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Environmental impacts of transformative land use and transport developments in the Greater Beijing Region: Insights from a new dynamic spatial equilibrium model

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ABSTRACT

This paper reports the insights into environmental impacts of the ongoing transformative land use and transport developments in Greater Beijing, from a new suite of dynamic land use, spatial equilibrium and strategic transport models that is calibrated for medium to long term land use and transport predictions. The model tests are focused on urban passenger travel demand and associated emissions within the municipality of Beijing, accounting for Beijing's land use and transport interactions with Tianjin, Hebei and beyond. The findings suggests that background trends of urbanization, economic growth and income rises will continue to be very powerful drivers for urban passenger travel demand across all main modes of transport beyond 2030. In order to achieve the dual policy aims for a moderately affluent and equitable nation and reducing the absolute levels of urban transport emissions by 2030, road charging and careful micro-level coordination between land use, built form and public transport provision may need to be considered together for policy implementation in the near future.

1. Introduction

Beijing's passenger transport annual CO_2 emissions rose from 9.38 million tonnes in 2003 to 15 million tonnes in 2012 (Wang et al., 2015). That is a rise by 60% over a decade. Such rises are typical in fast growing cities of emerging economies. Urban passenger transport is in fact one of the most challenging sectors for carbon and pollutant emission reduction across the world's cities. In faster growing regions the crux of the environmental impact problem is to cut emissions and emission exposure without stunting the initiatives for improving shared prosperity, social equity and economic growth.

Some radical travel demand management measures are already in place to stem the rapid rises in car use and car ownership. For instance, Beijing has implemented a weekday car use restrictions rota by the last digit of the car number plate in the main built area since 2008 and car purchase permit lottery since 2011; on high pollution days around half of the car fleet is kept off road; there have also been massive investments and operating subsidies in public transport.

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Nevertheless, greater growth in passenger travel demand may yet to come in such city regions owing to the increase in income and leisure time, transition to a knowledge-based economy and continued suburbanisation. Better vehicle and system control technologies might actually add to this growth, since they help reduce generalised journey costs.

The difficulties are to understand the magnitudes of such growths several decades into the future. Recent work by Schäfer (2015) is a rare example of modelling the long term travel demand trends in the US from 1900 to 2100 through aggregate modelling. The need for such a long planning horizon comes from slow timelines for getting major urban development projects approved and delivered, and from the very long lifespan of associated infrastructure assets. However, there is an apparent gap in medium to long term travel demand forecasting, which arises from the complexity of influences upon and interactions with urban traffic as well as uncertainties in vehicle, fuel and transport system control technologies. Although there are well known computable general equilibrium models and integrated land use and transport models that are capable of travel demand forecasting under relatively steady growth in developed countries (e.g. Anas and Liu, 2007; Anas et al., 2009; Bröcker and Korzhenevych, 2011; Echenique et al., 2013; Batty et al., 2013; Simmonds et al., 2013), there are few models available in fast growing developing countries that are capable of modelling the medium to long term trends under rapid transformations in land use and transport.

This paper aims to fill some of this gap in medium to long term travel demand forecasting for fast growing city regions through establishing a new type of operational urban land use and transport modelling. We then demonstrate its use through a systematic range of land use and transport scenarios in the Greater Beijing city region.

This model has three basic components: the first is a spatial equilibrium model regarding location and travel choices for millions of businesses and households in the city region and the urban agglomeration effects that arise from concentration of jobs and people (see Fig. 1(a)); the second is a dynamic model for allocating lumpy and non-divisible land and building floorspace investments, accounting for natural growth arising from extensions of existing premises, probabilistic distribution of discretionary investments and ad hoc policy interventions (see Fig. 1(b)); the third is a strategic transport model which share similar features of a conventional land use/transport model or a four-step transport model (see Fig. 2). Travel demand is forecast at the same time of predicting where people choose to travel in the city region, so that the forecasting procedure can engage with both land use and transport planners. Both traditional and new, online data sources are used to calibrate and validate the models.

In applying this model to Beijing, the time horizon is divided into decade-long periods in line with the observed government administration cycles and timelines for Five Year Plans (see Zhang, 2010). For each period, the models are first calibrated on observed data for two preceding decades (1990–2000 and 2000–2010), and subsequently run in forecasting mode for model verification and validation through comparing the modelled quantities and building rents with observed

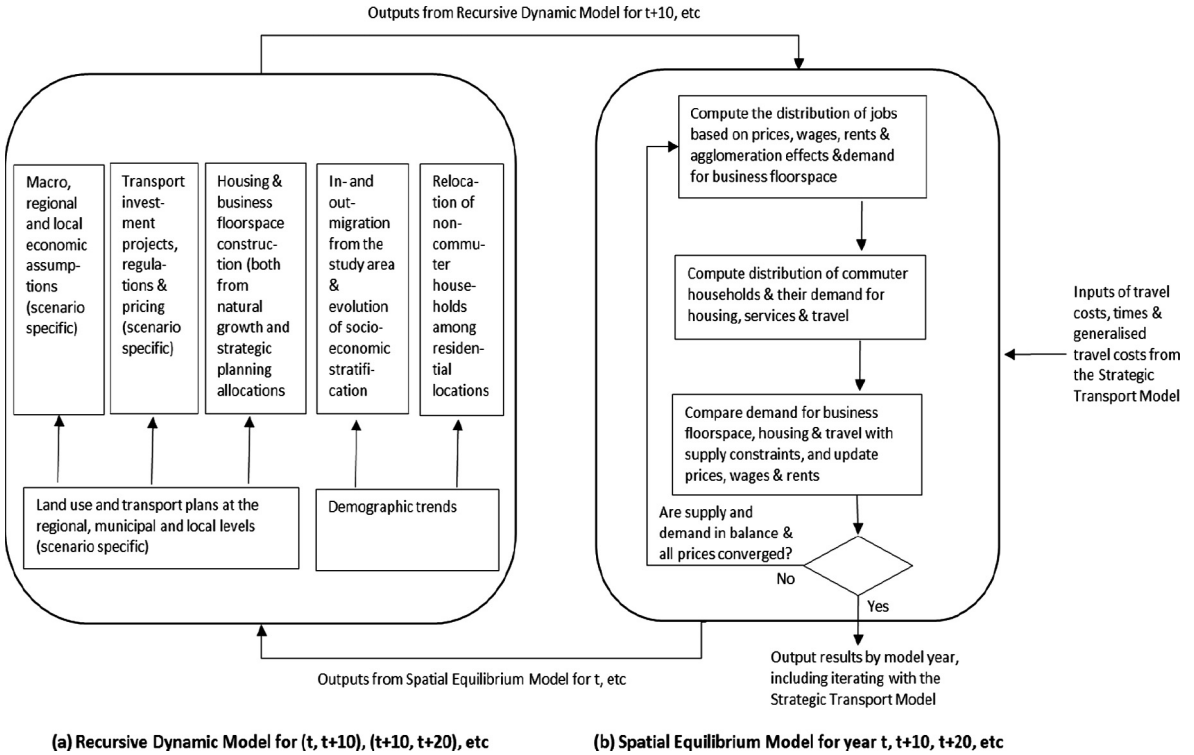

Fig. 1. Model components (1): Spatial Economic and Land Use Models.