ACIAR China Grain Market Policy Project Paper No. 2

# The Application and Extension of Jiangsu Agricultural Policy Analysis Model ( JAPA )

**Shudong Zhou**

College of Economics and Trade, Nanjing Agricultural University

## Abstract

A Jiangsu Agricultural Policy Analysis Model (JAPA model) is developed as a decision support tool for policy makers, and it can also be used for academic researchers to reveal the complex internal relationships among economic variables. The JAPA model combines an econometric model (LA/AIDS) with a programming model (Computable Partial Equilibrium Model). The objective of this model is to provide statistic indicators for the prediction of agricultural conditions, for agricultural policy evaluation and for agricultural policy simulation. This paper explains the methodological approach and demonstrates the application of the JAPA model.

## 1 Background

After the economic reform, Chinese society and economy are in a process of transformation from a planned to a market system. It is necessary at this stage to establish a market oriented intervention system for agriculture. This system should use modern economic theory and methods, analyse the given situation and processes quantitatively and systematically so that an effective policy can be carried out. To meet this demand a Jiangsu agricultural sector model for policy analysis has been developed in order to help policy makers draw scientific and effective policies.

The Jiangsu Agricultural Policy Analysis Model (JAPA model) is designed as a decision support tool for policy makers, and can also be used for academic researchers to reveal the complex internal relationships among economic variables. The objective of this model is to provide statistic indicators for the prediction of agricultural conditions, for agricultural policy evaluation and for agricultural policy simulation.

# 2 Structure of JAPA model

Econometric models and programming models are widely used for economic forecasting and for policy simulation. If these two model types are combined into one model, the result could have more profound significance for practical applications. JAPA model is a system model consisting of a combination of different sub-models. It includes a data bank, a series of econometric models, a non-linear programming model and an interactive display system. This display system allows a user to operate the model and to control the sub-models easily, and it can transfer information to sub-models within the JAPA Model (for details see Zhou, 1999).

## 2.1. Econometric model

In order to estimate human consumption level of various commodities and the price elasticities of major consumer goods, a Linear Approximation/Almost Ideal Demand System (LA/AIDS ) model is established. The Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980) has become popular worldwide. The AIDS model is usually specified as :

$$W_i = \alpha_i + \Sigma \gamma_{ij} \ln P_j + \beta_i \ln \left(\frac{X}{P}\right) \qquad (1)$$

with the theoretical restrictions imposed

$$\Sigma \alpha_i = 1 , \quad \Sigma \beta_i = 0 , \quad \Sigma \gamma_{ij} = 0 \text{ (homogeneity )}, \quad \gamma_{ij} = \gamma_{ji} \text{ (symmetry )}$$

The model that uses Stone's index is called the "linear approximate AIDS". The Stone index is specified as :

$$\ln P = \Sigma W_k \ln P_k \qquad (2)$$

A two-stage budgeting model is used to estimate expenditure share for crop products (wheat, rice, vegetables, fruits, tea and rapeseed) and animal products (pork, beef, poultry, egg and fish). To estimate the LA/AIDS model, household data from household survey of Jiangsu province for two years (1993 and 1994 ) are used. Those data included all major economic activities for 1000 households in the survey year.

The price elasticities are specified as :

$$E_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{W_i} - \frac{\beta_i}{W_i}\left| W_j + \sum_k W_k \ln P_k (E_{kj} + \delta_{kj}) \right| \qquad (3)$$

here $\sigma_{ij}$: Kronecker coefficient ($\sigma_{ij} = 1$ , when $i = j$, $\sigma_{ij} = 0$ , when $i \neq j$ )

$W_k$: share of total expenditure allocated to good k

$P_k$ : price of good k

P: price index

X: expenditure level

## 2.2. Non-linear programming model

A computable partial equilibrium model is established to describe production behaviour. The objective function of this non-linear programming model is to maximise producer and consumer surplus. It includes the crop sector and animal sector and it considers all the input items and output items on the supply side. It includes people's consumption, industrial use, feed, storage, loss, regional transport, international import and export on the demand side. Under the consideration of

geographical, natural agricultural conditions and social economic conditions, Jiangsu is divided into five regions.

The characteristics of the non-linear programming model are :

- the JAPA model includes 41 cropping and animal activities, 31 agricultural products ;
- interregional transport among 5 regions is considered as endogenous variable;
- international import and export are considered as exogenous variable ;
- labour cost, production cost and regional transport cost are incorporated in a non-linear manner.

### 2.3. Interactive display system

The JAPA model is a practical “decision-support” tool for policy makers. This model should be easy for policy makers to understand and to use. Because this model is relatively complex, an interactive display system has been established which makes it easier to go through the tables, change policy variables and then make simulations. This display system can transfer information from one sub-model to another sub-model. After non-linear programming model runs the simulation, the simulation results will be sent back to the display system.

## 3. Model application

For practical application, the JAPA model can make prediction for variables, such as population growth, cultivated land change, people’s income and expenditure level change. It can produce data for agricultural policy evaluation, such as nominal and effective protection rates, producer subsidy equivalent, domestic resource cost, self-sufficiency rate, and elasticities of supply and demand of agricultural products. For policy simulation, the JAPA model can be used for scenario analysis to find the consequence of policy change. For future policy making, it is possible to first make the baseline projection, and then on this basis to change some policy variables to simulate the effects of policy. By comparing the difference between the baseline

projection and policy simulation, it is easy to find the effects of the changes of policy variables.

### 3.1. Policy simulation

The JAPA model can be used to find the impact of a single policy variable change on agricultural production and consumption. However the JAPA model can also be used to simulate the comprehensive impact of many economic conditions and policy variables, which may change concurrently, on agricultural production, consumption and marketing. For example, it can simulate the possible consequence on Chinese agriculture after China joins the WTO. This will help policy makers to adjust the agricultural production structure and then merge into the world market step by step. For example, the JAPA model can make following simulation:

- the impact of population growth on the demand and supply of agricultural products;
- the impact of a decrease on cultivated land area on agricultural production and the prices of agricultural products;
- the influence of inflation on the supply and demand of agricultural products;
- the influence of price policy change on agricultural production;
- the influence of income level changes on the demand and supply of agricultural products;
- the impact of scientific and technological improvement on agricultural production;
- the impact of import and export policy changes on the production and consumption of agricultural products when more US wheat and oranges enter the Chinese market, what will be the impact on the production of wheat, oranges and also other agricultural products? How are the price levels of these products affected?
- the influence of increasing exports of some products, in China which has a comparative advantage, on the production of other agricultural products.

After policy simulation, the JAPA model will provide following results:

- the optimal production structure;
- the levels and comparative changes of agricultural products;
- total output of agricultural products in each region;
- regional trade between each region;
- the estimated prices and comparative changes of agricultural products;
- the employment of agricultural labour force;
- producer surplus and consumers surplus;
- self-sufficiency rates of agricultural products.

### 3.2. Policy simulation example: the impact of tariff-rate quota system

After China joins the WTO, China must open the markets of agricultural products. According to the China-U.S. Bilateral Agricultural Agreement, China will remove restrictions of import quantities of grain, cotton, edible oil, etc. and will use a tariff-rate quota (TRQ) system instead. The tariff-rate quota of wheat could be 7.3 million metric tons after China's access to the WTO, and it will increase step by step to 9.3 million metric tons in 2005. The tariff-rate quota of corn could be 4.5 million metric tons, and it could increase step by step to 7.2 million metric tons in 2005. The tariff-rate quota of cotton could be 0.743 million metric tons, and it could increase step by step to 0.894 million metric tons in 2005. In 2006 the tariff-rate quota will be removed. What could be the impact of these changes in the import of agricultural products on Chinese agricultural production and consumption? The JAPA model is used to make the simulation.

#### 3.2.1. Baseline projection

With the economic development, many exogenous frame condition variables will change. Therefore it is necessary to make a baseline projection. The baseline projection shows the production and consumption levels in the future without policy intervention, which provides a fair base for policy simulation.

Simulation plan:

The simulation year is 2005 and the following assumptions are made: population increases at the current growth rate; cultivated land decreases at the current rate of decline; the inflation rate is 50 percent (using year 1994 as base ); the average yield of rice and cotton will increase by 10 percent on the basis of 1994, and the average yield of wheat and rapeseed will increase by 20 percent. After simulation, the JAPA model shows the following results:

**Table 1 Simulated relative production levels and prices compared with base year (base 1994 = 100)**

| | Production levels | Prices |
|---|---|---|
| Rice | 103.00 | 143.95 |
| Wheat | 90.61 | 140.20 |
| Corn | 98.52 | 140.54 |
| Soybean | 59.37 | 182.20 |
| Barley | 89.45 | 150.02 |
| Cotton | 88.35 | 122.87 |
| Rapeseed | 110.23 | 156.25 |
| Flax | 32.23 | 181.23 |
| Vegetable | 120.75 | 157.54 |
| Fruit | 123.43 | 146.46 |
| Mulberry | 86.39 | 130.08 |
| Tea | 60.00 | 118.98 |
| Pork | 172.09 | 119.27 |
| Beef | 151.43 | 137.35 |
| Milk | 146.33 | 104.02 |
| Goat meat | 100.43 | 117.25 |
| Egg | 116.92 | 129.44 |
| Poultry | 134.47 | 124.88 |
| Fish | 154.17 | 127.96 |

Source: Model results.

Table 1 shows the estimated relative production levels and prices in Jiangsu in 2005. Owing to the decrease of cultivated land, crop production is under a tight restriction, population growth increases the demand of agricultural products, therefore, the agricultural production structure should be changed to meet the new situation. The

production levels of rice, rapeseed, vegetable and fruits will increase, the production levels of some other crop products such as wheat, corn, soybean, barley, cotton, flax, mulberry and tea may decrease because they do not have comparative advantage. As the people's living standard improves step by step, the demand for animal products increases, so animal production level increases quickly comparing with the base year 1994. Inflation increases the cost of agricultural production and, therefore, results in a price increase.

### 3.2.2. Simulation on tariff-rate quota

On the basis of baseline projection, we made simulation on wheat, corn and cotton import according to the China-U.S. Bilateral Agricultural Agreement. Comparing the tariff-rate quota in 2005 and the actual import levels of the three products in 1994, we assumed one fifteenth of the national import increase come to Jiangsu province, then we used the JAPA model to make a simulation. The simulation results are listed in Table 2.

**Table 2 Simulated relative production levels and prices compared with baseline (baseline = 100)**

| | Production levels | Prices |
|---|---|---|
| Rice | 100.58 | 99.53 |
| Wheat | 99.95 | 98.82 |
| Corn | 97.56 | 96.73 |
| Soybean | 105.43 | 98.76 |
| Barley | 100.56 | 98.69 |
| Cotton | 95.36 | 96.79 |
| Rapeseed | 99.79 | 99.53 |
| Flax | 105.70 | 97.68 |
| Vegetable | 100.09 | 99.47 |
| Fruit | 100.37 | 99.49 |
| Mulberry | 100.79 | 99.22 |
| Tea | 100.00 | 99.48 |
| Pork | 100.03 | 99.96 |
| Beef | 100.06 | 99.87 |
| Milk | 100.04 | 99.95 |

| | | |
|---|---|---|
| Goat meat | 100.00 | 99.91 |
| Egg | 100.00 | 99.99 |
| Poultry | 100.01 | 99.99 |
| Fish | 100.01 | 99.99 |

Source: Model results.

The simulation results show when China increases the import quantities of wheat, corn and cotton, the sown area of the three products would decrease, and the sown area of other crop products could increase. The gaps between supply and demand of crop products will reduce, this results in the price decrease of crop products. The feed price decrease will reduce the cost of animal production and causes the prices of animal products decrease.

The model also provides the results of a welfare analysis: the consumer surplus in crop products increases by 0.1 percent, the consumer surplus in animal products increases by 0.01 percent, which means the import increase of the three crop products is favourable to consumers. The producer surplus in animal products increases by 0.04 percent, which means the import is also favourable to animal producers, but the producer surplus in crop products decreases by 0.16 percent, which means the import is unfavourable to crop producers.

The model simulation results also show that owing to the import increase, the production structure will be adjusted. The total wheat output in Jiangsu province may decrease by 0.04 percent, the total corn output may decrease by 2.45 percent and cotton may decrease by 4.82 percent. At the same time the total rice output in Jiangsu may increase by 0.56 percent, soybean output increases by 5.36 percent, barley increases by 0.54 percent, rapeseed increases by 0.2 percent, flax by 5.73 percent, vegetable by 0.12 percent, fruit by 0.36 percent and etc.

Because of the decrease in total sown area, the agricultural labour input will decrease by 8.19 million labour days, the unemployment rate in agriculture will increase.

In general, the import increase of agricultural products will bring impacts on the agricultural production and consumption. The positive impacts are: it could reduce the

gaps between supply and demand of agricultural products; it will promote the agricultural production structure adjustment and optimise the resource allocation, and it could reduce the prices of agricultural products. This policy is favourable to consumers, and is favourable to animal producers. The negative impacts could be: it may cause the decrease of sown area of crop products; it will increase the agricultural unemployment; and this policy may reduce the income of crop producers.

# 4 Model extensions

The JAPA model will be updated and modified according to the current research purpose. The methodological approach can be used for research in other provinces.

On this basis a Chinese Agricultural Policy Decision Support System could be established in order to estimate the quantitative impacts of China's joining into WTO on agriculture:

- to find out what kind of impact could foreign import of agricultural products bring to Chinese agricultural production and the prices of agricultural products after trade liberalisation;
- according to comparative advantage, to provide the optimal solution of agricultural production structure in every provinces in China, to provide a reference for local government in making production structure adjustments;
- to find the export advantage of agricultural products and measure the potential of that export advantage;
- to simulate the consequence of alternative policy packages, and to provide quantitative evaluations of policy packages.

## References:


Bauer, S. and M. Kesting (1992), "Agricultural Policy in China: Application of Planning versus Market Principles", *Quarterly Journal of International Agriculture*, Vol. 31, No. 2 ( 1992 ), pp.175-192.

Bauer, S., M. Kesting, and S. Hummelsheim (1993), "A Regional Policy Analysis Model for Heilongjiang" *European Conference of Agricultural and Rural Development in China*, April, 1993, pp. 15-18.

Bauer, S. (1992), "A Non-linear Regional Programming Model for Agricultural Policy Analysis in Heilongjiang (HAPA)", Harbin-Beijing-Giessen, 1992.

Bauer, S. and H. Kasnakoglu (1990), "Non-linear Programming Models for Sector and Policy Analysis ( Experience with the Turkish Agricultural Sector Model)", *Economic Modelling*, July, 1990.

Deaton, A and J. Muellbauer (1980), "An Almost Ideal Demand System", *American Economic Review*, 70, 1980, pp. 312-325.

Howitt, E. (1995), "Positive Mathematical Programming", *American Journal of Agricultural Economics* , No. 2, 1995.

White, C. and E. Wetzstein (1995), "Market Effects of Cotton Integrated Pest Management", *American Journal of Agricultural Economics* , No. 3, 1995.

Hazell, R. and D. Norton (1986), *Mathematical Programming for Economic Analysis in Agriculture*, Macmillan Publishing Company, London.

Green, R. and M. Alston, (1990), "Elasticities in AIDS Models", *American Journal of Agricultural Economics*, Number 2, May, 1990.

Zhou Shudong (1999), *Regional Model for Agricultural Policy Analysis in Jiangsu / China*, Muenster - Hamburg - London.