The Effects of Various Factors in Particulate Matter Projects on Related Budget Allocations : The Case of Republic of Korea

By

UHM, Soyoung

THESIS

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

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Committee in charge:

Professor Liu, Cheol, Supervisor ______________________

Professor Lee, Junesoo ______________________

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ABSTRACT

THE EFFECTS OF VARIOUS FACTORS IN PARTICULATE MATTER PROJECTS ON RELATED BUDGET ALLOCATIONS

: THE CASE OF REPUBLIC OF KOREA

By

SOYOUNG UHM

Even though the Korean government directs majority of the funds allocated to solving poor air quality into projects related to transportation on the road, why it the performance of these projects not as good as other projects? To answer this question, this paper explores the impact of various factors on the budget of particulate matter in Korea by using a panel data analysis tool, the pooled OLS. After examining the relationship between factors and budget allocation in particulate matter projects, this research examined various features of projects with larger budget allocation. This paper focused on the performance indicator used in managing projects, the field, and the characteristic of projects through the ANOVA and Chi-square analysis. As a result, field factors can affect the budget of particulate matter response projects. This paper also found that there are relationships between field factors and performance indicator factors. Specifically, the transportation_road project which showed low performance with rich financial sources mainly used output indicators. On the other hand, industry projects which had a good performance result in reducing particulate matter emission with a small budget used both output and outcome indicators, not focusing on only output indicator. This gives implications for performance management and for budget allocation with

performance information. Simultaneously, this paper showed that the performance achievement rate used by the government in the evaluation of each project did not relate to the budget. This foundation means that the performance evaluation tool the government used was not so effective. The Korean government needs to improve performance management and evaluation, thus encouraging use of outcome performance indicators could better align with desired goals.

This research had limitations in gathering performance results from a whole field approach, not from each project. The limitation is natural given that tracking real performance results from each and every individual project is beyond the reach of any government. To verify the cause and effect between performance indicators and real results, further studies are needed to give more detailed implications to governments.

Keywords: Particulate Matter, Air quality budgetary policy, Budget allocation, Performance indicator, Performance effectiveness, Performance management.

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BLI	Better Life Index
EPA	United States Environmental Protection Agency
GAO	United States Government Accountability Office
IARC	International Agency for Research on Cancer
KRW	Korean Won (₩)
NABO	National Assembly Budget Office
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
PM	Particulate Matter
PM_{10}	Particulate Matter with diameters that are generally 10 micrometers(μm) and smaller
$PM_{2.5}$	Particulate Matter with diameters that are generally 2.5 micrometers(μm) and smaller
PPBES	Planning Programming Budgeting and Execution System
PPBS	Planning Programming Budgeting System
WHO	World Health Organization
ZBB	Zero-Based Budget

1. INTRODUCTION

"We will return clean air to you. Your right to breathe without any worry about health will be guaranteed with us." This is a very common slogan seen during every election period in Republic of Korea. It is because the air quality of Korea is the most terrible in The Organisation for Economic Co-operation and Development (OECD) countries. For this reason, one of the aspirations of many Korean is seeing a clean sky by reducing the level of particulate matters in the air.

The Korean government has continued to make efforts to reduce the concentration of particulate matter. The budget related to particulate matter has also increased dramatically, however, the concentration of particulate matter is still high. It is also necessary to examine whether the particulate matter budget is being effectively applied. It is also needed to check out whether the particulate matter budget is allocated mainly for reducing particulate matter effectively and it really leads to the reduction of particulate matter. Therefore, the aim of this paper is to offer suggestions for improving the performance of the budget for the particulate matter projects. To achieve this aim, this study examines factors that impact well performing budgets with respect to reducing particulate matter.

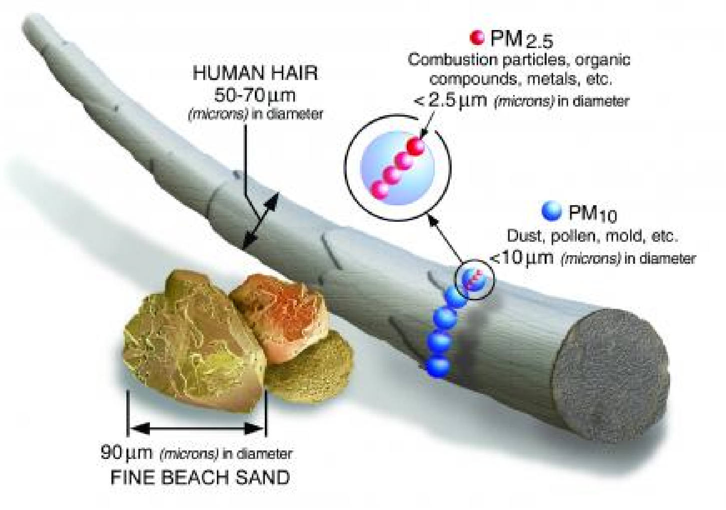
1.1 BACKGROUND OF THE STUDY

PARTICULATE MATTER

Particulate matter is an air pollutant mixture generated from hundreds of different chemicals. According to the United States Environmental Protection Agency (EPA), particulate matter includes Particulate Matter with diameters that are generally 10 micrometers(μm) and smaller (PM_{10}) and Particulate Matter with diameters that are generally 2.5 micrometers(μm) and smaller ($PM_{2.5}$). It is too small to be seen with the naked eye and so fine that it can easily be inhaled. Since it contains particles such as sulfur dioxide and nitrogen oxides, which are harmful to the human body, inhaling it causes various dangerous health problems. The International Agency for Research on Cancer (IARC), the specialized cancer agency of World Health Organization (WHO), classified outdoor air pollution and particulate matter as carcinogenic to humans (Group1) in 2013 (WHO, 2013). They added that exposure to particulate matter can lead and increase the risk of lung cancer.

This study deals with the budget-related aspects of addressing particulate matter. The Korean government does not distinguish PM_{10} and $PM_{2.5}$ when it implements policies or applies its budget. The budget aims to reduce all particulate matter, so this study did not make the distinction between each type either. The definitions and descriptions of PM_{10} and $PM_{2.5}$ are included simply as background information.

[Figure 1] Size comparison for PM particles

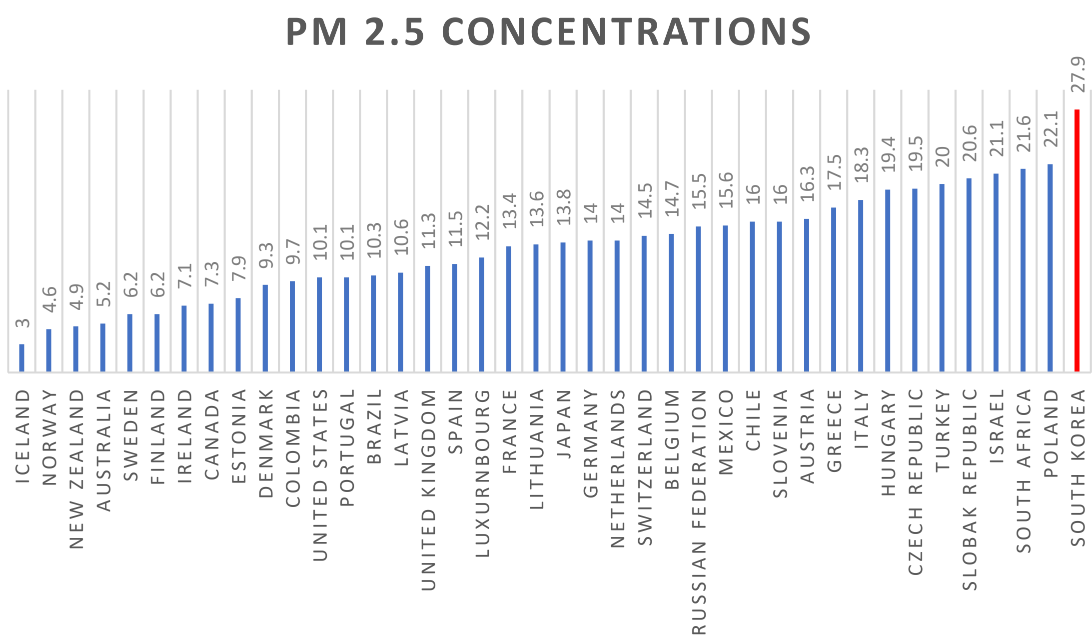


Source: EPA

THE LEVEL OF AIR POLLUTION IN REPUBLIC OF KOREA

OECD reports the Better Life Index (BLI). This index covers various living conditions and quality of life indicators and enables us to compare different levels across countries. According to the BLI released in 2018, air pollution in Republic of Korea is the most severe among the 40 countries studied, which includes OECD members and some other key partner countries like Brazil, Russia, and South Africa. This result was based on the population-weighted average of annual concentrations of $PM_{2.5}$ per cubic meter in the air for the last three years. Korea ranked at 40th with 27.9 micrograms per cubic meter, while the average of the 40 countries was 13.9 micrograms per cubic meter. $PM_{2.5}$ concentration in more than half of the countries exceeded the annual average guideline value of 10 micrograms per cubic meter, which the WHO recommends not to exceed. (WHO, 2006)

Figure 2. Air pollution among 40 countries (OECD members and some key partners)



Unit: $\mu g/m^3$
Source: The Better Life Index (OECD), 2018

Table 1. WHO Air Quality Guideline (AQG) for PM

Level	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Basis for the selected level
Annual mean	20	10	These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to $PM_{2.5}$ in the ACS study. The use of $PM_{2.5}$ guideline is preferred.
24-hour mean	50	25	Based on relation between 24-hour and annual PM levels.

Source: WHO, Air Quality Guidelines, 2006

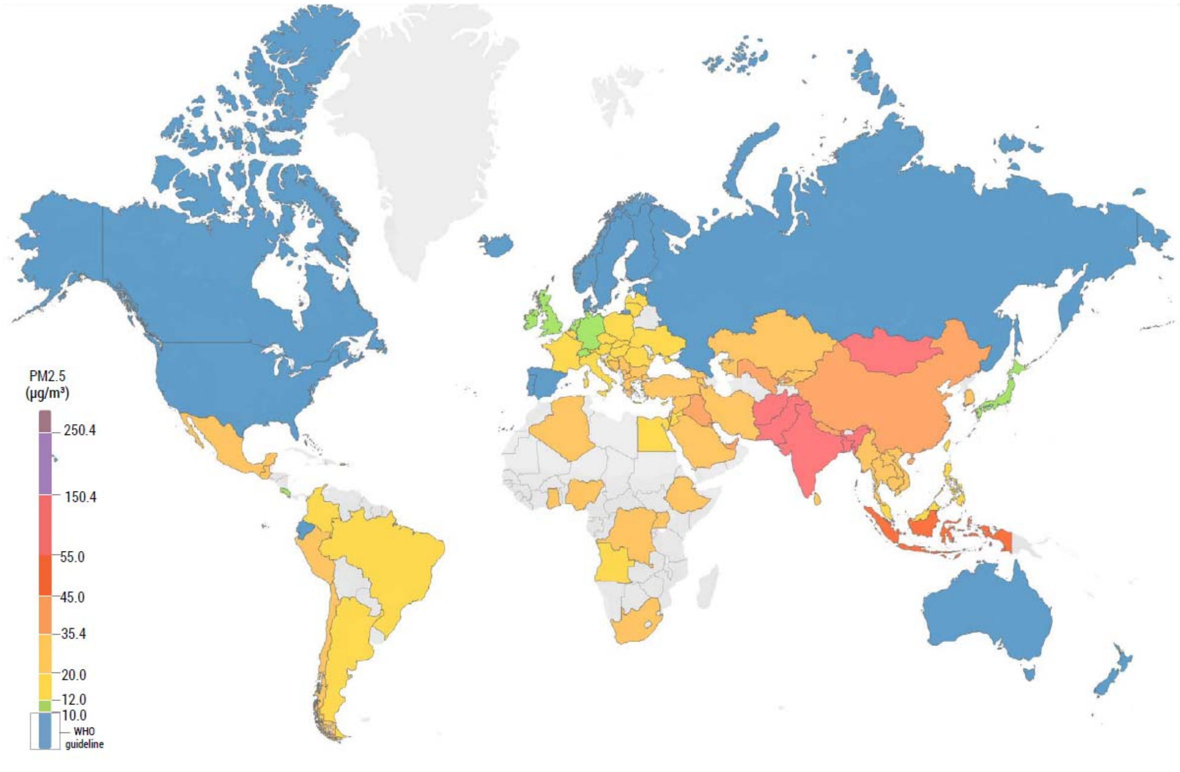
IQAIR, a leading Swiss company in the air quality filed, also releases an air quality report annually. The most recent, the 2019 World Air Quality Report, is based on $PM_{2.5}$ micrograms using data from public and private real-time monitoring systems. According to the country level sorted data on the estimated average $PM_{2.5}$ concentration, Republic of Korea (24.8 micrograms per cubic meter) was ranked at 26^{th} among 98 countries, but it remains the the worst among OECD countries (Table 2).

Table 2. Average $PM_{2.5}$ concentration world country/region ranking

Rank	Nation	$PM_{2.5}(\mu g/m^3)$	Rank	Nation	$PM_{2.5}(\mu g/m^3)$
1	Bangladesh	83.3	50	Malaysia	19.4
2	Pakistan	65.8	51	Croatia	19.1
3	Mongolia	62	52	Singapore	19
4	Afghanistan	58.8	53	Poland	18.7
5	India	58.1	54	Romania	18.3
6	Indonesia	51.7	55	Jordan	18.3
7	Bahrain	46.8	56	Egypt	18
8	Nepal	44.5	57	Philippines	17.6
9	Uzbekistan	41.2	58	Taiwan	17.2
10	Iraq	39.6	59	Italy	17.1
11	China Mainland	39.1	60	Ukraine	16.6
12	United Arab Emirates	38.9	61	Slovakia	16.1
13	Kuwait	38.3	62	Angola	15.9
14	Bosnia & Herzegovina	34.6	63	Brazil	15.8
15	Vietnam	34.1	64	Colombia	14.6
16	Kyrgyzstan	33.2	65	Argentina	14.6
17	North Macedonia	32.4	66	Hungary	14.6
18	Syria	32.2	67	Lithuania	14.5
19	DR Congo	32.1	68	Czech Republic	14.5
20	Myanmar	31	69	Latvia	13.3
21	Ghana	30.3	70	Belgium	12.5
22	Uganda	29.1	71	France	12.3
23	Armenia	25.5	72	Austria	12.2
24	Bulgaria	25.5	73	Japan	11.4
25	Sri Lanka	25.2	74	Germany	11
26	Republic of Korea	24.8	75	Netherlands	10.9
27	Iran	24.8	76	Switzerland	10.9
28	Thailand	24.3	77	Ireland	10.6
29	Kazakhstan	23.6	78	United Kingdom	10.5
30	Kosovo	23.5	79	Costa Rica	10.4
31	Macao SAR	23.5	80	Puerto Rico	10.2
32	Serbia	23.3	81	Russia	9.9
33	Peru	23.3	82	Spain	9.7
34	Laos	23.1	83	Luxembourg	9.6
35	Chile	22.6	84	Denmark	9.6
36	Greece	22.5	85	Malta	9.4
37	Saudi Arabia	22.1	86	Portugal	9.3
38	South Africa	21.6	87	USA	9
39	Nigeria	21.4	88	Ecuador	8.6
40	Algeria	21.2	89	Australia	8
41	Cambodia	21.1	90	Canada	7.7
42	Israel	20.8	91	New Zealand	7.5
43	Turkey	20.6	92	Norway	6.9
44	Hong Kong SAR	20.3	93	Sweden	6.6
45	Guatemala	20.2	94	Estonia	6.2
46	Ethiopia	20.1	95	Finland	5.6
47	Georgia	20.1	96	Iceland	5.6
48	Mexico	20	97	U. S. Virgin Islands	3.5
49	Cyprus	19.7	98	Bahamas	3.3

Source: IQAIR 2019 World Air Report, 2019

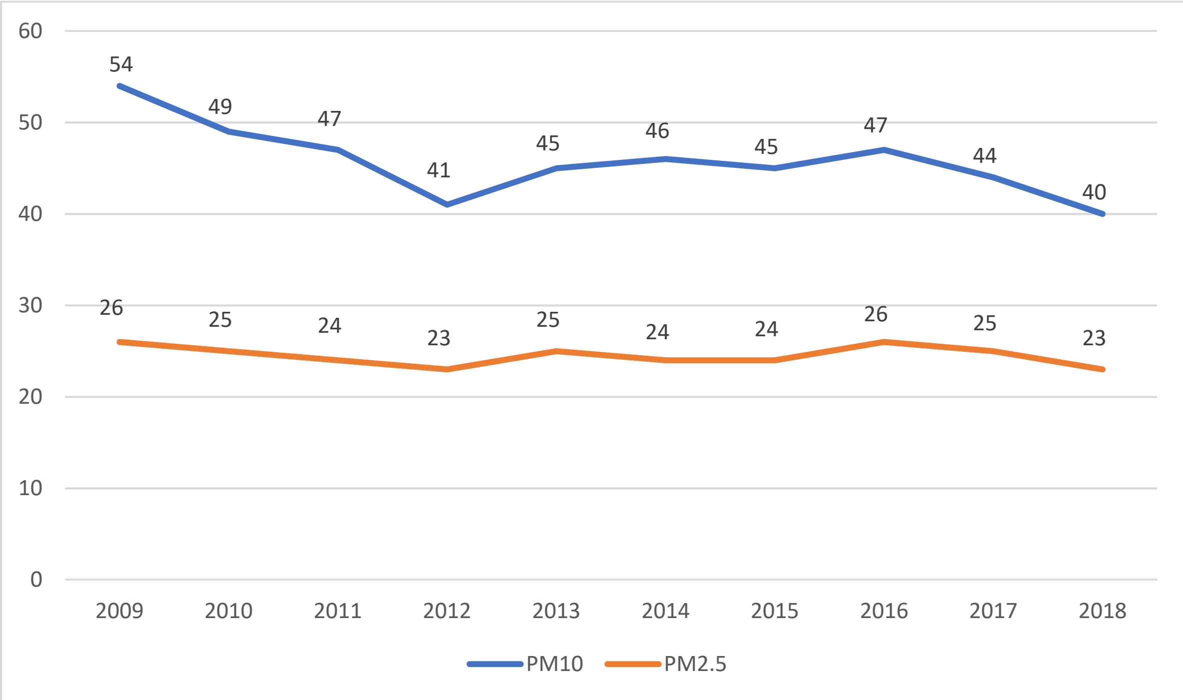
Figure 3. Global map of estimated $PM_{2.5}$ exposure by country/region in 2019



Source: IQAIR 2019 World Air Report, 2019

Looking at the trend of PM_{10} and $PM_{2.5}$ concentrations in Seoul, Republic of Korea, PM_{10} levels decreased slightly compared to 10 years ago. It was around 50 $\mu g/m^3$ in 2009 and 2010, but now it has decreased to the mid-40s $\mu g/m^3$. $PM_{2.5}$, however, has stayed around 24 $\mu g/m^3$ without much progress by repeating ascending and descending. For reference, in the case of $PM_{2.5}$, since it began to be measured nationwide from 2015, the data from Seoul were referred to (Korean government, 2019).

Table 3. 10 years trend of the annual average $PM_{2.5}$ concentration in Seoul, Korea



Unit: $\mu g/m^3$
Source: The Korean government, 2019

In Korea, the main causes of particulate matter are commonly sorted by field: power, industry, transportation_road, transportation_offroad, life, etc. According to data from the Ministry of Environment, the $PM_{2.5}$ emission amount by field in 2016 in Korea was 347,278 tons, 40 percent of those emissions, which was caused by the industry field. In 2016, the areas with the highest contribution to $PM_{2.5}$ emissions were: industry (40.9%), life (18.1%), transportation_offroad (15.6%), transportation_road (13.5%), and power generation (11.9%), very similar in order to the year 2015 data.

Table 4. $PM_{2.5}$ emission amount by field in Republic of Korea (2015-2016)

Field	Year 2015	Year 2016
Power	42,251 (12.6%)	41,475 (11.9%)
Industry	137,904 (41.0%)	142,141 (40.9%)
Transportation_road	39,193 (11.7%)	46,756 (13.5%)
Transportation_offroad	52,721 (15.7%)	54,121 (15.6%)
Life	63,998 (19.0%)	62,785 (18.1%)
Total	336,067 (100%)	347,278 (100%)

Unit: ton, %
Source: The Ministry of Environment, Republic of Korea

KOREAN GOVERNMENT'S RESPONSE TO PARTICULATE MATTER

For several years, the Korean government has released special policies to reduce the concentration of particulate matter.

The Park Geun-hye government prepared a special measure for particulate matter management in June 2016. The plan was to reduce the concentration of particulate matter in Seoul to 20 $\mu g/m^3$ by 2021 and to 18 $\mu g/m^3$ by 2026. It also announced that it will reduce particulate matter emissions by 14% compared to the 2014-level before 2021.

Since the Moon Jae-in government, which newly launched in May 2017, has set reducing particulate matter as one of its top priorities, it has prepared a total of three joint solution policies with the collaboration of related ministries. First, on September 26, 2017, the joint ministries established *Comprehensive Measures for Particulate Matter Management*. To respond to particulate matters effectively, related ministries were to prepare countermeasures to implement and promote more effective policies. There was participation in the plan from the Office for Government Policy Coordination, Ministry of Economy and Finance, Ministry of Education, Ministry of Science and ICT, Ministry of Foreign Affairs, Ministry of Agriculture, Food and Rural Affairs, Ministry of Trade, Industry and Energy, Ministry of Health and Welfare, Ministry of Environment, Ministry of Land, Infrastructure and Transport, Ministry of Oceans and Fisheries, and the Korea Forest Service. It devised strategies and plans to reduce particulate matter dust beyond the ministries. It included key goals and tasks by time and by field to promote them. The plan contained promises that particulate matter pollution level in Seoul will be reduced to 18 $\mu g/m^3$ by 2022, and domestic emissions of particulate matter will also be reduced by 30% compared to the 2014-level.

In addition, on November 8, 2018, the second joint measures for the related ministries was released as *a measure for strengthening the management of particulate matter*. The plan was revised to reduce domestic emissions of particulate matter by 35.8% compared to 2014 by 2022. The Korean government even defined particulate matter as a social disaster in March 2019, and on November 1, 2019, established the 3rd comprehensive measures to solve air quality problems. In this plan, there were no target adjustments; rather, more specific and detailed action plans and tasks including regional implementation tasks were included.

PARTICULATE MATTER BUDGET IN REPUBLIC OF KOREA

The budget related to solving particulate matter problems, whether it is applied or actual, also significantly increased. According to the Table 5, reorganized by the National

Assembly Budget Office (NABO) and based on the data submitted by various ministry in Korea, the particulate matter budget, which was KRW 915,527 million in 2016, increased to KRW 1,179,252 million in 2018. Even in 2019, the total budget was KRW 5,463,527 million, which is more than five times in three years.

Table 5. Particulate matter project budget by field (2016-2019)

Field		2016 Actual	2017 Actual	2018 Actual	2019 applied
Reducing domestic mission of PM	Power	274,772 (30.0%)	275,519 (23.4%)	524,145 (31.8%)	1,293,238 (23.77%)
	Industry	13,184 (1.4%)	37,344 (3.2%)	32,159 (2.0%)	342,741 (6.37%)
	Transportation _road	442,043 (48.3%)	591,538 (50.2%)	780,124 (47.4%)	2,554,651 (46.87%)
	Transportation _offroad	14,817 (1.6%)	45,704 (3.9%)	52,575 (3.2%)	231,491 (4.27%)
	Life	107,220 (11.7%)	120,860 (10.2%)	108,497 (6.6%)	596,196 (10.97%)
International cooperation		11,539 (1.3%)	11,575 (1.0%)	12,413 (0.8%)	37,813 (0.77%)
Protection sensitive people		14,022 (1.5%)	29,337 (2.5%)	78,897 (4.8%)	261,734 (4.87%)
Policy		37,930 (4.1%)	67,375 (5.7%)	57,850 (3.5%)	145,663 (2.7%)
Total		915,527 (100%)	1,179,252 (100.0%)	1,646,660 (100.0%)	5,463,527 (100.0%)

Unit: KRW million
Source: NABO, 2019

PERFORMANCE OF REDUCING PARTICULATE MATTER IN KOREA

The Korean government planned to reduce particulate matter concentration by 35.8%

of the level of emission from 2014 until 2022. According to NABO data based on the Ministry of Environment, Korea's particulate matter reduction performance was 7.6% in 2017 and 9.4% in 2018 compared to the level of 2014. Looking at the detailed data by field in 2018, the industry's reduction amount was 17,971 tons (14.6%) showing the best performance among different fields. On the other hand, the power generation, transportation, and life sectors remained at a reduction of around five percentage.

Here, it seems that the budget input and reduction performance are not proportional. Although nearly half of the budget was put into the transportation_road field, the transportation sector's reduction performance was low, while the industrial sector showed relatively good performance even though the budget was less than 10%.

Table 6. Performance to reduce particulate matter by field

Field	Emission Base 2014	Performance 2017	Performance 2018	Target 2022
Power	49,350 (100%)	1,387 (2.8%)	2,793 (5.7%)	11,681 (23.7%)
Industry	123,284 (100%)	17,971 (14.6%)	17,971 (14.6%)	62,400 (50.6%)
Transportation	90,361 (100%)	2,692 (3.0%)	5,601 (6.2%)	32,360 (35.8%)
Life	61,114 (100%)	2,727 (4.5%)	4,187 (6.9%)	9,675 (15.8%)
Total	324,109 (100%)	24,777 (7.6%)	30,552 (9.4%)	116,115 (35.8%)

Unit: ton, %
Source: NABO, 2019

1.2 OBJECTIVE OF THE STUDY

This paper examines factors that affect budget amount of particulate matter projects. I would like to analyze the characteristics of factors in the field that have a large budget. As can be seen from Table 5 and Table 6, the performance in reducing particulate matter was different for each field. Performance and budget input are not proportional. By identifying the characteristics of factors in each budget with different performances over five years, this paper attempt to make a partial explanation of which factor causes better performance. The purpose of this study is to provide some implications for policy-making that will help the performance-oriented budget system improve and contribute to effective allocation to reduce particulate matter in the real world.

1.3 DEVELOPMENT OF THE RESEARCH QUESTIONS

This paper focuses on factors that impact on budgets related to particulate matter. The main research question is: ***Which factor has an impact on the budget change of projects related to particulate matter?***

To clarify the question, this research proposes following subsequent research questions:

(i) Could the ***performance indicator factor*** *used to evaluate the project have an* ***impact on the budget*** *change of projects related to particulate matter?*

(ii) Could the project's ***field factor*** *have an* ***impact on the budget*** *change of projects related to particulate matter?*

(iii) Could the project's ***characteristic factor*** *have an* ***impact on the budget*** *change of projects related to particulate matter?*

(iv) Could the project's ***performance achievement rate*** *have an* ***impact on the budget change***

of projects related to particulate matter?

Moreover, this study examines the relationships between different factors and budget.

*(v) Which project **field factors** will tend to have a **large budget**?*

*(vi) Which project **performance indicator factors** will tend to have a **large budget**?*

*(vii) Which project **characteristic factors** will tend to have a **large budget**?*

This research also includes a study on the relationships between different factors:

*(viii) Is there **a relationship between field factors and performance indicator factors**?*

2. LITERATURE REVIEW

2.1. Theoretical Review

BASIC CONCEPT OF BUDGETING AND BUDGET REFORMS

A government budget is a strategic choice to allocate limited public financial resources by reflecting public needs and meeting national aims. It is beyond a simple financial plan (Mikesell, 2013). The traditional budget process includes budget preparation, budget approval, budget execution, and audit and evaluation (Kamensky, 2005).

What people want is for public services offered by governments to be valuable enough to warrant government expenditure. The budget process, however, did not provide an informal assessment. The first concerns focused on control of spending or inputs. This approach was good for controlling inputs but was not effective for management and planning. So many budget reforms have followed: traditional performance budgeting, program budgeting and planning programming budgeting system (PPBS), zero-based budgeting, and new performance budgeting (Mikesell, 2013).

Traditional performance budgeting stresses monitoring performance of activities, not on purchasing input sources. It can effectively check performance and accountability by comparing actual costs with target costs, but it is not clear that measured performance is the same as the service people want. The quality of measuring performance is a problem (Mikesell, 2013).

The program budget focuses on functions and programs, so it removes administrative boundaries between governmental agencies by combining services whose objective or purpose is similar. PPBS applied to the Department of Defense in 1961 and renamed as the planning programming budgeting and execution system (PPBES) in 2003. This approach considers expected future problems and make long term strategies by planning, programming, and budgeting (Mikesell, 2013).

The zero-based budget system (ZBB) is developing this year′s budget by excluding any previous experiences or references. Since only the most efficient programs could survive in the final budget through the removal of low-performance programs, the government could be more flexible and more effective. However, the rankings under ZBB could be different from those of the public (Mikesell, 2013).

New performance budgeting uses program evaluation information in each phase of budgeting. The money allocated to the agency is directly linked to the performance results of the agency under new performance budgeting. While traditional budgets link costs and outputs, the new performance budgets show performance results and related targets. One of the limitations of the new performance budgeting is that it eventually relies on outcomes, not outputs. This is a problem because outcomes are not easy to control and measure. Hence, in this system, governmental officials tend to focus on outputs because outputs can be more easily controlled (Mikesell, 2013).

In the case of Europe, performance budgeting is sorted by three models: presentational budgeting, performance-informed budgeting, and direct performance budgeting. Presentational budgeting makes use of performance information to communicate between government and the public. Performance-informed budgeting considers performance information in budgetary decisions. Direct performance budgeting connects each program′s budget and performance results (Sapała, 2018).

PERFORMANCE MANAGEMENT AND PERFORMANCE MEASUREMENT

Performance management is primarily concerned with how to improve performance. The fundamental framework of performance management is a cycle including the following:

planning, budgeting, management, evaluation. Planning is making the goals of the agency. Budgeting is an allocation process of limited resources. Management is making people and organizations achieve desired results by motivating and promoting them. Evaluation is analyzing performance. Performance measurement is a linking process between goals and indicators by measuring performance information (Poister, 2014).

PUBLIC SERVICE FLOW AND PERFORMANCE INDICATORS

Public service provision can be explained with four terms: inputs, outputs, outcomes, the well-being of the people. Inputs refer to the labor or goods purchased to make outputs. Outputs are results directly generated by the agency. They are closer to the agency's internal objectives rather than to their aims to be achieved. These focus on what the agency did to produce outcomes. Outcomes are directly linked to desirable results. These emphasize whether the agency achieved what they pursue. The boundary between outputs and outcomes is vague, but there is a difference between the two. Reducing outputs would make public people better off while reducing outcomes would not (Mikesell, 2013).

PERFORMANCE BUDGET IN KOREA

Since the 1980s, most OECD countries have been interested in a performance budget system that manages budgets based on performance results, away from input-oriented or output-oriented budget management. This was an effort to increase the performance of fiscal expenditures and increase efficiency. The Korean government became interested in performance budgeting in 1999, right after undergoing the Foreign Exchange Crisis in 1997. With the implementation of the National Financial Law, a performance plan started being prepared from the 2009 budget, which was submitted to National Assembly in 2008. A performance results report then began in the National Assembly from 2010 (Cook, 2015).

Performance budgeting has some limitations. There is a problem that outcomes can be affected by other factors. Outcomes are also hard to measure. Sometimes it is hard to cut the low-performance project budget due to its public characteristics (Cook, 2015).

Republic of Korea introduced the performance management system around 2008. This system was introduced to increase the efficiency of financial management and budget allocation and effectively achieve project objectives. However, unlike the purpose of the introduction, transparency and accountability could not be realized due to lack of a comprehensive management system (Lim & Lee, 2015).

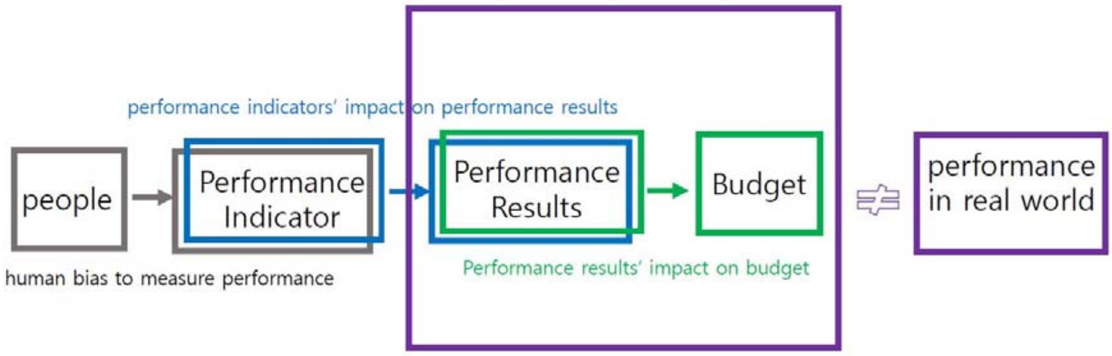
It is also difficult for the National Assembly to conduct a performance-based settlement review. Many experts point out that reasonableness of performance indicators, appropriation of setting target goals, and objectivity of measuring performances are troublesome in the performance result reports government submitted to the National Assembly (Ha et al, 2015).

Some point out that the linkage between budget allocation and performance indicators is weak. The performance indicator was originally intended to determine whether the desired results were achieved. The Ministry of Strategy and Finance in Korea introduced a program review system (developed in an integrated fiscal information system in 2016) and a program evaluation system to measure the performance of the projects promoted by the central government. The policy effort was to improve performance by assigning the budget according to performance. Nevertheless, there have been many critics that the correlation between performance indicators and budget allocation is insufficient (Park, 2013).

2.2. Empirical Review

Based on the particulate matter budget cases, this study starts with the question of why the performance results in the projects were disproportionately small even though the budget amount for that field was huge. This research reviewed previous studies about certain relationships among factors in a big process from human factors to performance indicators, from performance indicators to performance results, and from performance results to budget. Figure 4 includes this flaw.

Figure 4. Understanding of empirical review in this study



PERFORMANCE RESULTS' IMPACT ON BUDGET

First, this study looked at previous studies on the section where performance results lead to budget increases. This corresponds with the part marked in green in figure 4.

One relevant study from the United States was conducted on the United States General Accounting Office (GAO). As a result of analyzing the program rating of the Program Assessment Rating Tool (PART) - a system to integrate performance measurement and budgeting in the United States - and budget fiscal year 2004, performance rating was linked to budget funding in more than 80 percent of programs: although performance results were not the sole factor in a program budget (Posner, Fantone, McLain, Nowicki, Shipman, Beall & Nicholson, 2004).

In Republic of Korea, the results of the performance evaluation showed a positive correlation with the budget. Evaluation results, which was from program reviews, affected ministries' budget demands, government budget proposals, and increased the budget for the National Assembly from 2005 to 2008 (Park, Won, Kim & Park, 2008). There is a research that analyzed correlations between ratings of K-PART, which is the Korean version of PART, and governmental budget change. As a result, great performance results gave a positive impact on the increase of budgets while poor performance results negatively influenced budgets (Jung, 2012).

On the other hand, there are many studies that find no relationship between performance results and budget allocation. Baek (2018) performed regression analysis on the relationship between performance information, which is from the Budgetary Project Evaluation (BPE) from 2014 to 2016, and the budget for both mid-term and for the fiscal year. As a result, there was a positive relationship between 2014 and 2015, but there was no significant relationship in 2016, in which an integrated fiscal information system was introduced. Lee (2012) found that there is no linkage between budget allocation and performance results of national R&D projects in 2010 and 2011. Kim & You (2016) also said that factors other than performance results would influence budget allocation more as a result of regression analysis on national R&D projects.

PERFORMANCE INDICATOR'S IMPACT ON PERFORMANCE RESULT

This section corresponds to the blue colored region in figure 4. As a result of analysis, it was found that performance indicator characteristics partially influence the performance evaluation results. Projects using input indicators showed lower achievement of target performance goals than those using output indicators or outcome indicators. The performance evaluation results were also different for each projects field area. The achievement of the IT task projects was higher than that of the general financial task projects or R&D task projects (Yoo, Yoon & Kong, 2015).

HUMAN IMPACT ON PERFORMANCE MEASUREMENT

This section corresponds to the grey colored part in figure 4. Performance measurement is distorted because public officials who measure performance seek to avoid punishment resulting from low-performance results. Yoo (2013) explained this phenomenon by surveying the different levels of the government department. Even though the performance measurement is distorted, there is a vicious cycle in which distortion is fed back to the next performance plan or the following performance report.

2.3. Implications of the Review

Above all, from examining previous studies, the effect of performance results on the budget was different based on each study. For this reason, this paper decided to look at which performance indicators affect the budget. Instead, the performance result was also considered as a factor.

In a previous study (Yoo et al, 2015) did not distinguish between output and outcome when dealing with performance indicators and compared these with input. However, most of the particulate matter projects that have performance indicators use output or outcome as a performance indicator. As such, this study analyzes whether the performance indicator is an output or outcome as a factor that may impact on the budget.

Previous studies have dealt with sector indicators as another variable to consider along with performance indicators. Jung (2012) focused on whether it was an economic field project or a welfare field project. However, the Korean government has managed the particulate matter projects by each sector. Since the government already has a classification about the field in particulate matter projects, the prior approach is not appropriate for evaluating and analyzing the particulate matter projects. This paper will examine the effects of field factors on budgets by dividing them into areas where the government manages particulate matter problems: industry, power generation, transportation_road, transportation_offroad, life, protection of sensitive classes, international cooperation, and policies.

Besides, Jung (2012) included the size of the project and the operating agency of the project as other variables. The characteristics of particulate matter projects are different from those of other normal projects because they focus on reducing damage to the public. By adding a classification suitable for the nature of particulate matters, this study could be improved. The particulate matter projects can be divided into three main groups: reducing the causative substances that generate particulate matters, reducing the damage of people from the already generated particulate matters, and research about them. Another view is that particulate matter projects can be divided into whether it is to provide assistance to the private sector or to increase public facilities. Therefore this paper adds the characteristic factors of the particulate matters projects, and analyzes them by dividing them into cause substance reduction_public, cause substance reduction_private, cause substance reduction_research, risk reduction_public, risk reduction_private, risk reduction_research.

Table7. Summary of empirical review

Study focus	Author (year)	Data	Method	Independent variables	Explanatory variable	Impact
Performance results' impact on budget	Posner et al (2004)	234 programs in the president fiscal year 2004 budget	Regression analysis	PART results (score)	Proposed budget change	PART scores have positive effect on program funding.
Performance results' impact on budget	Lee (2012)	National R&D project with program review from 2010 to 2011 in Korea	Pearson Correlation coefficient analysis	Program results	Next year budget allocation	No correlation
Performance results' impact on budget	Jung (2012)	Program review result under K-PART from 2005 to 2010 in Korea	Regression analysis	Performance result (rating), Size of project, Characteristics of project, Field of project	Budget change	Positive correlation between performance result and budget change
Performance results' impact on budget	Kim & You (2016)	National R&D project	Panel Analysis	Performance result, Size of agency	Budget change	No correlation
Performance results' impact on budget	Baek (2018)	Performance result under BPE from 2014 to 2016 in Korea	Regression analysis	Performance result (score, rating), Size of project, Field of project, Characteristic of project	Annual average budget change	Impact depends on the period.

Table7. Summary of empirical review (Continued)

Study focus	**Author (year)**	**Data**	**Method**	**Independent variables**	**Explanatory variable**	**Impact**
Performance indicators' impact on performance results	Jang (2015)	Culture and Art projects under program review from 2005 to 2012 in Korea	Pooled OLS, Ordered logit analysis	Performance indicator, Performance results, Period of project, Size of project, Type of agency, Characteristic of project	Performance result (program review result)	Culture and art project (characteristic of project) has lower performance results
Performance indicators' impact on performance results	Yoo, Yoon & Kong (2015)	Performance indicators in performance result report in fiscal budget year 2013 in Korea	Chi square analysis, Binomial logit analysis	Performance indicator (input, output/outcome) Agency size, Project field	Performance result (Target goal achievement rate)	Output/outcome has higher results than input. Informalization project has higher results than others. Upper governmental agency has higher than lower level of agency.
Human impact on performance measurement	Yoo (2013)	Survey of government department officials	Compare means, F-test			Measurement has bias result from officials' tendency to avoid punishment.

3. DATA

This paper analyzes governmental projects to manage particulate matter in Republic of Korea over the last five consecutive years from 2015 to 2019.

As of 2019, KRW 5,463,527 million was invested in 19 ministries in response to national problems resulting from particulate matter. Much of this investment is received by the Ministry of Environment (KRW 3,212,668 million, 58.8%) and the Ministry of Trade, Industry, and Energy (KRW 1,176,686 million, 21.5%) (NABO, 2019).

Other ministries that have received particulate matter-related funding include: Korea Forest Service, Ministry of Science and ICT, Ministry of Land, Infrastructure and Transport, Korean National Police Agency, Ministry of National Defense, Ministry of SMEs and Startups, Ministry of Oceans and Fisheries, Ministry of Health and Welfare, Ministry of Agriculture, Food and Rural Affairs, Ministry of Education, Rural Development Administration, Ministry of Employment and Labor, Korean Meteorological Administration, Ministry of Food and Drug Safety, Ministry of Gender Equality and Family, Public Procurement Service, Ministry of Foreign Affairs. This is a numeric descending order (NABO, 2019).

This paper deals with the particulate matter response projects of 11 governmental agencies in total from 2015 to 2019: the Ministry of Environment, Ministry of Trade, Industry, and Energy, Korea Forest Service, Ministry of Land, Infrastructure and Transport, Korean National Police Agency, Ministry of National Defense, Ministry of Education, Korean Meteorological Administration, Ministry of Health and Welfare, Ministry of Agriculture, Food and Rural Affairs, and the Public Procurement Service.

The data include concrete information on each unit project: the objectives, program number, project details, budget year, budget amount, presence or absence of performance indicators, performance indicators, calculation method of performance indicators, achievement of target goal by performance indicators, performance results, achievement rates, and the field. The characteristic of each project was directly classified by the researcher after reviewing project purpose and the detailed content. The missing, incomplete, or wrong parts were supplemented by checking the final budget per year, performance plan, and performance report for each department. The total number of observations is 770.

4. METHODOLOGY AND HYPOTHESIS DEVELOPMENT

This paper uses the pooled OLS (Ordinary Least Square) method to analyze factors affecting the particulate matters budget. The pooled OLS is a method that estimates a linear regression model for panel data, ignoring that the data have a panel structure (Min & Choi, 2019).

The data that this paper intends to analyze is unbalanced panel data. The data are imbalanced. This is because some projects began in a certain year between 2015 and 2019 and as such the budget on those projects is allocated accordingly, while other budgets are allocated into projects covering all the consecutive years from 2015 to 2019. This paper uses panel data because there is information about budget amounts for each year of the same project.

It is recommended to determine a more suitable method among the pooled OLS model, the fixed effects (FE) model, and the random effects (RE) model when analyzing the panel data. First, as a result of performing an f-test to find out which model between the pooled OLS and the fixed effects model is more appropriate, this paper concluded that the fixed effect model is not suitable because F-test results omitted dummy variables so there was nothing left for those dummies to explain. This study deals with many dummy variables as important variables, so the fixed model could not be selected to analyze dataset.

Second, as a result of performing the Breusch and Pagan Lagrangian multiplier test to see which of the RE and the pooled OLS is more proper, it was determined that the pooled OLS is more suitable with a p-value of 1.00. Also, as a result of testing by the autocorrelation test method suggested by Wooldridge (2002), it was determined that there was no difficulty in analyzing by pooled OLS because no autocorrelation exists (Prob>F=0.1973).

Moreover, this paper aimed to examine whether a specific field project is related to a specific performance indicator or a certain project characteristic. So, the research decided to perform the ANOVA analysis, which compares the means of ratio facts that nominal factors have. Specifically, that is to examine the relationship between the field factor and performance indicator factor or between the field factor and project characteristic factor through examining how the average budget amount is different depending on field, performance indicator, or project characteristic. These attempts are intended to indirectly infer the relationship between actual particulate matters reduction performance and impact factors.

Finally, the correlation between nominal factors which are field factor and performance indicator factor was examined through Chi square analysis.

4.1. Pooled OLS

MODEL SPECIFICATION

This analysis model considered previous empirical studies on factors that impact budgets.

Budget = f {performance indicator factor, performance result factor, field factor, project characteristic factor}

Due to limitations of data this study collects, this paper excludes some factors like political factors, project size factors, project operating agency factors in previous studies. Instead, this study is more focused on the relationship and other factors. This study sets variables to fit into the research purpose.

Budget in next year = f {Budget in this year, Performance indicator factor, Project field factor, Project characteristic factor, Performance results}

The basic pooled OLS model is:

$$y_{it} = \partial + \beta x_{it} + \epsilon_{it}, \quad i = 1,2,\cdots,n \quad t = 1,2,\cdots,T_i$$

The model this paper developed is:

$$Budget_{i(t+1)} = \partial + \beta_1 Budget_{it} + \beta_2 Performance_{it} + \beta_3 Field_{it} + \beta_4 Charactor_{it} + \beta_5 Result_{it} + \epsilon_{it}, \quad i = 1,2,\cdots,n \quad t = 1,2,\cdots,T_i$$

There are basic assumptions to justify this model.

(assumption 1) $E(\in_{it}) = 0, all\ i\ and\ t$

(assumption 2) $var(\in_{it}) = \sigma^2, all\ i\ and\ t$

(assumption 3) $cov(\in_{it}, \in_{js}) = 0, all\ i\ \neq j\ and\ t \neq s$

(assumption 4) $cov(x_{it}, \in_{it}) = 0, all\ i\ and\ t$

DATA USED IN THE POOLED OLS

The total number of observations used in other methods was 770, however, observations used in the pooled OLS was 267. To see how the factors this year affect the budget for next year, this study excluded the observations of the year 2019 that lacked information on budget amounts for next year. Also, since performance indicators in particulate matter projects in Korea consisted mainly of outputs and outcomes, the study removed some projects using activity as a performance indicator from observations.

EXPLANATORY VARIABLE

This study set the explanatory variable as $Budget_{i(t+1)}$. The $Budget_{i(t+1)}$ means a budget ratio of the project i in year t+1. The reason for putting the year t+1 budget as the y variable is to see how the next year's budget will be affected by factors corresponding to the t year. The paper did not include the amount of budget when setting the budget variable. Rather, this paper set the y variable as a percentage of the total particulate matter budget in year t+1 for the specific project budget allocated in year t+1. This is because the particulate matter budget tends to increase significantly, and the budget amount level can fluctuate every year. This paper determined that using percentages over raw figures is more suitable to generalize the phenomenon.

INDEPENDENT VARIABLES

This paper uses Budget in year t, Performance indicator factor, Project field factor, Project characteristic factor, and Performance results as independent variables.

First, this study uses $\boldsymbol{Budget}_{it}$ as a basic independent variable. It also applies the ratio concept. The reason to behind choosing the ratio concept is the same as the reason for the explanatory variable. The variable refers to the ratio of the budget amount of the project i to the total particulate matter budget for year t.

Another independent variable is $\boldsymbol{Performance}_{it}$, which is the type of performance indicator the project i used in year t. This study focuses on the output indicator and outcome indicator among various performance indicators. This is because almost every project related to particulate matters use the two of them. For this reason, this study excluded projects using other types of indicators, like process/activity indicators, from the analyzed observations. Also, this paper categorized all the observations into output projects and outcome projects by thoroughly reviewing the calculation method of performance indicators and the basis for the calculation. This study used criteria suggested by Mikesell (2013) when distinguishing performance indicators.

While output focuses on the process to reach the outcome, the outcome is closer to the desired outcome to be achieved. Mikesell (2013) also presents six principles as distinct features of outcomes. Firstly, it should be related to citizens rather than internal procedures. Secondly, the outcome should be measurable. Third, service should be delivered to citizens rather than staying inside the institution. Other principles include that: the outcome should be significant, be manageable, and be verifiable (Mikesell, 2013).

Since which type of performance indicator is used is a nominal concept, this paper treats performance indicators as dummy variables: dummy for output, dummy for outcome. There are three: no performance indicator, output, outcome. Because dummy-1 is generally used to analyze dummy variable, there are only two dummy variables.

Next, $\boldsymbol{Field}_{it}$ is also used as an independent variable. This is about which field project i in year t belongs to. This paper subdivided all particulate matters projects into eight fields: industry, power generation, transportation_road, transportation_offroad, life, protection of sensitive classes, international cooperation, and policies. The criteria for dividing the field into eight were determined by standards set by the government, including the Ministry of Environment, as used in this analysis. The field category is also nominal, so the field information is treated as dummy variables. Because there are eight fields, this paper uses seven dummy variables for analyzing field factors.

This paper consistently uses the $\boldsymbol{Charactor}_{it}$ factor. This variable relates to the characteristics of the project i implemented in year t. This is a variable designed by the researcher considering the characteristics of the particulate matte projects. Particulate matter projects could be divided into projects focused on reducing substances that generate particulate matter and projects focused on protecting general people from the danger of inhaling particulate matter. Particulate matter projects could also be divided into projects to establish public facilities and systems, projects to support private companies, or individuals and projects related to research and study. For these reasons, this paper categorized characteristics of projects into six groups: substance reduction-public, cause substance reduction-private, cause substance reduction-research, risk reduction-public, risk reduction-private, risk reduction-research. These are also dealt with as five dummy variables.

Finally, there is the $\boldsymbol{Result_{it}}$ variable. This means performance result of project i implemented in year t. This is a performance information to show how well the project i is well achieved during year t to compare with a preset achievement goal. This paper set this variable as a ratio scale. Each agency set project goal of year t before implanting the project and reporting the real performance result after the year t, so this paper uses ratio information about how well achieved the goal of the year t is. The ratio information is created by dividing results of project i in year t into the goal of project i in year t.

HYPOTHESIS DEVELOPMENT AND EXPECTED RESULTS

- H1: Performance indicator factor affects budget in next year.

  This study expects that the performance indicator of the project i in year t can affect budget in year t+1. Budgets allocated to projects with an output indicator will increase more than those allocated to projects with an outcome indicator.

- H2: Field factor affects budget in next year.

  H2-1: Industry field factor affects budget in next year.

  H2-2: Transportation_road field factor affects budget in next year.

  The paper expects that budgets allocated to the projects in transportation_road field will be increased more than those allocated to the projects in any other fields.

- H3: Project characteristic factor affects budget in next year.

H3-1: Whether the project supports private sector or not affects budget in next year.

This research expects that budgets allocated to projects that support the private sector will be increased more than others.

- H4: Performance results affects budget in next year.

  This study expects that projects with high-performance in year t will receive a larger budget portion in year t+1.

4.2. ANOVA ANALYSIS

DATA USED IN ANOVA ANALYSIS

Even though observations were limited to 267 in the pooled OLS, this paper decided not to limit the observations in ANOVA analysis because ANOVA does not find direct affection between variables. Since it simply compares the means of budget amounts for the whole five years with different factors, this study uses all the 770 observations in performing ANOVA analysis.

DEPENDENT VARIABLE

Because the purpose of ANOVA analysis is to compare means, use of budget amount rather than budget ratio was deemed preferable. The unit of the budget figures is million KRW.

INDEPENDENT VARIABLES

The basic concept is the same with those used in the pooled OLS.

HYPOTHESIS DEVELOPMENT AND EXPECTED RESULTS

- H5: The average budget amount is different in each field.

  H5-1: The average budget amount allocated to projects in transportation_road field are higher than the budget amount allocated to other fields.

This paper expects that the average budget amount of transportation_road field projects is much more than those of other fields. This study also expects to be able to check how much the average budget amount differs in each field through ANOVA analysis.

- H6: The average budget amount for projects are different depending on which performance indicator the project uses.
- H6-1: The average budget amount allocated to projects with output indicator is higher than the budget amount allocated to projects with an outcome indicator.

- H7: The average budget amount for projects are different depending on the characteristics of the project.

  H7-1: The average budget amount allocated to projects to support the private sector in particulate matter reduction are bigger than those with other characteristics.

4.3. CHI SQUARE

DATA USED IN CHI SQUARE

Like ANOVA analysis, observation is not used as panel data. Of the 770 observations over the consecutive five years from 2015 to 2019, this analysis excludes projects without indicators and projects with no budget. As a result, a total of 248 observations were used in Chi square analysis.

VARIABLES

This analysis deals only with the relationship between performance indicators and field factors. Each variable is classified through the same method applied to the other previous analysis methods.

HYPOTHESIS DEVELOPMENT AND EXPECTED RESULTS

- H8: Field factors are related to performance indicator factors.

  H8-1: Transportation_road field factor is related to output indicator factor.

  This paper predicts that the rate of using output indicators in the transportation field projects would be higher than in other field projects.

5. DATA ANALYSIS

5.1 Pooled OLS

The proportion of the project budget in the total particulate matters budget ranges from 0.77% to 29.78% for the next year and rages from 0.3% to 29.781% for this year. Since the field factor and characteristic factor are dummy variables, they are distributed from 0 to 1 (Table 8).

Table 8. Summary of Variables in the pooled OLS

	N	Min	Max	Mean	SD
Budget ratio next year	267	0.0077	29.7810	1.3649	3.6239
Budget ratio this year	267	0.0030	29.7810	1.4650	3.6602
field_d1 (industry)	267	0	1	0.16	0.368
field_d2 (transportation_road)	267	0	1	0.27	0.447
field_d3(transportation_offroad)	267	0	1	0.04	0.208
field_d4 (life)	267	0	1	0.16	0.365
field_d5 (protection)	267	0	1	0.12	0.321
field_d6 (policy)	267	0	1	0.11	0.312
field_d7 (international cooperation)	267	0	1	0.04	0.208
characteristic_d1 (reduce_private)	267	0	1	0.34	0.475
characteristic_d2 (reduce_r&d)	267	0	1	0.04	0.208
characteristic_d3(protection_public)	267	0	1	0.12	0.325
characteristic_d4(protection_private)	267	0	1	0.04	0.199

characteristic_d5(protection_r&d)	267	0	1	0.11	0.312
outcome	267	0.00	1.00	0.1873	0.3909
Output	267	0.00	1.00	0.4494	0.4984
performance result	267	0.0000	274.7700	1.7726	16.7892

As a result of pooled OLS analysis, the budget ratio of the next year is explained by budget ratio in this year, industry field factor, and transporation_road factor at the level of significance ∂=0.05 (95% confidence level). The explanatory power of this model is 85 percent. The F-value is 89.24, which is statistically significant at ∂=0.001 level, so this pooled OLS analysis can be considered an appropriate model (Table 9). On the other hand, characteristic factors, performance indicator factors, and performance result factors does not affect the budget for the next year. This means that, at least for the particulate matter projects budget, which performance indicators are used and how much performance is achieved does not affect the budget for the next year. As a result of considering the VIF, a test for the collinearity statistic, the mean VIF was 1.36. Since VIF is less than 10, there is no multi-collinear problem.

Table 9. Factors that impact on particulate matter budget ratio in year t+1
(Results of the pooled OLS)

Variables	Coefficient (Std. Err)
Budget ratio in year t	**0.9120*** **
	(0.0276)
field_d1 (industry)	**0.8353***
	(0.4160)
field_d2 (transportation_road)	**1.0897** **
	(0.3678)
field_d3 (transportation_offroad)	1.0134
	(0.5495)
field_d4 (life)	0.7797

	(0.4067)
field_d5 (protection)	0.7605
	(0.5340)
field_d6 (policy)	0.7380
	(0.5149)
field_d7 (international cooperation)	0.7424
	(0.7599)
characteristic_d1(reduce_private)	0.2123
	(0.2415)
characteristic_d2 (reduce_r&d)	0.5632
	(0.4990)
characteristic_d3 (protection_public)	0.2916
	(0.4227)
characteristic_d4 (protection_private)	0.2231
	(0.5948)
characteristic_d5 (protection_r&d)	0.2004
	(0.5299)
outcome	-0.0251
	(0.2891)
output	0.2013
	(0.2489)
performance result	0.0057
	(0.0054)
Constant	**-1.0333****
	(0.4261)
R-squared	0.8510
Adjusted R-squared	0.8415
F value	**89.24*****
Observations	267

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Through reviewing the pooled OLS results, this paper can only accept the H2 hypothesis that performance indicator affects the budget for the next year. Whether a project is in the industry field or not affects next year's budget. Whether a project is in the transportation_road field or not also affects budget in next year (Table 10).

Table 10. Decision rule for pooled OLS

No	Hypothesis	Decision
H1	Performance indicator factor affects budget in next year.	Reject
H2	**Field factor affects budget in next year.**	**Accept**
H2-1	**Industry field factor affects budget in next year.**	**Accept**
H2-2	**Transportation_road field factor affects budget in next year.**	**Accept**
H3	Project characteristic factor affects budget in next year.	Reject
H3-1	Whether the project supports private or not affects budget in next year.	Reject
H4	Performance results affects budget in next year.	reject

To justify this analysis, this paper performed several tests. Analysis using the pooled OLS model is generally accepted if it satisfies homoskedasticity and there is no problem of contemporaneous correlation and serial correlation. For test homoskedasticity, this paper performed a likelihood-ratio test. The null hypothesis for the Breusch and Pagan Lagrangian multiplier test for random effects is that homoskedasticity is satisfied. It is about the assumption 2: $var(\in_{it}) = \sigma^2, all\ i\ and\ t$. As a result of the test, it failed to reject the null hypothesis (Prob>chi2=1.000). This paper also performed a test for autocorrelation. When there is no autocorrelation, the pooled OLS can be performed. By performing a test suggested by Wooldridge, the result failed to reject the null that there is no autocorrelation (Prob>F=0.1973).

5.2. ANOVA

AVERAGE BUDGET AMOUNT DEPENDING ON FIELD FACTOR

In Chapter 1, it is found that the budget funds allocated to respond to particulate matter problems was heavily invested in budget of the transportation_road field projects. However, ANOVA 1 is conducted to check how much more the transportation_road field budget was being allocated than other field budgets. Basic technical statistics results are as follows. The average budget for projects in transportation_road field is KRW 25, 819 million, the highest level (Table 11).

Table 11. Descriptive statistic results for budget amount depending on field factor

Field factor	N	Mean	SD
Power	45	35661.51	57422.657
Industry	130	3825.92	10473.255
Transportation_road	145	25819.23	78341.554
Transportation_offroad	20	11107.75	23616.844
Life	105	5097.95	11792.738
Protection	175	1590.39	5130.981
Policy	125	1884.34	4269.929
International	25	2638.52	3855.521
Total	770	9328.82	39011.145

Unit: million KRW

As a result of the F-test to find out that differences in average budget between field factors is statistically significant, the average budget is different in the project for each field (Table 12) (F=9.621, p <0.001).

Table 12. ANOVA table about budget depending on field factor (N=770)

		Sum of Squares	df	Mean Square	F	Sig
Field factor	Between groups	95039414296.044	7	13577059185.149	9.621	**.000*** **
	Within groups	1075278205352.868	762	1411126253.744		
	Total	1170317619648.912	769			

The Scheffe Test, a post-hoc test, is performed to confirm whether the differences between which fields were statistically significant (Table 13). As a result, the average budget for the transportation_road field was KRW 21,993 million more than the industry field (p<0.01), KRW 20,721 million more than the life field (p<0.05), KRW 24,228 million more than the protection field (p<0.001), and KRW 23,934 million more than the policy field (p<0.001). The average budget for the industry field was KRW 31,835 million less than the power field (p<0.01). The average budget for the power field was KRW 30,563 million more than the life field (p<0.01), KRW 34,071 million more than the protection field (p<0.001), and KRW 33,777 million more than the policy field (p<0.001).

Table 13. Summary of the Scheffe test for ANOVA 1
Dependent variable: Budget (Unit: KRW million)

	Transportation_road	Industry	Power	Transportation_offroad	Life	Protection	Policy	International cooperation
Transportation_road		**21993.305** **	-9842.284	14711.478	**20721.275** *	**24228.839** ***	**23934.884** ***	23180.708
Industry			**-31835.588** **	-7281.827	-1272.029	2335.535	1941.579	1187.403
Power				24553.761	**30563.559** **	**34071.123** ***	**33777.167** ***	33022.991
Transportation_offroad					6009.798	9517.361	9223.406	8469.230
Life						3507.564	3213.608	2459.432
Protection							-293.955	-1048.131
Policy								-754.176
International cooperation								

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

AVERAGE BUDGET AMOUNT DEPENDING ON PERFORMANCE INDICATOR

ANOVA 2 is performed to find out whether there are differences of average budget in the performance indicator. Table 14 shows descriptive statistic results for ANOVA 2.

Table 14. Descriptive statistic results for budget amount depending on performance indicator

Performance indicator	N	Mean	SD
No	478	2306.16	8237.366
Outcome	82	10500.45	16157.093
Output	210	24856.23	70625.655
Total	770	9328.82	39011.145

Unit: million KRW

The F-test for ANOVA 2 suggests that the average budget is different in the performance indicator (Table 15) ($F=26.004$, $p<0.001$).

Table 15. ANOVA table about budget depending on performance indicator factor (N=770)

		Sum of Squares	df	Mean Square	F	Sig
Performance indicator	Between groups	74317493903.005	2	37158746951.502	26.004	**.000** ***
	Within groups	1096000125745.908	767	1428944101.364		
	Total	1170317619648.913	769			

According to result of the Scheffe test for ANOVA 2, the average budget for projects with an output indicator was KRW 14,355 million more than those with an outcome indicator ($p<0.05$), KRW 22,550 million more than those without an indicator ($p<0.001$).

Table 16. Summary of the Scheffe test for ANOVA 2
Dependent variable: Budget (Unit: million KRW)

	Output	Outcome	No indicator
Output		**14355.778***	**22550.062*****
Outcome			8194.284
No indicator			

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

AVERAGE BUDGET AMOUNT DEPENDING ON PROJECT CHARACTERISTICS

This study performed ANOVA 3 about the average budget differences between each project characteristic. Descriptive statistics for ANOVA 3 are included in Table 17.

Table 17. Descriptive statistic results for budget amount depending on project characteristics

Project characteristics	N	Mean	SD
Reduction_public	205	7214.39	18424.825
Reduction_private	175	27749.23	75903.300
Reduction_r&d	70	1200.41	2009.556
Protection_public	195	2414.15	8876.618
Protection_private	35	1360.31	3530.117
Protection_r&d	90	2730.30	4997.557
Total	770	9328.82	39011.145

Unit: million KRW

The F-test for ANOVA 3 argues that the average budget is different in the project characteristics (Table 18) (F=11.269, p <0.001).

Table 18. ANOVA table about budget depending on project characteristics (*N*=770)

		Sum of Squares	df	Mean Square	F	Sig
Project characteristics	Between groups	80385505851.016	5	16077101170.203	11.269	**.000** ***
	Within groups	1089932113797.896	764	1426612714.395		
	Total	1170317619648.912	769			

As a result of the Scheffe test for ANOVA 3, the average budget for projects to support the private sector for the purpose of particulate matter reduction was KRW 26,548 million more than projects to support R&D with the purpose of particulate matter reduction (p<0.001), KRW 25,335 million more than projects to establish public systems with the purpose of protection (p<0.001), KRW 26,388 million more than projects to support the private sector with the purpose of protection (p<0.05), and KRW 25,018 million more than R&D projects for public protection (Table 19) (p<0.001).

Table 19. Summary of the Scheffe test for ANOVA 3
Dependent variable: Budget (Unit: KRW million)

	Reduction_public	Reduction_private	Reduction_r&d	Protection_public	Protection_private	Protection_r&d
Reduction_public		**-20534.843** ***	6013.971	4800.237	5854.071	4484.085
Reduction_private			**26548.914** ***	**25335.080** ***	**26388.914** *	**25018.929** ***
Reduction_r&d				-1213.734	-159.900	-1529.886
Protection_public					1053.834	-316.151
Protection_private						-1369.986
Protection_r&d						

* p < 0.05, ** p < 0.01, *** p < 0.001

This paper could support all hypotheses used in ANOVA analysis. The average budget amount is different in the field factor. Budgets for transportation_road projects are bigger than other projects. Also, the average budget is different depending on performance indicators. Projects with output indicators tend to have a larger budget. Moreover, projects to support the private sector with the aim of reducing causative substances tend to have more budget (Table 20).

Table 20. Decision rule for ANOVA analysis

No	Hypothesis	Decision
H5	**The average budget amount is different in each field.**	**Accept**
H5-1	**The average budget amount allocated to transportation_road projects is higher than the budget amount allocated to other fields.**	**Accept**
H6	**The average budget amount for projects is different depending on which performance indicator the project uses.**	**Accept**
H6-1	**The average budget amount allocated to projects with an output indicator is higher than the budget amount allocated to projects with an outcome indicator.**	**Accept**
H7	**The average budget amount for projects is different depending on the characteristics of the project.**	**Accept**
H7-1	**The average budget amount allocated to projects to support the private sector for reduction are bigger than those with other characteristics.**	**Accept**

5.3. CHI SQUARE

As a result of performing Chi square analysis, there is a statistically significant difference to using a performance indicator depending on fields at the level of significance ∂=0.001 (0.1% confidence level). x^2 is 27.106 and degree of freedom is 7.

Transportation projects tend to mainly use an output indicator regardless of whether they are road or off-road. On the other hand, industry projects tend to use output indicators and outcome indicators at a ratio of 6:4 (Table 21). The result shows that transportation_road projects are related to output indicators (Table 22).

Table 21. Chi square analysis between field factors and performance indicator factors

(N=248)

Field factor	Performance indicator factor		Total	x^2
	Outcome	Output		
Power	13 (43.3%)	17 (56.7%)	30 (100%)	
Industry	22 (42.3%)	30 (57.7%)	52 (100%)	27.106
Transportation_road	11 (15.5%)	60 (84.5%)	71 (100%)	(df=7)
Transportation_offroad	0 (0.0%)	15 (100%)	15 (100%)	
Life	15 (40.5%)	22 (59.5%)	37 (100%)	
Protection	5 (27.8%)	13 (72.2%)	18 (100%)	
Policy	12 (52.2%)	11 (47.8%)	23 (100%)	
International Cooperation	0 (0.0%)	2 (100%)	2 (100%)	

Table 22. Decision rule for Chi square

No	Hypothesis	Decision
H8	**The average budget amount is different in each field. Field factors are related to performance indicator factors.**	**Accept**
H8-1	**Transportation_road field factor is related to output indicator factor.**	**Accept**

6. CONCLUSION

Republic of Korea ranks globally as one of the worst countries in terms of air quality. The Korean government has concentrated on solving problems caused by increasing particulate matter in the air. Most of funding allocated to projects that respond to the particulate matter problem are related to projects in the transportation_road field. Unfortunately, however, the reduction of particulate matter from these projects is very low despite the large financial resources allocated in the budget. On the other hand, industry field projects showed relatively good performance despite receiving small portions of the budget. This paper explored this juxtaposition and tried to solve the question: which factors of a project can contribute to good performance results in the real world?

Since there was no research paper focused on particulate matter budgets, this study reviewed academic research dealing with the relationship between performance indicators and the performance achievement rate, and between performance results and budget allocations. Even though this research could not include all the factors contained in previous research, this paper set the variables as performance indicators, performance results, and budget by considering previous studies.

First, this paper attempted to examine factors that impact the budgets of particulate matter projects. The aim was to establish a statistically supported conclusion regarding relationships between the budget and the field. As a result of the pooled OLS, the field factor affects the budget. The transportation_road field and industry field factors affect the project budget ratio for the entire particulate matter budget.

This paper also performed ANOVA analysis to identify key features by comparing budgets with different factors. It is an analysis of how the average budget amount varies according to each field, each characteristic, or which performance indicator was used for the project. Furthermore, Chi-square analysis was conducted to determine the correlation between the field and performance indicators. As a result, the transportation_road budgets were larger than the budgets of projects of other fields. This paper concludes that projects with output indicators have more budgets and transportation_road projects have a tendency to use output indicators. On the other hand, industry field projects have balanced the use of output and outcome indicators.

This paper focused on the reason why real-world performance results are different between industry field projects and transportation field projects. While industry field projects show the best performance with a relatively smaller budget, real reduction of particulate matters in transportation_road field was insignificant even though lots of funding is allocated to that field. Considering that actual performance was good in a field that uses a lot of outcome indicators rather than a field that mainly uses output indicators, this paper indicates the necessity of policy to encourage each project use outcome indicators and to motivate operating government agencies to use output and outcome indicators in a balanced, proportionate manner.

Furthermore, this paper found that the goal achievement rate of each project did not affect budget allocation. This might mean that setting a performance goal and confirming how well it was achieved could simply be an administrative burden, rather than contributing to the real performance of each projects. Goal achievement rates were not linked to the budget, and it also did not relate to actual performance. It seems that the goal achievement rate did not serve a useful function as performance information. In this regard, the Korean government should conceive of a better system to connect the actual performance, performance management, and the budget allocation by considering the implications this paper proposes.

The limitation of this study is related to the data utilized. This study could not contain the direct relationship the actual performance and various factors. This is a clear limitation. However, it is impossible to observe how much actual reduction has been achieved based on each project level. Therefore, this study attempted to explain the cause of performance differences by examining projects in fields with good-performance and the characteristics of those projects. This paper may give some implications as to what kind of policy considerations should be made to substantially reduce particulate matter in Korea.

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