Impact of Promoting Wood Utilization in Buildings on CO2 Emissions in Japan

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Following the adoption of the Paris Agreement in 2015, the Japanese government declared its goal of becoming carbon neutral by 2050. To achieve carbon neutrality, it is essential to enhance CO2 absorption while simultaneously reducing CO2 emissions. Especially in the building sector, the use of wood, a highly carbon-storing material, can increase CO2 absorption. Therefore, the incorporation of wood in buildings is necessary as a sink measure to achieve carbon neutrality. In response to this trend, wooden buildings are being constructed taller and taller worldwide (Uniben et al., 2019), and several previous studies have demonstrated the CO2 emission reduction benefits of promoting the use of wood in buildings (Borjesson & Gustavsson, 2000; Gustavsson et al., 2006; Gustavsson et al., 2010).

However, the impact of increased societal demand for high-rise buildings on the countryâ€™s economy and environment is not clear. In Japan, the government enacted the Law on the Promotion of Utilization of Wood in Buildings for Realizing a Carbon-free Society in 2021 to promote the use of wood in buildings and achieve a carbon-neutral society. However, the Japanese government has yet to introduce a policy focusing on the scale of buildings (i.e., the number of floors in this study) to promote the use of wood. Therefore, this study addresses a crucial research question: How much can CO2 emissions be reduced by promoting the use of wood in residential construction in Japan, especially by increasing the number of floors in wooden building construction?

The novelties of this study are as follows. First, this study represents the first attempt to estimate the supply chain CO2 emissions of detailed construction methods based on the number of floors in houses (e.g., supply chain CO2 emissions of two-story wooden house). To this end, we adopted an Environmentally-Extended Input-Output (EEIO) analysis and calculated direct and indirect CO2 emissions in the construction supply chain of houses in Japan by construction method and by the number of floors, based on the Japanese Input-Output Tables in 2015 and the Embodied Energy and Emission Intensity Data (3EID) for Japan Using Input-Output Tables provided by the National Institute for Environmental Studies of Japan, and the statistical survey of building starts in 2015 by the Ministry of Land, Infrastructure, Transport and Tourism.

Second, this study estimated the change in CO2 emissions under scenarios of building technology improvement, specifically focusing on the construction of taller wooden buildings. This study analyzed how the direct and indirect CO2 emissions associated with demand for medium- and high-rise residential construction change with wood construction by varying the lumber, concrete, and steel sectors of the input data for houses by estimated construction method and number of floors.

As a result, direct and indirect CO2 emissions from the construction demand of houses in Japan amounted to 31,911 kt-CO2. We also found that for houses with 1 to 3 floors, the highest CO2 emissions come from wooden houses, however the CO2 emissions per wooden house were relatively small, largely due to the large number of wooden houses. On the other hand, for houses with 4 or more floors, the highest CO2 emissions were from reinforced concrete houses, influenced not only by the large number of houses but also by the significant CO2 emissions per house.

We then calculated the carbon storage for wood used in houses by construction method and by the number of floors, based on Forestry Agency guidelines. We found that for any number of floors, the

carbon storage in wooden houses was about four times greater than that in reinforced concrete houses. Additionally, we found that the direct and indirect CO2 emissions per square meter of wooden houses decrease as the number of floors increases. Furthermore, we observe that direct and indirect CO2 emissions in the construction phase of houses are significantly reduced in a scenario where the construction of high-rise residential wooden buildings is promoted.

Finally, based on these results, we propose a demand-side policy (i.e., subsidy policy and/or ecolabeling policy) to promote the construction of high-rise wooden houses.