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Analysing The Performance Efficiency of the Crop Insurance Scheme - Pradhan Mantri Fazal Bima Yojana in Cauvery Delta Zone of Tamil Nadu: Two – Stage Closed DEA Approach

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Abstract: In this study, we use Data Envelopment Analysis (DEA) to evaluate the efficacy of the Pradhan Mantri Fazal Bima Yojana (PMFBY) crop insurance program in Tamil Nadu's Cauvery Delta Zone. Assessing these schemes is crucial for agricultural risk mitigation, a key part of rural development. The Cauvery Delta Zone, known for its agricultural productivity, includes regions like Ariyalur, Cuddalore, Nagapattinam, Preambular, Pudukkottai, Thanjavur, Thiruvarur, and Tiruchirappalli. Technical efficiency is measured, and variables affecting inefficiency are identified using DEA. This methodology helps us understand the relative performance of PMFBY across various districts of CDZ. The DEA analysis results present efficiency scores and valuation metrics for each Decision-Making Unit (DMU) over the five years of Kharif season (2018–2022) using data from the Agricultural Insurance Company.

Keywords: *DEA, CDZ – Cauvery Delta Zone, Decision Making units, Insured, Valuation measures.*

1. Introduction:

A vital component of India's initiatives to protect farmers against agricultural hazards is the Pradhan Mantri Fazal Bima Yojana (PMFBY). Designed to offer full-fledged crop insurance, PMFBY is extremely important in areas such as Tamil Nadu's Cauvery Delta Zone, where a large number of people make their living from agriculture. Even if the plan's purpose is obvious, its efficacy depends on how well it performs in certain geographical settings.

A careful examination of PMFBY's implementation is necessary in Tamil Nadu's Cauvery Delta Zone, which is known for its lush fields and agrarian sector. A sophisticated assessment approach is required to precisely determine the scheme's impact due to the distinct socio-economic and agro-climatic circumstances of this area. Oftentimes, traditional assessment techniques are inadequate.

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This paper explores the performance efficiency of PMFBY in the Cauvery Delta Zone using Data Envelopment Analysis (DEA) methodology with closed system. Chavas, J. P., & Aliber, M.[1] in this paper, The use of DEA to analyse agricultural economic efficiency is covered in this work, along with some basic ideas that are relevant to the analysis of crop insurance efficiency. It evaluates the technical efficiency of these schemes in managing agricultural risks and explores policy implications for improving their performance and outreach to farmers.

Through the use of DEA, which enables the simultaneous evaluation of several inputs and outcomes, we hope to offer a thorough analysis of the scheme's effectiveness. By using this method, we want to pinpoint the PMFBY implementation framework's efficiency drivers and potential development areas. The technique has proven to be effective in evaluating the comparative effectiveness of a group of companies that utilise different but equivalent inputs to generate different but identical outcomes. Zhu, J. [3] This study uses DEA to assess the effectiveness of crop insurance schemes in Pakistan's Punjab province. In order to provide light on crop insurance programmes' performance and efficacy in reducing risks for farmers, it evaluates the technical, allocative, and scale efficiency of various programmes.

From that , the policy makers can refine the PMFBY to better meet the needs of farmers in the

Cauvery Delta Zone by identifying inefficiencies and best practices.

1.1 DEA Model

Traditional DEA approaches are extended to evaluate the decision-making units' (DMUs') long-term efficiency: data envelopment analysis (DEA). When evaluating an entity's (business, organisation, or geographic area) performance over an extended period of time, data envelopment analysis is especially helpful.

The authors of the DEA network approach, Fare and Groskopf, see DMU as a sub-system network. Many techniques have the potential to be applied to efficiency evaluation in the context of DEA. Jaforullah, M., & Whiteman, J.[5] In This paper, uses DEA to evaluate the efficiency of the Federal Crop Insurance Program in the United States. It examines the performance of the program in providing risk management tools to farmers and identifies areas for improvement in program design and implementation.

Cohen, A. J., & Siegelman, P.[4] This study employs DEA to analyze the technical efficiency of crop insurance schemes across different states in India. It assesses the performance of these schemes in terms of resource utilization and identifies factors influencing efficiency, such as administrative capacity and institutional arrangements. They emphasized its utility in identifying areas for improvement within insurance programs to enhance their effectiveness in mitigating agricultural risks.

1.2 Decision-Making Units

Decision-Making Units (DMUs) Data Envelopment Analysis (DEA) represents organisations, divisions, or areas that have been assessed for efficiency throughout a number of time periods. The efficiency of DMUs is evaluated over time, identifying trends and variations, using time series data. To help in understanding efficiency trends and guiding decision-making across several sectors, DEA benchmarks and evaluates the efficiency of DMUs.

Data Envelopment Analysis (DEA) is a method used to evaluate the efficiency of decision-making units (DMUs) over time, extending the traditional DEA framework to analyse performance dynamics. DEA is a non-parametric approach that assesses the relative efficiency of multiple DMUs by comparing their inputs and outputs (Cooper et al., 2004). The DEA adds a temporal dimension, allowing for the examination of efficiency trends and changes over sequential time periods.

In a DEA model, DMUs consume multiple inputs to produce multiple outputs, with data collected at regular intervals over time. Efficiency scores are calculated for each DMU for each time period, indicating their relative efficiency compared to others within the same time period. Efficiency scores range from 0 to 1, with 1 representing perfect efficiency.

A method for evaluating the effectiveness of organisational units known as Decision-Making Units (DMUs) that is based on linear programming is called Data Envelopment Analysis. With the help of available resources, a DMU's efficiency in producing a given set of outputs is to be measured. Efficiency or productivity, defined as the ratio of total outputs to total inputs, is the term used in DEA to evaluate the performance of DMUs. The performance of each DMU varies from 0 to 1 in respect to the best-performing DMU (or DMUs, if there are many best-performing DMUs), according to the relative efficiency values derived through the usage of DEA.

Shanmugam, K.R. & Venkataramani, Atheendar [7] Through their study, the authors concluded that the two-stage DEA model provides a robust method for assessing the efficiency of crop insurance schemes. By considering uncertainties inherent in agricultural data, it offers more realistic evaluations that can aid policymakers in optimizing insurance programs.

In the last few years, the two-stage closed DEA has been the subject of a sizable number of research as part of the expansion of the DEA network. Different performance metrics are generated for Stage 1 and Stage 2 by the two-stage closed DEA model.

1.3 Two-stage Closed DEA Model

The output measures of the first stage are taken to be the input measures of the second stage in the two-stage closed system of the DEA model, without any changes. Past studies have shown that two-stage DEA closed models can be used in a variety of applications. The DMU is viewed as a network of sub-systems under the DEA approach to the network that Fare and Groskopf developed. The

two-stage DEA system has been the subject of numerous research as the DEA network has grown in recent years.

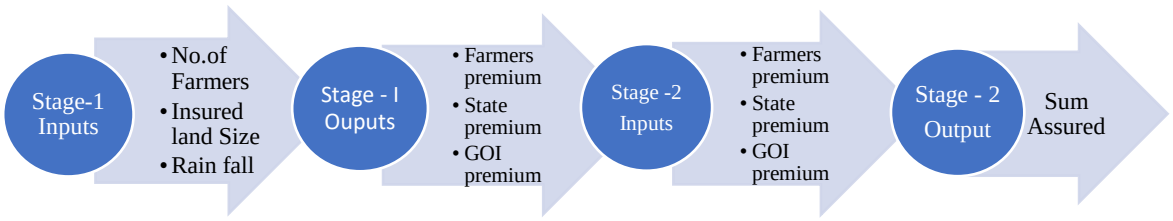
Kyrgiakos LS & Kleftodimos G et.al., & Kapil Raj, K., Srinivasan, S. & Nandakumar, C.D. [8,17], This work presents more complex DEA models with greater adaptability's and uses it to assess agricultural output efficiency. The model can be modified to investigate crop insurance efficiency. It examines the technical efficiency of these schemes in managing agricultural risks and investigates the impact of various factors on their performance, including premium rates and coverage levels. Sharma, K. R., Leung, P., & Zaleski, H. M [6] This paper utilizes DEA to assess the efficiency of crop insurance schemes in Karnataka, India. It evaluates the performance of these schemes in terms of their ability to provide financial protection to farmers against crop losses and explores opportunities for enhancing their effectiveness through improved design and implementation. Cooper, W.W., Seiford, L.M., Zhu, J.[2] This study uses DEA to evaluate the efficiency of crop insurance markets in Greece. It assesses the performance of different insurance schemes and identifies factors influencing their efficiency, such as product design, pricing strategies, and regulatory framework.

In contrast to all other previous efforts, this article uses data envelopment analysis to investigate and examine the current performance of the Pradhan Mantri Fazal Bima Yojana Crop Insurance scheme in the Cauvery Delta Zone of Tamil Nadu on an individual basis for the period (2018–2022). The first stage evaluates the insured efficiency of the chosen zone; the second stage uses returns to scale models to calculate the policy's valuation.

2. Data and Methodology:

Data collection:

The necessary information on Tamil Nadu's Cauvery delta zone was obtained for this study from the government sources for the years 2018–22. Moreover, an examination of the literature regarding the application of data envelopment analysis (DEA) reveals that numerous studies have utilised diverse pairings of inputs and outputs. Three input variables and three output variables for stage 1 and three input variables and one output variable for stage 2 were considered by the researcher for this study in order to provide a thorough analysis.



2.1 Constant Returns to Scale Model to stage 1

The original CCR model applied, but only to the skill that falls inside the constant returns to scale category. The Charnes and Cooper (BCC) model was a significant improvement in facilitating expertise that displays varied returns to scale. The input-oriented DEA model, which places an emphasis on minimising inputs and maximising outputs maintained at their current degrees, was employed in this work. The BCC model with a changeable return to scale is also taken into account.

Let the efficiency of q^{th} DMU out of N DMU's is defined as

$$Max\ E_q = \frac{\sum_{j=1}^{J} v_{jq}\, y_{iq}}{\sum_{i=1}^{I} u_{iq}\, x_{iq}} \quad (1)$$

Subject to the constraints,

$$\frac{\sum_{j=1}^{J} v_{jq}\, y_{iq}}{\sum_{i=1}^{I} u_{iq}\, x_{iq}} \leq 1\,; q = 1,2,\dots n \quad (2)$$

$$v_{jq}\,, u_{iq}\,, y_{jq}, x_{iq} \geq 0; i = 1,2,\dots, I,;\ \ j = 1,2,\dots J \quad (3)$$

Where,

E_q - is the efficiency of the q[th] Decision Making unit (DMU)

y_{jq} – j[th] output value of q[th] DMU

v_{jq} - Weight of the output variable of q[th] DMU

x_{iq} - i[th] input value of q[th] DMU

u_{iq} – Weight of the input variable of q[th] DMU

2.2 VRS model to stage 1

General format of Variable Return to Scale

The DEA model for considering variable return to scale, is as follows:

$$\text{Min } \theta_m \tag{4}$$

Subject to the constraints,

$$\text{Y}\lambda \geq Ym; \quad X\lambda \leq \theta Xm \tag{5}$$

$$\sum_{n=1}^{N} \lambda_n = 1; \tag{6}$$

$$\lambda_n \geq 0; \tag{7}$$

2.3 Output and Input variables of Stage 1

Currently, stage 1 inputs include insured land size, insured non-loanee farmers, and insured loanee farmers. The outcomes from step 1 are the framers' premium, state premium, and central premium. It's the Insured stage of crop insurance policy. And the outputs of stage 1 are considered as an input to the stage 2. Because it's a closed DEA model.

2.4 Problem Design

Output maximisation with CRS model: (Output Maximaisation)

Ariyalur (2018)

$$Max\ E_{Ariyalur} = \frac{192.89x_1 + 949.29x_2 + 949.29x_3}{61046x_4 + 16.14x_5 + 814.5x_6} \tag{8}$$

Subject to constraints,

$$\frac{552.74x_1 + 1478.83x_2 + 1478.83x_3}{127121x_4 + 54.44x_5 + 965x_6} \leq 1 \tag{9}$$

$$\frac{1601.1x_1 + 16498.49x_2 + 16498.49x_3}{294258x_4 + 148.95x_5 + 1079.8x_6} \leq 1 \tag{10}$$

$$\frac{56.7x_1 + 72.07x_2 + 72.07x_3}{5712x_4 + 2.15x_5 + 533.3x_6} \leq 1 \tag{11}$$

$$\frac{680.04x_1 + 3934.99x_2 + 3934.99x_3}{207654x_4 + 67.02x_5 + 692.1x_6} \leq 1 \tag{12}$$

$$\frac{1291.42x_1 + 5259.99x_2 + 5259.99x_3}{1156226x_4 + 116.59x_5 + 703.8x_6} \leq 1 \tag{13}$$

$$\frac{1921.04x_1 + 17129.13x_2 + 17129.13x_3}{324202x_4 + 179.1x_5 + 1173.3x_6} \leq 1 \tag{14}$$

$$\frac{162.24x_1 + 637.83x_2 + 637.83x_3}{42262x_4 + 13.66x_5 + 818x_6} \leq 1 \tag{15}$$

$$x_1, x_2 x_3 x_4 x_5, x_{6,} \geq 0$$

Corresponding LPP structure for the above problem

$$Max\ E_{Ariyalur} = 192.89x_1 + 949.29x_2 + 949.29x_3 \tag{16}$$

Subject to the constraints

$$61046x_4 + 16.14x_5 + 814.5x_6 = 1 \tag{17}$$

$$552.74x_1 + 1478.83x_2 + 1478.83x_3 - 127121x_4 - 54.44x_5 - 965x_6 \leq 0 \tag{18}$$

$$1601.1x_1 + 16498.49x_2 + 16498.49x_3 - 294258x_4 - 148.95x_5 - 1079.8x_6 \leq 0 \tag{19}$$

$$56.7x_1 + 72.07x_2 + 72.07x_3 - 5712x_4 - 2.15x_5 - 533.3x_6 \leq 0 \quad (20)$$

$$680.04x_1 + 3934.99x_2 + 3934.99x_3 - 207654x_4 - 67.02x_5 - 692.1x_6 \leq 0 \quad (21)$$

$$1291.42x_1 + 5259.99x_2 + 5259.99x_3 - 1156226x_4 - 116.59x_5 - 703.8x_6 \leq 0 \quad (22)$$

$$1921.04x_1 + 17129.13x_2 + 17129.13x_3 - 324202x_4 - 179.1x_5 - 1173.3x_6 \leq 0 \quad (23)$$

$$162.24x_1 + 637.83x_2 + 637.83x_3 - 42262x_4 - 13.66x_5 - 818x_6 \leq 0 \quad (24)$$

$$x_1, x_2 x_3 x_4 x_5, x_6 \geq 0$$

2.5 CRS results for Stage 1

The efficiency findings for the Insured stage sub-process are shown in the table below, which is based on output maximisation technical efficiency using the Constant Return to Scale model for the years 2018 -2022. The table shows that the crop insurance scheme achieved highest efficiency score of 1 by three districts Nagapattinam, Preambular and Pudukkottai in the CRS stage out of 8 Cauvery delta zone districts.

S.No	DMUs	Efficiency Score					Average	Rank
		2018	2019	2020	2021	2022		
1	**Ariyalur**	0.739	0.896	0.747	0.760	0.706	0.769	6
2	**Cuddalore**	0.529	0.704	1.000	0.943	0.784	0.792	5
3	**Nagapattinam**	1.000	1.000	1.000	1.000	1.000	1.000	1
4	**Preambular**	1.000	1.000	1.000	1.000	1.000	1.000	1
5	**Pudukkottai**	1.000	1.000	1.000	1.000	1.000	1.000	1
6	**Thanjavur**	1.000	1.000	1.000	0.903	0.962	0.973	2
7	**Thiruvarur**	1.000	0.800	1.000	1.000	1.000	0.960	3
8	**Tiruchirappalli**	0.643	1.000	1.000	1.000	1.000	0.929	4

Table-1: Technical Efficiency Results on Stage-1 under CRS Model

3. VRS model for Stage 1

$$Min\ x_7 - x_8 \quad (25)$$

Subject to the constraints,

$$192.89x_1 + 552.74x_2 + 1601.1x_3 + 56.7x_4 + 680.04x_5 + 1291.42x_6 + 1921.04x_7 + 162.24x_8 \geq 192.89 \quad (26)$$

$$949.29x_1 + 1478.83x_2 + 16498.49x_3 + 72.07x_4 + 3934.99x_5 + 5259.99x_6 + 17129.13x_7 + 637.83x_8 \geq 949.29 \quad (27)$$

$$949.29x_1 + 1478.83x_2 + 16498.49x_3 + 72.07x_4 + 3934.99x_5 + 5259.99x_6 + 17129.13x_7 + 637.83x_8 \geq 949.29 \quad (28)$$

$$61046x_1 + 127121x_2 + 294258x_3 + 5712x_4 + 207654x_5 + 1156226x_6 + 324202x_7 + 42262x_8 + 192.89x_9 - 192.89x_{10} \leq 0 \quad (29)$$

$$36352x_1 + 48207x_2 + 109682x_3 + 1904x_4 + 121213x_5 + 123483x_6 + 118763x_7 + 17266x_8 + 949.29x_9 - 949.29x_{10} \leq 0 \quad (30)$$

$$16.14x_1 + 54.44x_2 + 148.95x_3 + 21.5x_4 + 67.02x_5 + 116.59x_6 + 179.1x_7 + 13.66x_8 + 949.29x_9 - 949.29x_{10} \leq 0 \quad (31)$$

$$\sum_{i=1}^{10} x_i = 1 \quad (32)$$

$$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10} \geq 0 \quad (33)$$

All such 96 problems were generated from the collected data and solved by using Deap software.

3.1 VRS results of Stage 1

Utilising the Variable Return to Scale concept, output maximisation technological efficiency, Table 2 displays the mean performance of the selected area for the years 2018 -2022. The table shows that the crop insurance scheme achieved highest efficiency score of 1 by four districts Nagapattinam, Preambular, Pudukkottai and Thanjavur out of 8 Cauvery delta Zone districts.

S.No	Name of the DMUs	Efficiency Score of VRS					Average efficiency score	Rank
		2018	2019	2020	2021	2022		
1	**Ariyalur**	0.922	0.909	0.820	0.764	1.000	0.883	6
2	**Cuddalore**	0.893	0.820	1.000	1.000	1.000	0.943	5
3	**Nagapattinam**	1.000	1.000	1.000	1.000	1.000	1.000	1
4	**Perambalur**	1.000	1.000	1.000	1.000	1.000	1.000	1
5	**Pudukkottai**	1.000	1.000	1.000	1.000	1.000	1.000	1
6	**Thanjavur**	1.000	1.000	1.000	1.000	1.000	1.000	1
7	**Thiruvarur**	1.000	0.828	1.000	1.000	1.000	0.966	3
8	**Tiruchirappalli**	0.877	1.000	1.000	1.000	1.000	0.975	2

Table-2: Technical Efficiency Results for stage-1 under VRS Model

3.2 Overall mean Efficiency score in stage - 1

The crop insurance scheme Pradhan Mantri Fazal Bima Yojana is to meet the maximum efficiency score with only three districts of Preambular, Nagapattinam and Pudukkottai out of eight CDZ.

Name of the DMU's	Mean of CRS	Mean of VRS	Mean	Rank
Ariyalur	0.769	0.883	0.826	6
Cuddalore	0.792	0.943	0.867	5
Nagapattinam	1.000	1.000	1.000	1
Preambular	1.000	1.000	1.000	1
Pudukkottai	1.000	1.000	1.000	1
Thanjavur	0.973	1.000	0.987	2
Thiruvarur	0.960	0.966	0.963	3
Tiruchirappalli	0.929	0.975	0.952	4

Table-3: Mean efficiency score overall for Stage -1

4. CRS model for Stage 2

The following table supports the efficiency outcomes of the Valuation process (stage 2) and is based on output maximisation technical efficiency utilising the Closed DEA Constant Return to Scale model. This table shows that, two of Cauvery Delta

Zone districts Pudukkottai and Thanjavur in India out of the eight that were chosen for selection performed best during the valuation process.

S.No	DMUs	Efficiency Score of CRS					Mean of efficiency score	Rank
		2018	2019	2020	2021	2022		
1	**Ariyalur**	0.915	0.962	1.000	1.000	1.000	0.975	5
2	**Cuddalore**	1.000	1.000	0.978	1.000	0.991	0.994	3
3	**Nagapattinam**	1.000	1.000	0.992	0.998	0.985	0.995	2
4	**Perambalur**	1.000	1.000	1.000	0.969	0.817	0.957	6
5	**Pudukkottai**	1.000	1.000	1.000	1.000	1.000	1.000	1
6	**Thanjavur**	1.000	1.000	1.000	1.000	1.000	1.000	1
7	**Thiruvarur**	1.000	0.972	0.998	1.000	0.965	0.987	4
8	**Tiruchirappalli**	0.954	0.928	0.879	0.789	0.740	0.858	7

Table-4: Technical Efficiency Results of stage-2 under CRS Model

4.1 VRS Model for Stage 2

The following table shows the efficiency findings for the Valuation stage sub-process (Stage 2) for the financial years 2018–2022, based on the output maximisation technical efficiency using the Closed DEA Variable Return to Scale model. The table shows that the crop insurance scheme achieved highest efficiency score of 1 by three districts Pudukkottai, Thanjavur and Thiruvarur in the stage 2 out of 8 Cauvery delta Zone districts.

S.No	DMUs	Efficiency Score of VRS					Mean Efficiency Score of VRS	Rank
		2018	2019	2020	2021	2022		
1	**Ariyalur**	0.973	1.000	1.000	1.000	1.000	0.995	4
2	**Cuddalore**	1.000	1.000	0.979	1.000	1.000	0.999	2
3	**Nagapattinam**	1.000	1.000	1.000	1.000	0.986	0.997	3
4	**Perambalur**	1.000	1.000	1.000	1.000	0.857	0.971	5
5	**Pudukkottai**	1.000	1.000	1.000	1.000	1.000	1.000	1
6	**Thanjavur**	1.000	1.000	1.000	1.000	1.000	1.000	1
7	**Thiruvarur**	1.000	1.000	1.000	1.000	1.000	1.000	1
8	**Tiruchirappalli**	1.000	0.936	0.891	0.790	0.745	0.872	6

Table-5: Technical Efficiency Results of stage – 2 under VRS Model

4.2 Overall mean Efficiency score in stage - 2(Valuation Stage)

The crop insurance scheme Pradhan Mantri Fazal Bima Yojana is to meet the maximum efficiency score with only two districts Pudukkottai & Thanjavur in the stage 2 out of 8 Cauvery delta Zone districts.

S.No	Name of the DMU's	Mean of CRS	Mean of VRS	Mean	Rank
1	Ariyalur	0.975	0.995	0.985	5
2	Cuddalore	0.994	0.996	0.995	3
3	Nagapattinam	0.995	0.997	0.996	2
4	Preambular	0.957	0.971	0.964	6
5	Pudukkottai	1.000	1.000	1.000	1
6	Thanjavur	1.000	1.000	1.000	1
7	Thiruvarur	0.987	1.000	0.9935	4
8	Tiruchirappalli	0.858	0.872	0.8652	7

Table - 6: Mean efficiency score overall for Stage -2

5. Comparative Analysis

To evaluate the dependability of the DMU's efficiency score, the proposed system of the Closed two stage DEA method's sensitivity analysis is examined. By adjusting the input and output variables that are taken into consideration for each of the stage 1 and stage 2 subprocesses, the DEA technique affects the efficiency value of the DMUs.

S.No	Efficiency of mean score						
	DMUs	Stage 1			Stage 2		
		CRS	VRS	Mean	CRS	VRS	Mean
1	Ariyalur	0.769	0.883	0.826	0.975	0.995	0.985
2	Cuddalore	0.792	0.943	0.867	0.994	0.996	0.995
3	Nagapattinam	1.000	1.000	1.000	0.995	0.997	0.996
4	Preambular	1.000	1.000	1.000	0.957	0.971	0.964
5	Pudukkottai	1.000	1.000	1.000	1.000	1.000	1.000
6	Thanjavur	0.973	1.000	0.987	1.000	1.000	1.000
7	Thiruvarur	0.960	0.966	0.963	0.987	1.000	0.9935
8	Tiruchirappalli	0.929	0.975	0.952	0.858	0.872	0.8652

Table -7 : Mean efficiency score overall for Stage -1 & Stage2

For the modification in the return-to-scale models of DEA under the Insured stage, Table 3 demonstrates 3 DMU's have the greatest efficiency score of 1. The DMU's are Nagapattinam, Pudukkottai and Preambular. Table 6 demonstrates that despite revisions to the return-to-scale models of DEA under the scheme's valuation stage 2, the greatest efficiency scores of 1, had achieved by the DMU's of Pudukkottai & Thanjavur districts. The efficiency value is unchanged for the Pudukkottai DMU in both the CRS and VRS outcomes for the effectiveness stage.

6. Conclusion

An approach known as Two-Stage Closed Data Envelopment Analysis (DEA) was used to analyse the effectiveness of the Pradhan Mantri Fazal Bima Yojana (PMFBY) in the Cauvery Delta Zone of

Tamil Nadu. The efficacy of the plan in optimising crop insurance coverage and reducing resource consumption could be thoroughly assessed thanks to this methodology.

Through the application of the Two-Stage Closed DEA approach, several key findings emerged:

Efficiency Assessment

Within the Cauvery Delta Zone, the investigation revealed information about the effectiveness of PMFBY implementation in eight districts. In stage 1, the number of farmers, the size of the insured land, and the amount of rainfall are compared to the premiums received by the farmers, the state, and the government of India. In the stage-2, the output is Sum assured. It will use the comparison made with the stage -1 outputs as an input. From the stage- 2 calculation, we find that Pudukkottai and Thanjavur district's efficiency score was 1. Finally, from the overall comparative analysis, the efficiency score of 1 was achieved by the Pudukkottai district alone. A quantitative performance metric was provided by efficiency scores. The PMFBY programme in Pudukkottai district met its objectives and satisfied the expectations of farmers, as indicated by the efficiency score.

Recommendations for Improvement

Units identified as needing improvement were those with efficiency ratings lower than **1** in either stage. Policymakers and other stakeholders can focus interventions and strategies to improve the efficacy of the PMFBY plan in such regions by identifying inefficiencies and areas of underperformance.

Policy Implications

The analysis' conclusions have important policy ramifications for Tamil Nadu's PMFBY programme in the Cauvery Delta Zone. Policy decisions aiming at maximising resource allocation, boosting operational effectiveness, and eventually expanding the reach and impact of crop insurance coverage can be informed by the insights obtained from the Two-Stage Closed DEA approach.

In conclusion, the Two-Stage Closed DEA approach's implementation offered a solid foundation for assessing the PMFBY scheme's performance effectiveness in Tamil Nadu's Cauvery Delta Zone. Through the utilisation of this methodology, decision-makers and interested parties may make data-driven choices that will enhance the execution of crop insurance programmes and promote agricultural resilience in the area.

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