Weight Determining of Factors Influencing Grain Output Based on Entropy Weight Method

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Abstract This article selects 8 main factors (the number of rural employees, total power of agricultural machinery, effective irrigation area of crops, growing area of grain crops, fertilizer consumption, electricity consumption in rural areas, area affected and area covered) as the factors influencing grain output, and offers the method of determining weight of factors influencing grain output using entropy weight method. According to the relevant data in the period 1985-2005, we analyze the weight of factors influencing grain output in China by example. The results show that the electricity consumption in rural areas has the greatest impact on grain output, followed by total power of agricultural machinery, fertilizer consumption and area covered. To increase grain output, we must enhance the degree of mechanization, free people from the former process of direct cultivation, strengthen water conservancy construction, and do a good job in disaster prevention and mitigation.

Key words Grain output, Entropy weight method, Factors, Weight

The grain output forecast is a pivotal item in the major annual national program of lasting importance, therefore, predicting the grain output and retaining certain amount of grain reserve, can not only stabilize the people, but also effectively curb the fact that the hostile foreign forces threaten China by raising the prices of food products, so as to ensure China's stability and prosperity. Due to slowness of grain cultivation, the entire growth process is affected by a number of factors. In order to get objective and scientific forecast data of grain output, we must analyze the importance of influencing factors of grain output. For the grain output forecast, we should obtain the importance of factors influencing grain output and the weight of factors influencing grain output, through collecting the relevant data, in accordance with the actual situation and objective data[1]. For the influencing factors of grain output, I offer a method of determining the weight of factors influencing grain output, through the actual data collected.

1 Factors influencing grain output

In China, the statistical departments in general select 8 factors as factors influencing grain output: the number of rural employees, total power of agricultural machinery, effective irrigation area of crops, growing area of grain crops, fertilizer consumption, electricity consumption in rural areas, area affected and area covered[2].

2 Weight determining of factors influencing grain output based on entropy weight method

In order to better understand the main factors affecting grain output as well as the impact of these factors on grain output, I offer a method of determining weight of factors influencing grain output based on entropy weight method. The information entropy is a quantity used to describe disorder of the information contained in the information theory. I use the information entropy to measure the degree of disorder of information. The greater the entropy, the higher the degree of disorder, and the lower the effectiveness held by the corresponding information. Based on this principle, the information entropy is introduced into the determining of factors influencing grain output. The data sequence is formed through collecting the data, and then the information entropy of this data sequence is calculated. If there is a great difference degree of the data sequence, the factors influencing grain output provided will be evident, and the corresponding weight assigned to these factors is big. Through degree of variation of the data sequence, I determine the size of the effect of various factors on grain output[3].

The specific calculation steps of determining factors influencing grain output based on entropy weight method is as follows.

First, data collection and processing. I collect the relevant data from *Statistical Yearbook* to obtain the annual data of factors influencing grain output, normalize the original data x_{ij}, and calculate the proportion p_{ij}, namely:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad 0 \leqslant i \leqslant m \tag{1}$$

Second, entropy value calculation. For the influencing factor j, I use the data row under this influencing factor to calculate the entropy value of this influencing factor, namely:

$$e_j = -k\sum_{i=1}^{m} p_{ij}\ln p_{ij} \quad j=1, 2, \cdots, 8 \tag{2}$$

where $k>0$. In general, if $k=\frac{1}{\ln m}$, then $0 \leqslant e_j \leqslant 1$.

Third, deviation degree calculation. I calculate the deviation degree of the influencing factor j. For the influencing factor j determined, the smaller the impact of this influencing factor on

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grain output, the closer the data row under this influencing factor to the completely disordered state, and the greater the e_j, the smaller the deviation degree of this influencing factor, so I make the following definition:

$$g_j = 1 - e_j,\ j = 1, 2, \cdots, 8 \quad (3)$$

Fourth, weight calculation. After normalizing the deviation degree calculated, the value obtained is the weight of each influencing factor, which reflects the size of impact of this influencing factor on grain output forecast. The calculation formula of weight of the influencing factor j is as follows[4]:

$$w_j = \frac{g_j}{\sum_{j=1}^{8} g_j} \quad j = 1, 2, \cdots, 8 \quad (4)$$

3 Case study

According to *China Statistical Yearbook*, I collect and sort out the indicator value of China's grain output in the period 1985 – 2005, and all factors influencing China's grain output (Table 1). Then I use entropy weight method to calculate the weight of factors influencing grain output in China[5].

Table 1 China's grain output in the period 1985 – 2005 and indicator value of various influencing factors

Year	The number of rural employees $\times 10^4$ people	Total power of agricultural machinery $\times 10^4$ kW	Effective irrigation area $\times 10^3$ hm^2	Growing area of grain crops $\times 10^3$ hm^2	Fertilizer consumption $\times 10^4$ t	Electricity consumption in rural areas $\times 10^8$ kW · h	Area affected $\times 10^3$ hm^2	Area covered $\times 10^3$ hm^2
1985	37 065.1	20 912.5	44 035.9	108 854	1 775.8	508.9	44 370	22 705
1986	37 990.0	22 950.0	42 225.8	110 933	1 930.6	586.7	47 140	23 656
1987	39 000.0	24 836.0	44 403.0	111 268	1 999.3	658.8	42 090	20 393
1988	40 067.0	26 575.0	44 375.9	110 123	2 141.5	712.0	50 870	23 945
1989	40 938.8	28 067.0	44 917.2	112 205	2 357.1	790.5	46 990	22 449
1990	42 009.5	28 707.7	47 403.1	113 466	2 590.3	844.5	38 470	17 819
1991	43 092.5	29 388.6	47 822.1	112 314	2 805.1	963.2	55 470	27 814
1992	43 801.6	30 308.4	48 590.1	110 560	2 930.2	1 106.9	51 330	25 859
1993	44 255.7	31 816.6	48 646.0	110 509	3 151.9	1 244.8	48 830	23133
1994	44 654.1	33 744.0	48 792.0	109 544	3 317.9	1 473.7	55 040	31 383
1995	45 041.8	36 118.1	49 119.0	110 060	3 593.7	1 655.5	45 874	22 267
1996	45 288.0	38 546.9	50 381.4	112 548	3 827.8	1 676.5	46 989	21 233
1997	45 962.0	42 015.6	51 238.5	112 912	3 980.7	1 980.1	53 429	30 309
1998	46 432.3	45 208.0	52 296.0	113 787	4 083.7	2 042.1	50 145	25 181
1999	46 896.5	48 996.1	53 158.4	113 161	4 124.3	2 173.4	49 981	26 731
2000	47 962.1	52 573.6	53 820.3	108 463	4 146.4	2 421.3	54 688	34 374
2001	48 228.9	55 172.1	54 249.4	106 080	4 253.8	2 610.1	52 215	31 793
2002	48 526.9	57 929.9	54 354.8	103 891	4 339.4	2 993.4	47 120	27 319
2003	48 971.0	60 386.5	54 014.0	99 410	4 411.6	3 432.9	54 386	32 516
2004	49 695.3	64 140.9	54 478.7	101 606	4 636.8	3 933.0	37 106	16 297
2005	50 387.3	68 549.4	55 029.3	104 278	4 766.2	4 375.7	38 818	19 966

In order to calculate the importance of each influencing factor, namely the weight, prior to using entropy weight method to determine the weight of influencing factors, I use formula (1) to normalize the statistical data, and the normalized results can be seen in Table 2.

Table 2 Normalized results of China's grain output in the period 1985 – 2005 and indicator value of various influencing factors

Year	The number of rural employees	Total power of agricultural machinery	Effective irrigation area	Growing area of grain crops	Fertilizer consumption	Electricity consumption in rural areas	Area affected	Area covered
1985	0.039 6	0.024 7	0.042 2	0.047 4	0.025 0	0.013 3	0.043 9	0.043 1
1986	0.040 6	0.027 1	0.040 5	0.048 3	0.027 1	0.015 4	0.046 6	0.044 9
1987	0.041 7	0.029 3	0.042 6	0.048 5	0.028 1	0.017 3	0.041 6	0.038 7
1988	0.042 8	0.031 4	0.042 5	0.048 0	0.030 1	0.018 6	0.050 3	0.045 4
1989	0.043 7	0.033 1	0.043 1	0.048 9	0.033 1	0.020 7	0.046 5	0.042 6
1990	0.044 9	0.033 9	0.045 4	0.049 4	0.036 4	0.022 1	0.038 0	0.033 8
1991	0.046 0	0.034 7	0.045 8	0.048 9	0.039 4	0.025 2	0.054 8	0.052 8
1992	0.046 8	0.035 8	0.046 6	0.048 2	0.041 2	0.029 0	0.050 8	0.049 1
1993	0.047 3	0.037 6	0.046 6	0.048 1	0.044 3	0.032 6	0.048 3	0.043 9
1994	0.047 7	0.039 8	0.046 8	0.047 7	0.046 6	0.038 6	0.054 4	0.059 5
1995	0.048 1	0.042 6	0.047 1	0.047 9	0.050 5	0.043 4	0.045 4	0.042 2
1996	0.048 4	0.045 5	0.048 3	0.049 0	0.053 8	0.043 9	0.046 5	0.040 3
1997	0.049 1	0.049 6	0.049 1	0.049 2	0.055 9	0.051 9	0.052 8	0.057 5
1998	0.049 6	0.053 4	0.050 1	0.049 6	0.057 4	0.053 5	0.049 6	0.047 8
1999	0.050 1	0.057 9	0.050 9	0.049 3	0.058 0	0.056 9	0.049 4	0.050 7
2000	0.051 2	0.062 1	0.051 6	0.047 2	0.058 3	0.063 4	0.054 1	0.065 2
2001	0.051 5	0.065 1	0.052 0	0.046 2	0.059 8	0.068 4	0.051 6	0.060 3
2002	0.051 8	0.068 4	0.052 1	0.045 2	0.061 0	0.078 4	0.046 6	0.051 8
2003	0.052 3	0.071 3	0.051 8	0.043 3	0.062 0	0.089 9	0.053 8	0.061 7
2004	0.053 1	0.075 7	0.052 2	0.044 3	0.065 2	0.103 0	0.036 7	0.030 9
2005	0.053 8	0.080 9	0.052 7	0.045 4	0.067 0	0.114 6	0.038 4	0.037 9

I take $k=\frac{1}{ln21}$ and use entropy calculation formula $e_j=-\frac{1}{ln21}\sum_{i=1}^{m}p_{ij}\ln p_{ij}$ to calculate the entropy value of each influencing factor as follows:

e=(0.998 8, 0.979 8, 0.998 9,0.999 8, 0.986 5, 0.941 6,0.997 9, 0.993 9)

Then I calculate the deviation degree of each influencing factor, and the deviation degree vector is obtained as follows:

g=(0.001 2 0.020 2 0.001 1 0.000 2 0.013 5 0.058 4 0.002 1 0.006 1)

Finally, I normalize the deviation degree, so as to get the weight of each influencing factor as follows:

w=(0.011 8 0.196 5 0.010 3 0.002 1 0.131 5 0.567 9 0.020 7 0.059 1)

By comparing the size of weight of each influencing factor, we can find that the electricity consumption in rural areas has the greatest impact on grain output, followed by total power of agricultural machinery, fertilizer consumption and area covered. This indicates that in the process of grain output forecast, the size of electricity consumption in rural areas reflects the size of mechanized operation in rural areas. In order to increase food output, we must enhance the degree of mechanization, reduce the intensity of the artificial labor, free people from the former process of direct cultivation, and strengthen the work of management. In the mean time, fertilizer consumption and area covered also exert impact on grain output, indicating that the size of area affected has great effect on grain output, therefore, we should strengthen the construction of water conservancy, do a good job in disaster prevention and mitigation, ensure efficient irrigation in arid regions, and use water conservancy facilities to flood control in areas prone to flooding.

4 Conclusions

The prediction of grain output is a complex systematic project. In the process of predicting the grain output, we should take full account of the impact of various factors on grain output, and grasp the importance of each influencing factor, in order to effectively predict grain output, ensure scientificity and credibility of forecast data of grain output, and carry out directed improvement and regulation in the national macro-control[6]. In factors influencing grain output, the electricity consumption takes up a large proportion, indicating that in the production process of agricultural products, we should link pieces of farmland, and strengthen mechanization operation, so as to effectively improve the grain output and reduce the manpower input. Therefore, on the one hand, the analysis of factors influencing grain output can help the farmers to conduct directed improvement and cultivation in the process of improving varieties of grain or cultivating grain; on the other hand, the analysis of factors influencing grain output can help macroeconomic policymakers to seize the key factors for analysis and forecast in the process of forecasting grain output, so as to promote the accuracy of prediction of grain yield, and provide scientific and rational planning proposals for decision-makers.

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