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Optimal Choice of Cotton Subsidy Mode in China—Empirical Study Based on Principal Component Regression

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ABSTRACT

Adopt principal component regression for researching the optimal subsidy mode of cotton production in China. The result indicates that, from the perspective of economic stimulatory effect, the optimal cotton subsidy in China is farm chemical subsidy rather than seed subsidy. The reason is that there are frequent pest disasters in cotton producing areas in China. So farm chemical subsidy is the most important factor ensuring cotton production. Meanwhile, cotton varieties must be optimized and improved to increase the ability to resist pests and diseases, and the forecasting for pests and diseases in cotton production areas must be enhanced, early warning mechanism and monitoring must be built, and in addition, it is strongly recommended that if financial resources allow, subsidies like seed subsidy, fertilizer subsidy, machinery subsidy and irrigation subsidy could also put into effect in China.

Keywords: China; Cotton Subsidy; Import; Principal Component Regression

1. Introduction

Since mankind entered the 21st century, China's cotton import has been increasing yearly. In 2003, the total import was 870 thousand tons which was 5.1 times the total import in 2002; and in 2004, China imported 1.9 million tons of cotton, which was 11 times more than that in 2002, and in 2011, it reached 3.36 million tons, which was nearly 20 times that in 2002.

The sharply increasing import of cotton was caused by the following reasons, for one thing, the hot export of textile products since joining WTO led to sharply increasing demand of cotton; for another thing, some developed countries, especially America, have been providing cotton industry and cotton export with subsidies which has made those countries have huge competitive advantages of costs, large amount of cotton import at low cost must attack Chinese cotton industry to some extent. Though developed countries like America promised to conceal the cotton export subsidy and reduce some other policies of supporting cotton subsidies, in fact, the subsidy promised to conceal is less than 10% of the concrete subsidies. In order to increase the growers' income and

to increase the added value of textile products and to change the growth mode of trade as well, it's promptly necessary to implement the policy of cotton subsidy, for cotton is a kind of strategic material that is as important as foodstuff.

But nowadays, the problem is that the policies of mechanical subsidy and chemical fertilizer subsidy of cotton production are still not put into effect except seed subsidy. Thus, are all the subsidies of input factors effective? And is the seed subsidy just the optimal subsidy mode?

This paper adopts principle component regression to calculate the different elasticity values of input factors in cotton acreage, unit output and production profit then find out the best choice of cotton subsidy modes from economic view, and for testing whether the nationwide general seed subsidy is the most reasonable.

OECD [1] (2006) analyzed the economic effects of each kind of subsidy policy though Policy Evaluation Model (PEM), the result indicates that the distorted effect of input subsidy on output. Rossi Schmitz [2] (2005) researched the input subsidy of American cotton production and its multi-economy effects correspondingly, it's suggested that irrigation subsidy can significantly reduce the cost of production.

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Jiao Wang and Haifeng Xiao [3] (2006) researched the concrete effects of different subsidy modes in increasing food outputs through an empirical plan model (PMP) in their article The Assessment of the Effect of Direct Subsidy Policies of Chinese Grains; Bo Chen (2005) [4] researched the effect by the comparison of providing growers with subsidies directly and increasing the input of science and technology in food production through Uzawa model; Zhiyi Cao and Tiejun Zhang [5] (2006) particularly researched the machinery operation and income of the growers who benefit from the subsidy of machinery purchasing and then built a relationship model of increasing the income of growers and the subsidy of purchasing. However, so far no scholars home and abroad have studied the problem of cotton subsidy choice in China.

2. Model Selection and Data Processing

2.1. Basic Hypotheses

To facilitate sorting out data, building modes and calculating, the following hypotheses are needed.

1) Assume that the combined effects generated by such elements as seeds selected, fertilizers, pesticides, machinery and irrigation equal to the sum total effect brought by separate elements. The unselected input elements are usually fixed or non-controllable, the function of which can be reflected through constant term in production function model.

2) Assume that the production flexibility of the input factors is fixed. Obviously, the production flexibility of various input elements annually is flexible during a long time. So these hypotheses may, to some extent, affect the accurate calculation of output flexibility of various production factors.

3) Assume that the impact of climate, natural disasters on citrus production is neglected. Actually, citrus production is influenced by natural conditions. Particularly, frozen disaster in some areas is fatal. Therefore, these hypotheses will influence the accurate calculation of element flexibility and technology advancement.

4) Neglect the change of institutions and policy.

5) Suppose, under WTO, the subsidy measure adopted by Chinese government mainly includes seed subsidy, fertilizer subsidy, farm chemical subsidy, machinery subsidy and irrigation subsidy.

2.2. Model Selection

To facilitate the calculation of flexibility value of cotton acreage, yield, and production profit by input elements, we choose C-D function.

$$Y = \alpha X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5}$$

Where, Y is the cotton-growing area (or unit yield or the production profits). $X_1, \cdots, X_5$ respectively refers to seed costs, fertilizer costs, pesticide costs, machinery costs and irrigation costs. $\beta_1, \cdots, \beta_5$ respectively refers to output elasticity coefficient of the input of seeds, fertilizers, pesticides, machinery and irrigation.

Being taken the logarithm on both sides of the function, the model can be transformed into the following:

$$\ln Y = \ln \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2$$
$$+ \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5$$

2.3 Data Processing

To make research on the impacts of such elements as seed subsidies, fertilizer subsidies, subsidies for pesticides, machinery and irrigation subsidies on cotton production in China, we collected and sorted out the data, unit output of cotton in China during the time 1990-2011, labor profit unit area, as well as the seed costs per unit area, fertilizer costs, pesticide costs, machinery costs and irrigation costs (see **Table 1**).

It is noted that, cotton growers in China psychologically don't think labor cost at home is part of the total production cost. Thus, we define the labor profit as gross output minus total cost and plus the depreciation of family labor.

2.4 Data Diagnosis

Suppose

$$y = \ln Y, z_1 = \ln X_1, z_2 = \ln X_2,$$
$$z_3 = \ln X_3, z_4 = \ln X_4, z_5 = \ln X_5,$$

then calculate the Correlation Coefficients of z_1, z_2, z_3, z_4, z_5 using software SAS (see **Table 2**), when $N = 2$, Prob > $|r|$ under H_0: Rho = 0.

The data in **Table 2** indicate that the seed expenditure, chemical fertilizer expenditure, farm chemical expenditure, mechanical expenditure and irrigation expenditure of unit area are all significantly correlate with each other, which indicates that there exist multi-collinearity among the input factors.

The most common methods to solve multi-collinearity are principal component regression, ridge regression and least squares technique, while, principal component regression is used in this paper to solve such issue [6].

3. Model Building and Data Analysis

3.1. Score of Principal Components

When writing the data of variables z_1 - z_5 during 1990-2011 as an 18×5 matrix, and standardizing the vectors, we could get a standard matrix and then calculate the coefficient matrix of vectors $R = [r_{ij}]$ 5×5, where, r_{ij} is

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Tabel 1. Unit output, labor profit and input elements in China (1990-2011).

year	Unit Output kg/h	Labor Profit Y/h	Seed Fee Y/h	Fertilizer Fee Y/h	Farm Chemical fee Y/h	Machinery Fee Y/h	Irrigation Fee Y/h
1990	1017.0	6025.95	106.05	495.15	305.1	45.9	56.1
1991	1036.5	5720.85	113.55	561.45	343.8	68.55	93.3
1992	792.0	3040.35	104.55	584.85	414	73.2	104.55
1993	861.0	4493.25	132.75	658.35	453.75	82.95	107.55
1994	901.5	8546.1	174.3	904.05	625.05	114	152.1
1995	922.5	10841.4	230.4	1248.75	834.45	143.85	176.4
1996	916.5	10021.8	238.2	1361.55	720.75	165.15	194.25
1997	976.5	10358.1	260.1	1337.4	727.65	201.9	291.75
1998	1024.5	7534.65	270.6	1195.8	775.5	220.5	271.35
1999	1003.5	3619.35	286.2	1171.8	610.95	195	284.55
2000	1069.5	7443.6	282.9	1151.55	599.85	190.65	277.35
2001	1168.5	5329.05	317.85	1105.8	553.8	211.05	290.1
2002	1228.5	7839.15	319.65	1213.05	513.75	231.6	324.15
2003	1023	11337.45	368.4	1274.1	567.45	239.85	331.8
2004	1144.5	8142.15	466.2	1527.9	487.35	408	336.15
2005	1122	10394.1	449.85	1703.25	555.15	402.3	358.8
2006	1276.5	11016.3	537	1888.5	637.2	480.75	428.4
2007	1233	12337.65	565.5	2009.85	715.65	562.05	456.9
2008	1249.5	6712.05	601.2	2531.25	812.4	682.5	465.9
2009	1263.6	12195	616.2	2192.7	813	679.35	550.65
2010	1161.45	24177.75	669.15	2287.2	842.1	807.45	594.75
2011	1260.3	14355.15	776.7	2720.1	976.5	1336.05	757.8

Notation: original data come from *cost-benefit information on the national compilation of agricultural products* (1991-2012); Y/h means RMB Yuan per hectare.

Table 2. Pearson correlation coefficients.

variable	X_1	X_2	X_3	X_4	X_5
X_1	1.00000	0.96902 (<0.0001)	0.68672 (0.0004)	0.94017 (<0.0001)	0.97576 (<0.0001)
X_2	0.96902 (<0.0001)	1.00000	0.79728 (<0.0001)	0.92192 (<0.0001)	0.94601 (<0.0001)
X_3	0.68672 (0.0004)	0.79728 (<0.0001)	1.00000	0.70106 (0.0003)	0.73334 (0.0001)
X_4	0.94017 (<0.0001)	0.92192 (<0.0001)	0.70106 (0.0003)	1.00000	0.95107 (<0.0001)
X_5	0.97576 (<0.0001)	0.94601 (<0.0001)	0.73334 (0.0001)	0.95107 (<0.0001)	1.00000

Notation: the numbers in the brackets are the significance probabilities of the correlation coefficients, esp. it implies that it is significantly correlate when it is less than 0.05.

the coefficient of index i and index j (where $i, j = 1, \cdots, 5$), and then further calculate the eigenvalue λ_i (where, $i = 1, 2, \cdots, 5$) (see **Table 3**).

According to the secular equation of $R|R - \lambda I_5| = 0$, we can get the result using software SAS.

Five eigenvalues are indicated in **Table 3**, each of them corresponds with a principal component, and each principal component is a new variable. The contribution ratio of the first eigenvalue is 91.595%, it indicates that the first principal component (Prin1) has reflected 91.595 of the whole information; likewise, Prin2 can reflect 10.71% of the whole information and so on.

Each principal component is a linear function of standardized variables z_1 - z_5, when the yearly data of variables z_1 - z_5 from 1990 to 2011 are substituted, the scores

Table 3. Eigenvalues of the correlation matrix.

Obs	Eigenvalue	Difference	Proportion	Cumulative
1	4.57944380	4.22834122	0.9159	0.9159
2	0.35110258	0.30739402	0.0702	0.9861
3	0.04370856	0.02569110	0.0087	0.9949
4	0.01801747	0.01028988	0.0036	0.9985
5	0.00772758		0.0015	1.0000

of all the principal components (Prin1 - Prin5) can be calculated.

3.2. Principal Component Regressions

In order to find out the C-D function of unit output, production profit respectively of the variables seed fee, fer-

tilizer fee, farm chemical fee, machinery fee and irriga-tion fee, we must first find out the regression multicol-linearity function of the logarithms y of cotton acreage, unit output, production profit respectively of all the prin-cipal components Prin1 to Prin5. As the principal com-ponents are linear functions of principal components Prin1 to Prin5, the regression function of y the variables z_1 - z_5. Using the REG module of software SAS as well as pcomit = 1, 2, 3, 4 outvif sentences to calculate, the result could be shown as **Table 4**.

3.3. Model Analysis

1) Each of both the principal component functions of unit production and productive profit could retain a prin-cipal component, and 91.59% of the original information has been retained, which indicates that the final regres-sion model is effective. According to the collinearity diagnosis, all the IPCVIF values are less than 0.5, which indicates that final regression model has overcome the problem of multi-line.

2) In the regression model of unit output, the elasticity of seed expenditure, chemical fertilizers, farm chemical expenditure, mechanical expenditure or irrigation expen-diture to the unit output is positive, which indicates that increment of the above five kinds of expenditure can help increase the unit output. Especially, increased input of farm chemical will make the unit increase significantly.

3) In the regression model of labor profit, the elasticity of farm chemical expenditure is the biggest, which also indicates that, in order to improve Chinese cotton grow-ers' income, it's the most effective to increase farm che-mical expenditure.

4. Conclusion and Recommendations

4.1. Basic Conclusion

The above analysis has proved that increment of farm chemical expenditure will increase both unit output and labor profit. The major reasons are as follows [7]:

Firstly, in the growth period, cotton subjects to the harm by various pests. There are more than 300 kinds of pests in cotton field in China, among which 30 or more are major pests and more than 10 kinds of pests damage the cotton all year round. Due to the pests, there is 10% - 15% loss average year, 30% loss in some serious years. In China pesticide usage takes a large proportion in comprehensively preventing diseases and pests. Annually, pesticide usage in cotton field takes 25% - 30% in the total pesticide usage in China.

Secondly, the increment of farm chemical expenditure implies the dosage increase or the quality improvement of farm chemical. The serious problem of cotton produc-tion in China is the frequent plague of insects, and lower qualified varieties of cottons have weak ability to resist insect and disease disasters. According to our investiga-tion and statistical analysis, in order to ensure their cot-ton output, the cotton growers will have to spray insecti-cide 5 to 8 times in the season of cotton growing, and in the year of pests and diseases, cotton growers will have to spay more times, nonetheless, the increment of farm chemical can lead to the increment of cotton output and cotton growers' income.

Table 4. Principal component regression coefficients and model test.

Variable	Unit products			Labor profit		
	Parameter Estimate	t Value	Pr > |t|	Parameter Estimate	t Value	Pr > |t|
Intercept	6.97117	457.75**	<0.0001	9.01705	117.37**	<0.0001
Prin1	0.04689	6.44**	<0.0001	0.15413	4.19**	0.0007
Prin2	−0.11645	−4.43**	0.0004	0.06007	0.45	0.6569
Prin3	−0.03670	−0.49	0.6293	−0.45996	−1.22	0.2391
Prin4	−0.05911	−0.51	0.6177	−0.23117	−0.39	0.6983
Prin5	0.20903	1.18	0.2557	0.82456	0.92	0.3703
F value	12.59			4.06		
Pr > F	<0.0001			0.014		
R^2	0.7973			0.5593		
principal component regression	$y = 6.97117 + 0.04689\ \text{Prin1}$			$y = 9.01705 + 0.15413\ \text{Prin1}$		
Regression model	$y = 5.73894 + 0.0348z_1 + 0.0448z_2 + 0.06217z_3 + 0.0244z_4 + 0.032z_5$			$y = 4.96689 + 0.1144z_1 + 0.1472z_2 + 0.20434z_3 + 0.0802z_4 + 0.1068z_5$		
Collineation diagnose	z_1 (0.0455) z_2 (0.0468) z_3 (0.03440)			z_4 (0.0459) z_5 (0.045)		

Notation: 1) Prin1 - Prin5 are cross-cut, removing one of them will not impact the regression coefficient of the other principal components in the regression function; 2) *indicates significance under 0.05. **indicates significance under 0.01; 3) In the brackets on the last line in collinearity diagnosis is IPCVI.F., al-though two of the principal component regressions of unit output are significant, the IPCVIF of the farm chemical expenditure is 2.29053 when two of the principal components are retained to do principal component regression, it's much bigger than 0.5, which implies that the multicollinearity is still not eliminated, therefore, only one of the principal components could be retained to do linear principal component regression here; 4) the parameter estimates are the coeffi-cients of principal components.

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Therefore, the optimal choice is farm chemical subsidy other than seed subsidy for economic view. Increasing farm chemical subsidy most effectively stimulates the increase of labor profit. Moreover, farm chemical subsidy can regulate the market and induce more growers to buy high-performance and low toxicity as well as eco-friendly organic pesticides with sufficient fund, so that the quality of cotton and the natural environment are protected.

In addition, besides farm chemical subsidy, other choices like seed subsidy, fertilizer subsidy, machinery subsidy and irrigation subsidy also play a positive role on cotton production in China.

4.2. Recommendations

According to the above analyses, following recommendations would be given to the government [8]:

Firstly, encourage the natural control to play role in pest prevention and build pest supervision and disaster warning mechanisms; bring the natural control factors such as spices of resisting diseases and pests, natural enemy, ecological adjustments forced by human into full play in restraining pests, meanwhile, widely use non-chemical control measures like biological farm chemical, radiation-sterile technique, chemical and physical trapping and killing to gradually reduce the dependence on chemicals (Jinjie Cui *et al.*, 2007), and finally decline the use of farm chemicals. Of course, advanced preventive treatment will increase cotton growers' financial burden more or less.

Secondly, in China, special fund should be set to encourage the production of high-performance and low toxicity pesticide for scientific research institutes and enterprises. Strengthened efforts should be made to research pest prevention so as to make the high-tech plays a positive role.

Thirdly, genetic improvement and species optimization of cotton is encouraged so as to improve its capability of disease and pest resistance. And it's indispensable to strengthen the work of pest forecast and prevention and establish disease and pest supervision and early warning mechanism.

Finally, if the financial resource allows, it's necessary to combine subsidy of seed, fertilizer, farm chemical, machinery and irrigation. The proportion of the combination can depend on both state policy and cotton growers. But too scattered subsidy and low effects due to small number of separate subsidy should be avoided.

5. Acknowledgements

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