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Taiwan-Japan co-investments Bridgings' Performance Evaluation Based Subsidy Allocation and Targets Setting

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Project Name

Taiwan-Japan co-investments Bridgings' Performance Evaluation Based Subsidy Allocation and Targets Setting

(日台の技術協力における補助金の効率的配分と戦略的提携に関する研究)

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1. Introduction

1.1 Research Background

Since the 1990s, increasingly fierce global competition and the disappearance of the traditional domestic market have resulted in the rising importance of strategic alliances for global businesses and academia. Foreign enterprises are joining forces with other companies to lower production costs, gain access to new technologies, create new products, and enter new markets. These strategic alliances serve as a joint platform for championing the interests of both parties; enterprises will not only share resources, but also actively cooperate against competitors. However, while strategic alliances can help an enterprise obtain new technology, products, and markets in the short term, they also carry significant long term risks. These risks include the loss of a comparative advantage in a given technology, company autonomy, or even the loss of the company itself. Given these concerns, understanding the proper use of strategic alliances for business development is essential.

According to a survey by the Japanese Interchange Association (JIA), there are 17 cases of Taiwanese and Japanese combined strategic alliance investments in a third country between 2000 and 2001, 33 cases in 2002, and 36 cases in 2003. In many cases, the target of these strategic alliances is China. The Mizuho Research Institute in Japan has noted that China's market opening has forced Japanese firms to invest in China. From 1989 to August of 2006, there were over 359 cases of Japanese firms using Taiwanese resources to invest in China. Moreover, these cases accounted for 6.5% of Japanese firms' total international investments.

1.2 Research Objectives

Numerous studies on Asian investment trends note that Taiwan has a wealth of investment experience in China, as well as several advantages over competing countries, including a shared language and similar culture. As a result, Taiwan serves as a good intermediary bridge for foreign firms looking to expand into the Chinese market. This positional advantage, along with Taiwan's own economic needs, should help spur Taiwan and Japan into maintaining their close economic relationship. Taiwan continuously seeks a more prominent image within Asia, and also significantly benefits from Japanese technology and production quality. This is especially true for the semiconductor industry, which in Taiwan is closely linked to the medical instrument and biomedical technology sectors. While Japan may lead in many areas, Taiwanese firms can learn from their Japanese counterparts.

1.3 Research Motavition

Cultural compatibility is not only a crucial issue between a strategic alliance and a target country's market, but also within the strategic alliance itself. Here, the cultural similarities between Taiwan and Japan should again help open the door for the world's second largest economy. For example, when attempting to expand into the Chinese market in Beijing, the convenience store chain 7-Eleven faced significant cultural resistance and marketing failures (e.g., Chinese foods v.s sushi). In Shanghai however, 7-Eleven selected Uni-Present (a Taiwanese corporation) as its partner and was able to expand its chain of stores much more successfully (i.e., Taiwan is the best partner to understand Chinese policy and China's market characteristics). Moreover, Taiwanese firms have also had similar success penetrating other Asian marketplaces, such as Vietnam and Cambodia, due to Taiwan's early entry into these markets. Thus, if Taiwan and Japan collaborate, Taiwan can provide its cultural knowledge of the Chinese marketplace and business world, while Japan shares its technical expertise. By pursuing such potentially successful partnerships, Asian economies can remain active and thrive despite the economic slowdown occurring in America and Europe.

In summary, Japanese firms frequently have comparative advantages in both technology and quality management, while Taiwanese firms are able to best identify and navigate business opportunities within Asia and the global economy. Given the comparative advantages of these two economies, the Industrial Development Bureau of the Ministry of Economic Affairs (MEA) announced that Taiwan and Japan will establish a USD 15 million (about NTD 450 million) venture capital fund for Taiwan-Japan business partnerships. Meanwhile, the future of Taiwan will be given priority when financing such business cooperation projects, to encourage the development of Taiwan-Japan industrial cooperation through innovative services. In this way, the funds can be viewed as a type of subsidy with multiple possible applications.

1.4 Research Contributions

The research objective could be attributed into as follow: Without considering the target setting (i.e., economic and/or social needs), a Taiwan-Japan subsidy (either direct or indirect) suffers several disadvantages. First, freeing a firm from quotas is akin to providing a "free lunch." Such treatment is viewed as favouring firms and encouraging firms to delay upgrading their technology, handling necessary downgrades, or other operational adjustments. Second, “free quotas” without any attached strings reduce incentives to invest in cooperative services. Third, subsidy quotas may elicit profit-driven behaviour by interest groups, and a pricing system under unmerited operation may be influenced by artificial manipulation. These disadvantages highlight the need to design equitable and balanced subsidy policies. For example, suppose the Taiwan government is interested in allocating a subsidy to firms depending solely on the firms’ operation-losses. In this case, companies with larger operation-losses would obtain larger subsidies, compared with their potentially better-managed local competitors who, due to their superior management practices, suffer smaller losses. Because of the budgetary limits for subsidies, how to configure subsidy budgets and how to understand losses due to improper operation or other negative factors are important issues.

2. Resource Allocation

A subsidy is a form of financial assistance paid to a business or economic sector. Most subsidies are made by the government to producers or distributors in an industry to prevent the decline of that industry. Subsidies may distort markets, and can impose large economic costs. There are many different ways to classify subsidies, such as the reason behind them, the recipients of the subsidy, or the source of the funds (e.g., government). In economics, one of the primary ways to classify subsidies is by the means of distribution. In other cases, a subsidy may be an efficient means of correcting a market failure or improving socially necessary needs. Economics has also explicitly identified a number of areas where subsidies are justified, particularly in the provision of public services. Although subsidies may be inefficient, they are often more efficient than other policy tools used to benefit certain groups.

Over the past decade, there have been two perspectives on the global government's transportation subsidy policies: direct and non-direct. A direct subsidy refers to direct financial support for companies. Non-direct subsidies refer to subsidies for property expenses, but do not cover the market value of subsidized goods or services. Direct subsidies may also be more transparent, which may allow the political process more opportunity to eliminate wasteful hidden subsidies. In many instances, economics may suggest that direct subsidies are preferable to other forms of support. Roughly, a direct subsidy system can be divided by capital, operation and rate. Each category offers certain advantages and disadvantages, which are summarized in Table 1.

Table 1: The advantages and disadvantages of subsidy types

Type		Advantages	Disadvantage
Non-direct Type		1. Parallel with other subsidies 2. Does not quire government to raise funds 3. Directly implemented by the executive branch, without legislative approval	1. Need to coordinate, control and measures with relevant departments 2. does not incentivize industry to enhance cost control and improved operational performance 3. Fairness disputed
Direct Type	Capital	1. Encourages businesses to invest in new facilities, new equipment, and improved operational efficiency and service levels. Reduces operating costs 2. Encourages industry to expand service to new routes or in remote routes 3. Easier to control than other operating subsidies, easier to estimate the amount required.	1. Tends to improve the hardware of poorly managed industries, may not have direct benefits 2. Easy to promote over-investment, wasted resources and equipment idle

	Operation	Performance-based	1. Directly associated with system performance, the industry has to promote operational efficiency 2. Encourages the industry to attract more passengers 3. Subsidies to the actual operational performance standards are in line with the principle of fairness	1. Requires industry to provide considerable information. 2. Unable to predict the amount of subsidies needed 3. Difficult to establish a reasonable measure of performance indicators and description 4. Distribution is difficult to manage 5. Can not meet the financial needs of the industry 6. Gives attention to higher revenues, rather than the development of new routes of service
		Cost-based	1. The financial need of the industry is directly related to measures to ease this burden. 2. Allocation of funds is simple and easy to manage 3. Allows higher operating costs of services charged by the lower fares 4. Government policy objectives can be achieved	1. Difficult to determine the cost allocation 2. Result in encouraging the cost of unfairness 3. Unable to predict the amount of subsidies needed 4. Distribution and amount of subsidies not directly related to industry performance 5. Results in excessive use of certain production factors, leading to misallocation of resources
		Operation -Loss	1. Directly related to the financial needs of the industry, reduces the financial burden on the industry 2. When used with good accounting and auditing system, this distribution is simple and easy to manage 3. Industry requires less revenue to maintain service lines 4. Government controls fares, which helps ensure low fare rates	1. Inefficient industries will receive more subsidies, resulting in unfairness. 2. Without prompting the industry to improve its efficiency, the industry will not actively control costs, resulting in greater losses, creating a vicious cycle 3. Difficult to estimate the required amount 4. Large losses will result in a heavy burden on the government
	Rate		1. Can achieve the purpose of passenger care 2. Attracts more people to use public transport. 3. Meets the financial needs of the industry 4. Simple allocation of subsidy payments 5. Low-fare policy can be implemented	1. Does not urge the industry to enhance cost control and improve operational performance. 2. Must establish a complex formula for calculating subsidies and audit approach. 3. Industry will be responsible for losses to the government

Datasource: Wekipedia

Following the previously discussion, subsidy allocation is an important issue in the management of government. It refers to the process of allocation limited resources to different parts of an organization in order to satisfy the overall goals. In practice, the budget is always limited, so how to allocate it plays a pivotal role in determining a firm’s target. Because of this, budget allocation has veen an interesting topic to company management and researchers.

3. Modeling and Problem Formulation

Most of this existing literature created pricing/fare model subsidy estimation models. However, these models face a critical problem: how to decide the price. Recently, the use of data envelopment analysis has brough a new perspective to its study. In response, we employ the allocation-based data envelopment analysis (ABDEA) to allocate a limited subsidy budget to these firms (Taiwan-Japan), while also determining output targets based on their performance between before and after subsidies. Thus, our proposed approach does not require input and output pricing data, and instead relies on input and output quantities.

3.1 Notations

The proposed subsidy allocation model can be demonstrated in two phases. In the first phase, the decision maker wants to obtain an efficiency score for each unit by maximizing the average of efficiency scores of the units using CCR model. Once Phase I is completed, Phase II applies the Phase I results on allocating the subsidy and target setting of each unit by using the ABADEA model. In other words, in the second phase, the equitable subsidy allocation and target setting are evaluated by minimizing the maximum deviation of subsidy and capacity target setting at given levels of efficiency scores obtained from Phase I.

Assuming that the objective of decision maker is to allocate the subsidy budget to and set targets for each firm. Note that the joint firm has no power to the fixed input (i.e., subsidy) but can adjust capacity output (target) as mentioned above. Thus, its performance relies entirely on its existing inputs and outputs, and the government allocates its subsidy budget sets fixed targets with regard to the firm's current performance. Based upon this perspective, each unit is allocated a share of the fixed subsidy relying on its performance and how much capacity they need to provide in the next period. In the proposed model, the subsidy will be allocated and certain capacity output need to be set using a common set of weights which are attached to variables across all units, so that for each unit the relative efficiency before and after allocation remains un-changed. Table 2 presents the index and decision variables used in the following model construction.

Table 2: Description of notations

Variable /Notation	Definition/Item
N	Number of Taiwan-Japan business partnership
C	Total subsidy
Q	Total expected revenue requirements
n_i	Number of nonadjustable input variables
n_o	Number of demand-side output variables
j ($j=1,\cdots,N$)	Indexes for Taiwan-Japan business partnership
i ($i=1,..,n_i$)	Indexes for non-adjustable input variables
o ($o=1,..,n_o$)	Indexes for demand-side output variables
x_{ij}	The $i-th$ non-adjustable input variable of the $j-th$ firm
y_{oj}	The $o-th$ demand-side output variable of the $j-th$ firms
e_j^*	The efficiency scores of $j-th$ firms after phase I was applied
v_i	The common weights of $f-th$ input variables in phase I
u_o	The common weights of $o-th$ output variables in phase I
v_i^*	The optimal common weights of $f-th$ input variables in phase I
u_o^*	The optimal common weights of $o-th$ output variables in phase I
$\tilde{v}_i$	The common weights of $f-th$ input variables in phase II
$\tilde{u}_o$	The optimal common weights of $o-th$ output variables in phase II
c_j	The subsidy for $j-th$ firm
q_j	The required target for $j-th$ firm
w_c	The weights of subsidy variables in phase II
w_q	The weights of target output variables in phase II
$P_{j,\max}$	The maximum deviation of subsidy allocation for $j-th$ firm
$P_{j,\min}$	The minimum deviation of subsidy allocation for $j-th$ firm
$D_{j,\max}$	The maximum deviation of required target for $j-th$ firm
$D_{j,\min}$	The minimum deviation of required target for $j-th$ firm
ε	A small non-negative value
$\delta_j^{(p)}$	The maximum deviation among subsidy for $j-th$ firm
$\delta_j^{(d)}$	The maximum deviation among target for $j-th$ firm

3.2 Research Phases

Two phases are utilized to describe the proposed subsidy allocation with consideration of target settings. The first step determines the relative efficiency for each unit. The second step determines an equitable allocation of subsidies and sets future targets. As the initial work by Beasley (2003), who provided a DEA-based cost allocation method by maximizing the average efficiency across all DMUs for obtaining a unique fixed cost allocation. Amirteimoori and Kordrostami (2005) argue that Beasley's method is infeasible in many instances, and offer improvements by modifying his model. Based on Amirteimoori and Kordrostami (2005)'s discussion, the main difference between their two approaches is that Amirteimoori and Kordrostami replace the fixed-cost flexibility in Beasley's model with the maximum/minimum proportion of fixed cost to the maximum/minimum deviation of fixed cost. Here, we adopt Amirteimoori and Kordrostami's (2005) concept and extend the deviation of fixed cost to both subsidy allocation and a target setting in our model is described below.

Step 1: Determine the relative efficiency for each unit

Following the Amirteimoori and Kordrostami's (2005)'s steps, the Eq. (1.1) is used to estimate efficiency score for each unit via maximize the average of all unit efficiencies; the ratio programming is as Eq. (1.1) to (1.4).

$$\textbf{Max} \quad \frac{\sum_{j=1}^{N} e_j}{N} \tag{1.1}$$

$$e_j = \frac{\sum_{o=1}^{n_o} u_o y_{oj}}{\sum_{i=1}^{n_i} v_i x_{ij}}, \ j = 1, \ldots, N, \tag{1.2}$$

$$0 \le e_j \le 1 \tag{1.3}$$

$$u_o \ge \varepsilon, o = 1, \ldots, n_o, \tag{1.4}$$

$$v_i \ge \varepsilon, i = 1, \ldots, n_i$$

where ε is represented by a small non-Archimedean quantity.

Step II: Determine an allocation of subsidy for current period and set target for the next period.

$$\underset{\forall j}{\textbf{Min}} \ \underset{\forall (p),(d)}{\textbf{Max}} \left\{ \delta_j^{(p)}, \delta_j^{(d)} \right\} \tag{2.1}$$

(Maximum deviation of subsidy allocation)

The deviation $P_{j,\max} - P_{j,\min}$ denotes that the difference between the maximum and minimum deviation of the subsidy allocation to $j-th$ firms. In this setting, each unit is allocated a share of the subsidy in direct proportion to the cost it makes relative to the total cost all units make. This approach is widely used in practice for its simpleness in computation. If it is possible for $j-th$ unit to allocate subsidy proportionally to the ratio of its cost to total cost, then $P_{j,\max} = P_{j,\min}$. For each unit j, it might appear that an allocation is $\gamma_j C$, which implies that $\sum_{j=1}^{N}\gamma_j = 1$. That is, we can use the input cost ratio to illustrate this relation (i.e., $\gamma_j = \frac{\sum_{i=1}^{n_i} v_i^* x_{ij}}{\sum_{j=1}^{N}\sum_{i=1}^{n_i} v_i^* x_{ij}}$, $j = 1,\ldots,N$). Here, v_i^* is obtained from Phase I. If $P_{j,\max} = P_{j,\min}$, unit j obtains the ratio of total subsidy proportionate to γ_j. Based on $\gamma_j C$, the $c_j = \frac{\sum_{i=1}^{n_i} v_i^* x_{ij}}{\sum_{j=1}^{N}\sum_{i=1}^{n_i} v_i^* x_{ij}} C$ is supported. For unit π and ρ, equitable allocation can be supported as ($\left[\sum_{j=1}^{N}\sum_{i=1}^{n_i} v_i^* x_{ij}\right] c_\pi - \left[\sum_{i=1}^{n_i} v_i^* x_{i\pi}\right] C = \left[\sum_{j=1}^{N}\sum_{i=1}^{n_i} v_i^* x_{ij}\right] c_\rho - \left[\sum_{i=1}^{n_i} v_i^* x_{i\rho}\right] C$). As a result, if the allocation is more equitable, the deviation $\delta_j^{(p)} = P_{j,\max} - P_{j,\min}$ should be smaller. The objective function of subsidy allocation is to minimize the maximum deviation of $P_{j,\max}$ and $P_{j,\min}$ for all units.

$$\delta_j^{(p)} \geq P_{j,\max} - P_{j,\min} \tag{2.2}$$

$$P_{j,\max} \geq \left[\sum_{j=1}^{N}\sum_{i=1}^{n_i} v_i^* x_{ij}\right] c_j - \left[\sum_{i=1}^{n_i} v_i^* x_{ij}\right] C,\ j = 1,\ldots,N, \tag{2.3}$$

$$P_{j,\min} \leq \left[\sum_{j=1}^{N}\sum_{i=1}^{n_i} v_i^* x_{ij}\right] c_j - \left[\sum_{i=1}^{n_i} v_i^* x_{ij}\right] C,\ j = 1,\ldots,N, \tag{2.4}$$

<u>(Maximum deviation of target setting)</u>

Eqs. (2.5-2.7) are analogous to Eq. (2.2) – Eq. (2.4) for explaining the target setting.

$$\delta_j^{(d)} \geq D_{j,\max} - D_{j,\min} \tag{2.5}$$

$$D_{j,\max} \geq \left[\sum_{j=1}^{N}\sum_{i=1}^{n_o} u_o^* y_{oj}\right] q_j - \left[\sum_{i=1}^{n_o} u_o^* y_{oj}\right] Q,\ j = 1,\ldots,N, \tag{2.6}$$

$$D_{j,\min} \leq \left[\sum_{j=1}^{N} \sum_{i=1}^{n_o} u_o^* y_{oj} \right] q_j - \left[\sum_{i=1}^{n_o} u_o^* y_{oj} \right] Q,\ j = 1, ..., N, \tag{2.7}$$

Here, u_i^* is obtained from the Phase I.

(Each firm's Invariance Assumptions and Pareto-Minimality)

If the total subsidy (i.e., C) and target setting (i.e., Q) will be assigned in such a way that the relative efficiencies of all units remain unchanged in the based period.

$$\frac{\sum_{o=1}^{n_o} (\tilde{u}_o y_{oj} + w_q q_j)}{\sum_{i=1}^{n_i} (\tilde{v}_i x_{ij} + w_c c_j)} = e_j^*,\ j = 1, ..., N, \tag{2.8}$$

Thus, we followed the pareto-minimality condition from Cook and Kress (1999) that does not permit subsidy allocation and target setting only among inefficient firms. Here, w_q, w_c denote the weights of subsidy and target. Moreover, we remain the efficiency score for each unit is the same as in Phase I. This implies the decision maker provides these units with subsidy allocation based upon the based period performance (i.e., $e_j^*, j = 1, ..., N.$) and requires each unit the provision of the target capacity (i.e., $q_j^*, j = 1, ..., N.$) in the next period.

(Total Subsidy Allocation Constraint)

The total subsidy C is to be distributed among N units. That is, unit j is to be allocated to subsidy c_j, as in Eq. (2.9).

$$\sum_{j=1}^{N} c_j = C, \tag{2.9}$$

(Total Target Setting Constraint)

The total required target Q is also bundled among the N units with consideration of the subsidy given to each firm. That is, unit j is asked to meet a target of q_j if they receive a subsidy c_j, as in Eq. (2.10).

$$\sum_{j=1}^{N} q_j = Q, \tag{2.10}$$

(Additional Conditions)

$$c_j, q_j \geq 0,\ j = 1, ..., N, \tag{2.11}$$

$$u_o \geq 0, o = 1, \ldots, n_o \; v_i \geq 0, i = 1, \ldots, n_i \tag{2.12}$$

4. Illustrative Study and Discussion

Because this project is going now, the MEA cannot provide the related information for us to demostrate till the project closing. For illustrating, five variables are assumed, consisting of three inputs and one output for 11 Taiwan-Japan Joint firms. The three input variables include employees (x_{i1}, in number of persons), company sizes (x_{i2} , in thousand NTD) and operation cost (x_{i3}, in NTD). The output consist of expected revenue (y_{o1}, in NTD). Here, c (in NTD) and q (in NTD) are subsidy and required revenuse after subsidy, respectively. The raw data is presented in Table 3.

Table 3: Raw data of inputs and output of firms

DMU	x_{i1}	x_{i2}	x_{i3}	y_{o1}
1	52	8134	93967.80	47485800
2	64	5157	12490.275	24659520
3	10	197	86570.00	4774860
4	20	390	70675.01	2473677
5	27	393	142845.90	6048769
6	7	126	54468.47	2717760
7	8	117	55334.99	2655120
8	10	128	44443.42	2677840
9	6	117	46891.48	2427648
10	16	446	106000.00	3043200
11	13	58	51597.54	194000
Avg	233	15262	877697.36	99158194

Following the framework in Section 3, $n_i = 3$ and $n_o = 1$. Furthermore, we assumed that the MEA has budgeted only NTD (New Taiwan Dollars) 29.587251 million (i.e., C) for these firms in the 2012, while the total required expected revenue provision is 109.074013 million NTD (i.e., Q) in 2013. That is we assume that total required expected revenue provision is 10% addition of the level of 2012's. The results are shown in Table 4. Following Models (1) and (2), the subsidy allocation and required expect revenue for each firm are shown in column 3 and 4 of Table 4, respectively.

Table 4 shows that the MEA has allocated NTD 29,587,251 to each firm without affecting their relative efficiency scores.The value ($\delta = 0$) mean that the net deviation of the allocation of the subsidy and target seat-mile have already satisfied target setting.

Table 4: The Results from Eleven Observations

DMU j	e_j	c_j	q_j	$P_{j,\max}$	$P_{j,\min}$	$D_{j,\max}$	$D_{j,\min}$	$\text{Max}(\delta_j^{(p)},\delta_j^{(d)})$
1	0.980	10.377	40.273	7.50E-05	2.50E-05	7.50E-05	2.50E-05	3.00E-03
2	1.000	8.087	32.019	7.50E-05	2.50E-05	7.50E-05	2.50E-05	3.00E-03
3	0.854	1.235	4.177	7.50E-05	2.50E-05	7.50E-05	2.50E-05	3.00E-03
4	0.545	1.597	3.448	7.50E-05	2.50E-05	7.50E-05	2.50E-05	3.00E-03
5	1.000	2.428	9.613	7.50E-05	2.50E-05	7.50E-05	2.50E-05	3.00E-03
6	0.952	0.801	3.018	7.50E-05	2.50E-05	7.50E-05	2.50E-05	3.00E-03
7	0.906	0.830	2.978	7.50E-05	2.50E-05	7.50E-05	2.50E-05	3.00E-03
8	0.942	0.810	3.022	7.50E-05	2.50E-05	7.50E-05	2.50E-05	3.00E-03
9	1.000	0.697	2.760	7.50E-05	2.50E-05	7.50E-05	2.50E-05	3.00E-03
10	0.992	1.829	7.183	5.50E-04	2.50E-05	5.00E-04	2.50E-05	0.00E+00
11	0.165	0.894	0.583	5.00E-05	0.00E+00	0.00E+00	0.00E+00	3.00E-03
Average	0.85							
Sum		29.,587	109.074					
Min								0.00E+00

After conducting Model (1), we found that 3 firms (DMUs 2, 5, 9) reached the efficiency frontiers. For example, although DMU 2 is evaluated into the efficiency frontier, it can still be allocated NTD 8.087 million for subsidy and required increasing 32.019 NTD in unchanged its performance ways.

Table 5: The ratio of revenue after subsidy per un-subsidy for each Firm

DMU (j)	1	2	3	4	5	6	7	8	9	10	11
o_j	47.49	24.66	4.77	2.47	6.05	2.72	2.66	2.68	2.43	3.04	0.19
$o_j - q_j$ (million)	-7.21	7.36	-0.60	0.97	3.56	0.30	0.32	0.34	0.33	4.14	0.39
q_j / c_j	3.88	3.96	3.38	2.16	3.96	3.77	3.59	3.73	3.96	3.93	0.65

Table 5 also provides a guide for each firm. As a result, the proposed approach not only provides an equitable perspective to allocate subsidies, but also illustrates an overall target setting perspective. The first row of Table 5 denotes these firms expected revenue in the 2012 and the second row illustrates that these firm need to increase or decrease their expected revenue for the target.

5. Conclusion and Remarks

After the research, the results that describe ways to modify subsidy allocation to allocate resources to Taiwan-Japan co-investments with unchanged performance. We use two-step calculations for the application context, which will illustrate a number of suggestions for each firm. Our results show that performance-based targets provide different subsidy adjustments, demonstrating that the performance-based policy is optimal for allocating subsidies.

However, the analyses of this study have two limitations. First, we use the same weights to evaluate the variables. Specifically, we ignore the importance (or non-importance) of the variables. We suggest that the weight of the variables can be evaluated by analytic-network-process because their relationship is non-linear. In terms of weighting, we could also use expert guidance to acquire these weights.

Second, we did not collect real data for the subsidy case (i.e., we use simulated data to illustrate this case). However, this study provides evidence that systems with feedback effects do exist in the real world, as proven by illustrative applications.

Finally, we hope that this study makes a small contribution to Taiwan-Japan co-investors. We look forward to seeing research extensions as specified above.

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