MODELLING TRANSPORT ENERGY DEMAND AND EMISSIONS: DEVELOPMENT OF A GLOBAL PASSENGER TRANSPORT MODEL COUPLED WITH COMPUTABLE GENERAL EQUILIBRIUM MODEL

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Overview

Transport accounted for around 23% of carbon emissions in 2013, which cannot be ignored in terms of global greenhouse gas emissions and climate change. With levels of urbanization and motorization increasing rapidly worldwide, carbon emitted in the transport sector, especially passenger traffic, is projected to keep growing. Without the implementation of aggressive and sustained policy interventions, transport-related emissions could increase at a faster rate than emissions from the energy end-use sectors, with the potential to double by 2050. Because the continuing growth in traffic activities could outweigh all mitigation measures unless transport emissions can be strongly decoupled from gross domestic product (GDP) growth, decarbonizing the transport sector will be more challenging than for other sectors.

Integrated assessment models (IAMs) such as Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) model have been widely used for the climate change mitigation and impact assessment. AIM/CGE represents transport at a highly aggregated level, but technological details and behavioral determinants such as travel cost, travel time, modal split, and preference are not incorporated. On the other hand, transport mode decision model provides a methodology to estimate the travel demand and modal split, and is commonly applied to transport planning and policy analysis. However, it is difficult to deal with the interactive impacts of transport policy interventions on the macro-economy because the dynamic feedback or interplay between the transport sector and CGE models are seldom taken into consideration.

The paper is organized as follows. Section 2 describes the model structure, iterative algorithm, formulations, data source, and scenario settings. Section 3 presents the model integration and convergence of coupling for the CGE-Transport model and how the feedback of AIM/Transport updates the transport representation in AIM/CGE, followed by an analysis of results for the business-as-usual (BaU) and mitigation scenarios. Section 4 provides a discussion of the interpretation and the implications of the simulation results. Section 5 is a conclusion that summarizes the findings, with a roadmap for future research tasks.

Methods

To improve the transport sector representation in CGE models, this study developed a global passenger transport model, AIM/Transport, which was coupled with AIM/CGE. AIM/Transport can provide an elaborate technological description of the transport sector and evaluate the technological feasibility of transport policies, whereas individual transport models are not able to investigate the interaction between the transport sector and the macro-economy, and the response of other sectors to transport policy interventions. Coupling with AIM/CGE overcomes this shortcoming of AIM/Transport because the CGE model covers all goods and service transactions; thus, an interactive analysis of the transport sector and other sectors becomes possible. The transport representation in AIM/CGE is also enriched because the CGE model uses either a production function or price elasticity to represent the aggregated transport sector and, therefore, lacks an explicit transport representation, including mode and technological details.

Results

First, to integrate AIM/CGE and AIM/Transport, an iterative procedure was used to obtain the convergence between AIM/Transport and AIM/CGE. Numerical simulation results proved that the integration of AIM/CGE and AIM/Transport can achieve a convergence after thirteen iterations. The methodology for coupling the CGE-Transport model was demonstrated to incorporate the travel mode and transport technological details in AIM/CGE, to enrich the transport representation.

Second, a business-as-usual (BaU) scenario and a mitigation scenario were created then to test the robustness of the model integration and how the mitigation potential and cost would be modified coupling AIM/Transport. Results of BaU scenario show that travel demand, energy, and emissions differ among regions and transport modes. Modal shift from mass transit mode toward personalized mode in developing regions was more significant, while the modal split remained stable over the coming decades in developed regions.

Third, in the mitigation scenario, a carbon tax policy would motivate travelers to choose electrified transport and transport powered by biofuel for personal trips instead of travel modes that relied on oil. the goal of GHG emission reduction could be achieved by implementing a carbon tax policy, due to the shift from the use of fossil fuels to electricity and biofuel in the transport sector. Here the key finding was that the carbon price and mitigation cost were modified with the coupled CGE-Transport model. The transport sector makes an important contribution to global GHG emissions and the de-carbonization of the transport sector deserves more attention.

Conclusions

This paper proposes the coupling of a new passenger transport model, AIM/Transport and AIM/CGE. The numerical computation illustrated that coupled model can achieve a convergence, indicating that integration of the transport model and global CGE model was possible. Changes in mitigation costs with the feedback from AIM/Transport revealed that the importance of the transport sector was underestimated by AIM/CGE. The analysis of the interplay between the transport sector and macro-economy becomes feasible by using the coupling model.

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