The Impact of Price on Chemical Fertilizer Demand in China

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Abstract Since 1998, the national policies on chemical fertilizer in China have been concentrated in limiting price plus subsidizing, abolishing agricultural tax, giving direct subsidies to farmers, and other aspects. In order to analyze the impact of national policies on the consumption of chemical fertilizer, this article selects the consumption of chemical fertilizer per unit, chemical fertilizer price index and farmers' net income in different provinces during the period 1998 -2007 as variables, to conduct regression analysis of chemical fertilizer expenditure function, and calculate the price elasticity and income elasticity of chemical fertilizer demand in different provinces over the decade based on the regression results. The results show that at present the basic consumption of chemical fertilizer for agricultural development in China is 0.35 t/hm^2, and the consumption of chemical fertilizer is excessive in some provinces; the chemical fertilizer market has not been really established, and the price has little impact on demand. This indicates that the chemical fertilizer is essential for agricultural economic development, and it increases along with the increase of farmers' income; the intervention of the national policy in chemical fertilizer price is a fundamental reason for the rising demand for chemical fertilizer. This also to some extent indicates that the policy effect of merely using environmental taxes to change farmers' consumption of chemical fertilizer is limited; there is a need to transform the existing policies purely promoting agricultural economic development, toward giving different subsidies in accordance with whether the farmers' fertilization pattern is beneficial to the environment.

Key words Chemical fertilizer, Price elasticity of demand, Income elasticity of demand

Chemical fertilizer is an important factor influencing issues concerning agriculture, countryside and farmers, determining eco-environmental quality. There are many factors affecting the chemical fertilizer demand, such as population, agricultural economic development, planting structure, national policy, and environmental protection requirements. Among them, the intervention of the national policy in chemical fertilizer market and the impact of the national policy on consumer demand of chemical fertilizer, become the focus of discussion. Since 1998, the national policies on chemical fertilizer in China have been concentrated in limiting price plus subsidizing, abolishing agricultural tax, giving direct subsidies to farmers, and other aspects. Based on Gorman's indirect utility function and the demand function derived from Roy identity, we derive feasible consumption function of chemical fertilizer in China. In accordance with consumption of chemical fertilizer per unit sown area, chemical fertilizer price index, farmers' income and other panel data in China's 31 provinces during the period 1998 -2007, we try to probe into the calculation of price elasticity and income elasticity of chemical fertilizer demand in different provinces in different time, using STATA statistical analysis software package; based on the calculation results, we put forward the recommendations for controlling consumption of chemical fertilizer. Through the analysis of elasticity of chemical fertilizer demand, we strive to verify the extent to which the consumer demand of chemical fertilizer has been affected by chemical fertilizer price and farmers' income since 1998, and put forward policy optimization recommendations in favor of agricultural development and environmental protection.

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1 Research review

Given that the chemical fertilizer is a key factor in crop production (Jin Xuyun[1], 2006; Liu Aimin[2], 2005), some experts predict that before 2030, China's agricultural development will continue to be based on chemical fertilizer (Zhou Jianmin[3], 2001). In fact, the actual consumer demand for chemical fertilizer in China has verified the experts' prediction. Over the years, the actual consumer demand for chemical fertilizer has shown an increasing trend, and the consumption of chemical fertilizer per unit area increased from 0.254 296 t/hm^2 in 1998 to 0.343 197 t/hm^2 in 2007. Due to high loss rate of chemical fertilizer in China, the effect of chemical fertilizer on the agricultural production shows a decreasing trend, and the fact that the chemical fertilizer is responsible for environmental pollution, especially the water pollution, has been demonstrated. Some experts believe that China should develop a variety of measures to control the consumer demand for chemical fertilizer (Zhang Guanghui[4], 2009; Wang Yumei[5], 2009; Gu Hejun[5], 2009; Qiu Jun[7], 2007; Ma Ji[8], 2006; Pang Fengxi[9], 2006).

In this regard, many experts and scholars analyze the reason for increase in the consumer demand for chemical fertilizer, and point out that there are myriad factors influencing the consumer demand for chemical fertilizer, including population, economy, technology, and policies. The increasing demand for

food arising from China's population growth, the planting structure changing from grain to cash crops, and the over-reliance of agricultural economic development on chemical fertilizer, promote the consumer demand for chemical fertilizer (Zhang Weifeng[10], 2007 – 2008). Some scholars believe that since the 1980s, the national policy has been the root cause of increasing consumer demand for chemical fertilizer, and rise in the prices of chemical fertilizer has been ascribed to the effects of government and the market (Long Wen Jun[11], 2006); changes in farmers' income have been the reason for changes in prices of means of agricultural production (Li Ting, *et al.*[12], 2006); the price limiting policy of chemical fertilizer is the fundamental reason for over-reliance of agricultural production on chemical fertilizer (Shen Yudan, *et al.*[13], 2006).

For this reason, some scholars have put forward relevant proposals. Fox example, the environmental taxes of chemical fertilizer should be used for correcting farmers' behavior of fertilization (Xiang Ping'an, Zhou Yan, *et al.*, 2007); the state should gradually fade out of the preferential policy and price intervention policy of chemical fertilizer industry, which will be beneficial to transformation of farmers' agricultural production pattern and sustainable development of agriculture in China; from the perspective of positioning of the rural future development, and the dual goal of agricultural development and environmental protection, the environmental policy for agricultural development should be formulated; through the construction of green agriculture and ecological agriculture, the pollution problems of chemical fertilizer and other agricultural production should be solved[14]. In 2010, the National People's Congress also proposed that we will abolish subsidizing the development of chemical fertilizer industry, resume the value added tax of chemical fertilizer, and change indirect subsidies to direct subsidies for chemical fertilizer, in order to achieve the purpose of market regulating the supply and demand of chemical fertilizer.

However, these studies and proposals can not fundamentally answer the following questions: How do the national policies affect the actual demand of chemical fertilizer? How does the state fix policies to not only ensure the safety of the food production, but also bring the negative impact of chemical fertilizer on the environment down to a certain range? Whether the policy recommendations put forward by some scholars are feasible at present, such as taxation of chemical fertilizer and direct chemical fertilizer subsidies to farmers, whether they can help to motivate the farmers to scientifically and rationally consume chemical fertilizer?

In fact, since the China's distribution system reform of chemical fertilizer in 1998, the support policy of chemical fertilizer industry formulated for promoting agricultural development, has always been the policy "preference + limiting price + subsidizing" implemented for the chemical fertilizer enterprises over the years. Since 2003, China has focused on the policies for supporting agriculture, in order to increase farmers' income, such as raising the grain purchasing prices, increasing direct subsidies to farmers, establishing the linkage mechanism of rise in the price of chemical fertilizer and other means of agricultural production and increase in comprehensive direct subsidies to means of agricultural production. The price of chemical fertilizer under the state intervention has begun to be determined by the market. Therefore, the carrier of the policy role, the analysis of chemical fertilizer price, has become the core for solving problems.

At present, in the analysis of impact of chemical fertilizer price on demand, although some scholars point out that the price elasticity of chemical fertilizer is relatively stable, and the impact of price fluctuation in chemical fertilizer on its consumption is infinitesimal (Zhang Weifeng, 2007). However, we believe that the analysis of the price elasticity of chemical fertilizer still stays at the stage of understanding that chemical fertilizer is the necessity for agricultural production rather than the luxury. The correlation analysis is still focused on the qualitative analysis, lacking quantitative research on influence and amendment of the national policy with price as the carrier.

At the same time, some scholars (Long Wenjun, *et al.*, 2006; Shen Yu Dan, *et al.*, 2008) conducted research on the impact of the national policy on the consumption of chemical fertilizer, believing that the consumer demand for chemical fertilizer is greatly affected by policy factors, and policies have great impact on the price of chemical fertilizer, but there is a shortage of systematic in-depth analyses of the degree of impact of fluctuation in the price of chemical fertilizer on the demand for chemical fertilizer.

2 Theoretical method for calculating price elasticity of demand

This paper argues that the demand for chemical fertilizer and other goods can be denoted by the indirect utility function (Gorman, 1953), and farmer's utility function is as follows:

$$V(p, y) = \frac{y - a(p)}{b(p)}$$

where $V(p,y)$ is the indirect utility of the price $p = (p_1, p_2)$; Y is the average income of farmers; a(p) and b(p) are both linear non-decline concave function. Gorman has proved the linear relationship between the indirect function and the household demand function, and using Roy identity, the demand function of chemical fertilizer is as follows:

$$x_1 = \frac{\partial V(p, y)/\partial p_1}{\partial V(p, y)/\partial y} = \frac{\partial a(p)}{\partial p_1} + \frac{y - a(p)}{b(p)} \cdot \frac{\partial b(p)}{\partial p_1} \quad (1)$$

where $a(p)$ and $b(p)$ can be expressed as the following linear function:

$a(p) = \gamma_1 p_1 + \gamma_2 p_2$, $b(p) = p_1^{\beta} p_2^{1-\beta}$,

where γ_1, γ_2 and β are unknown coefficient. The corresponding demand function of chemical fertilizer (1) can be expressed as follows:

$$x_1 = \gamma_1(1 - \beta) + \beta\left(\frac{y - \gamma_2 p_2}{p_1}\right) \quad (2)$$

The corresponding linear expenditure function of chemical fertilizer can be expressed as follows:

$$x_1 p_1 = \gamma_1(1 - \beta) p_1 + \beta y - \gamma_2 \beta p_2 \quad (3)$$

The direct utility function (Stone – Geary utility function) is as follows:

$$U(x_1, x_2) = \beta\log(x_1 - \gamma_1) + (1-\beta)\log(x_2 - \gamma_2) \quad (4)$$

where parameter γ_1 and γ_2 are the required consumption of chemical fertilizer and the required consumption of other goods, respectively.

3 Empirical model derivation of chemical fertilizer price elasticity of demand in China

We have consumption of chemical fertilizer per unit area, farmers' net income and price index of chemical fertilizer in the Chinese provinces during the period 1998 – 2007. Assuming that $x_{i1j}(t)$ is the farmers' consumption of chemical fertilizer in province j in year t; $x_{i2j}(t)$ is the farmers' demand for other goods; $y_{ij}(t)$ is the farmer i's average income in province j in year t; $p_{1j}(t)$ and $p_2(t)$ are the price of chemical fertilizer and other goods, respectively. It is assumed that the price of other goods does not vary with different provinces.

According to the above linear expenditure function (3), we get the expenditure function of chemical fertilizer in different regions as follows:

$$x_{i1j}(t)p_j(t) = \gamma_{i1j}(t)(1-\beta)p_j(t) + \beta y_{ij}(t)/p_2(t) - \beta\gamma_{i2j}(t) \quad (5)$$

where $p_j(t) = p_{1j}(t)/p_2(t)$, $\gamma_{ikj}(t)$ is the coefficient of different commodities.

Assuming that $x_{k1j}(t)$, $k=1, 2$; $y_j(t)$ is the average demand of chemical fertilizer and other goods and farmers' average income in province j in year t, adjusted by the price $p_2(t)$. So the farmers' net income involved in this article does not need index deflator processing.

Thus, we get:

$$x_{1j}(t)p_j(t) = \gamma_{1j}(t)(1-\beta)p_j(t) + \beta y_j(t) - \beta\gamma_{2j}(t) \quad (6)$$

where $\gamma_{kj}(t) = \frac{1}{n_j(t)}\sum_{i=1}^{n_j(t)}\gamma_{ikj}(t)$, $k = 1, 2$. $n_j(t)$ is the number of farmers in province j in year t. We assume that $\gamma_{kj}(t) = \bar{\theta}_k + \theta_{kj} + \omega_{kj}(t)$. Here $\bar{\theta}_k$, $k=1,2$, θ_{kj}, $k=1, 2$, $j=1, 2, \cdots$, is the random effect when mean is equal to 0; $\omega_{kj}(t)$, $t=1, 2, \cdots$, $k=1, 2$, $j=1, 2\cdots$, is the random error of standard normal distribution when mean is equal to 0. Assuming that $\bar{\theta}_k$ is the time mean of θ_{kj}, $k=1, 2$. In this way, based on the assumption, the expenditure function of chemical fertilizer can be expressed as follows:

$$x_{1j}(t)p_j(t) = \bar{\theta}(1-\beta)p_j(t) + \beta y_j(t) - \beta\bar{\theta}_2 + [\theta_{1j} + \omega_{1j}(t)](1-\beta)p_j(t) - \beta[\theta_{2j} + \omega_{2j}(t)] \quad (7)$$

Here, we assume that $\eta_j(t) = \omega_{1j}(t)(1-\beta)p_j(t) + \theta_{1j}(1-\beta)[p_j(t) - \bar{p}_j] - \beta\omega_{2j}(t)$, where $\bar{p}_j$ is the mean of $p_j(t)$.

The error term $\eta_j(t)$ is the impact on chemical fertilizer demand caused by other unknown influencing factors with 0 as mean in different provinces in different time, possibly arising from the price differences in different regions in different time, interaction, *etc.* $\gamma_{kj}(t)$, $k=1, 2$. In addition, we assume that price is not correlated with time, and is also not correlated with time. After sorting, we get the following expression:

$$x_{1j}(t)p_j(t) = \alpha_j + cp_j(t) + \beta y_j(t) + \eta_j(t) \quad (8)$$

where $\alpha_j = -\beta\bar{\theta}_2 + \theta_{1j}(1-\beta)\bar{p}_j - \beta\theta_{2j}$ and $c = \bar{\theta}(1-\beta)$. α_j, $j=1, 2, \cdots$, is the random effect. Therefore, the total expenditure function of chemical fertilizer can be expressed as the linear regression model of chemical fertilizer price and farmers' income.

From expression (8), we can find that $p_j(t)Ex_j(t) = \alpha + \beta y_j(t) + cp_j(t)$, and get $Ex_j(t) = \frac{\alpha + \beta y_j(t)}{p_j(t)} + c$

According to the definition of elasticity, we get:

$$e_p = -\frac{\alpha + \beta\bar{y}_j}{\alpha + \beta\bar{y}_j + c\bar{p}_j},\quad e_i = -\frac{\beta\bar{y}_j}{(\alpha + \beta\bar{y}_j + c\bar{p}_j)\cdot\bar{p}_j}.$$

4 Calculation of elasticity of demand of chemical fertilizer

According to the panel data of 31 provinces in China during the period 1998 – 2007, our regression results are as follows.

Table 1 The regression results of consumption expenditure function of chemical fertilizer

Variable	Estimated value	Standard deviation	T value
Constant α_j	−0.017 565 6	0.003 352 4	−5.24
Price c	0.034 945 4	0.003 162 2	11.05
Income β	3.92e−06	2.63e−07	14.89

R – sq: within = 0.6598; between = 0.3691; overall = 0.3997

From Table 1, we can find that the mean of α_j is −0.017 565 6, fluctuating in [−0.020 918, −0.014 213 2]; the mean of C is 0.034 945 4, fluctuating in [0.031 783, 0.038 108]; the mean of β is 3.92E−06, fluctuating in [3.66E−06, 4.18E−06]; the three regression coefficients meet t – test, having statistical significance in the confidence interval of 95%. The explanation degree of model $R^2 = 0.659\ 8$, indicating that the farmers' net income and chemical fertilizer price index can explain 65.98% of the consumption of chemical fertilizer. The variables involved in statistical regression can be shown in the description of Table 2.

Table 2 Characteristics of the variables involved in regression of consumption expenditure of chemical fertilizer

Variable	Observed value	Mean	Standard deviation	Minimum	Maximum
Consumption of chemical fertilizer per unit area (t/hm^2)	310	0.287 846	0.100 924	0.108 202	0.595
Chemical fertilizer price index	267	0.997 828	0.055 385	0.86	1.17
Farmers' average annual net income (yuan)	310	3 007.16	1516.27	1 231.5	10 144.62
Expenditure of chemical fertilizer	267	0.028 085	0.010 109	0.010 387	0.056 805

Table 2 shows that in the provincial consumption of chemical fertilizer per unit area over a decade, the minimum consumption of chemical fertilizer is 0.108 202 t/hm^2, the maximum consumption of chemical fertilizer is 0.595 t/hm^2, and the average consumption of chemical fertilizer is 0.287 846 t/hm^2; chemical fertilizer price index has 267 observed values (the

minimum value is 0.86, the maximum value is 1.17, and the mean is 0.997 827 7; farmers' net income has 310 observed values (the minimum value is 1 231.5 yuan, the maximum value is 10 144.62 yuan, and average annual per capita income of farmers is 3 007.157 yuan. It can be seen that there is a great difference in consumption of chemical fertilizer per unit area and farmers' average annual net income between different provinces, between different years.

In other words, the regression results of Table 1 are as follows:

$$\begin{cases} \alpha_j = 0.017\,565\,6 \\ c = 0.034\,945\,4 \\ \beta = 3.92e-06 \end{cases}$$

According to the price elasticity of chemical fertilizer $e_p = -\frac{\alpha + \beta \bar{y_j}}{\alpha + \beta \bar{y_j} + c\bar{p_j}}$ and the income elasticity of chemical fertilizer $e_i = \frac{\bar{y_j} + \beta}{(\alpha + \beta \bar{y_j} + c\bar{p_j})\bar{p_j}}$ derived from expression (8), from $\gamma_1 = \bar{\theta}_1 = c/(1-\beta)$, we get: $\gamma_1 = 0.035$, namely the basic demand of chemical fertilizer is 0.35 t/hm^2.

In accordance with the above coefficients and formulas, we get the price elasticity of chemical fertilizer and income elasticity of chemical fertilizer in different provinces and years, which can be shown in Table 3 and Table 4.

Table 2 The price elasticity and income elasticity of chemical fertilizer demand in different areas

Province	α	β	*c*	Farmers' average net income	Average price index of chemical fertilizer	Price elasticity of chemical fertilizer	Income elasticity of chemical fertilizer
Beijing City	−0.017 566	3.92E −06	0.034 945 4	6004.068			
Tianjin City	−0.017 566	3.92E −06	0.034 945 4	4 705.904			
Hebei Province	−0.017 566	3.92E −06	0.034 945 4	3 021.577	0.998	0.196 231	0.407 084
Shanxi Province	−0.017 566	3.92E −06	0.034 945 4	2 426.871	0.999	0.299 807	0.354 561
Inner Mongolia	−0.017 566	3.92E −06	0.034 945 4	2 523.988	1.007	0.278 779	0.357 042
Liaoning Province	−0.017 566	3.92E −06	0.034 945 4	3 154.13	0.993	0.176 323	0.422 089
Jilin Province	−0.017 566	3.92E −06	0.034 945 4	2 777.639	0.997	0.237 091	0.387 778
Heilongjiang Province	−0.017 566	3.92E −06	0.034 945 4	2 767.288	0.988	0.241 577	0.394 83
Shanghai City	−0.017 566	3.92E −06	0.034 945 4	6 975.806			
Jiangsu Province	−0.017 566	3.92E −06	0.034 945 4	4 487.521	0.994	−0.000 73	0.509 11
Zhejiang Province	−0.017 566	3.92E −06	0.034 945 4	5 513.233	0.997	−0.104 05	0.557 436
Anhui Province	−0.017 566	3.92E −06	0.034 945 4	2 362.864	0.994	0.314 127	0.352 533
Fujian Province	−0.017 566	3.92E −06	0.034 945 4	3 876.326	1.005	0.072 379	0.461 671
Shanxi Province	−0.017 566	3.92E −06	0.034 945 4	2 672.823	0.996	0.255 728	0.379 527
Shandong Province	−0.017 566	3.92E −06	0.034 945 4	3 335.591	1.007	0.146 257	0.422 953
Henan Province	−0.017 566	3.92E −06	0.034 945 4	2 488.387	1.007	0.285 297	0.353 801
Hebei Province	−0.017 566	3.92E −06	0.034 945 4	2 742.693	0.996	0.243 441	0.385 638
Hunan Province	−0.017 566	3.92E −06	0.034 945 4	2 686.904	0.999	0.252 28	0.378 197
Guangdong Province	−0.017 566	3.92E −06	0.034 945 4	4 230.702	0.982	0.029 436	0.506 623
Guangxi Province	−0.017 566	3.92E −06	0.034 945 4	2 273.06	0.998	0.330 096	0.340 509
Hainan Province	−0.017 566	3.92E −06	0.034 945 4	2 639.431	1.017	0.254 905	0.359 232
Chongqing City	−0.017 566	3.92E −06	0.034 945 4	2 333.569			
Sichuan Province	−0.017 566	3.92E −06	0.034 945 4	2 373.151	0.995	0.311 714	0.352 707
Guizhou Province	−0.017 566	3.92E −06	0.034 945 4	1 649.511	1.002	0.464 109	0.269 829
Yunnan Province	−0.017 566	3.92E −06	0.034 945 4	1 793.351	0.992	0.436 618	0.293 683
Tibet	−0.017 566	3.92E −06	0.034 945 4	1941.144	0.999	0.399 224	0.305 55
Shaanxi Province	−0.017 566	3.92E −06	0.034 945 4	1 789.205	0.993	0.436 953	0.292 483
Gansu Province	−0.017 566	3.92E −06	0.034 945 4	1 724.604	0.996	0.450 206	0.282 811
Qinghai Province	−0.017 566	3.92E −06	0.034 945 4	1 855.36	0.991	0.422 897	0.301 544
Ningxia Province	−0.017 566	3.92E −06	0.034 945 4	2 175.325	0.996	0.350 767	0.332 263
Xinjiang	−0.017 566	3.92E −06	0.034 945 4	2101.861	1.004	0.362 062	0.318 588

Note: Due to the lack of statistics for the chemical fertilizer price index, the price elasticity of chemical fertilizer demand in the municipality directly under the Central Government is the missing value.

From the calculation results in Table 3, the average price elasticity of chemical fertilizer in China is 0.264 575, and the elasticity of the various provinces differs. The provinces, with the price elasticity of chemical fertilizer more than the national average, include Shanxi, Fujian, Guangdong, Guangxi, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Xinjiang, Ningxia, and Qinghai. This means that the impact of changes in the prices on chemical fertilizer demand in these provinces is greater than that in other provinces. In addition, the price elasticity of chemical fertilizer is only negative in Zhejiang and Jiangsu, indicating that the construction of market economy in these two provinces is sound, and they can give play to the regulatory role of market in the supply and demand of chemical fertilizer. The positive price elasticity in other provinces shows that the current market price of chemical fertilizer is distorted.

At the same time, by the calculation results in Table 3, we

can find that the income elasticity of chemical fertilizer in China averages 0.373 336; the elasticity is different in various provinces. From the whole country, the income elasticity of chemical fertilizer in Jiangsu, Zhejiang and Guangdong, is the largest; the provinces with the income elasticity of chemical fertilizer higher than the average include Hebei, Liaoning, Jilin, Heilongjiang, Fujian, Shandong. This means that the demand for chemical fertilizer in the above-mentioned provinces will rise along with further increase in farmers' income.

Table 4 The price elasticity and income elasticity of chemical fertilizer demand in different years

Year	α	β	C	Farmers' average net income	Average price index of chemical fertilizer	Price elasticity of chemical fertilizer	Income elasticity of chemical fertilizer
1998	−0.017 566	3.92E−06	0.034 945 4	2 301.434	0.958 846 2	0.342 261 791	0.346 522 791
1999	−0.017 566	3.92E−06	0.034 945 4	2 340.669	0.969 230 8	0.329 285 084	0.349 023 112
2000	−0.017 566	3.92E−06	0.034 945 4	2 400.595	0.909 629 6	0.345 092 763	0.362 215 628
2001	−0.017 566	3.92E−06	0.034 945 4	2 525.465	0.991 111 1	0.284 244 064	0.363 818 662
2002	−0.017 566	3.92E−06	0.034 945 4	2 674.759	1.043 846	0.240 858 848	0.372 308 619
2003	−0.017 566	3.92E−06	0.034 945 4	2 841.126	1.003 704	0.224 404 27	0.390 221 668
2004	−0.017 566	3.92E−06	0.034 945 4	3 161.399	1.057 778	0.162 713 501	0.412 332 985
2005	−0.017 566	3.92E−06	0.034 945 4	3 511.549	1.069 63	0.113 178 023	0.438 489 712
2006	−0.017 566	3.92E−06	0.034 945 4	3 871.048	0.975 555 6	0.075 428 553	0.466 988 484
2007	−0.017 566	3.92E−06	0.034 945 4	4 443.526	0.998 148 1	0.004 231 569	0.500 561 734

The calculation results in Table 4 shows that over time, decline in the price elasticity of demand of chemical fertilizer means that the price rigidity of chemical fertilizer is increasingly obvious, and changes in the price have less and less impact on the consumption of chemical fertilizer.

At the same time, Table 4 also shows that as time goes by, rise in the income elasticity of demand of chemical fertilizer means that the more the farmers' net income, the greater the demand for chemical fertilizer.

5 Conclusions and recommendations

In summary, we can draw the following conclusions.

(i) The increase in the demand of chemical fertilizer in China is affected by a variety of objective factors, such as the increase in population, the change in the growing structure and economic development, but the fundamental reason for the increase in the demand of chemical fertilizer is the implementation of national policies, especially the national policies for supporting development of the chemical fertilizer industry (such as limiting price and giving price subsidies to business, resulting in low price of chemical fertilizer) and the policies for supporting agriculture and benefiting farmers (giving farmers direct subsidies), which distort the real price of chemical fertilizer, making the market price of chemical fertilizer fail to reflect the true supply and demand situation, the price law misfire in the market of chemical fertilizer. This to a certain extent leads to the abuse of chemical fertilizer.

(ii) The truly effective market of chemical fertilizer has not yet taken shape in China. Among 31 provinces and cities involved in this study, only the market price of chemical fertilizer in Jiangsu and Zhejiang reflects the price law; the market price of chemical fertilizer in other regions cannot reflect the supply and demand relationship in the market.

(iii) "Direct subsidies for chemical fertilizer" and "direct subsidies for farmers" will continue to distort the price of chemical fertilizer, and expand the farmers' demand for chemical fertilizer, unfavorable to the protection of the environment. On the contrary, the increasingly rigid price elasticity of chemical fertilizer and increasing income elasticity indicate that the measure of collecting the chemical fertilizer tax and increasing the price of chemical fertilizer to correct farmers' consumer demand for chemical fertilizer is insufficient. Enhancement in farmers' income is the historical trend, therefore, the agricultural development policy, taking into account the environmental protection, should be that different levels of subsidies are given in accordance with difference in farmers' fertilization modes.

(iv) We calculate the basic demand of chemical fertilizer in China at 0.35 t/hm^2. Through comparison, at present, the consumption of chemical fertilizer in Beijing, Tianjin, Shanghai, Jiangsu, Fujian, Shandong, Henan, Hubei, Guangdong, Hainan and other provinces, has been more than the basic demand of chemical fertilizer. So we should strengthen management of chemical fertilizer in these provinces and reduce the damage of chemical fertilizer to the environment.

Therefore, in the process of promoting agricultural economic development, we should timely promulgate effective management measures of chemical fertilizer, taking the road of integrated development of agriculture and environment. At present, we should change the financial subsidies policy simply for improving the agricultural income. It is recommended that environment-friendly farmers' fertilization modes should be regarded as the basis of direct subsidies for farmers. We should gradually increase the marketization level of chemical fertilizer, strengthen the management of chemical fertilizer in the provinces whose consumption of chemical fertilizer exceeds the basic demand. Through the optimization of the national policy, we should achieve the coordination and unification of agricultural development objectives and environmental governance objectives.

References

[1] COWELL F. Microeconomics—principles and analysis[M]. Oxford:

Oxford University Press, 2006.
[2] JIN JY, LI JK, LI ST. Chemical fertilizer and food safety—the demand of chemical fertilizer for cereal crops[J]. Phosphate & Compound Fertilizer, 2006, 21(3): 1-6. (in Chinese).
[3] LIU AM, FENG ZM, YU G. Demand and supply balance of fertilizer resources in China based on agricultural crop demand (I)—nitrogen fertilizer resources[J]. Resources Science, 2005, 27(3): 41-46. (in Chinese).
[4] WU ZJ, ZHOU JM. Present situation, trend and strategy of control-released fertilizer and slow-released fertilizer in China[J]. Journal of Agricultural Science and Technology, 2001, 3(1): 73-76. (in Chinese).
[5] ZHANG GH, LIU ZP, LIAN YL, *et al*. Variation of groundwater quality and influence of pesticide and fertilizer on Hebei Plain[J]. South-to-North Water Transfers and Water Science & Technology, 2009, 7(2): 50-54. (in Chinese).
[6] WANG YM, HE QG. Measurement of shifts in increasing mode of Chinese agriculture[J]. Journal of Guangxi University: Philosophy and Social Science, 2009, 31(6): 26-30. (in Chinese).
[7] GU HJ, JI YQ. Effects of agricultural tax relief policy on farmers element input behavior based on empirical study of Jurong City, Jiangsu Province[J]. Journal of Agrotechnical Economics, 2008(3): 37-42. (in Chinese).
[8] QIU J. Effects of chemical fertilizers usage on water pollution and its regulation countermeasures[J]. Rural Economic Problems, 2007(S1): 75-80. (in Chinese).
[9] MA J. Farmers' Usage of chemical fertilizers in grain crops and its variables: a case in the north China Plain[J]. Journal of Agrotechnical Economics, 2006(6): 36-42. (in Chinese).
[10] PANG FX, TANG M, ZHU RX. A probe into the practical effects of the favored taxation of agricultural means of production and policy proposals[J]. Journal of Tongling College, 2006(6): 2-7. (in Chinese).
[11] ZHANG WF, XIU YX, MA J, *et al*. An analysis on driving force of fertilizer demand of china Ⅲ population, economy, technology and policy[J]. Resources Science, 2008(2): 213-220. (in Chinese).
[12] LONG WJ. Economic analysis on government restricting chemical fertilizer price behavior[J]. China Rural Economy, 2006(4): 75-80. (in Chinese).
[13] LI T, TAN YW, WANG XY. Practical evidence analysis about the influence factors of price change of agro-productive materials[J]. Xinjiang State Farms Economy, 2006(12): 14-18. (in Chinese).
[14] SHEN YD, DU ZQ, WANG YP. Inherent mechanism on agrochemical substituting and eco-friendly agrotechnical market[J]. Research of Agricultural Modernization, 2008, 29(1): 104-107. (in Chinese).
[15] XIANG PA, ZHOU Y, HUANG H, *et al*. Simulated study of green tax prompting for controlling fertilizer non-point sources pollution [J]. Journal of Hunan Agricultural University: Natural Sciences, 2007, 33(3): 328-331. (in Chinese).
[16] HOU YP, XIE JG, YIN CX, *et al*. Effects of soil testing and formula fertilization on maize yield and fertilizer utilization efficiency [J]. Journal of Anhui Agricultural Sciences, 2010,38(18):9452-9454. (in Chinese).
[17] TANG Shan, GUO XS, CAO WD, *et al*. Effect on the rice growth and yield in the combined application of fertilizer and astragalus sinicus at equal quantity [J]. Journal of Anhui Agricultural Sciences, 2011,39(14):8405-8407. (in Chinese).
[18] SHI X, YUAN L. Effect of Combined application of manure and chemical fertilizer on the dynamic changes of purple soil nutrient and soil enzyme activities[J]. Agricultural Science & Technology, 2011, 12(5): 765-767, 775.

(From page 6)

puts forth the following recommendations: first, increasing the level of residents' income, and mobilizing the residents' enthusiasm of participation in the construction of non-commercial forests; second, increasing the residents' educational level, strengthening the publicity of environmental protection; third, focusing on the construction of public facilities with forests as the main body (such as forest park); fourth, enhancing the capacity of government departments on the management of compensation funds, and increasing the transparency of use of compensation funds.

References

[1] ZHANG M. A discussion on the compensation standard for ecological forest[J]. World Forestry Research, 2010, 23(3): 69-72. (in Chinese).
[2] SONG M, HENG CY, HU B. Evaluating farmland external profit by using CVM method[J]. China Land Science, 2000, 14(3): 19-22. (in Chinese).
[3] HANEMANN WM. Welfare evaluations in contingent valuation experiments with discrete responses[J]. American Journal of Agricultural Economics, 1984, 66(3): 332-341.
[4] XU ZM, ZHANG ZQ, LONG AH, *et al*. Comparison and application of different contingent valuation methods in measuring total economic value of restoring Ejina Banner's ecosystem services[J]. Acta Ecologica Sinica, 2003, 23(9): 1841-1849. (in Chinese).
[5] ZHANG M. Positive analysis on residents' willingness to compensate for the ecological forests—a study based on an investigation of Guangzhou City[J]. Journal of Jiangxi Agricultural University: Social Sciences Edition, 2011(1): 42-49. (in Chinese).
[6] Mitchell DC, Carson RT. Using survey to value public goods: the contingent valuation method[M]. Washington DC: Resource of the Future, 1989.
[7] LIANG S, JIANG N, GU SZ. Analysis on urban waterhead farmers' environment protection willing and influencing factors[J]. China Rural Economy, 2005(5): 55-60. (in Chinese).
[8] LI Y, BAI M, ZHANG W, *et al*. Analysis on the influence factors of residents willingness to pay for improving air quality in Beijing[J]. China Population. Resources and Environment, 2002, 12(6): 123-126. (in Chinese).
[9] ZHANG P, DONG Q, XU YM. Analysis of willingness to pay and influences to non-use value of Baiyangdian wetland[J]. Rural Economy, 2008(4): 16-19. (in Chinese).
[10] BAI XF, TAN XY, GUO ZC. Empirical study on willingness to pay for ecological value of forest resources: taking region of Beijing-Tianjin-Tangshan-Chengde as example[J]. Technology Economics, 2009, 28(5): 47-53. (in Chinese).
[11] YANG X, ZHOU SK. Review of non-commercial forest compensation policy[J]. Journal of Anhui Agricultural Sciences, 2010, 38(21):11597-11601. (in Chinese).
[12] ZHAO L, ZHANG PT. The Research of Impact of Returning Cultivated Land to Forests in Poverty Areas around Beijing-Tianjin on Local Economy[J]. Asian Agricultural Research,2010,2(12):20-22,27.
[13] WANG HM, ZHANG DB, ZHOU CM. Study on assessment index system for the ecological benefit of public welfare forest in Qingliangfeng Nature Reserve[J]. Journal of Anhui Agricultural Sciences, 2011,39(19): 11565-11566. (in Chinese).