# A STUDY ON CORRELATION BETWEEN ELEMENTS OF AHP FOR GOVERNMENT R&D PROGRAMS

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**ABSTRACT**

The pre-feasibility study for government programs, which was introduced in 1999, is the preliminary research conducted in advance of program implementation. Its goal is to contribute to decision-making of new government programs for the purpose of improving the effectiveness of public finance. In case of a R&D programs, multiple elements are applied to measure not only economic analysis, but also technology and policy issues. The analysis results are reviewed and combined to deliver the final results.

In this study, we analyzed pre-feasibility studies on government R&D programs, which have been carried out since 2008. The analysis unit and content of each criterion, which are key elements in a comprehensive decision making structure, are examined. The results show that the elements of decision making structure of pre-feasibility study have correlation, which should be dealt with other tools.

## 1. Introduction

As the budget for government research and development programs has grown and these programs are undertaken for the medium and long-term period, various aspects should be taken into consideration. Private R&D programs led mainly by large conglomerates have been carried out for the purpose of developing new products and have resulted in an immense success in both the domestic and global markets, contributing to government wealth creation. Under the circumstances, there have been strong calls for the government to define the role of government R&D programs and to enhance the effectiveness of them. To meet the growing calls for improvement, various evaluation studies have been performed; including ones conducted within the ministries, high-level assessment, in-depth assessment and other ex post evaluation. In addition, pre-feasibility studies have been performed to predict the potential results of implementation. A variety of analysis methods, such as experimental design and statistical review, have been utilized to examine a causal relationship among the results, effects, outputs and inputs, for the purpose of obtaining a more systematic analysis of government R&D programs(Dunn, 2008). An attempt to measure the benefits and effects of government R&D programs is the part of such endeavors.

In case of a pre-feasibility study on government R&D programs, multiple criteria are applied to measure not only economic effects, which are measured in the form of the ratio of output against input, but also technological and policy effects. Sub-criteria within the criteria include concrete plans, technological viability, overlap with existing programs, consistency with higher-level plans, cooperation system,

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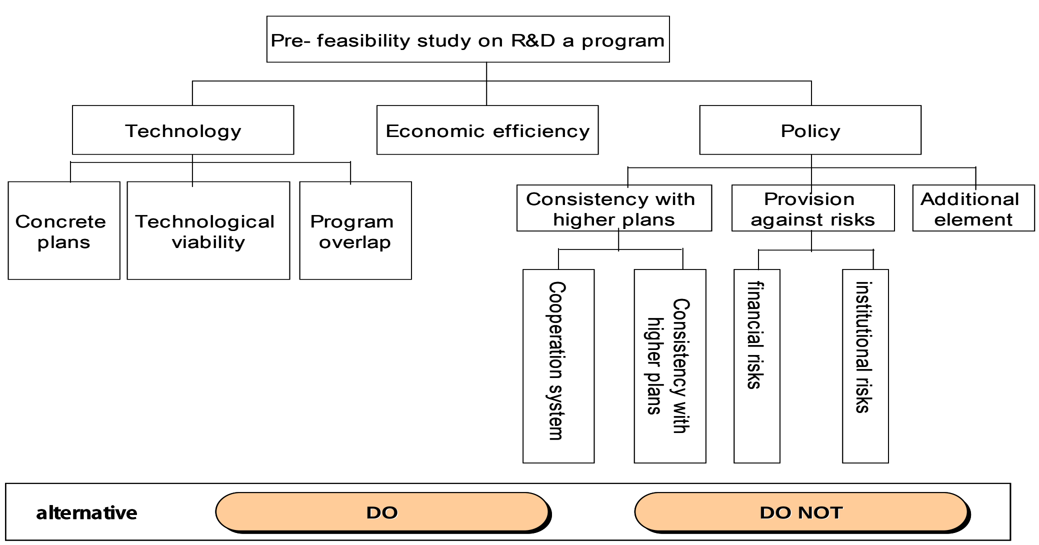
provision against risks, and economic efficiency. The analysis results are reviewed and combined to deliver the final results. In order to integrate analyses properly, we built a decision hierarchy based on the assumption that those multiple elements are independent in the pre-feasibility study on R&D programs.

In this study, pre-feasibility studies on government R&D programs, which have been carried out since 2008, are analyzed. The analysis unit and content, which are key elements in a comprehensive analysis, are examined, in order to identify the possible correlations, such as similarity, cooperative relations, auxiliary relations, rivalry relations, competitive relations, and substitute relations. Also, a survey is conducted on experts, who have participated in pre-feasibility study as advisor or project manager. Such analysis efforts contribute to the establishment of a decision-making model for producing appropriate results and to charting future directions for improvement.

## 2. Decision making in pre-feasibility study on government R&D program

The pre-feasibility study, which was introduced in 1999, is the preliminary research conducted in advance of program implementation, for the purpose of improving the effectiveness of public finance programs. Under the President's executive order, it is carried out for the government programs whose budget is over 50 billion won and whose government subsidy is over 30 billion won. At the time of introduction, construction-related programs were the sole subject of study, but later on IT-related programs and R&D center, cluster, research equipment-related programs became the subjects of pre-feasibility studies respectively. In addition, government R&D programs under the Science Technology Act and other programs in the fields of social welfare, health-care, education, labor, culture and tourism, environmental protection, agriculture, fishery, industries, SMEs were added onto the list. A total of 427 pre-feasibility studies on government programs have been conducted during the 1999-2009.

**Figure1. Schematics of decision making structure of pre-feasibility study on a government R&D program**




It's challenging to predict the future results and make control measures beforehand due to the uncertainty and unpredictability. However, when public budget execution is dependent solely on ex post evaluation, it's difficult to avoid the potential waste of resources and to find out who is accountable for the funds already being spent. In this sense, the pre-feasibility study, which is ex-ante evaluation, is regarded as the effective system that can positively contribute to policy makers' decision making process.

In general, a series of factors to be considered for decision making process include multiple alternatives, criteria for choosing alternative solutions, weights of criteria, scores of the criteria, and the integration of results, and then multi-criteria analysis methods are applied. In Korea, AHP(Analytic Hierarchy Process) method has been utilized over the last 10 years as a means to collect decision-making information for construction-related government program in pre-feasibility studies. AHP is the efficient method in solving the multi-criteria problems (Triantaphyllou, 2000). The pre-feasibility study on government R&D programs also uses AHP, even though the decision structure is somewhat different from that of previous one; elements of technology have been added to reflect the characteristics of R&D programs.

## 3. Correlation between elements

Various methods can be used to assess correlation between elements in the pre-feasibility study of R&D programs. In this study, correlations are divided into two types: correlation in scoring and correlation in weighting.

Correlation in scoring shows that the relation between two elements has directions. The results of the pre-feasibility study are divided into two cases, 'feasible' and 'non-feasible'. The chi-square test was used to identify whether one element is found feasible when the other feasible, and vice versa. Correlation in weighting means that a relationship exists in variation of weighting factors between two elements. In other words, the increasing or decreasing weights of one element changes that of another element. The Pearson correlation coefficient is used to indicate the direction of relationship between elements. In addition, expert surveys were conducted to assess correlation between elements.

### 3.1 Chi-Square Test

A chi-square test is any statistical hypothesis test in which the sampling distribution of the test statistic is a chi-square distribution when the null hypothesis is true, or any in which this is asymptotically true, meaning that the sampling distribution can be made to approximate a chi-square distribution as closely as desired by making the sample size large enough. The pre-conditions for the chi-square test are: 1) each observed datum should be counted one of cells 2) each observed count (from a random sample) should be independent 3) samples should be sufficient (expected counts should be at least 5 for each cell). Statistics are derived using $n_{ij}$, the number of observation, and $u_{ij}$, number of expectation if satisfying all of the three conditions. The test statistic equals the minimum value of zero when the observed counts and expected counts are the same. The chi-square value increases if the difference between $n_{ij}$ and $u_{ij}$ widens when the sample size is fixed and it can be said that the null hypothesis is dismissed. If the sample size increases, the statistic approximately follows the chi-square distribution.

**Table 2 Results of Chi-square test**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | 65.464** | 60.647** | 8.143** | 8.078** | 55.875** | 5.365* | 16.136** | 47.201** | 127.259** |
| 2 | 65.464** | - | 39.255** | 21.043** | 13.393** | 55.934** | 9.492** | 16.205** | 67.461** | 80.060** |
| 3 | 60.647** | 39.255** | - | 36.743** | 10.889** | 55.592** | 0.261 | 18.432** | 51.971** | 92.259** |
| 4 | 8.143** | 21.043** | 36.743** | - | 24.624** | 15.322** | 3.329 | 5.898* | 22.163** | 26.896** |
| 5 | 8.078** | 13.393** | 10.889** | 24.624** | - | 14.205** | 0.549 | 1.935* | 8.991** | 15.379** |
| 6 | 55.875** | 55.934** | 55.592** | 15.322** | 14.205** | - | 5.169* | 15.526** | 66.867** | 82.971** |
| 7 | 5.365* | 9.492** | 0.261 | 3.329 | 0.549 | 5.169* | - | 0.702 | 11.908** | 7.449** |
| 8 | 16.136** | 16.205** | 18.432** | 5.898** | 1.935** | 15.526** | 0.702 | - | 17.576** | 11.145** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 47.201** | 67.461** | 51.971** | 22.163** | 8.991** | 66.867** | 11.908** | 17.576** | - | 115.007** |
| 10 | 127.259** | 80.060** | 92.259** | 26.896** | 15.379** | 82.971** | 7.449** | 11.145** | 115.007** | - |

**1: Concrete plans, 2: Technological viability, 3: Program overlap, 4: Consistency with higher-level plans, 5: Cooperation system, 6: Provision against risks, 7: Policy impact, 8: Policy etc., 9: Economic efficiency, 10: Overall**

The results using the above method are provided in the table 1. The null hypothesis is that the elements are independent. Test results indicate that the null hypothesis about most elements, 40 out of 45 pairs except for the political impact variables, are rejected, meaning that correlation exists between elements. Correlation may not be identified if confining the elements to a specific group, grouped according to specific standards such as result value, program period, and total expenditure. However, as sub-dividing the cases can result in insufficient expected counts, additional data needs to be gathered for accurate analysis of the overall test result.

### 3.2 Pearson correlation coefficient analysis

The Pearson correlation coefficient is widely used to identify the relationship between elements. It is a measure of the correlation, which is linear dependence, between two variables X and Y, giving a value between +1 and −1 inclusive. In sciences, it is widely used as a measure of the strength of linear dependence between two variables. If the variables X and Y are identical, the correlation coefficient is +1 and 0 if different and -1 if the variables are identical in opposite direction.

In this study, the correlation coefficient was calculated on weighting factors applied to elements in decision making structures of the pre-feasibility study. Elements with a certain significance level were considered; significance level 5.0%. A negative linear relationship was identified for most elements, which is attributable to the structure of hierarchy.

**Table 3. Results of Pearson correlation coefficient analysis**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | -0.577** | -0.252** | -0.328** | 0.094 | 0.042 | -0.121 | -0.028 | 0.015 |
| 2 | -0.577** | 1 | -0.350** | -0.067 | -0.195** | -0.141* | 0.153* | -0.023 | -0.075 |
| 3 | -0.252** | -0.350** | 1 | -0.083 | 0.121 | -0.023 | -0.074 | 0.209 | -0.148 |
| 4 | -0.328** | -0.067 | -0.083 | 1 | -0.334** | -0.197** | -0.055 | -0.255 | 0.002 |
| 5 | 0.094 | -0.195** | 0.121 | -0.334** | 1 | 0.005 | -0.384** | -0.197 | -0.052 |
| 6 | 0.042 | -0.141* | -0.023 | -0.197** | 0.005 | 1 | -0.434** | 0.123 | 0.003 |
| 7 | -0.121 | .153* | -0.074 | -0.055 | -0.384** | -0.434** | 1 | -0.715** | -0.394** |
| 8 | -0.028 | -0.023 | 0.209 | -0.255 | -0.197 | 0.123 | -0.715** | 1 | -0.579* |
| 9 | 0.015 | -0.075 | -0.148 | 0.002 | -0.052 | 0.003 | -0.394** | -0.579* | 1 |

**1: Concrete plans, 2: Technological viability, 3: Program overlap, 4: Consistency with higher-level plans, 5: Cooperation system, 6: Provision against risks, 7: Policy impact, 8: Policy etc., 9: Economic efficiency, 10: overall**

Among the elements of technology, concrete plans showed a strong negative linear correlation with the technological viability, and also showed a weak negative linear correlation with economic efficiency and program overlap. In addition, technological viability and program overlap showed a strong negative linear correlation. Such results imply that research participants consider the technological viability as an opposing concept when assigning the weighting factor of concrete plans.
Among the policy elements, the consistency with higher-level plans showed a strong negative linear correlation with provision against risk factors. The element of cooperation system showed a strong negative linear correlation with provision against risk factors. Also, there was a strong negative linear correlation between program risk factors and policy impact.

A strong negative linear correlation was found between economic efficiency and the consistency with the higher-level plans, and a weak correlation with cooperation system. This means that the importance of economic efficiency was set low for assessing programs when the consistency with the higher-level plans is dominant issue in decision making.

### 3.3 Expert Survey

As the population group for face-to-face interviews, 230 experts who had participated in the R&D pre-feasibility study as an advisor were chosen (multiple responses allowed). Among the survey participants, 64.9% responded that there was no correlation among the nine elements. Survey participants who said there was no correlation between elements can be divided by area of specialty: policy experts (81.8%), technology experts (61.2%) and economic experts (66.7%).

**Table 4. Results of expert survey on existence of correlations**

| | | Yes | No | Sum |
|---|---|---|---|---|
| Total | | 35.1 | 64.9 | 100.0 |
| Specialty | Technology | 38.8 | 61.2 | 100.0 |
| | Policy | 18.2 | 81.8 | 100.0 |
| | Economics | 33.3 | 66.7 | 100.0 |
| | Policy/Economics | 33.3 | 66.7 | 100.0 |
| | Technology/Policy | 50.0 | 50.0 | 100.0 |
| | N/A | 100.0 | 0.0 | 100.0 |

Responses also varied by type of element. Among the survey respondents, who said element of concrete plans has correlation with other elements, 49.0% counted technological viability as related elements. Among the experts, who said element of technological viability has correlation with other elements, 34.0% counted concrete plans as related elements, and 27.7% did economic efficiency. Most replied that program overlap had no correlation with other elements: only 9.3% and 7.0% regarded as related elements concrete plans and economic efficiency respectively. In addition, most survey respondents said there was no correlation between the consistency with higher-level plans and cooperation system whereas 23.3% of respondents found a correlation between the two elements and 14.0% said there was a correlation with provision against financial risks. With regard to the provision against financial risks, 76.7% said that there were no correlating elements. A majority of respondents saw no correlation with institutional risk factors. Most respondents said that there were not elements correlated with economic efficiency. Among the respondents, 13.6% and 9.1% counted as relate elements technological viability and concrete plans, respectively.

Along with the expert survey, a survey was carried out on the relativity between elements among experts who participated as a project manager in the pre-feasibility study (multiple responses allowed). Among them, 92.9% responded that institutional risk factors had no relation with other elements and 85.7% did cooperation system. Concrete plans, technological viability, economic efficiency and program overlap were counted as elements having correlation with other elements. Above 50% said correlation existed between the technological viability and concrete plans.

Both surveys indicate that correlations exist between elements in the pre-feasibility study, which is also proven in the correlation tests conducted using the statistical method mentioned above.
The reason why difference in responses varied between the PM group and expert group is that the PM group conducted overall analysis related to technology, policy and economics whereas the expert group engaged in analytical studies involving one's area of specialty. However, a more fundamental reason for the differing perspectives needs to be identified through an in-depth follow-up study.

## 4. Conclusion

In this study, we found that correlations exist between elements in decision making structure of pre-feasibility study on government R&D program. Tests were conducted and expert surveys were carried out to assess the correlation between elements. A test was conducted on the scoring of elements and a correlation analysis was done on variation of weighting factors. Expert groups and PM groups were surveyed. Correlations could be indentified from all results. The analytical network process can be applied to reflect the correlations between elements (Saaty and Varga, 2006) (Tuzkaya, Önüt, Tuzkaya, and Gülsün, 2008). However, the process of expert judgment on R&D program contains measurement problems, which was identified during the expert survey: experts said that some of the elements were hard to score. That being said, developing an easier and more objective scoring model for each element should be considered first and further studies need to be carried out rather than using quantitative analysis techniques to reflect the correlation between elements. In addition, as pre-feasibility study on government R&D program is still in the initial stage, we have to collect organized data to assess the correlations with respect to the program type.

**REFERENCES**

Evangelos Triantaphyllou (2000). *Multi-Criteria Decision Making Methods: A Comparative Study*. Kluwer Academic Publishers.

William N. Dunn (2000). *Public Policy Analysis; An introduction, 4th edition*. Prentice-Hall.

Thomas L. Saaty, Luis G. Vargas (2006). *Decision Making with The Analytic Networking Process; Economic, Political, Social and Technological Applications with Benefits, Opportunities, Costs and Risks*. Springer.

Gülfem Tuzkaya, Semih Önüt, Umut R. Tuzkaya, Bahadır Gülsün (2008). An analytic network process approach for locating undesirable facilities: An example from Istanbul, Turkey, *Journal of Environmental Management, 88,* 970-983.