

How do Tolls and Carbon Taxes Impact Welfare and CO₂ Emissions? A Nonhomothetic CES Approach*

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Abstract

CO₂ emissions from urban residents' energy use primarily stem from transportation and housing energy consumption. This study numerically evaluates the impact of carbon tax and congestion tolls on social welfare and CO₂ emissions in cities, considering the spatial density endogenously. In the evaluation, four categories of goods are defined (housing, primary, secondary, and tertiary industries), and nonhomothetic CES utility functions are adopted, allowing for the consideration of variations in income elasticity and the unit of CO₂ emissions among goods. Parameters of the utility function are estimated with the 2009-2020 Keio Household Panel Survey. The result of setting the external cost per ton of CO₂ emitted at 6,217 Japanese yen is as follows. Carbon tax yields about 3.5% of the welfare gain of the first best policy, and congestion tolls yield about 97.6%. Congestion tolls reduce CO₂ emissions from commuting by about 13%, but the CO₂ emission reduction are completely offset by the CO₂ emission increases caused by the increased consumption of goods due to the general-equilibrium income effect, resulting in a 0.03% increase overall. Carbon tax only changes the allocation of goods consumed subject to the income constraint, resulting in a minute 0.04% reduction in CO₂ emissions. Even when a lower CO₂ cost is set, the result remains similar.

Keywords: Congestion tolls; carbon taxes; carbon dioxide; nonhomothetic CES preferences

JEL Classification: R10, R40, Q50

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