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EVALUATING FINE DUST POLLUTION IN REPUBLIC OF KOREA BY STATISTICAL REASONING, AND ITS APPLICATIONS

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Abstract: The frequency and intensity of micro dust is one of the most critical issues in the global environmental problem. It is one of the most important global environmental issues facing the world, and it is an important topic that needs to be improved. China has reported a significant improvement in air quality over the past due to its harsh smog warfare policy, but many scientists, journals, and press releases point to the fine dust effects of China and China does not recognize it. Baekryeong Island is a Korean island which is located in the forefront military frontier area of North Korea. It is located at the forefront military base adjacent to China. It is reported that the value of fine dust concentration in Baekryeong Island is close to that of Seoul. There are articles claiming that China's overseas dust particles have significant effect on the fine dust concentration in Baekryeong Island considering that the pollution level of Baekryeong Island, which has lower levels of population and vehicles densities compared to those of Seoul, is close to that of Seoul. On the other hand, some argue that that the high density of fine dust in Baekryeong Island are mainly due to factors such as pollutants emitted from the forefront military bases, the influence of North Korea, which is geographically close to the North, and ships that cannot control pollutants. The purpose of this article is to provide a more specific statistical basis for the claim that one of the factors influencing the high density of fine dust in Baekryeong Island is China's fine dust. This article also briefly summarizes the origin, diagnosis and subsequent international cooperation of fine dust.

Keywords: fine dust issues, global environmental problems, statistical reasoning, particulate matter

Areas of review: Business Statistics, Operations Management

I. INTRODUCTION

The international journal Nature in 2017 reports that the ultrafine dust emitted from China harms the health of people around the world, and the fine dust in spring suggested that 7 million people died worldwide in a year [1]. According to this paper [1], super fine dust (PM2.5) with a diameter of less than 2.5 ›3 moves across the country, and other countries, such as China, can lead to premature death. China has the greatest number of early deaths due to fine dust, with 1.9 million deaths, followed by India with 580,000, Southeast Asia with 450,000, the Middle East and North Africa with 280,000, Eastern Europe with 220,000, and Western Europe with 200,000. Other East Asian countries including Republic of Korea, Mongolia, North Korea and Japan account for about 89,000 people. Analysis shows that 90% of premature deaths from cardiovascular diseases are due to ultrafine dusts designated as carcinogens [1].

According to a report by the Financial Times in the UK in 2017, South Korea's Seoul, along with China's Beijing and New Delhi, India, has become the most serious air pollution source [3]. In June 2016, the Organization for Economic Cooperation and Development (OECD) warned serious air pollution problems in Republic of Korea, surrounded by fine dust, and called for aggressive responses [5].

The OECD published a report on the economic consequences of outdoor air pollution, which calculated

the social costs associated with increased particulate and surface ozone [4]. In the neighboring countries, Republic of Korea and Japan accounted for half of the total, 39,900. The analysis shows that 90% of premature deaths from cardiovascular diseases are due to ultrafine dusts designated as carcinogens [4].

According to a recent report on the smog in the Seoul area, China's Xinhua news agency mentions that the cause of the smog that sometimes appears in Seoul is caused by the basin terrain, population density, large diesel cars, enormous quantities of dust and vehicles, and that it does not rule out the effects of smog from neighboring country.

In recent years, Republic of Korea's fine dust problem has become a major social issue. On March 26-27 and April 6, 2018 in Seoul, Republic of Korea reported that it showed the highest level of fine dust in the world, and this year (2018), the PM2.5 warning has been issued four times already. The ultrafine dust warning, which increases the risk of lung disease and heart disease, is issued when the average concentration per hour is over 90 μg / m^3 for 2 hours. According to the Ministry of Environment of the Republic of Korea, smog formation from China is getting worse and the period of occurrence is shortened, even if domestic pollutant emissions are reduced, high concentration fine dust is not decreasing. Although China reported a significant improvement in air quality over the past due to its harsh smog warfare policy, many scientists and journals have pointed to the fine dust effects of China and China has not acknowledged that.

Baekryeong Island is the island of the Republic of Korea and is the largest island of the five islands in the west of the 5th degree. It is 149km from Pyongyang in North Korea, 225km from Weihai in China, and the shortest distance from the mainland of Shandong Peninsula. The Marine Corps of the Republic of Korea (ROK) Marine Corps is stationed on the forefront of North Korea as a military base [7]. It is reported that the value of fine dust concentration in Baekryeong Island is close to the value of fine dust concentration in Seoul [7]. Accordingly, there are articles or news claiming that China's overseas dust particles have significant effect on the fine dust concentration in Baekryeong Island considering that the pollution level of Baekryeong Island, which has lower levels of population and vehicles densities compared to those of Seoul, is close to that of Seoul [7]. On the other hand, some argue that that the fine dust concentration in Baekryeong Island are mainly due to factors such as pollutants emitted from the forefront military bases, the influence of North Korea, which is geographically close to the North, and ships that cannot control pollutants [11,13].

The purpose of this article is to provide a more specific statistical basis for the claim that among the factors affecting the high dust density of Baekryeongdo, fine dust from China is one of the significant influencing factors. This article also briefly summarizes the origin, diagnosis and subsequent international cooperation of fine dust in conclusion.

The rest of this article is organized as follows: In Section 2, this article briefly presents the definition and severity of fine dust. In Section 3, this article presents the statistical basis for the claim that one of the factors influencing the high dust density index of Baekryeongdo is China's fine dust. In section 4, this article concludes this paper, and its implications.

II. SUMMARY: DEFINITION AND SEVERITY OF FINE DUST [6]

Dust is divided into total dust, minute dust (PM 10) with diameter less than 10 μm and ultrafine dust with diameter less than 2.5 μm (PM 2.5) depending on particle size. When exposed to fine dust for a long time, the immunity is rapidly lowered, and it can be exposed to various diseases such as cardiovascular diseases, skin diseases, eye diseases, as well as respiratory diseases such as colds, asthma and bronchitis [4]. Ultrafine dust having a diameter of less than 2.5 μm is particularly susceptible to penetration into the bronchi and deep into the lungs of the human body. (PM 2.5 environment standard setting study, National Institute of Environmental Research, 2006) Heavy metal content is high enough to be called as fine heavy metal rather than fine dust [6]

In Republic of Korea, the atmosphere is often smogged by a lot of fine dust and other air pollutants coming from China. Particularly troublesome is the seasonal limitation of dust, but fine dust is the moment

when the wind blows in the direction of Korea. Given that China is the country with the largest amount of fine dust, there are factors that cause harm to the neighboring country as well as even to Japan. In addition, there are factors that cause damage to the neighboring countries such as the Republic of India, Pakistan, Bangladesh, Iran, Afghanistan, northern Vietnam, and the Arabian Peninsula and Sahara Desert [4]. For literature review on particulate matter(PM), readers are referred to Karagulian *et al.* [2]. For literature review on desert dust and health, see Sternberg and Mona Edwards [3]. For literature on PM, readers are referred to literature listed in [6]

III. STATISTICAL ANALYSIS

This article approaches the issue of high density of fine dust in Baekryeongdo, the value of which is close to that of Seoul, using statistical reasoning:

Assumption 1: Factors affecting the fine dust index in Baekryeongdo are assumed to be (i) the influence of geographically adjacent North Korea, (ii) the substances emitted from the foremost military units, which are the main factors suggested in the counter-argument.

Since it is difficult to directly obtain data or quantify the factors that indicate the influence of geographically adjacent North Korea or the substances emitted from the forefront military bases of Baekryeongdo, this article takes an alternative approach: This article selects one region in Republic of Korea, the environment of which is very similar to that of Baekryeongdo: Yanggu, Gangwon-do, Republic of Korea. It is known that Yanggu is a county in the middle of North Gangwon Province in Republic of Korea, and is facing the North Korea on the border of the military demarcation line to the north [6]. In Yanggu, there are two ROKA infantry divisions resident in the forefront, and it has a relatively small number of population density, and vehicles compared to those of Seoul [6]. Therefore, main factors affecting the fine dust index in this region are expected to be the factors such as the elements of the forefront military bases or North Korea due to the characteristics of the forefront:

Assumption 2: Factors affecting the fine dust index in Yanggu are assumed to be (i) the influence of geographically adjacent North Korea, (ii) the substances emitted from the foremost military units, which are the main factors suggested in the counter-argument.

Under this assumption 2, the following hypothesis was set for the fine dust index in this area (Yanggu):

H_0 (Null hypothesis): Average of fine dust concentration in Yanggu = average of fine dust concentration in Seoul.

H_1 (Alternative hypothesis): The factors of the nearest military bases in the Yanggu and neighboring North Korea have no significant effect on the increase of the fine dust index of Yanggu to the level comparable to or exceeding Seoul 's fine dust index. Therefore, the concentration of fine dust in Yanggu County will be smaller than the concentration of fine dust in Seoul. (Average of fine dust concentration in Yanggu < average of fine dust concentration in Seoul)

Under the assumption that the null hypothesis is true, the fine dust concentrations of Seoul and Yanggu are compared between 2016 and 2019.

Fine dust (PM10) Monthly air pollution (unit: μg/m³)

	Yanggu	*Seoul*
2016 Jan	34	50
2016 Feb	34	45
2016 Mar	47	64
2016 Apr	55	71
2016 May	38	56
2016 Jun	26	45
2016 Jul	23	33
2016 Aug	19	34
2016 Sep	23	37
2016 Oct	25	38
2016 Nov	37	52
2016 Dec	29	48
2017 Jan	42	53
2017 Feb	37	46
2017 Mar	54	60
2017 Apr	43	56

Note 3-1> The above data was extracted from the Ministry of Environment, Air pollution status in Republic of Korea [10]

Note 3-2> Statistical analysis was performed by extracting only the comparable year of each data.

Since each data pair and the number of data is 16, a pairwise test was used to compare the differences between the two populations. The following is the result of the pairwise comparison test:

t-test results:
Pairwise comparison
test

	Yanggu	*Seoul*
Average	35.375	49.25
Sample variance	119.7166667	116.067
Number of observations	16	16
Pearson's correlation coefficient	0.940806874	
difference betweentwo means (under H0)	0	
d.f	15	
t statistics	-14.84183598	
P(T<=t) p-valueone-sided	1.12722E-10	
t one-sided	1.753050356	
P(T<=t) two-sided	2.25443E-10	
t two-sided	2.131449546	

As can be seen from the above table, the null hypothesis that the two population groups have the same mean is true is rejected because the p-value is 1.127222E-10, which is less than the significance level 0.01. In other words, the assertion of the alternative hypothesis that the concentration of fine dusts in Yanggu is less than the concentration of fine dust in Seoul is statistically significant, and the reliability of this conclusion is 0.99.

Note 3-3> The same statistical analysis was conducted for the various regions (such as Ko-sung, Jeong-Sun, Hoeng-Sung, Ulreung-do) of Korea with the forefront military bases, as well as Yanggu in Gangwon-do. All of them have the same conclusions as those presented in this article. Note that in order to check the effect of a remote island, fine dust of Ulleung-do [9] and fine dust of Seoul was also compared. And it was concluded that the fine dust of Seoul was higher than that of Ulleung-do, and the reliability of this conclusion is 0.99. Therefore, this article presents only one result of Yanggu.

Conclusion on the factors affecting the fine dust index of Baekryeongdo, and implications

This article now goes back to our original question on the factors that have a major impact on the fine dust of Baekryeongdo Island. The most important factors that influence the fine dust of Baekryeongdo are suspected to be the factors influenced by the forefront military influence brought about by counterinsurgency and the geographically adjacent factors of North Korea.

Although it is not exactly geographically consistent with Baekryeong Island, we can see through examples of (Yanggu, Gangwon-do), which is similar to Baekryeongdo's environment (geographically close to North Korea, with the forefront military bases) that factors such as (i) the influence of geographically adjacent North Korea, and (ii) the substances emitted from the foremost military units do not have a significant effect on the increase of the fine dust index of Yanggu to the level comparable to or exceeding Seoul 's fine dust index. Now we apply this conclusion to the issue of micro dust index of Baekryeongdo: If our assumption 1 is true, there is not enough reason to expect the micro dust index of Baekryeongdo to be as high as that of Seoul. But, in reality, it is reported that the micro dust index of Baekryeongdo is as high as that of Seoul. This means that our assumption 1 is not true. Therefore, among the factors affecting the high dust density of Baekryeongdo, it can be said that the factor of fine dust coming from China is one of main factors that significantly affects high density of fine dust in Baekryeongdo.

Note 3-4> This conclusion cannot be said to be accurate because Baekryeongdo and Yanggu are not geographically identical. It can be said that this is a conclusion based on approximate statistical analysis.

IV. CONCLUSIONS AND IMPLICATIONS

Problems such as fine dust, desertification, dustiness, and global warming are all connected global environmental problems. They are all connected issues, and solving one problem cannot expect other problems to be solved. Unlike developed countries where industrialization and urbanization have progressed gradually since the Industrial Revolution, developing countries that have

undergone rapid economic growth, industrialization and rapid population growth have continued to put more emphasis on economic development, We can think that such fine dust issues naturally occurred when we focused on the industry that industrial countries avoided because of relatively lack of awareness, or when we deal with industrial waste from developed countries.

The statistical analysis presented in this article provides a statistical basis for the claim that China's fine dust is one of the significant influencing factors of high density of fine dust in Baekryeong Island. It is an approximate analysis because Baekryeongdo and Yanggu do not have exactly same geographical environment.

The world is a respiratory community and air cannot follow the border. In the end, the world must face its head to form a joint research team to identify the cause of the pollution, and to improve the air quality. It is necessary to identify and plan the management accordingly. Here are some specific ways we can practice. It is known that Korean annually uses 45 billion Chinese chopsticks, and 36 billion Japanese uses disposable wooden chopsticks. It is known that more than 90% of disposable wooden chopsticks are imported from China. When the forest disappears due to excessive logging, the forest turns into a sand dune or desert, and a strong wind blows, causing the sand to cross the Yellow Sea and cross the Yellow Sea, causing yellow dust or fine dust particles flying over the Korean peninsula. It occurs mainly in the Xinjiang area and the Huanghe river, and it causes serious damage by including contaminants such as sulfurous acid cadmium, cadmium, lead and aluminum from the Chinese factory area. Therefore, reducing the use of disposable wooden chopsticks that cause desertification, and endeavoring to make forests and trees, will be expected to prevent desertification, one of the fundamental causes of fine dust and dirt, and hope that the earth and the environment will change a little bit better now can be.

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REFERENCES

Qiang Zhang, Xulia Jiang, Dan Tong, steven J Davis, Hongyan Zhao, Guannan Geng, Tong Feng, Bo Zheng, Zifeng Lu, David G. Streets, Ruijing Ni, Michael Brauer, Aeron van Donkelaar, Hong Huo, Zhu Liu, Da Pan, Haidong Kan, Yingying Yan, Jintai Lin, Kebin He, Dabo Guan, Transboundary health impacts of transported global air pollution and international trade, *Nature,* Vol. 543, pp. 705-709, (30 March 2017).

Federico Karagulian, Claudio A Belis, Carlos Francisco C. Dora, Annette M. Pruss-Ustun, Sophie Bonjour, Heather Adair-Rohani, Markus Amann, Contributions to citis' ambient particulate matter (PM): A systematic review of local source contributions at global level, *Atmospheric Environment,* Vol. 120, November 2015, pp. 475-483.

Troy Sternberg, Mona Edwards, Desert dust and health: a central asian review and steppe case study, *International Journal of Environment Research and Public Health*, 2017, November 14(11).

The economic consequences of outdoor air pollution, *OECD report*, June 09, 2016.

South Korea joins ranks of world's most polluted countries, *The financial times*, March 29, 2017.

https://en.wikipedia.org/wiki/Asian_Dust

https://en.wikipedia.org/wiki/Baengnyeongdo

https://en.wikipedia.org/wiki/Yanggu_County,_Gangwon

https://en.wikipedia.org/wiki/Ulleungdo

http://kosis.kr/statHtml/statHtml.do?orgId=106&tblId=DT_106N_03_0200076&conn_path=I3

http://news.mk.co.kr/newsRead.php?no=257887&year=2017

https://www.cnbc.com/2018/01/15/smog-coated-south-korea-declares-pollution-emergency.html

http://english.yonhapnews.co.kr/national/2018/01/19/0301000000AEN20180119005100315.html