Drivers of Change in the Carbon Footprint of Japanese Housing Construction from 2011 to 2020

Topic: Input-Output Analysis: Sustainable Production and Consumption policies (1)
Author: Ai Nagata
Co-Authors: Sora Matsushima, Shigemi KAGAWA

Climate change mitigation is a critical global challenge, and the building sector plays a pivotal role, accounting for more than one-third of global energy-related CO2 emissions. In Japan, the housing market is characterized by a â€œscrap-and-buildâ€• culture, where the average lifespan of a building is approximately 30 yearsâ€”significantly shorter than in Western countries. This high turnover rate means that construction activities, as a flow, carry substantial weight in determining the nationâ€™s greenhouse gas emissions. While the Japanese government has promoted energy conservation standards and the use of wood to reduce operational emissions, it remains unclear how the carbon footprint (CF) of housing construction itself has evolved over time. Previous studies using Input-Output analysis have successfully quantified the CF of Japanese housing at specific points in time. However, these static evaluations fail to identify the drivers of changes over time or separate the effects of physical housing demand from monetary fluctuations. To formulate effective supply-side policies, it is essential to understand whether changes in emissions are driven by technological improvements, changes in housing size (scale), or fluctuations in the number of housing starts (quantity).

An important research question is: what are the structural drivers behind the temporal changes in the carbon footprint of Japanese housing construction? To the best of our knowledge, this study represents one of the first attempts to identify the drivers of changes in the CF of Japanese housing construction by distinguishing between monetary and physical drivers of demand. We utilized high-resolution linked Input-Output tables for 2011, 2015, and 2020, deflated to 2020 constant prices using the GRAS method, combined with the Embodied Energy and Emission Intensity Data (3EID) for Japan Using Input-Output Tables provided by the National Institute for Environmental Studies of Japan. The novelty of this study lies in the proposed Structural Decomposition Analysis (SDA) framework. We extended the conventional SDA by decomposing the final demand vector into three physically interpretable factors: construction cost per floor area at constant prices (quality effect), floor area per housing unit (scale effect), and the number of housing starts (quantity effect). By integrating physical statistics such as floor area and number of units into the monetary SDA, we isolated the impact of â€œequality upgradingâ€• from simple changes in construction volume.

The results show that the annual CF of housing construction in Japan declined significantly between 2011 and 2020: by 26.6% for wooden housing and by 32.0% for non-wooden housing. The decomposition analysis identified that the primary driver of this reduction was structural improvement within the supply chain, accounting for a significant portion of the decline. Sectoral analysis revealed that decarbonization in the electricity sector and efficiency gains in road freight transport were the largest contributors. This suggests that broader grid decarbonization and logistics efficiency are spilling over to reduce the embodied carbon of housing.

However, a more complex picture emerges when examining demand-side factors. Reductions in the floor area per unit (downsizing) and a decrease in the number of housing starts contributed to the decline, reflecting a market trend toward smaller homes amidst rising property prices. In stark contrast, the increase in construction cost per floor area consistently acted as an emission-increasing factor, offsetting nearly half of the reductions achieved through downsizing. This â€œequality upgradingâ€• indicates that the shift toward high-performance, high-value-added buildings requires greater inputs from carbon-intensive upstream sectors. Specifically, sectors such

as pig iron and ferro-alloys were identified as increasing factors, suggesting that the demand for high-spec building envelopes intensifies embodied carbon.

These findings highlight a critical trade-off: while the Japanese housing sector is achieving emission reductions, this is largely dependent on a quantitative contraction of the market and external grid decarbonization. The qualitative shift toward higher-performance buildings is paradoxically increasing embodied carbon intensity. Therefore, a dual strategy is required. On the supply side, policy should target the decarbonization of basic materials, such as promoting green steel and low-carbon concrete, to mitigate the impact of quality upgrading. On the demand side, rather than relying on market-driven downsizing, policies should promote the renovation and extended use of the existing stock to decouple the pursuit of housing quality from new construction emissions.