
1 Introduction

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The transport sector holds a special place in economics for a number of reasons. First, several basic concepts that are widely used in economic analysis originated from the study of developments and policy issues in transport. Jules Dupuit (1844) established the foundations of surplus theory and welfare economics while he was grappling with the social value of transport infrastructure. The seminal theory of discrete choice developed by Daniel McFadden (1974) and others was motivated by a desire to understand and predict individual choices of transport mode. William Vickrey's (1963) well-known work on transport congestion and queuing has been applied well beyond the transport sector. And the self-financing theorem due to Herbert Mohring and Mitchell Harwitz (1962) arose from the question of whether efficient traffic congestion charges suffice to pay for the construction of an optimally sized road.

Second, the costs of transport are central to economic activity as Adam Smith (1776) recognized in his famous observation on how the scale of production is limited by the extent of the market. Indeed, transport costs play a special role in several fields of economics. In spatial economics transport costs underlie land rent (Johann Heinrich von Thünen), location choices of firms (Alfred Weber) and the existence of location and price equilibrium in competitive markets (Harold Hotelling, 1929). Transport costs are also central in the new economic geography (Paul Krugman, 1991) which seeks to explain the extent of agglomeration in human activity over space and disparities in regional development.

Conversely, due to many facets of transport markets, economic theory is widely applied to the transport sector. In some parts of the transport sector – notably infrastructure – public management is preeminent, and issues arise in which welfare economics and social choice theories can be brought to bear. This is also true where redistribution and equity are concerns as is often the case for regional transport. The private sector dominates in other parts of transport, such as operations, and industrial organization economics comes to the fore. With increasing frequency transport infrastructure and services are provided by a mix of public and private institutions, often via concessions and public–private partnership (PPP) arrangements. Private finance has been introduced in fields which used to be the realm of public management and funding, and here the theories of contracts and regulation are an indispensable tool. Transport is also a major source of externalities, both negative (for example, pollution) and positive (for example, agglomeration externalities and economics of traffic density), and theories of corrective taxation and subsidies pioneered by Arthur Pigou (1924) can be applied. Last but not least, economic analysis has enlightened the links between transport and economic development. Transport is a kind of kaleidoscope of the various aspects of economic analysis.

Another feature of transport economics is that the issues relate very much to the real world and scholars are devoted to answering practical questions. The path from theory to application is often shorter in transport economics than in other fields of economics. New concepts and theoretical developments are quickly adapted towards application, and combined with expert advice and field experience into policy recommendations for decision makers.

Transport is an exciting and rapidly evolving field. The main drivers of change are technological progress and societal evolution. In recent years new technologies of information and communication have emerged that are leading to major innovations in applications such as traveler information services and pricing of infrastructure usage. These technologies have also profoundly transformed logistics for firms, and they are beginning to have noticeable impacts on the daily activity and travel patterns of households. The volume of travel is affected by two opposing forces: economic growth, on the one hand, which tends to boost mobility, and concerns about the environment and energy supply which tend to dampen it.

The structure of transport markets has also changed a lot. The trend is towards more competition, but generally imperfect oligopolistic or monopolistically competitive competition. Competition takes various forms entailing not only classical price competition, but also competition in frequency and other dimensions of service quality with widespread use of price discrimination and other practices for market segmentation. The governance of the transport sector is itself changing with opposing trends towards both more and less regulation depending on the country and mode of transport. Governments and other institutions are also grappling with how to address the effects of transport on local environments and global climate change.

These various developments in the transport sector are influencing transport research. We are seeing renewed interest from researchers in the way transport interacts with the wider economy. There have been important developments in the economic analysis of markets and regulation, and in the economics of information. There is growing appreciation for the importance of network structure in applications ranging from congestion pricing of road traffic to competition in airline markets. And increasingly sophisticated econometric methods are being brought to bear in such diverse applications as transport demand, price discrimination, economies of scale and scope, and the importance of travel time reliability.

The various aspects and developments in transport and transport economics reveal both the value of a *Handbook in Transport Economics* and the challenges in preparing one. The value is clear since a handbook allows scholars, students, consultants and decision makers to learn and master in one volume the main themes, issues and methods in the economics of transport. The challenges arise because of the sheer diversity in the nature of transport across modes, countries and time, as well as the diversity of regulatory frameworks and economic methods used in the study of the field.

The chapters of the *Handbook* have been written by acknowledged experts in their fields. Each chapter provides a state-of-the-art review of the latest research and scholarly thinking from the author's or authors' distinctive viewpoint. Many authors also discuss how their findings can be used by decision makers in the public and private sectors for the general purpose of improving transport policy objectives and the means of achieving them.

The *Handbook* has been structured to complement the organization of the textbook by two of the editors, Emile Quinet and Roger Vickerman's *Principles of Transport Economics* (Edward Elgar, 2004). There are two reasons for doing so. First, it will enable the reader to move from the basic introduction of principles in the textbook to a more detailed and advanced elaboration of key issues here. Second, the textbook is divided into parts that provide a logical sequence for study of the transport system.

Although each chapter in the *Handbook* is designed to be read on its own as a self-contained treatment of one topic in transport economics, many of the topics are so interconnected that a piecemeal reading will fail to provide a full picture of the linkages and challenges facing the transport sector as a whole. For instance, pricing, investment and regulation are closely interrelated and require an appreciation of the economics of transport demand, the structure and determinants of costs and the wider economy which transport serves. Readers are therefore encouraged to progress systematically through the *Handbook* from Part I through Part V.

Part I sets the transport sector within the framework of overall economic activity, mainly through the concepts and mechanisms of spatial economics. The tools are general equilibrium models, urban modeling and analyses of urban growth.

Next, as it is normal for the study of any economic sector, the demand for and costs of transport are analyzed in Parts II and III. Transport demand has a number of idiosyncratic features that require specific attention and models. Among the more recent models are improved discrete choice models, choice of departure time models and activity-based programs. Collectively, these models constitute a major improvement on traditional four-step models that are still widely used by both researchers and practitioners.

More so than for most other economic sectors, infrastructure and external costs account for large fractions of the costs of transport. Scale economies can be significant for infrastructure and under the conditions of the self-financing theorem efficient user charges do not fully pay for the costs of construction. A need for subsidy then arises. External costs create another type of market failure that calls either for additional user charges or some other means of intervention.

With the basics of transport demand and costs in hand it is possible to study how transport services should be procured. This analysis can be conducted at two levels. The first, which is the more theoretical and normative, is founded on surplus theory, draws on the lessons of welfare economics and can be thought of as providing recommendations to a benevolent planner. This social choice perspective is developed in Part IV of the *Handbook* on 'Optimal public decisions'. Another point of view, closer to the paradigm of public choice theory and positive analysis, examines the process of 'Competition and regulation' dealt with in Part V. The reference paradigms here are principal-agent analysis, the theories of contracts and incentives and industrial organization theory.

We now summarize the main contributions of the chapters in each of Parts I–V.

PART I: TRANSPORT AND SPATIAL ECONOMY

Although transport planning has traditionally involved the modeling of interactions with the economy, the relationship between transport and the rest of the economy has acquired a greater emphasis through the development of the New Economic Geography.

Although links with local urban and regional economies feature in land-use transport interaction (LUTI) models, the new economic geography (NEG) offers a more formal economic modeling of these relationships. This has also linked to a renewed interest in the role of transport costs in determining the magnitude and patterns of international trade. Both the traditional and new lines of research are included in this first section of the *Handbook* with an emphasis on spatial economics.

Part I begins with a thorough review of two classical and related but contrasting approaches to the traditional modeling of urban and regional systems. Johannes Bröcker and Jean Mercenier (General equilibrium models for transportation economics) present a general equilibrium approach. General equilibrium (GE) models build on rigorous modeling of the way microeconomic agents respond to market signals when maximizing their own objectives. From the interaction between the resulting supply and demand decisions, and conditional on the organizational structure of each market, new signals emerge that feed back on the optimal decisions of all agents. The computation of a GE consists in determining a system of signals and an allocation of resources between individuals, sectors of activities, regions and time periods, such that all agents are at their optimum subject to their respective budget, technological and other constraints. The set of transactions conducted in each market leaves each agent simultaneously in equilibrium such that there is no incentive to change behavior. Chapter 2 concludes by reviewing how GE models can be used in transport economics, particularly in evaluation and appraisal, while recognizing the restrictive assumptions which need to be made and the effort required to obtain the required information.

Michael Wegener (Transport in spatial models of economic development) describes the more traditional but still widely used set of LUTI models. His chapter offers a valuable comparison of different types of models, detailing their particular strengths and weaknesses. The first part deals with multiregional economic models which are not based on individual firm or household behavior, but on regional aggregates such as gross domestic product or employment, possibly classified by economic sector. Some of these models explicitly specify trade flows between regions and some do not. The second part of the chapter deals with models which focus on the intraregional location of firms with various degrees of spatial and sectoral resolution. The most recent development is fully microscopic models of firm life cycles ('firmography') and firm location within metropolitan regions that use stochastic Monte Carlo simulation. These models typically work with high-resolution grid cells as spatial units. The chapter concludes by assessing how well the models deal with the new challenges of energy scarcity and climate protection.

The remaining chapters of Part I deal with more detailed spatial analysis based on mechanisms of the NEG. Miren Lafourcade and Jacques-François Thisse (New economic geography: The role of transport costs) provide the background to transport–economy interactions in their review of the NEG and its contribution to economics. Economic geography explains why human activity is concentrated in a large variety of economic agglomerations rather than distributed uniformly over space. At the core of the NEG approach is the trade-off between increasing returns and transport costs. The chapter presents historical data to show that falling transport costs may contribute to rising spatial income inequalities over very long time periods. It then provides an overview of the main explanations proposed by NEG for the emergence of a core-periphery structure in a world of falling transport costs. The theory also indicates that, once obsta-

cles to trade are sufficiently low, spatial inequalities might well vanish. Hence, evidence is found to show that spatial inequalities would first rise and then fall. Next, the chapter shows how transport costs can be modeled and measured, and describes the results from the few empirical attempts to test the predictions of NEG models. The chapter concludes with some implications of NEG for transport economics and policy.

In the following chapter (Transport costs and international trade), Alberto Behar and Tony Venables investigate the effect of transport costs on international trade. They begin by examining the relationship between transport costs and the volume and nature of international trade and then explore why trade costs vary across space and time, showing that trade costs have not fallen as much as is commonly believed. The core of their chapter is a detailed analysis drawing on the empirical literature of the impact of transport costs on trade and the determinants of those costs. The chapter concludes with a more detailed look at the estimation problems encountered in such empirical work.

In the final chapter of Part I, Takatoshi Tabuchi (City formation and transport costs) applies the models and mechanisms of NEG to the development of cities. He focuses on the heterogeneity of space and the effect of externalities that reinforce the advantages of locations. Changes in spatial structures both within and between cities may be explained by the decrease in transport costs. A simple general equilibrium model is used in order to examine how perfect competition is inconsistent with the existence of transport costs. A typical urban economic theory of a monocentric city in heterogeneous space is briefly sketched and then extended with technological externalities. The assumption of perfect competition is replaced by monopolistic competition with pecuniary externalities in an NEG model, which is then combined with urban economics. The chapter shows how some of the stylized facts of urban economics can be explained by the trade-offs between commuting cost, face-to-face communication cost and intercity trade cost leading to the negative gradients of rent and population density and the suburbanization of households. Together the models of urban economics and NEG can explain the existence of polycentric cities. Thus, it is shown that distance is a significant factor in economic theory as well as in the real world, despite all the developments in transport technologies.

PART II: THE DEMAND FOR TRANSPORT

While Part I of the Handbook sets the scene by describing the role of transport in the economy, the following two parts deal with the core of transport economics – demand and costs. The five chapters relating to demand cover approaches to modeling demand as well as the key element in the evaluation of demand – the value of time savings. These chapters do not attempt to review all aspects of transport demand modeling. Practice in this field is well known, and good summaries are found elsewhere. The focus here is on the main recent developments.

One of these developments concerns the value of time – a core element in the evaluation of transport demand. The nature of the demand for transport is that it involves an input of time by the individual for personal transport or by the shipper in the case of freight. The value of this time varies between individuals (or shipments), and indeed between different journey purposes for the same individual, and is not reflected accurately in any price paid for transport. Travel time savings constitute the most important

user benefit from transport improvements. David Hensher (Valuation of travel time savings) provides a comprehensive review of value of travel time savings (VTTS) with attention to both theory and application. His chapter begins with an overview of the major theoretical approaches and empirical paradigms that have evolved to value time savings, especially the progress in how revealed (or market) preference and stated choice data is being used to estimate models. Mixed logit models and stated choice methods have now become the state of the art (and to some extent practice) in deriving estimates of VTTS. Drawing on these models and methods, the author presents empirical evidence to illustrate the range of useful measures for components of travel time in passenger and freight contexts, some of which are handled using the Hensher formula which combines information from marginal productivity and utility maximization conditions.

One of the main contributions of transport studies to wider economic applications is the development of discrete choice models. Joan Walker and Moshe Ben-Akiva (*Advances in discrete choice: mixture models*) explain how recent advances in discrete choice models have been driven by the growth in computer power and use of simulation, which have allowed for unprecedented flexibility in model form. Their chapter provides a brief review of the foundations of discrete choice analysis and the classic model forms of probit and the generalized extreme value (GEV) family (for example, logit, nested logit and cross-nested logit) before moving on to mixture models which are being used in a wide array of statistical modeling procedures as a way to relax restrictive assumptions and generalize model forms. It concludes by presenting empirical results from a land-use and transportation study, which is used to demonstrate the various discrete choice model formulations.

Another advance in traffic modeling is the dynamic modeling framework, pioneered by the work of Vickrey, and subsequently Arnott, de Palma and Lindsey. Recent advances in this field are reviewed by André de Palma and Mogens Fosgerau (*Dynamic traffic modeling*). They begin by providing an overview of the conventional static equilibrium approach which combines demand (for mobility) and supply (road capacity). In the static model, both the flow of trips and congestion delay are assumed to be constant. A drawback of the static model is that the time interval during which travel occurs is not specified so that the model cannot describe changes in the duration of congestion that result from changes in demand or capacity. This limitation is overcome in the Vickrey bottleneck model which combines congestion in the form of queuing behind a bottleneck with users' trip-timing preferences and departure time decisions. de Palma and Fosgerau derive the user equilibrium and social optimum for the basic bottleneck model, and explain how the optimum can be decentralized using a time-varying toll. They then review some extensions of the basic model that encompass elastic demand, user heterogeneity, stochastic demand and capacity and small networks. They conclude by identifying some unresolved modelling issues that apply not only to the bottleneck model but to trip-timing preferences and congestion dynamics in general.

A contrasting approach that is gaining interest is reviewed in the following chapter by Abdul Rawoof Pinjari and Chandra Bhat who discuss activity models (Activity-based travel demand analysis) for passenger transport. The interest in analyzing the potential of travel demand management policies to manage travel demand has led to a shift in the focus of travel demand modeling from the statistical prediction of aggregate-level, long-term, travel demand to understanding disaggregate-level (that is individual-level)

behavioral responses to short-term demand management policies such as ridesharing incentives, congestion pricing and employer-based demand management schemes (alternate work schedules, telecommuting and so forth). Since individuals respond in complex ways to such changes in travel conditions, traditional trip-based travel models may be limited in their usefulness and activity-based methods have been developed in response. Pinjari and Bhat discuss the salient aspects of the activity-based approach by presenting a theoretical and policy-oriented comparison of the trip-based and activity-based approaches. They review the emerging developments and future research directions along three important dimensions of activity participation and travel: inter-personal interactions, time and space. They then examine ways in which activity-based travel forecasting systems can be integrated with other modeling systems (such as land-use models and dynamic traffic assignment models) to build larger and more comprehensive urban modeling systems.

Although much of the work on transport demand has been developed for personal transport, many of the principles can be transferred to freight transport demand. There are however some crucial differences that justify devoting a separate chapter to freight transport in the context of the overall treatment of logistics and supply chain management. Logistics has changed a lot in recent decades, leading to an increasing integration between transport and the management of firms. Logistics draws on a number of disciplines in which pure economic analysis holds a minor role. Michel Beuthe (Economics of transport logistics) redresses this imbalance by using economic principles to address the fundamental question of the total logistic costs of activities. Costs are incurred in transportation and inventory management, and are affected by choice of route and consignment size. Michel Beuthe demonstrates the importance of these processes and offers lessons which have an immediate application in a number of areas (see, for example, the discussion of maritime shipping by Mary Brooks).

PART III: THE COST OF TRANSPORT

The demand for transport establishes the benefits from transport infrastructure and the services provided with it to transport people and freight. Part III deals with the costs of building the infrastructure and operating the services. The costs of transport include both the direct costs of transport operators and infrastructure managers and the external costs which transport imposes both on other users, for example, through congestion and accidents, and on non-users through energy consumption, local air pollution and greenhouse gas emissions. Part III of the *Handbook* addresses some approaches for internalizing these external effects. We delay a full discussion of congestion until the following section, where it is dealt with in the context of congestion pricing.

The costs of transport operators are analyzed by Leonardo Basso, Sergio Jara-Diaz and Bill Waters (Cost functions for transport firms). Operator costs are shaped by the fact that the costs of the various services produced on a transport network are interdependent through network effects. The emphasis in their chapter is less on mode-specific issues than on the nature of a transport cost function, and the challenges and methods of estimating the function. They cover a range of theoretical topics including the economics of multiple-output production and costs, and economies of scale, scope and traffic

density on transport networks. They then review the empirical evidence on these economies. Traditional methods of estimating cost functions have had rather limited success in predicting firm behavior. Various methodological advances to improve predictive accuracy have been developed in the last 15 years, and these are reviewed in the chapter.

Much of the innovation in transport has been concerned with enhancing productivity. Tae Oum, Katsuhiko Yamaguchi and Yuichiro Yoshida (Efficiency measurement theory and its application to airport benchmarking) review the theory of efficiency measurement and illustrate it with an application to airports. Efficiency measurement and benchmarking are useful both for comparing the efficiency of a firm relative to its peers/competitors and for investigating the effects of a public policy or regulation. They are also useful to a firm seeking to improve its efficiency performance relative to a benchmark unit. Efficiency measurement is critical for industries where firms do not face strong competition since the market cannot be relied on to discipline firms effectively. Prominent examples in transportation are firms that provide infrastructure for airports, seaports, highways and urban transit systems. Airports are an important and challenging example. The fact that airports produce multiple outputs using a common set of inputs calls for a delicate and sophisticated treatment in measuring their efficiencies. The chapter presents the conventional methodologies of efficiency measurement such as data envelopment analysis, stochastic frontier analysis, productivity indexes and some recent developments in efficiency measurement literature. It then provides a literature review of results on airport efficiency measurement, recent advances on airport efficiency measurement and some recent empirical estimates of the effects of ownership forms and governance structures on airport efficiency.

Transport is distinguished from many other economic sectors by the importance – both absolute and relative – of external costs. There is a significant and rapidly growing body of literature within transport economics on the estimation of these costs. Another branch of literature deals with how to control externalities following the theoretical guidelines established by Arthur Pigou and Paul Samuelson.

Stef Proost sets the scene in a complete guide to the concept and use of external costs in transport economics (Theory of external costs). The chapter addresses some basic questions: what are external costs, why do they arise in market economies, is there any difference between external costs generated by producers and consumers, how do external costs interact with other market failures and what does this imply in terms of policy instruments? A theoretical general equilibrium model is used to define the concept of external cost and how the marginal external cost is related to the efficiency properties of the standard competitive equilibrium. Since the general equilibrium model is rather cumbersome, the use of the external cost concept for policy analysis is shown with the help of two simple illustrations: the optimal pollution model and the partial equilibrium model. The principal external costs encountered in transport are briefly discussed and the properties of different policy instruments are analyzed. Finally the chapter considers the use of external cost concepts and policy instruments in a second-best context where more than one market failure is present.

America and Europe differ substantially in terms of levels of external costs, approaches to evaluating external costs and policies toward controlling external costs. Accordingly, two chapters provide separate treatments for the two sides of the Atlantic. The US approach is discussed by Mark Delucchi and Don McCubbin (External costs of trans-

port in the United States). Their chapter provides a comprehensive coverage of road, rail, air and water transport; passenger transport and freight transport; and congestion, accident, air pollution, climate change, noise, water pollution and energy-security costs. A separate section of the chapter is devoted to each of the main types of external cost. Each section first reviews methods and issues in the estimation of the costs associated with that externality, and then presents estimates of those costs. Wide variations in estimation methods, data and assumptions confound the comparison of estimates across modes. Delucchi and McCubbin conclude that external safety and congestion costs will remain significant until major changes in transportation activity occur. The mitigation of energy-security costs and climate-change costs depends on the pace of introduction of non-petroleum fuels, which is difficult to predict. Air pollution costs are likely to be of diminishing importance.

The European approach to external transport costs is summarized by Rainer Friedrich and Emile Quinet (External costs of transport in Europe). Internalization of external costs is one of the priorities of the European Commission. This is reflected in the large number of European studies which have been concerned not only with evaluating external costs, but also with the means of implementing their findings in terms of pricing and charges, in estimating the potential gain which would be derived from their implementation and in featuring what could be the use of the corresponding revenues. The majority of the European studies are designed to be integrated directly into project evaluation or transport pricing. By contrast, American studies have been largely the product of independent research centers, typically without direct translation into practical applications. Methodologically, the approaches used in Europe and the US are similar, but the emphasis is often on different goals. The costs of energy security are a higher priority in the United States than Europe, whereas environmental costs and the positive externalities from transport such as those embodied in the Mohring effect play a larger role in European studies. The ranking of external costs by importance is generally the same in the two continents: the largest cost is congestion followed by accidents, air pollution and noise. Climate change costs are the smallest. Whilst the estimation of the polluting and climate change effects of transport involve both difficult issues of scientific measurement and difficult monetary evaluation problems which have been the subject of much debate and controversy there remain two issues where transport interacts with more developed surrogate markets.

The following two chapters in Part III are devoted to these interactions. Henrik Andersson and Nicolas Treich (The value of a statistical life) are concerned with the value of human life. This has been a controversial topic on both philosophical and technical grounds, but the fact remains that transport accidents are a major cause of deaths and there is a need to place a value on reducing this toll. The value of human life can be estimated both directly through productivity and labor markets and indirectly through insurance. The authors take care to distinguish between the value of a *statistical* life (VSL) and the amount that individuals are willing to pay to save an identified life. It is the VSL that is of interest for public policy. The chapter focuses on the willingness to pay (WTP) approach to estimating the VSL. It surveys some classical theoretical and empirical findings on the VSL, but also attempts to clarify some of the issues often raised by the application of the WTP approach to the study of mortality risks. Procedures for eliciting preferences for safety have advanced considerably, but new questions continue

to arise. The decision problem of a social planner who must select optimal public safety expenditures is contrasted with the situation in which individuals make their own decisions that may have social consequences. The estimates presented in the chapter depend, however, on some key assumptions, in particular on the utility derived from bequests. To date we have little sense of the properties of bequest utility, and how it should vary across the population and time.

Besides safety issues, the relationships between transport and energy markets are of critical and growing importance. Ken Button (Transport and energy) discusses the links between the two markets. Energy is a major input for transport and it is also significant for its strategic implications. The chapter describes how historical developments in energy and transport have evolved in parallel. The emergence of developing countries has changed the picture in terms of current and future world consumption patterns. Distortions in the energy market have consequences for transport that arise from several factors: non-renewability of oil reserves; the oligopolistic and cartelized nature of oil supply; environmental effects of energy consumption; and the conflict with policy towards the oil industry and the market imperfections which arise from the diverging objectives of different countries. Various policy options and instruments are considered which can modify consumption patterns: taxes and subsidies, vehicle fuel-efficiency standards, controls on vehicle use and the development of alternative technologies. In Button's opinion, some combination of all of these instruments is likely to be needed to support efficient usage of energy for transport.

Concluding Part III, and as an application of the concepts described in earlier chapters, Yossi Berechman, Bekir Bartin, Ozlem Yanmaz-Tuzel and Kaan Ozbay (The full marginal costs of highway travel: Methods and empirical estimation for North America) analyze the full marginal costs (FMC) of highway travel. FMC is defined as the overall costs incurred by society from an additional unit of transportation output. It is composed of direct costs to users and indirect costs to society from non-internalized externalities. The chapter begins by characterizing the optimal price and capacity level for a transport link and deriving a formula for the extent to which user charges cover the costs of infrastructure. Empirical evidence on scale economies in capacity provision is presented. Empirical estimates are then reviewed for the FMC of highway travel inclusive of vehicle operating costs, travel time costs, accident costs, environmental costs and infrastructure costs. The chapter concludes with an application concerning three major roadway widening projects on the Northern New Jersey highway network. The application illustrates the importance of conducting full-cost analysis at the network level in order to account for the effects of expanding individual links on equilibrium traffic flows on links, and between origin-destination pairs, over whole road networks.

PART IV: OPTIMAL PUBLIC DECISIONS

For many years the public sector has been involved in transport as both direct provider and regulator. This relationship has been changing recently in response to pressure on public budgets and a belief in the effectiveness of introducing competition. Parts IV and V of the *Handbook* explore the basis of policy towards transport. Part IV deals with optimal collective decisions from a welfare economics perspective, while Part V

deals with competition and regulation from a point of view more akin to public choice theory.

Part IV begins with an introduction to surplus theory which underlies any discussion of the wider value of transport. Yoshi Kanemoto (Surplus theory) shows how the concept of consumer's surplus lies at the heart of cost-benefit analysis (CBA). Starting from the original concept developed by Jules Dupuit, the practical application of CBA spread to a variety of public infrastructure projects during the first half of the twentieth century. This chapter reviews the theoretical foundation of CBA using the money-metric utility function as a basis for consumer's surplus and examines compensating variation, equivalent variation and Marshallian consumer's surplus. The chapter shows how this approach differs from a financial appraisal, with the main difference arising from the use of shadow prices. It then describes how the distribution of benefits can be analyzed within a general equilibrium framework. Finally, consideration is given to consumer's surplus measures in random utility discrete choice models that are widely used in transport demand models.

Peter Mackie, Dan Graham and James Laird (The direct and wider impacts of transport projects: a review) review the state of the art in applying cost-benefit analysis to the practical appraisal of projects. They emphasize two aspects of project appraisal for which recent advances have been made. One is how appraisal can incorporate the wider economic impacts of transport projects – a topic that links back to Part I of the *Handbook*. The other is how to address issues relating to the values of time and human life as discussed in Part III. The chapter reflects on both the relative importance of the various aspects of wider impacts and the extent to which the outcomes vary from project to project. The authors conclude that it is difficult to develop general rules about the magnitude of the wider impacts.

The next two chapters deal with the important issue of pricing. Simon Anderson and Régis Renault (Price discrimination) deal with price discrimination which is widely employed in transport markets as well as other sectors of the economy. Anderson and Renault discuss the rationale for price discrimination and how discriminatory prices compare with welfare-maximizing pricing. Price discrimination arises when a firm sells different units of the same good at different prices. Examples include special tariffs for certain customer groups (for example, students or senior citizens), varying prices with the number of units purchased and varying prices by time of day, week or season. The chapter examines the basis for each form of pricing, and discusses the extent to which price discrimination depends on the market power of the firm and the possibility of arbitrage between consumers. It also reviews empirical evidence on the incidence of such pricing practices under different market structures.

Georgina Santos and Erik Verhoef (Road congestion pricing) focus on congestion pricing of roads which is becoming an increasingly popular subject as proposals for various forms of road pricing surface around the world. The authors return to the use of pricing for internalizing transport externalities, discussed in Part III, and provide an in-depth review of the theory and practice of road pricing. The chapter begins by presenting the simple textbook theory of the optimal congestion charge. It then describes complications to the theory such as the dynamics of traffic flows, and second-best pricing when other markets are distorted (for example, other transport modes are not optimally priced) or when there are constraints on what roads can be tolled or on how tolls can be

differentiated by type of traveler. Since congestion pricing is rather limited in practice there is relatively little evidence on how well it can work. The chapter reviews four operational schemes that are working well: High Occupancy Toll lanes in the US, Singapore's electronic road pricing system, London's congestion charging scheme, and Stockholm's congestion tax. Interestingly, none of these schemes were designed on the basis of first-best or second-best theoretical guidelines, but rather for ease of comprehension and use. The chapter concludes by discussing welfare-distributional and acceptability issues that continue to impede widespread implementation of road pricing.

The following two chapters in Part IV deal with the role of information in transport, which is growing in importance with the development of new technologies of information and communication. Piet Rietveld (The economics of information in transport) discusses some economic aspects of information in transport. If travelers lack complete information on the travel alternatives available to them they could make suboptimal choices and hence could benefit from acquiring more information. This chapter analyzes the costs and benefits of two primary modes of information acquisition: information search – for example by means of Advanced Traveler Information Systems (ATIS) – and information acquisition via trial and error. Given rapid advances in ATIS technology it seems likely that ATIS will gain importance as a source of information although situations will remain in which trial and error is more cost-effective. In some contexts, such as transport on congested road networks, better information conveys benefits not only directly to travelers who receive it, but also indirectly through changes in the decisions of informed travelers to uninformed travelers as well. This implies that, in the absence of direct corrective mechanisms such as congestion pricing, there are positive externalities in the information market which makes a case for subsidies to users or providers of information services.

The second chapter on information and transport by Caspar Chorus and Harry Timmermans (Personal intelligent travel assistants) describes how rapid technological developments in mobile communications and satellite technology are leading toward what can be called a Personal Intelligent Travel Assistant (PITA). PITAs go beyond existing ATIS in providing information that is: dynamic or predictive personalized (that is, based on a traveler's preferences, location and current circumstances); and multimodal. PITAs can provide travelers with three types of service: information about the attributes of a known alternative, information about an unknown alternative, or advice on what option to choose. Given the large investments required for the successful development and deployment of PITA services, a clear understanding of their benefits is needed. This chapter provides models of the value of information from PITA services. After reviewing the value of information from a generic conceptual perspective, it develops specific formalizations of information value for the three types of PITA service.

Any means of allocation has distributive implications. In his chapter (Equity dimensions of transport policy), Alain Trannoy argues that equity has been a much less central concept in transport than in other fields such as education, health or housing. He reviews the equity dimensions arising in the design of transport infrastructure, and discusses the relevance and implications of criteria such as maximum or minimum average distance. He advocates the use of Nash bargaining solutions, shows the paradoxes which may arise from equity solutions when growth is taken into account and suggests a new criterion taking into account growth, welfare and migration in situations where regions have

strong cultural identities. The equity dimensions of classical CBA are examined and the equity issues which arise in the cost sharing of infrastructures. Trannoy then reviews the equity issues in transport operations, such as transfers in kind (for example, free transport for old people), compensating commuters and the equity issues of congestion. Finally, he considers the potential for defining indicators of equity which encompass both transport infrastructure and operations, stressing the importance of equality of opportunities of mobility, and hence providing a means of judging the transport policies of various countries.

The final chapter in Part IV by Jonathan Gifford (Psychology and rationality in user behavior: the case of scarcity) examines some of the non-economic factors which may affect the way transport capacity is used. Gifford focuses on non-conventional aspects of managing scarcity in transportation resources. He provides an overview of the relevant theoretical perspectives from the behavioral literature – an interdisciplinary approach including psychology, sociology and economics – and examines how its concepts apply to transportation decisions and transport policy. The chapter briefly touches upon the transportation demand management (TDM) literature as it relates to the management of scarcity before concluding with a summary of the challenges in designing effective TDM tools, and identifying opportunities for future research.

PART V: COMPETITION AND REGULATION

This final part of the *Handbook* considers various issues related to how the mix of competitive forces and regulatory constraints affects transport markets. The discussion draws on the theories of asymmetric information, uncertainty, incentives and contracts.

An overview of the issues is provided by Marco Ponti (Competition, regulation and public service obligations), who presents both a theoretical overview and the experience of a former regulator in the transport sector. The chapter outlines both the rationale and the means for public intervention, and shows how the principles of service provision can be satisfied in very different ways through concessions, private finance, tariff regulation and competition. Several key issues for transport regulation are developed: congestion and the regulation of access; problems of price-cap regulation; the regulation of investment and of quality of service; and the specific problem of the number of tills (that is, whether to regulate provision in a particular sector in its totality or separately for each element). The analysis shows how effectively regulation can influence policy towards transport in terms of efficiency, innovation and investment. Finally, the way in which regulation can accommodate the exercise of public service obligations and distributional issues is demonstrated. The chapter concludes that Demsetz-style competition can be compatible with social objectives, and that liberalization does not necessarily undermine the role of the state but rather requires reinforcement of regulations and control of market failures.

The following two chapters consider issues relating to infrastructure provision, and in particular the use of PPPs. Elisabetta Iossa and David Martimort (The theory of incentives applied to the transport sector) underline the potential problems arising from the implementation of PPPs in transport and their incentive properties. These include the optimism embodied in forecasts and the frequency of renegotiation resulting from

such optimism, but it is also recognized that PPPs can be a great success. Because of this diversity of outcomes the authors see it necessary to revisit the theoretical basis of PPPs to establish whether and how mechanisms for successful PPPs can be established. Four principal determining factors are analyzed: the degree of integration of functions (planning, construction, operation); the transfer of risk from public to private sector; the duration of contracts and the use of private finance. Starting with a simple model of incentives the authors present a series of results which have as common elements the degree of integration of functions, the role of the regulator (providing a link with Marco Ponti's chapter) and the length of contracts.

To complement this theoretical analysis Antonio Estache, Ellis Juan and Lourdes Trujillo (Public-private partnerships in transport) provide a general survey of experiences with PPPs in transport. They provide a historical account of the development of PPPs and their increasingly important role in recent decades. Many PPPs have failed, and yet enthusiasm for PPPs has continued undiminished. The main issues which arise are examined: the financial aspects as the main driving force for the growth of PPPs and the increasing sophistication of the financial arrangements. Using historical examples, it is shown that risk lies at the core of problems with PPPs in terms of their consequences and management. Finally the chapter considers the role of the public sector, not least in providing an overall structure for the system – providing a link with the discussion of regulation of previous chapters. The authors consider that the recent financial crisis has not reduced the appetite for PPPs, but has reinforced the need to consider the means of implementation and the contracts which accompany such partnerships.

The remaining chapters deal with a range of issues arising in individual modes. Richard Arnott (Parking economics) considers parking: an aspect of private car usage which is frequently overlooked. Much infrastructure and space is devoted to parking, and the deadweight loss due to inefficient parking policy may be as large as that due to the underpricing of urban automobile congestion. Yet much less work has been done on the economics of parking than on the economics of traffic congestion. Arnott reviews the nascent literature on the economics of parking with particular attention to downtown parking. The economics of parking are complicated by a number of market distortions. Most shopping center parking and employer-provided parking is free to users, and most on-street parking is underpriced. However, parking garages and parking lots derive market power from their unique locations, and set parking fees above marginal cost. A further consideration is that the demand for parking is derived from the demand for automobile travel which is generally underpriced. As a result of these and other complications, existing parking policies can be difficult to assess, and new policies can be difficult to formulate and optimize. Nevertheless, with improvements in the parking models used by transportation planners and growing acceptance of pricing policies, there is reason to hope that parking pricing and other practices will become more economically efficient in the foreseeable future.

Philippe Gagnepain, Marc Ivaldi and Catherine Muller-Vibes (The industrial organization of competition in local bus services) provide an overall review of the local bus service industry. Drawing on a broad literature survey they first examine the major characteristics of demand and costs for local bus service and how they can be estimated. They then describe the characteristics of competition which appears to play out mainly with respect to service frequency rather than fares. Both theory and empirical evidence

overwhelmingly suggest that the industry is not contestable. Local operators usually have monopoly power and can earn high profits. Various factors militate against contestability: entry barriers; sunk costs; the advantages of incumbents in terms of economies of experience, scale, traffic density and scope; the use of practices that raise rivals' costs and the ability of incumbents to change fares and timetables rapidly.

Chris Nash (*Competition and regulation in rail transport*) looks at the rail sector. This has undergone enormous changes in the UK in the past two decades from a sector which was dominated by large state-owned vertically integrated monopolies to one where the vertical integration has been largely unbundled and competition introduced. Competition occurs both for franchised local monopolies (that is, competition for the market) and in some cases on-track between competing operators (that is, competition within the market). The chapter reviews the wide variety of organizational and regulatory structures for the rail industry to provide evidence on what approaches to competition and regulation work best and in what circumstances. It then considers research on the specific issues of vertical separation, open access competition for freight and passenger traffic, franchising for freight and passenger traffic, and regulation and infrastructure charges. The chapter concludes that most railway reforms have had some beneficial effects, but that all such reforms are a compromise between introducing competition and minimizing transactions costs and loss of economies of scale, density and scope. It appears that different solutions work best in different circumstances, but it is difficult to provide definitive evidence or recommendations on what type of regulation and form of competition should be implemented in a given market.

The next two chapters deal with aviation. David Gillen (*Airport governance and regulation: three decades of aviation system reform*) examines the evolution of airport governance and the various forms it takes, and assesses the case for privatization. He describes the different types of economic regulation that have accompanied this evolution which range from tight rate-of-return regulation to liberalized light-handed implicit regulation. He also reviews arguments that have been made both for and against economic regulation. Several policy-relevant conclusions are drawn. First, airports are not hybrid corporations that must choose between serving customers or shareholders. Second, if regulation is deemed necessary, light-handed regulation seems superior even to dual till rate-of-return regulation. Third, airline deregulation has shifted the balance of power away from airports and toward airlines. Fourth, dynamic efficiency (that is, innovation in terms of new types of aviation service or ways to manage airports such as congestion pricing) has been underemphasized in the debate over privatization. Gillen argues that regulators should take the 'long view' and foster the competitive process rather than emulating the competitive outcome.

Anming Zhang, Yimin Zhang and Joseph Clougherty (*Competition and regulation in air transport*) look at changes in competition and regulation in the airline industry. Following US airline deregulation in the late 1970s there has been a worldwide move away from government regulation towards liberalization of air services and 'open skies'. The unleashing of airline competition has induced airlines to take a number of strategic actions including: mergers and consolidation; competition over service frequency, flight scheduling and fares; hub-and-spoke network formation; and international alliance agreements. This chapter provides a review of research into the reasons behind, and welfare implications of, these strategic actions. It departs from previous reviews of the

topic in employing game-theoretic analysis, by systematically examining the international dimensions to air transport competition, and by focusing on recent developments such as rapid growth of the cargo sector which carries nearly 40 per cent of world trade by value.

Similar to the treatment of airports and airlines, two chapters in Part V look at maritime transport by dealing separately with seaports and shipping companies. Eddy Van de Voorde, Hilde Meersman and Thierry Vanelslander (Competition and regulation in seaports) examine changes in the port sector. The port sector has been subject to privatization and deregulation with consequences for competition within as well as outside the sector. At the same time, increased cooperation and merger activities have been driven by the search for scale economies and control over the logistics chain. The authors show how the resulting concentration may lead to abuses of market power that undermine the advantages of deregulation. The chapter starts by defining the key concepts of a seaport, port activities, port players and port competition. It then focuses on two major forces which impact the port sector: changes in organizational structures of the ports as a consequence of privatization and deregulation, and efforts by shipping companies to gain control over the logistics chain. Finally, it discusses some changes that are likely to affect port competition in the near future.

Mary Brooks (Competition and regulation in maritime transport) reviews the changing competitive environment in the market for maritime transport services. She begins with a general summary of maritime freight transport, and then provides separate in-depth descriptions of the market structure and regulation of tanker and dry bulk markets (called tramp markets), and liner markets. Tramp markets have been treated in a relatively laissez-faire fashion with only limited regulation from a competition perspective. By contrast, competition authorities have heavily regulated the liner market and Brooks explores the reasons for this very different approach.

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We have attempted in this *Handbook* to provide a comprehensive account of the major areas of interest in transport economics and many of the big changes in both analysis and empirical evidence. Nevertheless, some topics have not been covered. One reason is that for some topics, such as transport demand elasticities, CBA and transport demand modeling, there are good, recent reviews or manuals to which little could be added. Another reason is that the sheer number of subjects that could be included would greatly exceed the feasible length of the *Handbook*.

Nevertheless, it is possible from the contents of the *Handbook* to highlight a number of subjects and policy issues deserving further attention. We mention just a few here. As the chapters in Part I demonstrate, our understanding of the relationship between transport and the spatial economy has changed fundamentally in the past two decades and the topic is wide open for more theoretical and empirical research. For example, only recently has reliable empirical evidence become available on the magnitude of the economy-wide impacts of transport projects and further work could confirm that these effects should be incorporated into standard project evaluation practice. Another priority is to develop further the activity modeling approach which seeks to explain transport demand from consistent utility-theoretic principles in terms of the underlying

ing demand to undertake activities at different locations at different times. The advent of ATIS and other technological developments in information and communication will have wide-ranging implications for passenger and freight transport that deserve attention. Encouragingly, the theory of regulation is gaining influence with regulatory policy makers as well as becoming better at predicting outcomes, and with further advances it can be hoped that a better balance between competition and appropriate forms of regulation can be achieved. It is clear from this non-exhaustive review that transport economics is an evolving field and that the state-of-the art developed in this *Handbook* will have to be updated in due course.

Finally we must pay tribute to the the *Direction de la recherche et de l'innovation* of the French Ministry in charge of Environment, to the University of Kent and to the Ecole Normale Supérieure de Cachan for financial support, and more especially to Nicolas Coulombel who took on the responsibility for ensuring consistency in the presentation of the final manuscript, but also reviewed the overall coherency of the book and provided valuable advice on the contents of the individual chapters. We also acknowledge the contribution to this volume made by Bill Waters who died suddenly during the final stages of completion. He made a huge contribution to many areas of transport economics and will be greatly missed.

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