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The future of mobility in cities: Challenges for urban modelling

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ABSTRACT

Urban development in the last two centuries has been driven by an unprecedented growth in mobility made possible by abundant and cheap energy. Yet this trend will not continue forever. Despite technological innovation, finite fossil fuel reserves will in the long run lead to increasing costs of transport. Moreover, to fight global warming many governments have set ambitious greenhouse gas reduction targets, and to achieve them fossil fuels must become more expensive either through market developments or by political intervention. This paper gives an overview about the drivers, feedbacks and constraints of urban mobility and location in a possible future in which transport energy will no longer be abundant and cheap. It asks whether current urban models are able to adequately model the impacts of significantly higher transport costs and demonstrates by an example how it can be done.

1. Introduction

The rise of the modern city is built on mobility. The evolution from the medieval city in which all movements were on foot to today's sprawling agglomerations has only been possible with first the railway and later the automobile. The Garden City movement promised a life in a healthy environment in harmony with nature and heralded the exodus to the suburbs. Employers, retail and services followed their workers and clients. With growing spatial division of labour, travel and goods transport have increased and so have their environmental impacts.

The suburban arcadia depends on abundant and cheap energy. Over two centuries people have continued to travel more but pay less. Yet this trend will not continue forever. Finite fossil fuel reserves and high costs of alternative vehicles and fuels will, despite technological innovation, lead to increasing costs of transport. Even more important is the imperative to contain global warming. In most countries greenhouse gas emissions have continued to grow, and transport is a major contributor. More and more governments have set ambitious greenhouse gas reduction targets. To achieve them would require both technological innovation and price incentives to induce changes in mobility and location behaviour.

What does this mean for cities? How will higher transport costs affect mobility and location patterns? Will distances travelled to workplaces, shops, services and leisure become shorter? Will there be a renaissance of public transport? Will goods from far-away places be substituted by deliveries from local suppliers? Will face-to-face communication be replaced by telework and videoconferences? Will suburbanisation be halted or even reversed? Will modern lifestyles based on freedom of movement be reoriented towards a new sense of neighbourhood? Will greenfield shopping centres be abandoned for local shops? Will suburban locations decline in attractiveness and value? What will be the impacts on equity? Will there be a social divide between those who can maintain their mobility and those who must give up their cars?

If urban planning is to respond to the challenges of energy scarcity and climate change, it needs to answer these questions.

Unfortunately, most transport and land-use models of today have not yet responded to the new challenges. Many urban models are not prepared to model policies, such as the promotion of more energy-efficient vehicles or alternative fuels and the necessary refuelling infrastructure, redirection of transport investment to public transport, transport demand management and anti-sprawl legislation, and the resulting distributive effects and social conflicts. Many do not consider travel costs in trip generation, trip destination and mode choice. Many do not forecast induced or suppressed trips. Many use price elasticities estimated in times of cheap energy. Many do not consider household travel and housing budgets. All this means they will underestimate the response to rising transport costs.

The fundamental changes in the priorities of planning caused by energy scarcity and climate change will have significant impacts on the theory and method of urban modelling: less reliance on observed behaviour, more foundation on strong theory, less statistical calibration, more plausibility analysis, less focus on preferences, more attention to constraints.

The paper gives an overview about the drivers, feedbacks and constraints of urban mobility and location in a possible future in which transport energy will no longer be abundant and cheap.

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It asks whether current urban models are able to adequately model the impacts of significantly higher transport costs and demonstrates how it can be done using an example from a European Union project.

2. Mobility and location

The term mobility indicates both the willingness and capability for movement and the movement itself. Mobility has many dimensions, such as intellectual, social, professional or spatial mobility. Spatial mobility comprises temporary relocations, such as trips, as well as permanent relocations, such as change of job or migration. Permanent relocations imply changes in the locations of activities. Location decisions create relationships between humans and space: by physical change (e.g. construction), use of space (e.g. living or working) or local attachment (e.g. identity, habit, integration).

Hence spatial mobility and location are fundamental alternatives of spatial behaviour. While spatial mobility aims at overcoming space, location aims at using it. Increasingly, physical mobility is substituted by telecommunications, but telecommunications also create desire for more personal face-to-face interaction and hence physical mobility.

Originally spatial mobility implied freedom, emancipation and opportunity. Rural-to-urban migration brought freedom from hunger and serfdom, outmigration to America freedom from religious suppression. Travel pioneers, such as Erasmus of Rotterdam or Mozart, laid the foundations for the cultural identity of Europe. Goethe, writing home from his Italian journey, described the fundamental experience of travel, which survives as a shadow even in today's mass tourism:

> "I feel like a child that has to learn to live again…. I cannot tell you how much I have gained in humanity…. I have already given up many ideas I held fixed which had made me and others unhappy, and have become much freer here. Every day I am peeling off another shell and hope to return as a human being." J.W. Goethe: *Italian Voyage* (1787)

At Goethe's time, spatial mobility was a privilege of nobility and a small number of affluent citizens. Today, the railway, the car and the air plane have brought a level of mass mobility never known before in human history.

However, more and more also the negative sides of unlimited spatial mobility are becoming apparent. As it grows to perfection, it destroys not only the very preconditions for its success but also the happiness it promised:

1) The end of the isolation of rural regions has its counterpart in sprawl at urban peripheries. Outmigration no longer leads to freedom from backwardness and suppression but to rejection by richer nations. International exchange promotes tolerance and knowledge of foreign cultures but goes hand in hand with mass tourism and the exploitation of nature. Participation of rural areas in metropolitan cultures reduces disparities but also endangers regional identity.
2) Easy and cheap travel opportunities facilitate wide networks of friendship and social relations but at the expense of local contacts. Affordable mobility facilitates labour force participation of women but subjects them to the double burden of work and household. Spatial mobility facilitates social and job mobility but often also enforces separation of partners and fragmented families. Automobility for all is a fiction as large parts of the population (the elderly, the poor, the handicapped) remain excluded.
3) Efficient transport systems are vital for the economic competitiveness of regions but also increase the disadvantage of peripheral regions not connected. Improvements of transport infrastructure stimulate the demand for more transport resulting in increasing congestion, energy consumption, greenhouse gas emission and air pollution leading to problems of sustainability and global and intergenerational equity.

3. Theory

There is a broad range of theoretical approaches in engineering, urban economics and geography to model changes in mobility and location behaviour in response to changes in transport cost (for more details see Wegener and Fürst, 1999):

a) *Technical* theories interpret cities as mobility systems. Spatial interaction theories explain mobility as a function of size and attraction of origins and destinations and an inverse function of travel time and travel cost, or both, between them. This is the gravity or spatial interaction model underlying most travel demand models. Inversely, if it is possible to make inferences from the distribution of human activities to spatial interactions, it is also possible to identify the location of activities giving rise to a certain pattern of mobility defined as above. This is the spatial interaction location model. The first urban spatial interaction location model was the 'Model of Metropolis' by Lowry (1964).
b) *Economic* theories interpret cities as markets. They assume that locations with good accessibility are more attractive and have higher market values than peripheral locations. The model of urban land markets by Alonso (1964) assumes that firms and households choose locations at which their bid rents, i.e. the land prices they are willing to pay given their production and transport costs, equal the asking rents of landlords. Firms with higher added value per unit of land will pay higher prices than firms with less intensive use of land. This explains why jewellers are found in the centre, whereas trucking companies have their yards on the periphery.
c) *Social* theories interpret cities as the result of individual or collective appropriation of space. Action space theory analyses activity patterns which lead to characteristic spatio-temporal behaviour and hence locations. Hägerstrand (1970) introduced time budgets, within which individuals command action spaces of different size and duration subject to capacity, coupling and institutional constraints. Based on action space theory, Zahavi et al. (1981) proposed the hypothesis that households within their time and money budgets maximise spatial opportunities (i.e. travel distances), in contrast to most travel demand models used in the planning practice which assume that trip rates are fixed and travellers minimise travel times needed to perform these trips.

All three theories of mobility and location were well suited to explain the impacts of travel becoming faster and less expensive in the past:

1) If travel becomes *faster* or *less expensive*, people make *more* and *longer* trips.
2) If travel becomes *faster* or *less expensive*, people choose *more distant* locations.
3) If people get *more affluent*, they make *more* and *longer* trips and choose *more distant* locations.
4) If people have to *work less*, they make *more* and *longer* trips and choose *more distant* locations.
5) If all this happens together, people make *more* and *longer* trips and choose *more distant* locations.

Conversely all three theories can be used to predict what will happen if travel becomes slower or more expensive: people will