Transportation Networks and the Optimal Location of Human Activities

A Numerical Geography Approach

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TRANSPORT ECONOMICS, MANAGEMENT AND POLICY

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A Numerical Geography Approach
Isabelle Thomas

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The first version of this research was written as a dissertation to attain the title of Agrégé de l'Enseignement Supérieur at the University of Louvain, Louvain-la-Neuve, Belgium (Thomas, 2000), which is equivalent to a second doctoral dissertation. It is here published in a slightly modified version.

Although only my name appears on the title page, there are many contributors to this book that I would like to sincerely thank. Even though I cannot acknowledge all of them, I do wish to thank some of my mentors, advisors, co-authors and colleagues. Their presence can be witnessed at almost every page of the text. I would like to express my sincere thanks and gratitude to the following:

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1. Introduction

1.1 GENERAL CONTEXT

Let us start with an example that was – some years ago – the starting point of my interest in the topic developed in this book: the planning of the spatial organisation of police patrols within the Belgian provinces (see Thomas, 1993 and 1994, for further details). For administrative reasons, each province was considered separately. From police and census data, it is easy to estimate the demand for the emergency police services both by type and quantity, at every point of the studied area. From transportation studies, travel times, travel distances and other travel attributes between all pairs of points representing the studied area were computed. The problem then consisted in planning the police patrol services, given a limited budget. One item in the budget was the construction of permanent facilities, the other being the total transportation costs for the patrols. The allocation of demand to facilities, and hence the type and size of the facilities, greatly depends on the number and location of the facilities. The problem in this scenario was to define the limits of the service areas around each facility. Travel times were minimised in order to meet the budget, but also in order to be as close as possible to the users; moreover, the service should not be too far away from the users (equity constraint). Several maps were drawn in order to illustrate the results; some clearly showed that service areas elongate along the main transportation axes. This means that transportation axes apparently influence the results of the optimal location models. Hence when planning the spatial structure of facilities, one also has to take into account the possible and mutual effects of the transportation investments. This was the starting point of the analyses reported in this book.

Hence the chapters of this book aim at presenting an account of how far optimal location-allocation results depend on changes in the shape and size of the transportation network, using a geographical perspective. In other words, our general question is: how far does the spatial structure of the transportation system influence the optimal location of human activities?

This book provides insights into some of the many factors creating spatial differences in optimal location and allocation of human activities.

The literature devoted to location-allocation models generally deals with the problem of where to locate one or more facilities in order to achieve some objective function(s). Location-allocation models are concerned with the location of facilities to serve the distribution of clients best. Thus, this set of models both locates facilities and allocates individuals to them. Their interest is based on the commonly known equity-efficiency dilemma. This is obviously a very important family of problems with countless applications; such location problems arise in many design problems, be it the location of facilities, plants, vehicles, people, services or any other function. While the literature on location modelling has produced a myriad of different operational decision models, very few of them have raised the issue of the influence of the transportation network on the operational results and the decision framework (see Section 1.2 for further details).

Optimal location problems often take place within a given transportation system which is often represented by a network with nodes (for example population centres, crossroads or transhipment centres) and links connecting pairs of nodes (for example roads). Let us note that the terms 'graph' and 'network', 'vertex' and 'node', as well as 'edge' and 'link' will here be used interchangeably. In this given context, transportation depends on the characteristics of the nodes (for example demand for transport) and occurs along the links/edges; it is taken to connote the generalised costs of travel encountered by individuals in carrying out their activities or by firms in moving freight. By generalised costs, we mean some combination of monetary outlays, time length and/or efficiency of travel between specific locations. This way of considering transportation explicitly regards travel as generating negative utilities to the trip-maker. These costs are primarily a function of the supply of transportation infrastructure and of the demand for travel; the latter is, in turn, derived from the demand of individuals and firms for spatially distributed activities (such as employment, commercial outlets or residential locations) which generate and attract trips. Generically, these activities are referred to as land-use activities. The particular distribution and level of intensity of land-use activities are the key factors, which delineate the spatial organisation of regional and urban areas.

When transportation costs decline, it is interesting to know what this would mean to urban patterns of spatial organisation, that is, the compact city versus the suburbanisation process and the development of edge cities. What does this new transport and communication systems imply in terms of systems of cities? In terms of regional development? The study of the interrelationships between land-use planning and transportation has already been discussed in urban and regional economics and geography (see Anas,