Modelling the Environmental and Social Impacts of the Measures for an Aging Population: the Widespread Adoption of Care Robots in Japan

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An aging population is an urgent issue, particularly in economically developed countries. In Japan, where aging has been increasingly severe, the number of people receiving long-term care certification is rising alongside the aging population and is projected to reach 9.88 million by 2045. However, the Care Work Foundationâ€™s reports indicate that approximately 70% of the staff in long-term care facilities already feel understaffed. Ensuring the quality of care services while improving the working environment for care workers has become an urgent priority in Japan. In response to this situation, the Ministry of Health, Labour, and Welfare (MHLW) has been promoting the adoption of care robots in the long-term care sector. However, while the introduction of care robots may alleviate labor shortages in long-term care facilities, the labor force required to produce the robots through the supply chain may increase in the future. The trade-offs between labor force savings in long-term care facilities through the introduction of care robots and the labor force required as care robots become more widespread remain unclear. Furthermore, while greenhouse gas (GHG) emissions are expected to rise by facilitation in care robot manufacturing, the extent of this increase remains uncertain. Given the above, this study aims to quantify the supply chain GHG emissions (i.e., carbon footprint; CF) and labor force impacts expected to arise from the anticipated increase in demand for care robots in response to needs of long-term care in Japan.

To achieve this objective, an environmentally extended input-output (IO) analysis was conducted based on hybrid IO analysis (Wiedmann, 2009) by combining the market forecast data for care robots (Current Status and Future Outlook of the Worldwide Robotics Market published by the Fuji Keizai Group) and the labor force data for 2020 (i.e. employment coefficient matrix). Japan's IO tables do not represent the sector for care robots separately; they are grouped under the â€œrobotsâ€• sector. Therefore, based on the robotics market data, the robotics sector was expanded as follows in Japanâ€™s IO tables. After expanding the sectors, the labor intensity was calculated by dividing the working hours by sector obtained from the employment matrix by the total output for each sector. The GHG emissions intensity was calculated by dividing the direct emissions obtained from the 3EID (National Institution for Environmental Studies, Japan) by the total output for each sector. The market forecast data for care robots has released market projections through 2030. The market size up to 2050 was projected based on values from 2021 to 2030, with linear growth assumed. The number of working hours that can be reduced by facility through the introduction of each robot is based on the project reports for the MHLW's Care Robot Introduction Support Project Subsidy. We estimated the total working hours expected to be reduced by extracting the daily working hours reduced through the use of care robots per care robot retrieved from Business Report for the Care Robot Introduction Support Project Subsidy Implemented by the MHLW and multiplied it by the future care robot sales forecast in the robotics market data.

As a result, it is estimated that the increased demand for robots will require an additional 4,419 workers directly and indirectly throughout the entire supply chain in 2050. However, the widespread adoption of care robots is projected to reduce labor demand in care settings by 75.4 million hours by 2050. If care workers work 1,702 hours per year averagely, based on the Monthly Labor Survey (MHLW), this would result in a reduction of 44,256 workers by 2050. In particular, an increase in labor demand is expected during the manufacturing stages of robots such as â€œbearingâ€• and â€œrotating electric machine.â€• In contrast, the CF is expected to increase by 85,194 t-CO2eq in 2050.

Regarding the novelty of this study, we focus on care robots that the government plans to introduce in the future, and for the first time quantitatively identify their impact on GHG emissions and the

workforce. The proliferation of care robots has revealed that the number of workers that can be reduced by introducing robots exceeds the number of workers required for manufacturing. However, based on current market projections, care robots will only be able to meet a very small portion of the care demand expected to increase by 2050 owing to the aging population. For future studies, it is necessary to estimate the number of robots required in the future based on actual demand and to calculate their impact through interviews with care facilities and other means. Furthermore, to reduce the CF in the care robotics sector, which is expected to grow in the future, it was suggested that supporting the promotion of renewable energy and prioritizing technical intervention in pig iron production technology would be essential.