The Productivity Analysis of Eco-feed Production Technologies in Japan

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In 2022, Japan imported 75% of its livestock feed, comprising 30-60% of livestock industry expenses, with swine production relying on imports up to 63%. Persistent dependence poses a risk of increased domestic feed prices. The government targets a 34% feed self-sufficiency rate by 2030. Eco-feed, utilizing food waste, is proposed to boost self-sufficiency, reduce feed costs, and cut food waste. However, concerns arise about the suboptimal efficiency and inadequate management of Eco-feed production facilities.

Few studies have attempted to estimate the production efficiency of Eco-feed production plants (e.g., Nakaishi and Takayabu, 2022). This study focuses on scrutinizing the production efficiency of Eco-feed plants. It involves the identification of both efficient and inefficient plants, along with a quantitative estimation of the potential for cost reduction linked to the elimination of inefficiencies. Additionally, we assess both the efficiency of production technology and production scale. We offer recommendations for enhancing production efficiency and propose efficient plants as benchmarks for those facing inefficient operations.

In this research, employing Data Envelopment Analysis (DEA), we conducted a production efficiency analysis encompassing a total of 45 plants. This includes 28 plants with the dry method, 11 plants with the liquid method, and 6 plants with the fermentation method. It is important to note that although Nakaishi and Takayabu (2022) identified inefficient Eco-feed plants in Japan, they did not distinguish between Eco-feed production technologies. Therefore, Nakaishi and Takayabu (2022) failed to establish a reference Eco-feed production frontier for a specific Eco-feed production technology. The novelty of this study is twofold. First, this study is the first attempt to examine the production efficiency with a focus on a specific Eco-feed production technology. Second, we revealed cost reduction potential achieved through improving the production technology of the inefficient Eco-feed plants identified in this study.

We compiled a comprehensive input-output database for the production activities of 45 specific Eco-feed plants in Japan. This database includes two inputs, namely the number of employees (person) and the amount of biomass delivered (t), and one output, which is the amount of Eco-feed produced. Additionally, we calculated a normalized efficiency score ranging between 0 and 1 for the 45 specific Eco-feed plants via DEA.

This study utilized two DEA models: the Constant Returns to Scale model and the Variable Returns to Scale model. The adoption of these models enables the estimation of three efficiency types: Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE), and Scale Efficiency (SE). This facilitates the identification of whether inefficiencies arise from production technology or production scale. The cost reduction potential was calculated by subtracting the OTE efficiency value from 1, and subsequently multiplying the result by the costs associated with Eco-feed production, encompassing labor and transportation expenses.

Based on the results, the average OTE scores were 0.44 for the drying method, 0.52 for the liquid method, and 0.47 for the fermentation method, with 37 plants scoring below 1. This suggests that there is room for improvement in many plants. Additionally, the average PTE scores were 0.62 for the drying method, 0.75 for the liquid method, and 0.62 for the fermentation method. The average SE scores were 0.74 for the drying method, 0.67 for the liquid method, and 0.68 for the fermentation

method. This indicates that for the drying and fermentation methods, SE is higher than PTE.

This implies that there is potential for improvement in production technology rather than scale economies for the drying and fermentation methods. Conversely, in the liquefaction method, the lower PTE compared to SE suggests a potential for improvement in production scale. Moreover, concerning the reduction potential, for the drying method, liquid method, and fermentation method, labor costs could be decreased by 693 million yen, 404 million yen, and 250 million yen, respectively. Additionally, it was determined that transportation costs (number of trucks per day) could be reduced by 57, 39, and 0.47 for each respective method.

This study revealed the potential for cost reduction, encompassing labor and transportation costs, in inefficient plants. We also offered guidelines on whether to enhance production technology or production scale to improve the productivity of inefficient plants. Consequently, inefficient plants should seek inspiration from efficient reference plants and make improvements in either production technology or scale to boost production efficiency. This, in turn, could contribute to an elevation in Japanâ€™s feed self-sufficiency rate, a further reduction of food waste, and a potential decrease in feed prices.