

# Firm-Level Heterogeneity in CO<sub>2</sub> Emissions in International Aviation: The Case of Japan

Topic: Industrial Ecology

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To address global warming, countries are working on decarbonization across various sectors. According to the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), carbon dioxide (CO<sub>2</sub>) emissions from Japan's transportation sector accounted for 18.5% of total emissions in 2022, with the aviation sector contributing 5% of these transportation emissions.

With globalization, the demand for passenger travel continues to rise. Particularly, CO<sub>2</sub> emissions from international flights are expected to increase if no measures are taken, given the expanding global demand for air travel. However, the CO<sub>2</sub> emissions estimated by the MLIT do not include emissions from international flights. To advance decarbonization in the aviation industry, it is essential to estimate CO<sub>2</sub> emissions from both domestic and international flights.

This study estimates the direct CO<sub>2</sub> emissions from international flights operated by Japan's major airlines, Japan Airlines (JAL) and All Nippon Airways (ANA). The objective of this research is to propose effective policies to achieve decarbonization in the aviation industry.

To estimate the direct CO<sub>2</sub> emissions and direct CO<sub>2</sub> emissions per capita from international flights operated by JAL and ANA, we examined the flight distances and fuel efficiency by aircraft type for more than 80,000 direct international flights using international flight schedule data. This study assumed that the aircraft fuel tanks were full, and all seats were occupied. The CO<sub>2</sub> emission factor was sourced from the National Institute for Environmental Studies' 3EID Book for jet fuel, published in 2015. Data on international flight schedules were sourced from the MLIT and the Japan Travel Bureau (JTB), published in 2023. Information on aircraft was obtained from the ANA website. Flight distances were calculated using figures from the International Civil Aviation Organization (ICAO).

The annual number of flights estimated in this study was 44,000 for JAL and 38,000 for ANA in 2023. The annual direct CO<sub>2</sub> emissions from international flights associated with JAL and ANA amounted to 11.4 Mt-CO<sub>2</sub>. CO<sub>2</sub> emissions from JAL were 5.69 Mt-CO<sub>2</sub>, while emissions from ANA were 5.72 Mt-CO<sub>2</sub>. The analysis revealed that despite JAL having more flights than ANA, its CO<sub>2</sub> emissions were lower. In terms of fuel efficiency, JAL achieved 0.100 kilometers per liter (km/L), while ANA achieved 0.096 km/L. This indicates that JAL was using more fuel-efficient aircraft and operating more efficiently, resulting in lower CO<sub>2</sub> emissions.

Further analysis based on departure regions revealed that the highest number of annual flights was to Asia (48,000 flights), followed by North America (25,000 flights). In terms of annual CO<sub>2</sub> emissions, North America had the highest emissions (5.70 Mt-CO<sub>2</sub>), followed by Asia (3.74 Mt-CO<sub>2</sub>). Notably, despite having half the number of flights to North America compared to Asia, the CO<sub>2</sub> emissions were 1.5 times higher.

Moreover, the analysis of CO<sub>2</sub> emissions per passenger on a single flight revealed that JAL emitted 0.76 t-CO<sub>2</sub>, while ANA emitted 0.81 t-CO<sub>2</sub>, across all routes. Further analysis based on departure regions revealed that ANA had higher CO<sub>2</sub> emissions per passenger on flights to and from all regions except Europe. The difference was most significant on flights to and from the Americas, with JAL emitting 1.17 t-CO<sub>2</sub> per passenger and ANA emitting 1.23 t-CO<sub>2</sub>. These

results indicate that ANA's flights to and from the Americas are a major contributor to its higher CO<sub>2</sub> emissions.

This study estimated the direct CO<sub>2</sub> emissions from international flights operated by major Japanese airlines. The results indicate that ANA's international flights have a greater environmental impact than those of JAL. Additionally, we found that the direct emissions from these two major airline companies accounted for a significant portion of the total direct and indirect CO<sub>2</sub> emissions embodied in the final demand of Japan's aviation service sector. Therefore, key stakeholders should take strong leadership in reducing CO<sub>2</sub> emissions across the relevant supply chains.

To achieve decarbonization in the aviation industry, the government should encourage ANA to improve its operations. Additionally, since flights to North America, which have longer flight distances, produce higher CO<sub>2</sub> emissions, both airlines should actively use more fuel-efficient aircraft and prioritize the introduction of Sustainable Aviation Fuel (SAF).