterprise to carry out traceability management. In terms of products, efforts should be made to center on the industrial development and select the "vegetable basket" products such as vegetables, fruit, tea, animal products and aquatic products with high commodity rate and suitable for packing marks to carry on the pioneering exploration.

26.4.6 Upgrading Capability

Efforts should be made to carry on the activity of standardizing the production of "vegetable basket" products on a large scale, actively guide the production enterprises of agricultural products, farmers' cooperatives and production bases for certified agricultural products to establish the production archives and standardize the packing and marking of agricultural products; and carry out the management of voucher and invoice demand on the wholesale markets of agricultural products and organically link up packing marks, production archives and voucher and invoice demand. At the same time, efforts should be made to strengthen IT training and guidance, encourage and support such implementing subjects as agricultural producers and operators, wholesale markets and supermarkets to set up the internal traceability management system, constantly improve the IT application, accelerate the dovetailing with the quality traceability information platform and voluntarily disclose to the public the information concerning the process of safe production of agricultural products.

26.5 Policy Suggestions

Improving the traceability management for agro-product quality and safety is not only a livelihood project for ensuring consumption safety, but it is also a significant strategic choice for intensifying the capabilities of supervision over agro-product quality and safety. The vigorous implementation of quality safety traceability will inevitably need to integrate and inaugurate the existing management modes of and control measures for agro-product quality and safety and particularly, need to change and optimize the management conception, implementation procedures and technical means. Therefore, it is needed to release relevant policies as support and guarantee.

26.5.1 Intensifying Connection of Functions

The new round of the reform in food safety supervision mechanism extends the duties of agricultural departments from the supervision and management of the production link of agricultural products to such links as purchase, storage and transportation before their entry into the wholesale and retail markets or production and processing enterprises and the objects to be supervised are expanded from agricultural enterprises and cooperatives to such production and operation subjects as brokers, wholesalers and retailers. To accomplish the full-process traceability, the agricultural departments should not only do a good job in the filing and supervision management of the production and operation subjects on the links of production and circulation, but should also strengthen the coordination and cooperation with SFDA and clearly specify the traceability marks of agricultural products as the inspection voucher for market access so as to realize unified inspection and marking. Therefore, these two departments should jointly release as soon as possible the guiding opinions on strengthening the traceability management for agro-product quality and safety to make unified arrangements, carry out joint enforcement and develop resultant force.

26.5.2 Making More Capital Investment

Efforts should be made to adhere to the approach of combining administrative promotion with market operation. The early-stage construction shall mainly be supported by the earmarked financial funds set up by the government and the later-stage operation shall mainly depend on attracting social funds so as to gradually establish the mechanism for diversified investment in the quality safety traceability of agricultural products. Firstly, it is to arrange the funds earmarked for the construction of the traceability management platforms at the national, provincial, municipal and county levels and list the funds for the operation and maintenance of the said platforms in the financial budget to ensure the scientific construction and continuous operation of the traceability management for agro-product quality and safety. Secondly, it is to optimize the structure of agricultural subsidies, incorporate the protection of agro-product quality and safety as among the major tasks of the Ministry of Agriculture and set up the subsidy for traceability marking of agricultural products to guide the production and operation subjects to get involved in traceability management. Thirdly, it is to set up the scientific research funds to support the applied research on traceability management methods and related technologies. Fourthly, it is to encourage the social resources to get involved in the construction of the traceability management for agro-product quality and safety and utilize the traceability information services to realize the increment of value.

26.5.3 Organizing Technical Training and Guidance

The IT-based traceability management for agro-product quality and safety features higher technical demand. It is both needed to cultivate a number of talents who can accurately grasp the key points of system construction and promote China's traceability management for agro-product quality and safety, and it is also needed to shape a number of professional talents who can master the technical points of traceability information and solve related technical problems. In light of the actual conditions that the overall management level of agricultural production enterprises, farmers' cooperatives, producing bases and wholesale markets in China is rather low and they are rather weak in their ability to apply the software systems, the agricultural departments should not only provide these implementation subjects with the unified basic traceability information system, but should also organize the all-round training to guide them to learn the operation and use. The implementation subjects, who have better conditions and higher demand for traceability precision, should be encouraged and supported to independently research and develop the traceability information system suitable for them based on the existing one.

26.5.4 Carrying on Publicity and Popularization of Traceability Concept

In pushing ahead the continuous development of the traceability management for agro-product quality and safety, on the one hand, it is needed to establish the system of market access; and on the other hand, it is needed to be driven by the benign market competition. Among them, the crux lies in whether or not the consumers accept and are willing to bear the expenses for the protection of consumption safety. Therefore, on the one hand, publicity needs to be reinforced to actively guide the consumers to know the traceability identification code and accept the safety signal such code brings; and this can guide the consumers' purchase acts and thus fundamentally inspire the producers' enthusiasm for carrying out traceability. On the other hand, the information platform should be fully utilized to improve the value of the information on production safety and promote the dovetailing of production and marketing so as to enhance the willingness of the implementation subjects to carry out traceability.

Acknowledgment The authors would like to thank industry experts for the fruitful and inspiring discussions on the topics of this paper. This work was partially supported by Bureau of Supervision and Administration for Agro-product Quality and Safety of the Ministry of Agriculture.

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Chapter 27
Text Segmentation Model Based LDA and Ontology for Question Answering in Agriculture

Depeng Hu, Wensheng Wang, Shuyu Liu, Nengfu Xie, and GuoWei Yin

Abstract Question answering system based on text collections has been one research focus in information technology. The significant problem for text collections was how to construct models for text and segmentations. An approach to building topic models based on a formal generative model of documents, Latent Dirichlet Allocation (LDA), is heavily cited in the machine learning literature, but its feasibility and effectiveness in information retrieval is mostly unknown. In this paper, we study how to efficiently use LDA to improve answer retrieval. We propose an LDA-based segmentation model within the language modelling framework, and evaluate it on text segmentation collections for agriculture cultivation. Gibbs sampling is employed to conduct approximate inference in LDA and the computational complexity is analyzed. The process of generating answers in agriculture cultivation question answering system (ACQA_onto) was presented. We demonstrate LDA's improved expressiveness over traditional QA system based information retrieval with visualizations of answers accurate.

Keywords Text segmentation • LDA • Domain ontology • Question answering system • Agriculture cultivation

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*, 307
DOI 10.1007/978-3-642-54389-0_27, © Springer-Verlag Berlin Heidelberg 2014

27.1 Introduction

Automated question answering (QA) has become an interesting research field since AI applications. In the classical question answering system, there need to construct knowledge database and rule corpora for reasoning. Computing power has strongly increased, and the general methodology has changed from use of hand-encoded knowledge bases about simple domain to the use of text collections as the main knowledge source over more complex domains (Question answering in restricted domains an overview). Today's knowledge databases have immensely benefited from many sophisticated information resources, such as web pages, blogs, scientific articles et al. Standard text mining and information retrieval techniques usually rely on word matching and do not take into account the similarity of words and structure of documents within the corpus. When working with large corpora of documents it is difficult to comprehend and process all the information contained in them. Building document models is a critical part of any approach to information processing. Typically, documents are represented as a "bag of words", meaning that the words are assumed to occur independently. However, if each word were seen as one feature of the document, the presentation of document was high-dimensional (Xing et al.). In data mining tasks such as classification, retrieval and extraction, it is often necessary to model the associated data from the originally high-dimensional features to appropriate lower dimensional latent representations. Numerous approaches for capturing low-dimensional latent representations are available, especially in the context of information retrieval. For example, latent semantic indexing (LSI) (Deerwester et al. 1990a) extends a linear transform of word counts into a latent representation space of document semantics. The probabilistic latent semantic indexing (pLSI) model (Hofmann 1999) extends the LSI idea with a generalization of the Expectation Maximization algorithm, the utilized model is able to deal with domain specific synonymy as well as with polysemous words. The mixture of unigrams model (Blei et al. 2003) is a special case of pLSI where each document is associated with only one topic. The latent Dirichlet allocation (LDA) model by Blei et al. offers a more expressive and generalizable text modeling scheme by associating with each document a unique latent topic mixing vector represented by a random point in a simplex. These approaches use a latent variable model that represents documents as mixtures of topics (Semi automatic construction of topic ontology).

An increasing number of recent information retrieval systems employ ontologies to help the users clarify their information needs and retrieve more accurate documents. O. Dridi (2008) presented An IR techniques based on ontologies. Stein L. Tomassen (2006) described how to adapt ontologies for understanding user's purposed and integrate ontologies with standard vector-space model. A model for the exploitation of ontology-based knowledge bases is presented in Castells et al. (2007). The aim of this model is to improve search over large document repositories. Salton et al. (1975) presented the model include an ontology-based scheme for the annotation of documents, and a retrieval model based on an adaptation of the classic vector-space model. While in Wu et al. (2007) Ontology is used to describe domain knowledge; logic reasoned and the frequency of terms are used to choose fitting expansion words. This way, higher recall and precision can be gotten as user's query results. In Diaz-Galiano et al. (2007) the authors present an approach to expand queries that consists in searching terms from the topic query in an ontology in order to add similar terms (Ye et al. 2007).

Recent research on QA has led to various algorithms for compiling relevant texts on topics such as people, organizations or events. Most of these approaches applied IR(information retrieval) or IE (information extract) techniques based on score word or sentence, and just extracted information about name entity of who, where, when, et al. (Blair-Goldensohn et al. 2004; Weischedel et al. 2004; Dang et al. 2007; Kaisser et al. 2006).

However, most answers of QA are not the phrases in a document or a few keywords but the relevant segments of document. So we proposed the text segmentation model for QA. The task text segmentation is approached from a topic modelling perspective. We introduce a new application of latent Dirichlet allocation topic model: to segment a text into semantically coherent segments. A major benefit of the proposed approach is that along with the segment boundaries, it outputs the topic distribution associated with each segment.

The agricultural domain is one of the most significant domains in need of automated QA that can aid farmers, extension workers and researchers in their information and knowledge need (From Web Resources to Agricultural Ontology a Method for Semi Automatic Construction; Hu et al. 2012) presented the restricted domain ontology models and concept level vector model of documents for agriculture cultivation question answering system. The induction of ontology raised automated question answering to a high level.

This paper is organized as follows. Section 27.2.1 gives a short overview of the related work on topic models. Section 27.2.2 gives an introduction to the text segmentation modeling methodology we used. Details about system architecture are presented in Sects. 27.3 and 27.4 presents the experiment results, followed by the conclusions in Sect. 27.5.

27.2 Background on Ontology

27.2.1 Latent Semantic Indexing (LSI)

Laudauer and Dumais proposed Latent Indexing (LSI) (Miao and Wei 2007; Deerwester et al. 1990b; Laudauer 1997; Yu et al. 2006), which was an adaptation of classical vector model. The basic thought is that there are some latent semantic structures between words in documents, so systems can discover latent semantic relations from the documents automatically and organize documents into semantic space structure by statistical analysis. The correlation of index and text can be computed through decomposing the measurement matrix in singular value decomposition (SVD) (Chang et al. 2007), and be organized into the same semantic space, which can be represented as a matrix $A = (a_{ij})_{t \times d}$, where $t \geq d$, and respectively represented the total number of indexes and texts. The row vector represents the number that different words appear in text, and column vector represents number of different document in sets, and a_{ij} represents the number that index i appear in document j.

The decomposition $A = U \sum V^T$ is called singular decomposition of matrix A. There exist orthogonal matrices U and V, and a diagonal matrix $\sum$. U is a t by t orthogonal matrix and V is a d by d orthogonal matrix, and columns of U (or V) are called left (or right) singular vectors of matrix A. Diagonal matrix $\sum$ is t by d matrix and the elements are $a_1, a_2, \cdots, a \min(t, d)$, iff $a_1 > a_2 > a_3 \cdots, a \min(t, d) > 0$, numbers $a_1, a_2, \cdots, a \min(t, d)$ are singular values of the matrix A. Let $\text{rank}(A) = r$, and there exists k where $k \leq r$ even $k \ll (t, d)$.

Definition 1. Let us have k, $0 < k < r$ and singular value decomposition of A:

$$A_k = U \sum V^T = (U_k U_0) \begin{pmatrix} \sum_k & 0 \\ 0 & \sum_0 \end{pmatrix} \begin{pmatrix} {V_k}^T \\ {V_0}^T \end{pmatrix} \tag{27.1}$$

We call $A = U_k \sum_k {V_k}^T$ a k-reduced singular value decomposition (rank-k SVD).

By computing SVD, we can get a k-reduced matrix consisting of k nonzero numbers. The matrix can express latent semantic relations the same as the ones in whole document, and eliminate noise effect phenomenon which caused by polysemy and synonymy. The value of k was experimentally determined to several tens or hundreds, but exact value of k is however a mystery, it is dependent on the number of topics in collection.

If every document contains only one topic (Papadimitriou et al. 1998), we obtain a latent semantics – semantically related terms will be close in concept space and will result in similar answer set when querying. This addresses the third of above mentioned problems. And since the first co-ordinates of D_k have the greatest influence on similarity, the clustering results are better. Experimentally was k determined to several tens or hundreds (e.g. 50–250), exact value of k is however a mystery; it is dependent on the number of topics in collection.

27.2.2 Latent Dirichlet Allocation (LDA)

Blei et al. (2003) introduced a new, semantically consistent topic model: Latent Dirichlet Allocation, which immediately attracted a considerable interest from the statistical machine learning and natural language processing communities.

Latent Dirichlet allocation is a widely-used topic model, often applied to textual data, and the basis for many variants. This paper gives the review of formalism of

LDA. In statistical language processing, one common way of modeling the contribution of different topics to a document is to treat each topic as a probability distribution over words, viewing a document as a probability mixture of these topics (Ueda and Saito 2003). If there are T topics, the probability of ith word in a document as

$$p(w_i) = \sum_{j=1}^{T} p\left(w_i \middle| z_i = j\right) p(z_i = j), \tag{27.2}$$

Where z_i is a latent variable indicating the topic from which the ith word was drawn and $p(w_i|z_i = j)$ is the probability of the word w_i under the jth topic. $p(z_i = j)$ gives the probability of choosing a word from topics j in the current document, which will vary across different documents.

Figure 27.1a shows the graphical model corresponding to the LDA generative model. To generate a new word w in a document, one starts by first sampling a hidden topic z from a multinomial distribution defined by a vector θ corresponding to that document. Given the topic z, the distribution over words is multinomial with parameters ϕ_z. The LDA model ties parameters between different documents by drawing θ of all documents from a common Dirichlet prior parameterized by α. It also ties parameters between topics by drawing the vector ϕ_z of all topics from a common Dirichlet prior parameterized by β. In order to make the independence assumptions in LDA more explicit, Fig. 27.11b shows an alternative graphical model for the same generative process. Here, we have explicitly denoted the hidden topics z_i and the observed words w_i as separate nodes in the graphs (rather than summarizing them with a plate). From Fig. 27.1b it is evident that conditioned on θ and ϕ, the hidden topics are independent (Hidden Topic Markov Models).

The topics discovered by LDA capture correlations among words, but LDA does not explicitly model correlations among topics. This limitation arises because the topic proportions in each document are sampled from a single Dirichlet distribution. The Graphical model representation of LDA is presented in a and b two different methods, while the complete generative process is presented in Fig. 27.2.

27.2.3 Gibbs Sampling

Latent Dirichlet allocation is a relatively simple model. There have been suggested several alternatives for approximate inference: Estimate Maximize (EM) or variational EM, Expectation propagation (EP) (Semi automatic construction of topic ontology; Dridi 2008; Tomassen 2006; Castells et al. 2007; Salton et al. 1975) and Gibbs sampling (Griths 2002; Griths and Steyvers 2004; Pritchard et al. 2000). Gibbs sampling is a special case of Markov-chain Monte Carlo (MCMC) simulation (MacKay 2003; Liu 2001) and often yields relatively simple algorithms for approximate inference in high-dimensional models such as LDA. This approach

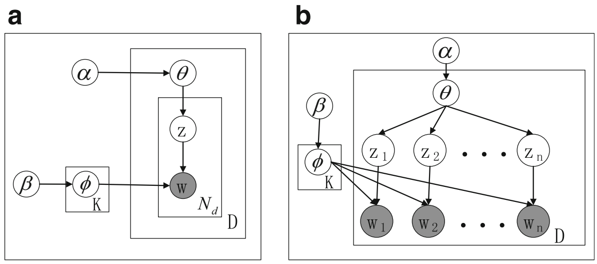

Fig. 27.1 (**a**) Graphical model representation of LDA. The *boxes* are "plates" representing replicates. The outer plate represents documents, while the inner plate represents the repeated choice of topics and words within a document. (**b**) The repeated word generation within the document is explicitly drawn rather than using the plate notation

//topic plate
For all topics $t \in [1,T]$ do
  Sample mixture components
//document plate
For all document $d \in [1,D]$ do
  Sample mixture proportion $\theta_d \sim Dir(a)$
  Sample document length $N_d \sim Poiss(\xi)$
  //word plate
  For all words $n \in [1,N_d]$ in document d do
    Sample topic index $z_{d,n} \sim Mult(\theta_d)$
    Sample term for word
$w_{d,n} \sim Mult(\phi_{z_{d,n}})$

Fig. 27.2 Generative model for latent Dirichlet allocation

was selected and present a derivation that is more detailed than the original one by Griffths and Steyvers (Griths 2002; Griths and Steyvers 2004).

[B]The strategy for discovering topics differs from previous approaches in not explicitly representing θ or ϕ as parameters to be estimated, but instead considering the posterior distribution over the assignments of words to topics, $p(z|w)$. We then obtain estimates of θ and ϕ by examining this posterior distribution.

Evaluating $p(z|w)$ requires solving a problem that has been studied in detail in Bayesian statistics and statistical physics, computing a probability distribution over a large discrete state space. A Monte Carlo procedure was employed for this problem, resulting in an algorithm that is easy to implement, requires little memory, and is competitive in speed and performance with existing algorithms.

Table 27.1 The probability model for LDA

$w_i \mid z_i, \phi^{(z_i)} \sim \text{Discrete}(\phi^{(z_i)})$
$\phi \sim \text{Discrete}(\beta)$
$z_i \mid \theta^{(d_i)} \sim \text{Discrete}\ (\theta^{(d_i)})$
$\theta \sim \text{Discrete}(\alpha)$

The probability model for Latent Dirichlet Allocation was addressed, with the addition of a Dirichlet prior on ϕ. The complete probability model is show in Table 27.1.

α and β are hyperparameters, specifying the nature of the priors on θ and ϕ. In this article we assume symmetric Dirichlet priors, with α and β each having a single value. These priors are conjugate to the multinomial distributions θ and ϕ, allowing us to compute the joint distribution $p(w, z)$ by integrating out θ and ϕ. Because $p(w, z) = p(w|z)p(z)$ and θ and ϕ only appear in the first and second terms, respectively, we can perform these integrals separately. Integrating out ϕ gives the first term

$$p(w|z) = \left(\frac{\Gamma(w\beta)}{\Gamma(\beta)^w}\right)^T \prod_{j=1}^{T} \frac{\prod_w \Gamma(n_j^w + \beta)}{\Gamma(n_j^w + w\beta)}, \tag{27.3}$$

in which n_j^w is the number of times word w has been assigned to topic j in the vector of assignments $\mathbf{z}$, and $\Gamma(\cdot)$ is the standard gamma function. The second term results from integrating out θ, to give

$$p(z) = \left(\frac{\Gamma(T\alpha)}{\Gamma(\alpha)^T}\right)^D \prod_{d=1}^{D} \frac{\prod_j \Gamma(n_j^d + \alpha)}{\Gamma(n_j^d + T\alpha)}, \tag{27.4}$$

where n_j^d is the number of times a word from document d has been assigned to topic j. Our goal is then to evaluate the posterior distribution.

$$p(z|w) = \frac{p(w, z)}{\sum_z p(w, z)}, \tag{27.5}$$

Consequently, we apply a method that physicists and statisticians have developed for dealing with these problems, sampling from the target distribution by using Markov chain Monte Carlo. In Markov chain Monte Carlo, a Markov chain is constructed to converge to the target distribution, and samples are then taken from that Markov chain (Liu 2001; Gilks et al. 1996). Each state of the chain is an assignment of values to the variables being sampled, in this case $\mathbf{z}$, and transitions between states follow a simple rule. We use Gibbs sampling (Liu 2001), known as the heat bath algorithm in statistical physics (Geman and Geman 1984), where the next state is reached by sequentially sampling all variables from their distribution when conditioned on the current values of all other variables and the data. To apply this algorithm we need the full conditional distribution $p(z_i|z_{-i}, w)$. This distribution can be obtained by a probabilistic argument or by cancellation of terms in Eqs. 27.3 and 27.4, yielding

$$p(z_i = j | z_{-i}, w) = \frac{\frac{n_{-i,j}^{(w_i)} + \beta}{n_{-i,j}^{(\cdot)} + w\beta} \bullet \frac{n_{-i,j}^{(d_i)} + \alpha}{n_{-i,\cdot}^{(d_i)} + T\alpha}}{\sum_{j=1}^{T} \frac{n_{-i,j}^{(w_i)} + \beta}{n_{-i,j}^{(\cdot)} + w\beta} \bullet \frac{n_{-i,j}^{(d_i)} + \alpha}{n_{-i,\cdot}^{(d_i)} + T\alpha}} \tag{27.6}$$

where $n_{-i,j}^{(\cdot)}$ is a count that does not include the current assignment of z_j. This result is quite intuitive; the first ratio expresses the probability of w_i under topic j, and the second ratio expresses the probability of topic j in document d_j. Critically, these counts are the only information necessary for computing the full conditional distribution, allowing the algorithm to be implemented efficiently by caching the relatively small set of nonzero counts.

With a set of samples from the posterior distribution $p(z|w)$, statistics that are independent of the content of individual topics can be computed by integrating across the full set of samples. For any single sample we can estimate θ and ϕ from the value **z** by

$$\hat{\phi}_j^{(w)} = \frac{n_j^{(w)} + \beta}{n_j^{(\cdot)} + w\beta} \tag{27.7}$$

$$\hat{\theta}_j^{(d)} = \frac{n_j^{(d)} + \beta}{n_{\cdot}^{(d)} + w\beta} \tag{27.8}$$

27.3 Segmentation Algorithms

The representation for documents was bag-of-word for traditional QA system. Depeng et al. (Hu et al. 2012) presented the new model for a document was built conceptual vectors for paragraphs. In this paper we divided documents into segments semantically which were similar to the conceptual vectors, but segments were more suitable for semantic analysis.

Figure 27.3 presented the architecture of QA system based on ontology which approached segmentation algorithms for answers extracting. There were three main modules in the architecture. In the question analysis module, three pieces of information were extracted by linguistic analysis: domain feature words (FWs), a question type, and an answer type (AT). Domain feature words were extracted with the Hidden Markov Model (HMM) algorithm. The second part was information retrieval module based on ontology which algorithm was originated from conceptual vectors at (Hu et al. 2012). The approach of using ontology for information retrieval made the retrieval accuracy more efficient. Segmentation algorithms were used for the answer extraction module.

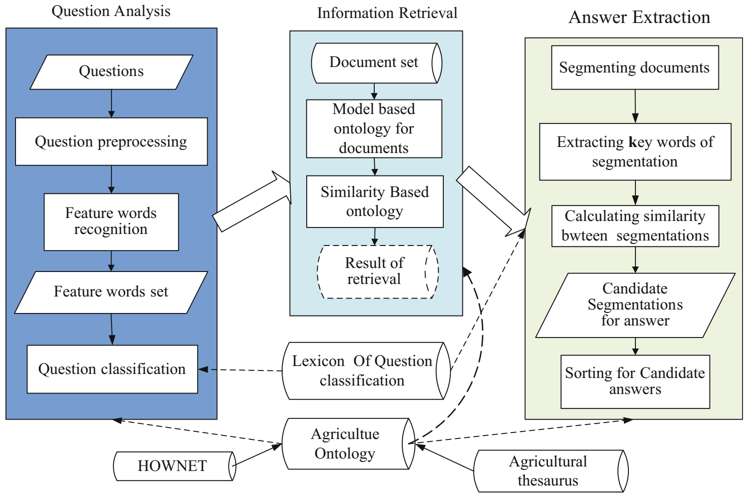

Fig. 27.3 The architecture of QA system based on ontology

There were four sub-processes in the answer extraction module was presented in Fig. 27.3.

The first algorithm was segmenting documents, following was the steps of this algorithm:

Step 1: Running Gibbs sampling algorithm for corpus vocabulary with iterative enough e times.
Step 2: Running Gibbs sampling algorithm based on sentences according the formula (6), traversing all words in the text to be segmented, iterative a few times.
Step 3: Calculating values of θ and ϕ according to formula (27.7) and (27.8).
Step 4: Calculating the probability distribution of the segments $p(w/s$, according to the formula $p(w|s) = \sum_{j=1}^{T} \phi_w^{(z=j)} \bullet \psi_{z=j}^{s}$.
Step 5: Based on $p(w|s)$, calculating the similarity between sentences with Clarity metric.
Step 6: Combining local minimum boundary estimation strategy, through similarity between the sentence fragments recognize borders.

The second sub-process was the extracting key words from segmentations. Text was segmented into several segments $t_1, t_2, \ldots\ldots, t_h$. when a new segment $t_k(1 \le k \le h)$ was added to the domain corpus, Gibbs sampling algorithm should be run on each segment in order to obtain segment $t_k(1 \le k \le h)$ vocabulary probability distribution, according to the formula $p(w|t_k) = \sum_{j=1}^{T} \phi_w^{(z=j)(z=j)} \bullet \psi_{z=j}^{t_k}$.

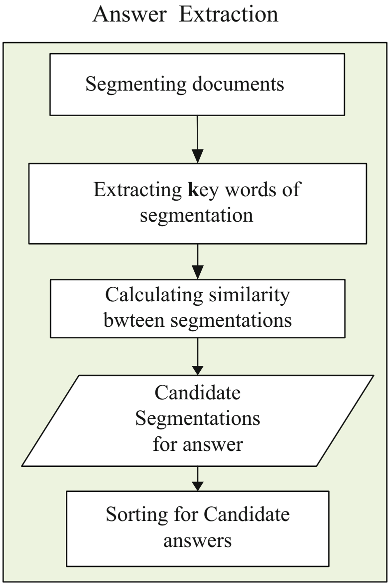

Fig. 27.4 The process of answer exaction with segments

The define of Shannon information of the segment $t_k(1 \le k \le h)$ was based the probability distribution of word w in segment $t_k(1 \le k \le h)$:

$$I(w) = -N(w)InP\left(w \middle| t_k\right), 1 \le k \le h \qquad (27.9)$$

Where, N (w) is the frequency of word w in segment $t_k(1 \le k \le h)$, if I(w) was bigger, the word w more important for the segment tk. The Shannon information of each word was calculated and select the first n words with largest I(w) of each segment, which forms the keywords string of each segment and represented the segment theme $TM_i = \{w_1, \cdots, w_F\}$. These keywords improved the accuracy of extracting answers (Fig. 27.4).

The third sub-process was calculating the similarity between questions and segmentations. Calculating the similarity between each feature words of question $Q = \{w_1, \cdots, w_k\}$ and each keyword on every segment $TM_i = \{w_1, \cdots, w_F\}$, the feature words of question came from questions analysis. Then summate the similarity of feature words for every segment, and choose the first s segments with highest similarity as the answer extraction results.

The last process was sorting the candidate answers by their similarities.

Fig. 27.5 The results of answer extracting with similarity between segmentation and question

27.4 Experiments Results and Analysis

The corpus in Chinese for agriculture cultivation question answering system consists of 630 files. In the experiments, we used the first 490 files as training data, and the other 140 files as testing data. In the training data, we used sizes of labelled sentences: 65,839 sentences. The other sentences (1,778) were used as unlabeled data for semi-supervised learning methods.

In the experiments, we applied the concepts of domain ontology in agriculture as topics for LDA in training. The similarity between segmentation and question computed with vector space model.

Figure 27.5 showed the results of answer extracting with the approach LDA, the answers were segmentations of the texts. The similarity based ontology between segmentation and question were computed and listed followed the segmentations.

The similarity highest five segmentations were presented as the results for questions.

27.5 Future Works

This study was developed under strict constrains. The corn cultivation ontology which based on Agriculture Thesaurus was built by experts of CAAS. Future work is encourage which would build ontology through unsupervised text mining and information extraction (IE). The ACQA_onto system has only a few thousands of question answer pairs now, with the increasing of documents at repository with time, future work could employ stochastic process, such as Hidden Markov Model

(HMM) to develop more accurate answer extracting model. In the domain of agriculture cultivation, there are more question types than just factoid questions. How and why question types are common, such as "how to control the Cnaphalocrosis medinalis Guenee?" Future work could concentrate on the approach for providing answers to complex queries, such as how and why question types.

Acknowledgements This paper is the sub item of key Technologies for Agricultural Field Information Comprehensive Sensing and Rural extension (Item No.: 2011BAD21B01) of National Science and Technology Support Program.

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Chapter 28
Research on Search Technology of Agricultural Information Based on Geographical Perception

Jian Wang, Yuchun Pan, and Bingbo Gao

Abstract Aiming at the problem of the traditional agricultural search engineer based on agricultural topics having limited for geographical perception during searching, technologies of position index and the location query for building prototype searching system of agricultural information based on geographical perception are presented. We analysis search engine system structure, key technologies, data structure and build a prototype searching system of agricultural information based on geographical perception by using existing key technologies such as carve word and search technology, search technology based on geographical names and gazetteers. The system we have built achieves more satisfactory results.

Keywords Information retrieval • Query expansion • Geographical perception • Geographical retrieval

28.1 Introduction

With the development of computer and Internet technology, agricultural information resources on the network have been greatly enriched (Duping 2010). With these vast amounts of information resources, farmers and agricultural workers urgently needed to find agricultural knowledge resources and information quickly and efficiently which is timeliness and appropriate to their specialization. Under these circumstances, vertical search technology research and application for agricultural information was widely carried out in china and foreign. However, since agricultural information had strong geographic elements, agricultural information

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_28,

in the user's area was very important to him for searching, which determined the importance for processing of temporal and spatial elements during the process of searching agricultural information. If a search engine lacked the support of the location (region) filter, it would certainly affect the validity of the search results and experience of users.

Development for the research on the technology of information search (especially in cognitive information search) provided a new approach to break through the technical difficulties in the temporal and spatial perception (Li Zhisheng 2009). In China, a lot of research and application for the place names search were carried out and made many research achievements in area of gazetteers data structures, the segmentation for search information that user inputted, search keywords and the geographical name library matching, distributed dynamic search and so on (Ye Mi and Zhegn Cheng 2010). However, objects of these studies were information with evident geography. The method of mining region information from WebPages which implied location information was lack of studies (Winters 1999). On the other hand, through less research for search technology on spatial and temporal elements, there were some progress and gradually formed a certain degree of consensus on the technology on more efficient research paradigms in search area based on the information behavior of information seekers and releasers from cognitive point. The exploratory research for these technologies was carried out in the project of GIR (Geographic information retrieval) in EU Sixth Framework (Yu Wei et al. 2006). From the point of field development, to solve the space-time perception technical difficulties in the scenarios of information search in network already had a certain condition. This project gradually became one of important directions of technology development for the information search in network (Liuyu and Zhangjing 2007).

The technology of perception and handling for temporal and spatial elements which involved the complexity and multi-disciplinary research topics, such as human spatial cognition, intelligent information processing for vast amounts of information, intelligence and information science, had been one of difficulties for information search technology in network (Li Lihong and Li Hanrong 1995). How to effective access to geographical constraints that inherent in the need of users and accurately express geographical connotations of the various types of information objections was the key issue of temporal and spatial perception which would achieve optimal matching for needs and information of users (Zhangdong 2011). So in this passage, we tried to breakthrough some difficulties, such as constraints access and expression for temporal and spatial elements and provided key technologies and prototype systems based on geographical perception which could achieve higher recall rate, more query efficiency and better user experience.

28.2 Materials and Methods

28.2.1 The Subjects

"Agricultural Search" (http://www.sdd.net.cn) was a well-know agriculture search engine in China which achieved a vertical search for agricultural information resources. "Agricultural Search" was a useful tool that could provide information of agriculture science and market for enterprises, departments and farmers. The topics of "Agricultural Search" included the main aspects of the field of agriculture such as planting, breeding, agricultural, market, business, personnel, policy, management. "Agricultural Search" was developed based on lucene engine. It included four function modules (web crawler system, full-text analysis indexer, full text search and customer service) and three data storage management modules (site list, document library of agricultural information and full-text indexing library). However, "Agricultural Search" only achieved content search according to the agricultural theme and could not search geographical information that Involved in contents. In this passage, we made "Agricultural Search" as object and explored how to add the location search function to search engines, which could make "Agricultural Search" as a prototype system with geographical perception. This research would be of great significance for the future and development of agricultural search engine.

28.2.2 The Overall Program

Through the analysis of the content and data structure of document database, place names appearing in the document content can be described as the basis for judging the location (regional) information that involved in the content of document. This would mean that place name which appearing in the document most should be the place where the event described in the document taken place. Meanwhile the title of the document and he source could also serve as basis for determining the position for content of the document. We could do word segmentation for location in the title and contents of documents by using gazetteer that was established with location and create a new inverted sort index. Through this method, region index of documents was built. At the same time, the gazetteer created above could be used in full-text search engine to analyze the constraints derived place names in the user's search and build the location (region) query which would search in full-text indexing library containing the subject index and the location index. The result that met other constraints and the location in the content which would consistent with the user specified could be returned to the user.

28.2.3 Key Technologies

The character of technology of agricultural information based on geographical perception was essentially within paradigm of cognitive information search. The main process of this technology was describing cognitive experiments as the primary means of time and space constraints which found in the user's information needs and making Cognitive systems engineering and framework for knowledge representation as a means for expressing the spatial and temporal elements of agricultural information that exited in text. During this process, two key technologies were involved: the technology for location index designing and the technique for location query building.

28.2.3.1 Location Index Designing

In this passage, we applied the technology of location segmentation for judging position (area) information implied in documents. We used method of dictionary word segmentation to title, content and source of the record in the "info" table which exited in the text library of agricultural information. In order to reduce the simple matching error, the method of word segmentation was combination of a maximum matching and maximum segmentation which could cut out maximum number of words from each sentence. During the process of segmentation, the vocabulary with obvious features in input strings was identified and separated firstly. Using these terms as the interval point, we cut the original input string into smaller strings and segmented them with dictionary. The result for segmentation was matched with the gazetteer term. When this matching succeeded, the name of location was inputted and built inverted sort index with this name. There were three fields in location index: title, content and source which indicated title columns, the contents columns and source columns of the index.

As "Agricultural Search" ran with Lucene, the position index was built based on the Lucene score formula. The Lucene score formula was shown in formula 28.1 in which tf (tind) expressed the frequency of key words in the document. When the number of keyword for geographical names that appear in the document was more, the score was more. On the other side, t.getBoost() was a search weighting factor which could set different weights to some fields in the query. In this way, the domain that was more relevant to the theme had a higher weight.

$$\begin{aligned}\mathrm{Score}(q,d) &= \mathrm{coord}(q,d) * \mathrm{queryNorm}(q) \\ &\quad * \sum\nolimits_{t\ \mathrm{in}\ q}\Big(\mathrm{tf}(t\ \mathrm{in}\ d) * \mathrm{idf}(t)^2 * t.\mathrm{getBoost}() * \mathrm{norm}(td)\Big) \qquad (28.1)\end{aligned}$$

After analyze a lot of documentation of agricultural information that had been crawled, we could find that geographical names would generally describe the location of the incident (regional) when the title of a document included geographical names. It indicated that the title of documents would be an important source for position that implied in the document. So we established a separate domain for the title and set a higher Boost for title during the process of query. It denoted that when documents with the same situations, the one which title contained the place name of users' searching had higher score.

In practical application process, there could be two or more geographical names in the content of a document. For example, in one document named "the stage supply short, corn prices in ShanDong raised again." It said that "as the local grain resources had ran out and imported food from Heibei and Heinan had not been available, the corn supply in Shandong became shortage and corporate had difficult for purchase corn." From this document, we could find that although the document mentioned Hebei and Henan, conditions of short supply and prices rising for corn in Shandong were main topic of this document. This signified that the document was more relevant to Shandong. After investigating the content of document in the agricultural information library, we could find that the position names that the event occurred (topic geographical names) were described repeatedly in the most documents of the library which number was 3–5 times more than that of other position names (non-topic geographical names). Thus, the score of topic geographical names through Lucene assessment mechanism was higher than that of non-topic geographical names. As documents user search for sorted according to score, the document with topic geographical names which users inputted would be more forward in the search result list.

For some document which included some special position names such as "our city", "our county", "our province" and titles would not include geographical names, sources of these documents were also stored as a field for searching position names. As the field of document source also contained the information of location, we made word segmentation and indexing with them and set low Boost value for these fields during the process of search.

As every document in "Agricultural Search" was stored as a record in database, the value of each record property, Info_ID, was also written to the index to identify each document. This value was only used as an identifier and did not participate in the word segmentation. On the other hand, the value of "Info_ID" property was not unique, so this value combined with the source and the title of document could be identified a record. This could mean that the source and the title of document should be written to index as a basis for extracting the content when searching. This rule for writing index was a necessary condition for users to determine whether to extract the full content of a document when getting search result. On the side of efficiency, as source and title, two properties of a document, were very short strings, the memory for storing these property values in index would not be too much. When reading them from the index, time-consuming would be much shorter than that of reading from database.

28.2.3.2 Location Query Building

As the position index building alone in full text index library, we could construct topic queries and position queries independently when set up query. In general, there were two methods for building position queries: one was for the query interface that had not specific location in user service, the other was for the query interface that had not specific location (University Consortium for Geographic Information Science 2006). For the former, we should analysis the search statement inputted by the user which included topic and location. For the latter, we should analysis statement of the geographical location (region) which provided by users. During the actual operation, we made word segmentation with the search statement based on position names and obtained some keywords for geographical names. With these keywords, we could construct query statements for tile, content and source and set different weights for different fields through Qury.setBoost (float) which could change the proportion of the different domains in the total score. It indicated that the weight of topic domain was highest, that of content domain was second and the weight of source domain was lowest.

In general, location (region) had the characteristics of multi-level which signified that low-level areas would belong to high-level regional. For example, as Lishui and Gaochun belonging to Nanjing city, there were two conditions for searching “Nanjing”, one was for information of Nanjing urban district; the other was for information of Nanjing’s town and village. To solve this problem, advanced query interface was set up for user make a choice. For the first condition, we could construct the location query in accordance with the process mentioned above. For the other condition, we could build geographical name ontology which would deduct position keywords to get the low-level position names affiliated the region. With these locations, we built extended location query for multi-level regional search.

28.3 Experiments and Analysis

In order to test the rationality of the program, we achieved this scheme by programming based on Lucene and information document library of “Agricultural Search” and test the accuracy of the scheme according to the search results.

We first built position name dictionary for setting up location index. This position name dictionary included national administrative units at all levels (such as the name of the provincial, city, county, township and village), the common district (such as Northeast, North China, Yangtze River Delta region and so on) and countries in the world. As there were few using for abbreviated form of provinces and regions (such as Shan, Gan) in crawled documents, these words would be not included in the position name dictionary that had been built above. On the other hand, due to limitless for Chinese word segmentation supported by the default parser of Lucene, analysis. Analyzer class of Lucene was extended for word segmentation with the position name dictionary and methods of the maximum matching and segmentation designed by "Agricultural Search". In addition, as some new webpage were clawed by "Agricultural Search", we changed the method of index written to index updating for increasing new documents index to index library.

During the process of building location inquiry, the first stage was making word segmentation for search word that users inputted using analyzer of Chinese place names mentioned above. Then query statements were built with results of word segmentation using query class that provided by Lucene. In order to realize queries based on multi-level areas, the geographical name ontology was built automatically according to RDF syntax, ontology properties and affiliation of the various position names. Then the inference engine of geographical Names was designed based on Jena's API and embedded into query module of "Agricultural Search". When the position name that users required was low level on geographical names, it should be deducted by inference engine and the deductive result would be added into search keywords for building query statements.

When the scheme test platform was achieved, we built position index with information library of "Agricultural Search" and made query tests with it. The result that was showed in Table 28.1 indicated that the accuracy of location search could be more than 80 %. From the Table 28.1 which was the retrieved result for "HongShan" as a search term we could find that the tenth record of it was "The Hongshan red flower stalk listed" which refers to prices and sales of the red flower stalk in supermarkets of Wuhan. The record's to topic was Wuhan and not Hongshan and then this record was a wrong query result. Apart from this record, others records' topics were about "Hongshan" and precision rate was 96 %. In addition, we also used "Jiangsu" as keyword for searching and got 4,758 records among which the topic of more than 85 % were about "Jiangsu".

On the other hand, through we made some preliminary progress on search technology of agricultural information based on geographical perception, there were still some insufficient for this search engine which were embodied as follows:

1. Documents that didn't include location information would not make word segmentation with Chinese geographical names and could not be built index with the method in this passage automatically. For example, a document named "Milk trap door doomed no winners" which corresponded to China didn't contain any location about a region of China. So this document could not be processed by search engineer of this passage. How to resolve this problem was needed the further research.
2. In China, some different places had the same name. For example, there were city named Xian in Shanxi province while the name of town in Haiyuan county of Ningxia province was also Xian. When we use Xian as keyword for searching, results were included documents of both Xian city and Xian town.

Table 28.1 The first ten retrieved results for "HongShan"

SN	ID	Title	Score
1.	201106280053000738	Star Agriculture Co., Ltd of Hubei	0.6875548
2.	201106300093000515	The "greased Beauty" Rice appeared in River City	0.60148513
3.	201106280183000763	The work for choosing the 2011 autumn dominant species	0.5893327
4.	201106290193000572	Vigorously promote quality upgrading works to promote the development of ways	0.5893327
5.	201106300323000843	Investment for participate in the Fair of 2010 high quality rice in China (Wuhan)	0.49111056
6.	201106300253000276	Rebar that fallen from the high pierced the worker's back	0.48617464
7.	201106280323000911	Men brought the problem food for rights claims to earn more than 10 million 1 year	0.41672114
8.	201106290093000795	Looking forward to "Time Lock" for food sales	0.41672114
9.	201106300353000907	Why various barriers cannot stop the expired food in the large supermarket	0.41672114
10.	201106300353100082	The Hongshan red flower stalk listed	0.41672114

3. When searching in documents which contained words similar to the position names, some wrong records would be gotten. For example, Hongshan chicken which was a local brand, Taiwan green, English sheepdog and so on.

So there would be more research and work needed for building a better search platform based on geographical perception.

28.4 Conclusions and Discussions

The aim of this study was exploring the search technology of agricultural information based on geographical perception and the method for adding the technology into "Agricultural Search". In order to achieve this aim, we analyzed system structure, key technology and data structures of "Agricultural Search" and found the problem to be solved. Then some key technologies that were existed such as the Chinese word segmentation, search technology of geographical names and location dictionary were use for reference. At last, we presented a method location index and the position query that were independent for search with the agricultural theme and achieved the location (region) retrieve. Test results showed that precision ratio of location search using the method of this passage was above 80 % and this result was pleased.

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Chapter 29
Temporal Changes and the Influencing Factor of China Importing Genetic Resources of Livestock and Poultry

Fang Liu, Huaping Long, Yuze Yang, and Zhongwei He

Abstract Based on 31 provinces' panel data of the imported animal genetic resources from 1996 to 2010, this paper intends to achieve two goals. The first one is to examine the temporal changes and trends of China's genetic resources import since 1996. As a whole, the import of animal genetic resources shows a clearly rising trend but the import fluctuation of different breeds varies in different extent. The other goal is to determine the factors that have contributed to the above changes. An ANCOVA model is built and the result shows that domestic consumption demand, technological progress and supportive policy contribute to the import expansion of livestock and poultry. While the live animal supply from breeding farms has a statistically negative impact on the livestock and poultry import. Therefore, through the increasing supply of livestock and poultry from breeding farms, China can have less reliance on or even get rid of the imported breeds during the development of animal husbandry in the future.

Keywords Livestock and poultry • Genetic resources • Temporal changes • Animal husbandry

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Supported by National Natural Science Foundation of China "An Empirical Analysis on the impact of Import Animal Genetic Resources on China's Livestock Economy" (71073011), "Beijing Innovation Team of Technology System in Dairy Industry" and Program for New Century Excellent Talents in University (NCET-10-009).

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S. Xu (ed.), *Proceedings of 2013 World Agricultural Outlook Conference*,
DOI 10.1007/978-3-642-54389-0_29, © Springer-Verlag Berlin Heidelberg 2014

29.1 Introduction

Genetic Resources of livestock and poultry refers to livestock and poultry as well as their genetic materials such as germ cells (eggs), embryos, semen and other gene substance. Before the Opium War in 1840, China was a self-sufficient agricultural country and closed its door to international market for a long time. Since 1840, China's door was opened by British cannon and several breeds of livestock and poultry were introduced into China from different countries from then on. In the early period of the twentieth century, some intelligent Chinese began to feed several varieties of livestock and poultry imported from other countries. The import situation of animal genetic resources changes from "passive introduction" to "initiative import". The imported genetic resources have been playing an important role in enriching China's livestock and poultry resources, breeding new livestock and poultry breeds, and improving the production performance of domestic livestock and poultry.

It goes without saying that genetic resources of livestock and poultry are important to the development of animal husbandry. Hence, many experts around the world have launched researches on the protection and utilization of genetic resources of livestock and poultry. Since 1970, 40 % of livestock and poultry breeds have been disappeared. (Lawrence Alderson 1978). Livestock and poultry breeds are disappearing at the speed of three breeds vanished in 2 weeks, and the most rapidly disappearing animal are horse, bovine and swine (Scherf 2000). Within avian breeds globally, 30 % are at risk and 9 % are extinct. The proportion of breeds at risk and extinct is highest in chickens (Hoffmann 2009). At the beginning of twenty-first century, domestic experts noticed that the population of many livestock and poultry suffered a drop in various degrees and some breeds even had been extinct. From then on, they began to focus on the protection and utilization of livestock and poultry. Two hundred thirty one breeds of livestock and poultry in China were investigated based on the threatening assessment system. The result showed that: 16 breeds were under severe threat; 9 breeds under threat, 17 breeds under minor threat; 57 breeds under potential threat; 132 breeds safe (Yuehui Ma et al. 2001). Although the protection of genetic resources got much attention in recent years, genetic resources of livestock and poultry are still disappearing fast in China (Ruibiao Li et al. 2002). Over the past 20 years, indigenous breeds which lack of high productive capacity were gradually replaced by several imported breeds and hybrid breeds. In addition, due to the difficulty in genetic resources protection and some ineffective protection, the number of indigenous breeds in China is declining day by day (Jiangtao Ou 2005). Through the survey of genetic resources of livestock and poultry in 17 provinces of China, results showed that: the population of 138 indigenous breeds increased; 3 breeds remained the same; 147 breeds decreased. Among the declining breeds, 7 breeds had been extinct, 9 breeds endangered and 50 breeds in imminent danger (Yuehui Ma et al. 2005).

From the above studies, we see that experts around the world have researched and got many achievements on the protection and utilization of genetic resources of livestock and poultry. Some experts focused on the worldwide genetic resources and some other experts are more interested in domestic genetic resources. The population, distribution and threatening degree of indigenous breeds are under continuous attention and dynamic research in China. This article is going to achieve two goals. The first one is to find the temporal changes of the imported genetic resource of livestock and poultry in China. The other one is to determine the factors that have contributed to the above changes. We sincerely hope that this article can provide helpful views and attract more experts to research the impact of imported animal genetic resources on China's animal husbandry development.

The rest of this paper is organized as follows. The next section describes the data and then examines the import trends of genetic resources of livestock and poultry since 1996. Taking the swine import as an example, Sect. 29.3 presents the empirical framework for analyzing the factors contributing to the trends. Results are also presented in Sect. 29.3, and conclusions and implications are drawn in Sect. 29.4.

29.2 Data

29.2.1 Data Sources

The data in this section comes from *China's Custom Statistics Yearbook*. We choose the heads of livestock and poultry to reflect the live animal import and the weight to reflect semen and embryo import (Table 29.1).

29.2.2 Data Process

With the statistic software EVIEW 7.0, we process the data in the above table. From Table 29.2, we find that the import of bovine fluctuates strongest (std. deviation = 3.85). And chicken is relatively stable compared with other live animal import (std. deviation = 0.46).

29.2.3 Data Analysis

29.2.3.1 Analysis on Swine Import over Time

From Table 29.1, we can see a clearly rising trend in China's swine import. China imported over 23,000 swine during the 11th Five-year period (2006–2010). However, the total quantity of imported swine is only about 18,000 over the past

Table 29.1 Imported genetic resources of livestock and poultry in 1996–2010

Year	Swine/ thousand heads	Bovine/ 10,000 heads	Sheep goat/ thousand heads	Chicken/ million heads	Bovine semen/ ton	Other animal semen/ton	Animal embryo/ ton
1996	1.134	0.048	0	1.127	0.035	0.001	0
1997	1.342	0.034	0.604	0.993	0.017	0	0.037
1998	1.767	0.165	1.868	0.647	0.095	0	0.024
1999	1.815	0.01	2.317	0.735	0.016	0.045	0.215
2000	3.364	0.058	2.713	0.983	0.064	0	0.025
2001	1.256	0.278	1.467	0.726	0.167	0.041	0.338
2002	1.163	1.143	4.173	0.989	0.366	0.761	0.63
2003	1.797	5.001	10.487	1.195	0.337	0.002	4.046
2004	1.898	13.244	2.78	0.953	0	0.26	0.411
2005	3.238	4.959	1.813	1.266	0.323	0.02	0.159
2006	2.489	1.507	0.157	0.966	1.857	0.065	0.185
2007	2.414	1.474	0.062	1.294	1.189	0.071	0.092
2008	11.613	1.508	0	1.944	1.811	0.029	0.074
2009	2.833	3.745	0.012	2.008	2.106	0.128	0.092
2010	4.053	8.799	1.279	2.092	4.405	0.549	1.763

Sources: China's Custom Statistics Yearbook

Note: The weight of chicken $\leq$185 g

Table 29.2 Descriptive statistics of the imported genetic resources

	Minimum	Maximum	Mean		Std. Deviation	Variance
Genetic Resource	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Swine	1.13	11.61	2.8117	0.66839	2.58865	6.701
Bovine	0.01	13.24	2.7982	0.99317	3.84651	14.796
Sheep and goat	0.00	10.49	1.9821	0.68963	2.67092	7.134
Chicken	0.65	2.09	1.1945	0.11986	0.46423	0.216
Bovine semen	0.00	4.41	0.8525	0.31977	1.23848	1.534
Other animal's semen	0.00	0.76	0.1315	0.05853	0.22670	0.051
Animal embryo	0.00	4.05	0.5394	0.27538	1.06653	1.137

Sources: Table 29.1

10 years (1996–2005). It's worth noting that China created a historical peak of swine import in 2008. Due to the H1N1 flu in 2009, Ministry of Agriculture of P.R. C suspended imports of swine from USA, Canada and Mexico. Swine import fell dramatically to nearly 3,000 in 2009. But the import of swine rebounded soon in the next years.

29.2.3.2 Analysis on Bovine Import over Time

Imported bovines include dairy cattle, beef cattle and few buffaloes. Dairy cattle account for the majority of imported bovines as China usually import the semen and embryo of beef cattle. Before the year of 2000, China imported a very small number of bovines each year. With the rapid development of dairy industry, China needs more dairy cattle to meet the domestic demand for dairy product. Therefore, the dairy cattle import turned up two round of climax in 2004 and 2012 respectively. Annual import of dairy cattle amounted to about 130,000 in 2004. According to the data from China's custom agency, China imported 100,000 heifers in the year of 2011 and imported more in 2012.

29.2.3.3 Analysis on Sheep and Goat Import over Time

From 1996 to 2010, the varying curve of sheep and goat import appeared one single peak obviously in 2003. Annual import of sheep and goat amounted up to 10,000 in the year of 2003. Looking into the structural composition of sheep and goat import, we noticed that the appearance of the import peak was due to the sharp increase of Boar Goat in 2003. The crazy import was mainly caused by irrational speculation. One Boar Goat can even be sold in domestic market for over RMB 100,000 in 2003. After the heat of Boar Goat import dropped down, the import of sheep and goat fell down rapidly since 2004.

29.2.3.4 Analysis on Chicken Import over Time

The import of chicken consists of layer and broiler import. About 98 % of the imported chicken's weight is lower than 185 g. Therefore, this article use the data of the imported chicken whose weight lower than 185 to reflect the chicken import. The import of chicken increased steadily from four million in the ninth five-year (1996–2000) to eight million during the 11th five-year period (2006–2010). And we find a phenomenon that the import quantity of broiler is higher than that of layer each year. Two reasons can well explain the phenomenon. On the one hand, China's residents have an increasing demand for chicken meat. Per capita consumption of chicken meat accounted for 5 % in per capita meat consumption in 1982. The proportion rose up to 20 % in 2011. On the other hand, China depends on import to offer enough broiler breeds. At present, imported broiler breeds have accounted for 90 % in China's broiler breed market while imported layer breeds accounted for only about 50 % in China's layer breed market.

29.2.3.5 Analysis on Semen and Embryos Import over Time

From Table 29.1, there is a clearly rising trend of bovine semen import. As China's bovine industry enters in the period of transformation, the pace of bovine breeds improvement is quickening. More live bovine, as well as semen and embryos, will be imported. As for the semen and embryos import of other animals, there isn't a clear trend during the 15 years. Sharply increase of semen and embryos import might occur in one particular year. For example, China imported numerous swine semen in 2002. In addition, we found that more semen and embryos would be imported if the domestic production of semen and embryos was low in China, and vice versa (Fang Liu et al. 2012).

29.3 Econometric Approach and Results

29.3.1 Factors Affecting Changes and Econometric Model

This paper uses four independent variables to explain China's swine import: (i) domestic consumption demand. As the improvement of people's living standard, China needs to import several varieties of high productive breeds to meets people's demand for meat. Here we use the price of pork to reflect the demand for pork and we assume that consumption demand has a positive effect on the swine import; (ii) domestic swine supply. Here we use the heads of pig coming from the breeding farms to reflect China's capacity of offering improved swine, including piglets, boars and sows. And we assume that pig supply has an opposite effect on the swine import; (iii) technological progress. Here we use the total machinery power in animal husbandry to stand for the technological progress and we assume it has a positive impact on swine import; (iv) supportive policy. Swine Improvement Policy was carried out since August in 2007. Pregnant sows through artificial insemination can get the government subsidy of RMB 40 per head each year. Besides, there were extra subsidies for swine introduction in each pig breeding farms. Therefore, we assume that the supportive policy has a positive effect on China's swine import. Taking the above four factors into consideration, we build an ANCOVA Model. The model to be estimated is expressed as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 D + \mu$$

Y presents the heads of swine import; X_1 presents the price of pork; X_2 presents the swine supplied from breeding farms; X_3 presents the technological progress in animal husbandry; D presents the dummy variable for supportive policy and μ are unobservable factors affecting Y.

29.3.2 Data Sources and Process

In this section, the data of X_1 and X_2 comes from *China's Animal Husbandry Yearbook* (2001–2010). The price of pork has been adjusted by consumer price index (CPI), regarding January of 2001 as the base period. And X_3 comes from *China's Agricultural Statistical Data*. X_3 is used after natural logarithm processing.

As for X_4, we use “0” to present that supportive policy had not been carried out before 2008, and “1” presents that the policy had come into force since 2008.

29.3.3 Results

The estimated results of the ANCOVA model are shown in Table 29.3. All the factors that were hypothesized to affect the swine import have statistically significant impact on the change of swine import. Domestic consumption demand, technological progress and supportive policy have a statistically positive effect on swine import. Swine supply from breeding farms has a statistically negative effect on swine import. Therefore, through the increasing supply of livestock and poultry from breeding farms, China can have less reliance on or even get rid of the imported breeds during the development of animal husbandry in the long term.

29.4 Conclusions and Implications

29.4.1 Conclusions

Based on 31 provinces’ panel data of the imported animal genetic resources from 1996 to 2010, this paper examines China’s import trends of genetic resources of livestock and poultry since 1996. As a whole, the import of animal genetic resources shows a clearly rising trend but the import fluctuation of different breeds varies in different extent. The import of bovine fluctuates strongest, compared with swine, chicken, sheep and goat. Import peaks are often caused by the sharp increase of one single breed. More semen and embryos would be imported if the domestic production of semen and embryos were at a low level in China, and vice versa. Then we build an ANCOVA model to analyze the factors contributing to the trends. Domestic consumption demand, technological progress and supportive policy have a statistically positive effect on the livestock and poultry import. While the live animal supply from breeding farms has a negative effect on the livestock and poultry import. Therefore, through the increasing supply of livestock and poultry from breeding farms, China can have less reliance on or even get rid of the imported breeds during the development of animal husbandry in the long term.

Table 29.3 Estimated results of the ANCOVA model

Explanatory variables	Coefficients	t-statistic
Domestic consumption demand	0.69^{**}	3.13
Swine supply from breeding farms	-1.40^{***}	−3.60
Technological progress	8.84^{*}	1.96
Supportive policy	13.63^{***}	3.67
F-statistic	11.04^{***}	
R-squared	0.90	

Note: *, ** and *** indicate the statistical significance at 10 %, 5 % and 1 % levels respectively

29.4.2 Implications

29.4.2.1 Increase the Supply of Livestock and Poultry from Breeding Farms

The empirical result shows that domestic supply of swine from breeding farms does have an opposite impact on swine import from other countries. Therefore, better protection and further utilization of domestic genetic resources have significant importance for the breeding of livestock and poultry. In that way, more high productive breeds can be offered from breeding farms. Only then will China have less reliance on imported breeds and seize the initiative in animal husbandry development.

29.4.2.2 Establish the Supervising and Warning Mechanism

China still needs to optimize the regional distribution for developing animal husbandry and improve the ability to respond to market shock caused by external factors, like the outbreak of animal diseases. Dynamic supervision on the price and production of livestock and poultry is essential in case that the production falls and price rises dramatically. If the price rises up to a warning level, local governments can adjust the supply by releasing the stock of livestock and poultry products, encouraging more products transported from other provinces, or even through the product imported from other countries if necessary. Thus, the price of livestock and poultry product can be stabilized on the market.

29.4.2.3 Continue to Carry Out the Subsidy Policy for Artificial Insemination

To better implement the subsidy policy, China needs to follow several steps carefully: firstly, set the subsidy standard and determine its coverage regions; secondly, determine the contributive proportion between central and local government; thirdly, supervise the delivery of subsidy. Thus farmer's annual income can be guaranteed and the productivity of livestock and poultry will be improved during the development of China's animal husbandry.

Acknowledgements We gratefully acknowledge the National Natural Science Foundation of China for funding the research "Empirical Analysis on the Impact of Imported Animal Genetic Resources on China's Livestock Economy" (No.71073011). This paper is just a part of the research achievement. Possibly needless to say, all errors and views are those of the author.

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