An Analysis of Supply Chain Efficiency in the Japanese Food System

Topic: Input-Output Analysis: Regional policies (6)
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Reducing food waste has become an urgent global challenge. Target 12.3 of the SDGs calls for halving per capita food waste at the retail and consumer levels and reducing food losses along production and supply chains by 2030. In Japan, approximately 22 million tons of food waste are generated annually, including around 15 million tons from the business sector and 7 million tons from households. Reducing food waste is therefore a critical national policy objective. Since food waste is generated at every stage of the food system, including production, processing, distribution, and consumption, effective mitigation requires a comprehensive understanding of the structure and efficiency of the entire food supply chain.

This study evaluates the efficiency of food supply chains induced by final demand for food services across Japanâ€™s 47 prefectures in 2015. To achieve this, we integrate a prefecture-level input-output dataset constructed from multiregional inputâ€“output (MRIO) analysis with Data Envelopment Analysis (DEA). The IO framework enables us to capture both direct and indirect economic activities induced by food service demand, while DEA allows for a relative efficiency assessment across prefectures. Inputs consist of direct and indirect intermediate inputs, labor (number of employees), and capital induced by food service final demand. Outputs include food service final demand (a desirable output) and food waste emissions (an undesirable output). Efficiency scores are normalized between 0 and 1, with values closer to 1 indicating higher efficiency relative to the best-performing prefectures.

The empirical results show that the national average efficiency score is 0.84, indicating an improvement potential of approximately 16% relative to the efficiency frontier. Nineteen prefectures are identified as fully efficient , while the remaining 28 prefectures exhibit varying degrees of inefficiency. Efficiency scores range from 0.50 to 1.00, revealing substantial regional disparities in supply chain performance. Slack analysis further demonstrates that food waste emissions are the primary contributor to inefficiency, exerting a larger impact on efficiency scores than intermediate inputs, labor, or capital. This finding suggests that inefficiency in the food supply chain is driven more by waste generation than by excessive input use alone.

To identify the structural emission sources of food waste, we apply Structural Path Analysis (SPA) within the MRIO framework. The prefecture-level structural path analysis reveals that the generation structure of food waste can be broadly classified into two types. The first type, termed the â€œwithin-prefectureâ€“drivenâ€• structure, is characterized by a strong concentration of emissions in the local food manufacturing sector. For example, in Hokkaido, 73.4% of food waste induced by final demand for food services originates from the prefectureâ€™s own manufacturing sector, with the dominant pathâ€”"within-prefecture food manufacturing â†’ food servicesâ€•â€”alone accounting for 65.3% of total emissions. This pattern suggests that inefficiency is primarily embedded in upstream production structures.

In contrast, the second type, the â€œother-prefectureâ€“drivenâ€• structure, exhibits reliance on manufacturing sectors located outside the prefecture. In Gifu Prefecture, the largest pathâ€”"food manufacturing in other prefectures â†’ food servicesâ€•â€”accounts for 52.7% of total emissions, most of which originate from Aichi Prefecture. This indicates that inefficiency may be linked to interregional supply chain configurations rather than local production alone.

These findings carry important policy implications. First, food waste reduction strategies should prioritize interventions at the manufacturing stage rather than focusing exclusively on downstream food service operations or consumer behavior. Second, because emissions are concentrated in a small number of structural paths, targeted interventionsâ€”such as improving production planning, enhancing demand forecasting accuracy, optimizing inventory management, and strengthening coordination between manufacturers and food service operatorsâ€”are likely to yield disproportionately large reductions. Concentrating policy efforts on these key pathways may therefore achieve greater effectiveness compared to broad, uniform regulations.

In summary, by integrating IOA, DEA, and SPA, this study proposes a novel analytical framework for evaluating food supply chain efficiency and identifying key structural sources of food waste at the regional level. The framework provides not only a diagnostic tool for assessing inefficiency but also a strategic basis for prioritizing policy interventions aimed at achieving SDG Target 12.3. Moreover, the approach is transferable to other countries with available inputâ€“output tables, contributing to international efforts toward supply chainâ€“based food waste reduction.