Environmental Efficiency in the Utilization of Factor Inputs in Japanese 47 Prefectures

Topic:
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In 2013, Japan had a total railway length of 27,445 km. Five prefecturesâ€”Tokyo, Osaka, Aichi, Fukuoka, and Hokkaidoâ€”accounted for a significant portion, representing 22.3% of the total railway length. Conversely, nine prefectures, including Okinawa and Nagasaki, contributed to a marginal portion, amounting to less than 1% of the total railway length. As a result, infrastructure stock levels varied among prefectures in Japan. It is crucial to note that a higher infrastructure stock level leads to a higher gross prefectural product but also results in larger CO2 emissions due to energy consumption in infrastructure use, such as electricity consumption in railway passenger and freight transport.

On the other hand, despite Japan experiencing a continuous population decrease since 2008, the national government and local authorities have made excessive investments in infrastructure, such as railways. An important research question is how to estimate the potential economic losses and excessive environmental impact resulting from â€˜inefficientâ€™ investments in public infrastructure and housing construction necessary for economic activities in a specific prefecture.

With this background, Eguchi (2017) used panel data on the physical stocks of buildings and infrastructure, labor force, and gross regional product of 46 Japanese prefectures during the study period between 1970 and 2010 and identified inefficient prefectures with productivity improvement potentials. It is important to note that Eguchi (2017) did not analyze CO2 reduction potential achieved through efficient factor inputs at the prefecture level. This study is an important follow-up investigation into the relationship between production factor use and the environment. Using data envelopment analysis (DEA), we estimated the environmental efficiency score of factor inputs, including urban stocks, in each prefecture in Japan in 2013 and identified inefficient prefectures.

The input data include the total length of railway lines in each prefecture (Institution for Transport Policy Studies, 2023), the total number of houses in each prefecture (Ministry of Internal Affairs and Communications, 2023), and the number of employees in each prefecture (Cabinet Office, 2023). The output data consist of the prefectural gross domestic product (Cabinet Office, 2023) and energy-related COâ„ emissions of each prefecture (Ministry of the Environment). The analysis is conducted using both single-input single-output and three-input two-output models.

The results from a simple productivity indicator analysis show that the gross regional product per kilometer of railway line varied significantly across prefectures. For example, Okinawa had the highest value (303.2 billion JPY/km), 12.8 times the national average (23.7 billion JPY/km). In particular, prefectures including metropolitan cities like Tokyo (101.1 billion JPY/km), Osaka (49.7 billion JPY/km), Kanagawa (46.7 billion JPY/km), and Aichi (40.8 billion JPY/km) also exhibited higher values. Conversely, Iwate had the lowest value (4.5 billion JPY/km), which is 0.01 times that of Okinawa. Regions such as Hokkaido (7.4 billion JPY/km), Tohoku including Aomori (6.6 billion JPY/km), and Akita (5.5 billion JPY/km), and the Sanin region including Shimane (5.5 billion JPY/km) showed relatively low values.

Gross regional product per house also varied across prefectures. Tokyo had the highest value (14.43 million JPY/house), which was 1.76 times the national average (8.2 million JPY/house). Other high values were observed in the Tokai and Hokuriku regions, including Aichi (11.25 million

JPY/house), Fukui (10.31 million JPY/house), Shizuoka (10.23 million JPY/house), Toyama (10.08 million JPY/house), and Shiga (9.9 million JPY/house). Conversely, Nara had the lowest value (5.91 million JPY/house), which is 0.4 times that of Tokyo. Western Japan, including Kochi (5.95 million JPY/house), Kagoshima (6.08 million JPY/house), Nagasaki (6.39 million JPY/house), Miyazaki (6.46 million JPY/house), and Okinawa (6.49 million JPY/house), showed relatively low values.

Thus, urban stocks contributed to economic outputs, but they have worsened the environment by emitting a huge amount of CO2 during the construction stage of those railways and houses. The results from a combined analysis framework of DEA analysis and infrastructure LCA analysis showed that there is a significant CO2 reduction potential through the efficient accumulation of urban stocks in inefficient prefectures located in the Tohoku and Kyushu regions identified in this study. In conclusion, based on the benchmark prefectures, we suggest infrastructure use guidelines for the inefficient prefectures.