Analysis of Meteorological Disasters and Its Impact based on Production Function

Chen Yunfeng[1,2], Li Lianshui[1], Cui Mengmeng[3] and Wang Jin[3]

[1]*School of Applied Meteorology, Nanjing University of Information Science & Technology, Nanjing, China*
[2]*China Meteorological Press, Beijing, China*
[3]*Jiangsu Engineering Center of Network Monitoring, Nanjing University of Information Science & Technology, Nanjing, China*
yunfengcmp@sina.com, {llsh, cuimengmeng, wangjin}@nuist.edu.cn

Abstract

The preliminary analysis of the direct economic losses of meteorological disasters in the nearly 20 years, using the C-D production function and the factor of meteorological disasters, to measure the overall impact of meteorological disasters on the national economy. Using the 1989-2008 meteorological disasters data with economic and social statistics information established a production function model including meteorological disasters factor. The results showed that meteorological disasters have brought a loss of 9.72% to the national economy each year , is nearly four times of the average annual direct economic losses to GDP ratio (2.44%); meteorological disasters of the best and the worst year for GDP fluctuating between 11.5% -14.5% , meteorological disasters impact on the national economy is huge.

Keywords: *meteorological disasters; production function; disaster factor; economic losses*

1. Introduction

Meteorological disasters accounted for more than 70% of the natural disasters in China, and like other geological disasters such as landslides, mudslides and marine disasters such as storm surges, red tides and biological pest mostly caused by the weather hazard. Therefore, studying the meteorological disasters impact on national economy is very important and necessary. Natural disasters system is a complex system, in contrast, the direct economic losses of material form caused by disasters is easier to measure, but the socio-economic impact caused by disasters is multifaceted, particularly, huge disaster, catastrophe, affecting a wide range and long duration of follow-up effects, the impact of disasters will be further spread in the national economy system, causing a greater loss [1-3]. This would involve estimation of the indirect economic losses, which is a very complex issue. The definition of indirect economic losses has a different view [4-6], there are some scholars researched on the estimation of indirect economic losses, but these estimations are still rough and uncertain [7-12].

The study of the meteorological disasters impact, usually more concerned about the direct economic losses, whiles little research on the total economic impact of meteorological disasters. Clearly, analysis of meteorological disasters impact on national economy and only considering the direct economic loss is not enough, but also considering the indirect economic losses, the investment cost of disaster prevention and resilience, the cost of casualties, and so on. In this paper, the C-D production function and the meteorological disasters factor are utilized to assess the overall impact of meteorological disasters on the national economy.

2. Background

Direct economic losses are caused partly by natural disasters which include the loss of agricultural, industrial and mining losses, loss of infrastructure, loss of public facilities, family property damage, and so on. Thus, while China's civil affairs department counts the natural disaster in addition to the population casualties and direct economic losses but also collapsed houses, damaged houses, dead livestock, the area of affected crops (demolished area) and other indicators, but according to statistical indicators of the natural disasters economic losses made by Ministry of Civil Affairs can be seen that these types of indicators actually have been reflected in the statistics of the direct economic losses. In other words, the two indicators which are population casualties and direct economic losses can completely reflect the disaster. This paper will first use the disaster factor of the C-D production function direct reference of the existing research results. After processing the original disaster data using the normalization method, the normalized value of the deaths and direct economic losses can be obtained. Then the composite index of meteorological disasters is integrated [13]. Other economic and social information are from the "Statistical Data Collection of New China over Past Fifty-Five Years" and "China Statistical Yearbook" over past years.

3. Methods based on Cobb- Douglas Production Function

Cobb-Douglas Production Function is the most widely used production function in economics, usually referred as the C-D production function. In the case of the same technical and economic conditions, outputs and inputs of labor and capital relationship can be expressed as:

$$Y=\mathrm{A}\ K^{\alpha}\ L^{\beta} \qquad (1)$$

Where Y represents output, A represents the level of technology, K represents the amount of capital invested, and L represents the amount of labor input, α, β represents the output elasticity of K and L. The exponent α represents capital elasticity, indicating that when the productive capital increases 1%, the output increases α% in average; β is the flexibility of the labor force, indicating that when the labor put into production increases 1%, the output increases β% in average; A is a constant, that can affect yield, but neither alone attributable to the capital nor alone attributable to the labor factors [14]. The economic significance of α is the proportion of labor remuneration in total output (relative share), the economic significance of β is the proportion of capital return in total output.

Formula (1) introduces the weather disaster factor M, having the following functional form:

$$Y=\mathrm{A}\ K^{\alpha}\ L^{\beta} M^{\ \gamma} \qquad (2)$$

Taking the logarithm of formula (2) on both sides:

$$\ln Y = \ln A + \alpha \ln K + \beta \ln L + \gamma \ln M \qquad (3)$$

Where Y is the annual GDP value, K is the total fixed asset investment, L is the annual employment of the country, M is the composite index of meteorological disasters. Using statistical information of the above-mentioned elements between 1989-2008, regress formula (3), to calculate A, α, β, γ.

4. Meteorological Disasters Impact on National Economy

Taking use of GDP between the year 1989-2008, social fixed asset investment (comparable prices, 1978 = 100), the number of employment, etc, socio-economic statistics, and calculate comprehensive disaster index according to the literature [13] (see Table 1), using formula (2) and (3) to calculate.

Table 1. Elements Referenced by the Production Function

Year	GDP (Comparable Prices,100 Million Yuan)	Number of Employment	Social Fixed Asset Investment (Comparable Prices,100 Million Yuan)	Comprehensive Disaster Index
1989	8095.426	55329	2101.191	4.96
1990	8626.525	64749	2087.338	5.89
1991	9732.574	65491	2499.777	7.24
1992	11307.64	66152	3393.574	5.39
1993	12938.08	66808	4786.635	5.66
1994	14217.67	67455	5027.168	6.9
1995	15317.13	68065	5788.36	5.81
1996	16556.55	68950	5329.96	7.7
1997	17871.24	69820	5644.06	4.29
1998	19252.35	70637	6479.516	6.92
1999	20748.98	71394	6907.615	4.19
2000	22860.51	72085	7584.73	4.3
2001	25092.72	73025	8515.673	3.87
2002	27758.41	73740	10034.58	3.83
2003	30960.29	74432	12666.2	3.39
2004	35076.42	75200	15462.35	3.15
2005	39626.7	75825	19095.69	3.67
2006	44994.27	76400	23326.96	4.73
2007	50553.08	76990	27803.69	3.91
2008	57522.48	77480	32961.74	4.2

Get following regression equation by Formula (3):

$$\ln Y = -6.126 + 0.598\ln K + 0.981\ln L - 0.14\ln M \qquad (4)$$

The goodness of fit can be 99.6%. In addition, F = 670.888, along with the Sig value close to 0, it can also be seen the overall fitting effect of the model is very good. The level

significance of model parameters, all the Sig values are less than 0.05, can be considered variable coefficients are significant.

It can be seen from Formula (4):

$$Y=0.002185\,K^{0.598}\,L^{0.981}M^{-0.14} \qquad (5)$$

γ =-0.14 indicates that meteorological disasters have a negative impact on the national economy, if the disaster factor increases by 1%, the GDP value decreases by 0.14%. $\gamma/(\alpha+\beta+\gamma)$ =-9.72%, shows that meteorological disasters cause an average loss of 9.72% to the national economy every year, is nearly four times of the average annual direct economic losses to GDP(2.44%). In other words, considering the meteorological disasters affect the entire social and economic system, its impact to the national economy is 9.72% of GDP value each year.

Table 2. Model Outputs (100 Million Yuan)

Year	GDP	Module Prediction GDP	Best Year	Worst Year	Best-Worst	Changes Amplitude (%)
1989	16992.3	15987.02	17036.15	15032.33	2003.823	11.79253
1990	18667.8	18699.44	20411.8	18010.93	2400.873	12.86104
1991	21781.5	21162.51	23777.55	20980.79	2796.758	12.84006
1992	26923.5	28449.47	30671.37	27063.74	3607.621	13.39952
1993	35333.9	40197	43633.95	38501.65	5132.303	14.52515
1994	48197.9	50450.62	56304.35	49681.73	6622.618	13.74047
1995	60793.7	66413.2	72356.17	63845.51	8510.662	13.99925
1996	71176.6	66664.29	75550.7	66664.29	8886.408	12.48501
1997	78973	77916.14	81359.44	71789.8	9569.643	12.11761
1998	84402.3	79416.41	88666.92	78237.76	10429.16	12.35649
1999	89677.1	88183.35	91776.83	80981.88	10794.96	12.03758
2000	99214.6	94190.18	98384.74	86812.55	11572.19	11.6638
2001	109655.2	104469.6	107524.1	94876.95	12647.18	11.53359
2002	120332.7	115586.2	118792.9	104820.2	13972.63	11.61167
2003	135822.8	138028.8	139455.1	123052.1	16402.96	12.07673
2004	159878.3	164899.3	164899.3	145503.5	19395.75	12.13157
2005	183867.9	187936.7	192000	169416.6	22583.39	12.2824
2006	211923	209067	221310.8	195279.9	26030.98	12.28322
2007	249530	251818.2	259554.4	229025.2	30529.25	12.2347
2008	300670	294112.9	306200.2	270184.4	36015.82	11.97852

Table Note: ① Best year is the output for the smallest M value of the 3.15 comprehensive disaster index value in 2004; Similarly worst year is the output for the biggest M value of the 7.7 comprehensive disaster index value in 1996.

② "Best-Worst" is the difference of best year output and worst year output.

③ The Changes Amplitude is the "Best-Worst" ratio of GDP.

Table 2 is the model output of using the formula (5). For instance, in 2008, if we come across a good year as 2004, the value of GDP will achieve 30.62 trillion Yuan which is 553 billion Yuan higher than the real GDP; if we met the worst year as in 1996, the value of GDP was 27.0184 trillion Yuan which was 3.0486 trillion Yuan lower than the real GDP value. The D-value between the best and worst year is 3.6015 trillion Yuan and the amount of variations is nearly 12%. The variations between the best and worst year range from 11.5% to 14.5% over the years. That is to say Meteorological disasters will have a great influence on the national economy.

5. Conclusion and Discussion

This article utilizes of c-d production function to input meteorological disasters disaster factor. According to the overall impact by Meteorological disasters on the national economy we go through a quantitative analysis and conclude that:

(1) Every year the national economy loss caused by meteorological disasters is 9.72%. It is nearly four times of average annual direct economic losses as a proportion of GDP (2.44%).

(2) The variations between the best and worst year range from 11.5% to 14.5%. That is to say meteorological disasters will be a great influence on the national economy.

It is not comprehensive to measure the effect of the national economy by simple using meteorological disasters. However, it is very difficult to calculate the indirect loss cause by the disaster accurately especially the link economic loss, in addition of disaster prevention and mitigation investment, the value of the casualties also exists technical difficulties. In addition the influence of various economic loss cause by Meteorological disasters to the national economy is far from only this aspect, it will also have a complex influence on the whole social and economic system. The influence is very wide and strong. This article measure the national economy overall caused by meteorological disaster by using the mature production function theory introducing meteorological disaster factor, the method is simple, and through the statistics test, the result is credible.

Acknowledgement

This work is supported by the project of Scientific Research of Public Service Industry, “Assessment Methods and Technology Research of the Meteorological Services Effective” (GYHY200806017).

References

[1] China Meteorological Administration. 2010. China's Meteorological Disasters Yearbook. Beijing. Meteorological Press, **(2010)**, Preface.

[2] Y. Wei, “The Complexity of Natural Disasters”, Geographical Sciences, 18(1), pp. 25-30, **(1998)**.

[3] T. Liu and T. C. Yan, “Positive analysis of meteorological disaster loss and regional difference”, Journal of Natural Disasters, 20(1), pp. 84-91, **(2011)**.

[4] R. Boisvert, “Indirect economic consequences of a catastrophic earthquake. Direct and indirect economic losses from lifeline damage”, FEMA Contract EMW - 90 - 3598, Development Technologies Inc., Washington, DC, USA, **(1992)**.

[5] Y. Huang, Z. Yang and Y. Shao, “Disaster Indirect Economic Loss Measurement”, Disaster science, 9(3), pp. 7-11, **(1994)**.

[6] S. Xu, "Loss Concept of Disasters Economic and Industry Associated Indirect Economic Losses Measurement", Journal of Natural Disasters, 7(4), pp. 7 – 15, **(1998)**.

[7] A. Hu Aijun, N. Li and P. Shi, "Extreme Weather Events Lead to Destruction of Infrastructure and Indirect Economic Loss", Economic Geography, 29(4), pp. 529-533, **(2009)**.

[8] X. Zhang and G. Mei, "Disaster Economic Research on Two Elements Multi-Sectoral CGE Model", Journal of Natural Disasters, 8(1), pp. 9 – 15, **(1999)**.

[9] Q. Yu and R. Shen, "Disaster Economic Loss Assessment Theory and Methods", Disaster science, 11(2), pp. 10-14, **(1996)**.

[10] K. Yin and W. Sun, "Research on the index system of the storm surge disaster economic loss assessment", Chinese Fisheries Economics, 29(3), pp. 87-90, **(2011)**.

[11] X. Liu and Y. Zhao, "Geomorphic Hazards Indirect Economic Loss Assessment: Debris Flows", Geography Progress, 27(3), pp. 7-12, **(2008)**.

[12] J. Lin and J. Zhong, "Earthquake Disaster Industry Related Damage Assessment", World Earthquake Engineering, 23(2), pp. 37-40, **(2007)**.

[13] Y. Chen and G. Gao, "Preliminary Analysis of China Meteorological Disasters Loss of Nearly 20 Years", Weather, 36 (2), pp. 1-5, **(2010)**.

[14] X. Dong, X. Wang and L. Chen, "Cobb-Douglas Production Function Theory and Research", Productivity Research, 3, pp. 148-150, **(2008)**.

Author

Chen Yunfeng

Chen Yunfeng received his bachor degree from the Department of Meteorology of Nanjing Meteorological Institute in 1984. He received the MBA degree from the College of Business Administration, University of International Business and Economy in 2002. Now, he is pursuing his Ph.D. degree in the School of Applied Meteorology, Nanjing University of Information Science & Technology. His main research interests include the meteorological disaster assessment and the meteorological services evaluation etc.