Promoting economic, environmental and health sustainability in transport networks: A multi-objective modelling approach

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Abstract

Sustainable development in transport follows the concept of sustainability as meeting the needs of the present without compromising the ability of future generations to meet their own needs. To enhance sustainability in transport, we need to promote the use of more sustainable modes of transport such as public transport, walking and cycling, and at the same time reduce the use of private vehicles. Congestion pricing is a policy instrument that has been applied in many cities around the world, e.g. Singapore, London and Stockholm, as part of an integrated strategy not only to reduce congestion but also to improve the environment in terms of air quality and hence reduce the negative impact of vehicle emissions on health. To support transport policy analysis, it is important to be able to assess if such an integrated strategy can help achieve these three objectives. Here we will look at how congestion pricing might bring benefits to two groups of users: road users and cyclists.

By charging road users an appropriate toll, we can maximise the effectiveness of congestion pricing by applying a bilevel optimisation approach, whereby the upper level represents the decisions of the planner or policy decision maker, and the lower level represents the decisions of the travellers. We consider three objectives at the upper level: (1) minimise system travel time; (2) minimise total vehicle emissions; and (3) minimise negative health impact. The impact on health is modelled as the level of pollutant uptake during the journey. For the lower level, we adopt a time surplus maximisation bi-objective user equilibrium model, assuming that all users have two objectives: (1) minimise travel time; and (2) minimise toll cost.

To help commuter cyclists achieve their objectives of getting to work on time and maximising their health benefits, we propose a multi-objective route choice model, for example, with minimisation of travel time and pollutants uptake as the two objectives in a bi-objective routing problem. We obtain equilibrium flow and link average speed as a result of congestion pricing from the lower level equilibrium model. Together with other transport network information on link type, lane width, gradient, etc., we can then estimate both travel time and pollutants uptake at a reasonably accurate level. In particular, the pollutant uptake will be dependent on exercise level as well as the concentration of pollutants. Given an origin and a destination, to be provided by a cyclist, we apply a multi-objective shortest path algorithm to determine an efficient set of routes such that neither the total travel time nor the total pollutants uptake can be reduced without worsening the other. With our model, cyclists can more easily trade-off between time and pollutant uptake, and select a route with reasonable travel time at an appropriate exercise level with minimal negative impact on health.

Biography

Dr. Judith Wang is currently Associate Professor in Transport Engineering - Resilient Transportation, based in the School of Civil Engineering and Institute for Transport Studies at University of Leeds in the UK. She received her MSc(Eng) in Transport Planning and Engineering from University of Leeds in 1993 and PhD from Hong Kong University of Science and Technology in 2004. Prior to moving to the UK, she had worked for the University of Auckland in New Zealand for more than eight years, as a Lecturer in the Department of Civil Engineering, a Research Fellow in the Energy Centre and a Senior Research Fellow in the Department of Engineering Science. She has had a 20-year career in transport planning, with considerable experience not only in academia, but also nine years of practical experience in the transport industry in Hong Kong as well as in New Zealand, specialising in modelling and planning of transport services and infrastructure.

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