POLICY ANALYSIS OF TRANSPORT NETWORKS
Transport and Mobility Series

Edited by
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Policy Analysis of Transport Networks

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Contents

List of Figures vii
List of Tables ix
List of Contributors xi
Preface xv

1 New Trends in Policy Making for Transport and Regional Network Integration
   Marina van Geenhuizen, Aura Reggiani and Piet Rietveld 1

PART I POLICY ANALYSIS IN THE TRANSPORT FIELD

2 Equity Issues in the Evaluation of Transport Policies and Transport Infrastructure Projects
   Piet Rietveld, Jan Rouwendal and Arno van der Vlist 19

3 Economic Impact Assessment for Analysing the Viability of Regional Airports in Norway
   Svein Bråthen and Knut S. Eriksen 37

4 Modelling the Short-Term Impact of a Nuclear Accident on Transportation Flows
   Peder Axensten 61

5 Models and Realities: Choosing Transit Projects for New York City
   Robert E. Paaswell and Joseph Berechman 77

6 A Framework for Identifying and Qualifying Uncertainty in Policy Making: The Case of Intelligent Transport Systems
   Marina van Geenhuizen and Wil Thissen 101

7 An Evaluation of Benefits from Aircraft and High-Speed Train Substitution
   Moshe Givoni 119

8 The Value of Travel Time in Passenger and Freight Transport: An Overview
   Luca Zamparini and Aura Reggiani 145
## CONTENTS

**PART II  TRANSPORT POLICIES AND REGIONAL NETWORK INTEGRATION**

9  Less Friction and More Traffic? Examples of the Impact of the Fixed Links of the Great Belt and Øresund on Danish Firms’ Organization of Transport and Logistics  
*Leif Gjesing Hansen*  
165

10  Accessibility Impacts of the Trans-European Railway Network  
*Juan Carlos Martín, Javier Gutiérrez and Concepción Román*  
189

11  The Role of Infrastructure in Location Preferences of Firms: An Overview of Empirical Research for the Netherlands  
*Frank Bruinsma and Piet Rietveld*  
215

12  The Spatial Consequences of Air Transport Deregulation: An Overview of the French Case since 1995  
*Pierre Zembri*  
235

13  ICTs and High-Order Integration of Remote Regions. Distance as a Remaining Barrier?  
*Marina van Geenhuizen*  
257

14  Interaction in the Baltic Sea Area. Patterns from an Aviation Perspective  
*Jan Henrik Nilsson*  
275

15  Structural Convergence of the National Economies of Europe  
*Marco Percoco, Sandy Dall’erba and Geoffrey J.D. Hewings*  
287

*Index*  
309
List of Figures

3.1 The Norwegian airport network 38
3.2 Increasing returns to scale pricing strategies and dead weight loss 40
3.3 Economic loss for air passengers from airport closure 42
3.4 Aircraft costs per supplied seat related to aircraft size, from Equation (3.2) 49
3.5 Adverse circular and cumulative effects of an airport closure 55
4.1 A hypothetical scenario based on the weather conditions of 26 August 1998 62
4.2 Using a fictitious source to equal the sum of sources and the sum of sinks 64
4.3 The importance of giving $t$, of Equation (4.7), a good value 67
4.4 Resulting evacuation flows based on the final radioactive deposition of the 26 August scenario 69
4.5 Details of Figure 4.4: the evacuation zone along the Bothnia Gulf (A) and the evacuation zone by the accident site itself, at Polyarnye Zori (B) 70
4.6 Using a fictitious ‘stay’ node $q$ 71
4.7 Open-air effective dose equivalent rate in the city of Umeå, Sweden, during the year following the Chernobyl accident 73
5.1 Estimated peak period 6–10 am transportation ridership coming to and from Manhattan 80
5.2 Candidate projects for evaluation 88
6.1 A system-based policy framework to identify uncertainty 104
7.1 Two options of travel on the LHR to Paris route: by air and by HST 120
8.1 Evolution of VTTS freight transport by road in EU-US (1999 US$ per shipment per hour) 153
8.2 Evolution of passenger transport by road VTTS in the UK (as a percentage of the wage rate) 156
8.3 Evolution of passenger transport by road VTTS in the US (as a percentage of the wage rate) 157
8.4 Evolution of passenger transport by road VTTS in Sweden (as a percentage of the wage rate) 157
8.5 Evolution of passenger transport by road VTTS in Australia (as a percentage of the wage rate) 157
9.1 The location of the Great Belt and Øresund 166
9.2 Systems of actors and activities, which are central in the relationships among firms transport and infrastructures 170
9.3 Focus on three types of firms in a transport and logistics chain perspective: manufacturing, transport, and distribution firms 172
List of Figures

9.4 The effects of the Great Belt fixed link on firms located in different counties in terms of change in route selection, increased transport, expansion of market, and increased turnover 184
12.1 The reconfigured market – 1998 to 2004 241
12.2 Two examples of the multiplication of air transport possibilities between provincial towns (official timetables, working days, summer 2003) 245
12.3 An Example of Opening of a Regional Capital to the Outside: Rennes (official timetables, summer 2003, direct flights only) 246
12.4 French airports served by Buzz just before its purchase by Ryanair (2002) 247
12.5 Change in radial routes of the Air France group between 1993 and 2000 249
14.1 Baltic Sea area 276
14.2 Traffic to Moscow, in seats per week 283
15.1 Total index of inequality in productive structure 290
15.2 Index of inequality in productive structure by sector 290
15.3a Probabilistic economic landscapes of the EU economy (country-by-country) 296
15.3b Probabilistic economic landscapes of the EU economy (sector-by-sector) 297
15.3c Probabilistic economic landscapes of the EU economy (country-by-sector) 297
15.4a Absolute importance hierarchy by sector 1965–85 298
15.4b Absolute sensitivity hierarchy by sector 1965–85 298
15.4c Absolute importance hierarchy by country 1965–85 299
15.4d Absolute sensitivity hierarchy by country 1965–85 299
15.5 The hollowing out process 300
15.6 Importance Matrix intensities over time 301
15.7 Importance Matrix variances over time 301
# List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>The structure of the book</td>
<td>8</td>
</tr>
<tr>
<td>2.1</td>
<td>Poverty figures for EU countries (1996)</td>
<td>22</td>
</tr>
<tr>
<td>3.1</td>
<td>Factors important for selecting candidate airports for the CBA</td>
<td>46</td>
</tr>
<tr>
<td>3.2</td>
<td>Passengers on arrivals and departures in 2001</td>
<td>47</td>
</tr>
<tr>
<td>3.3</td>
<td>Net present value (in million €) to society and to selected stakeholders</td>
<td>51</td>
</tr>
<tr>
<td>4.1</td>
<td>Vehicles per hour based upon the class field in the road layer of the BGDB</td>
<td>66</td>
</tr>
<tr>
<td>4.2</td>
<td>The test scenario</td>
<td>68</td>
</tr>
<tr>
<td>5.1a</td>
<td>Agency abbreviations</td>
<td>84</td>
</tr>
<tr>
<td>5.1b</td>
<td>Regional agencies influential in transportation investments in New York City</td>
<td>84</td>
</tr>
<tr>
<td>5.2</td>
<td>Regional transportation decision makers</td>
<td>85</td>
</tr>
<tr>
<td>5.3</td>
<td>List of projects</td>
<td>87</td>
</tr>
<tr>
<td>6.1</td>
<td>Uncertainties of relevance to policy making for AGV</td>
<td>109</td>
</tr>
<tr>
<td>7.1</td>
<td>Comparison of HST and aircraft Operation Costs (OCs) on the LHR to Paris route (in euros)</td>
<td>123</td>
</tr>
<tr>
<td>7.2</td>
<td>Flight Operation Costs (OCs) on the LHR to CDG route under different assumptions (in euros)</td>
<td>124</td>
</tr>
<tr>
<td>7.3</td>
<td>Comparison of HST and flight Operation Costs (OCs), including environmental costs, on the LHR to Paris route (in euros)</td>
<td>124</td>
</tr>
<tr>
<td>7.4</td>
<td>Travel time comparison between aircraft and HST journeys (in minutes)</td>
<td>127</td>
</tr>
<tr>
<td>7.5</td>
<td>Comparison between aircraft and HST journey characteristics (in euros)</td>
<td>128</td>
</tr>
<tr>
<td>7.6</td>
<td>Value of Time comparison between aircraft and HST journey (in euros)</td>
<td>129</td>
</tr>
<tr>
<td>7.7</td>
<td>Summary of Local Air Pollution (LAP) and climate change analysis for the LHR to Paris route (seat per route)</td>
<td>133</td>
</tr>
<tr>
<td>7.8</td>
<td>Benefits from substitution of aircraft services with HST services on the LHR to Paris route using CBA (in euros per seat per route)</td>
<td>136</td>
</tr>
<tr>
<td>7.9</td>
<td>Benefits from substitution of aircraft services with HST services on the LHR to Paris route using MCA (in units per seat per route)</td>
<td>137</td>
</tr>
<tr>
<td>8.1</td>
<td>VTTS in freight transport by road (in 1999 $US per shipment per hour)</td>
<td>152</td>
</tr>
<tr>
<td>8.2</td>
<td>VTTS in freight transport by rail (in 1999 $US per ton per hour)</td>
<td>153</td>
</tr>
<tr>
<td>8.3</td>
<td>VTTS in passenger transport by road (as a percentage of the average wage)</td>
<td>154</td>
</tr>
<tr>
<td>9.1</td>
<td>The analytical framework</td>
<td>173</td>
</tr>
</tbody>
</table>
List of Tables

9.2 Influence of the new fixed links on the scheduling of product flow via changes in transport logistics for different types of firms 176
9.3 Influence of the new fixed links on the management of transport resources via changes in transport logistics for different types of firms 181
10.1 Characteristics of the selected accessibility indicators 194
10.2 Travel time savings produced by TEN-Ts in some international routes 196
10.3 Classification of European cities according to accessibility indicators (the reference set) 198
10.4 DEA-accessibility index for the main European cities in scenarios A, B and C 203
10.5 Accessibility inequality indices 207
11.1 Hypothetical effects of transport infrastructure improvements on manufacturing 219
11.2 Tendencies in the location of the manufacturing sector as a function of transport costs 220
11.3 Reported importance of location factors by Dutch firms located in the Randstad 222
11.4 Perceived impacts of new highway infrastructure on the functioning of firms (% of respondents) 223
11.5 Combinations of preferences for situational factors of office holding companies in the Amsterdam region 224
11.6 Strengths and weaknesses of types of entrepreneurial surveys 225
11.7 Examples of choice sets in the stated preference analysis 227
11.8 Values of location factors as used in the questionnaire 228
11.9 Results of the logit model 228
11.10 Results of the logit model (dummies for economic sectors included) 230
12.1 Changes in Air France fares on four main radial routes 237
12.3 French hubs in 1998 242
12.4 Traffic change at airports currently or having been regional hubs 244
13.1 Types of distance 259
13.2 SURFnet4 and SURFnet5 networks in the Netherlands 265
13.3 Classification scheme of call centres (simplified with two extremes) 268
13.4 Location factors in call centre development in Amsterdam 269
14.1 Air traffic from Warsaw and the Baltic states’ capitals to three categories of destinations, 1988–2001, in seats per week 281
15.1 Geographical Importance Matrix (1985) 295
15.2 Sector Importance Matrix (1985) 295
15.3 Country-by-Sector Importance Matrix (1985) 296
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Preface

Transport phenomena are continuously changing in nature, making policy analysis in the transport field a fascinating activity, often dealing with new problems, whose possible resolution is fraught with conflicting interests and concomitant uncertainty. An important change that has become pertinent in recent years concerns the increasing threat of terrorism, as well as the vulnerability due to natural disasters and climate change. Another trend concerns the increasing ineffectiveness of policy makers to concretely realise transport infrastructure projects or to efficiently implement the major changes that are needed to meet the challenges of the coming years. Also, the current transport impact on regional development, possibly leading to regional convergence, has led to considerable debates. Equity issues cannot be ignored when one wants to develop plans to improve the performance of transport and communication systems. The present book brings together a coherent group of contributions to these themes, with the aim of providing a picture of new important research challenges, relevant for policy analysis and decision making.

The contributions to this volume are mainly the result of a series of meetings of the NECTAR cluster on networks. These meetings took place in, among other venues, Potenza (Italy), Ikaria (Greece), Lund (Sweden), Cergy-Pontoise (Paris). The editors wish to thank the local organizers Giuseppe Las Casas, Maria Giaoutzi, Kerstin Cederlund and Pierre Zembri for the creative atmosphere of the meetings and for their hospitality. Special thanks are also given to Roberto Patuelli for his very systematic work in the coordination of the editing process, to Patricia Ellman for her accurate work in language editing, and to all the referees for their careful comments on earlier versions of the papers. Last, but not least, the Editors wish to express their gratitude to Valerie Rose and Carolyn Court of Ashgate for their kind assistance and cooperation.

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Chapter 1

New Trends in Policy Making for Transport and Regional Network Integration

Marina van Geenhuizen, Aura Reggiani and Piet Rietveld

1.1 Introduction

Over recent decades, the formulation of transport policy has become an increasingly complex task. This is because transport is not pursued for its own sake, but is derived from other activities such as living, working, production and recreation, which are themselves subject to increased complexity. The point is that new lifestyles and new methods of production are generating an increased demand for transport, including higher frequencies of service and longer travel distances. While new technologies are helping to make transport systems more powerful and efficient, at the same time, they also introduce additional complexities due to problems of unreliability and feedback effects.

Another reason for the growing complexity arises from the many, and often conflicting, goals involved in the determination of transport policy, such as increasing the capacity of the network to accommodate larger and quicker flows, reducing costs, and limiting environmental impacts (for example, Beuthe et al., 2004). The stakeholders concerned are increasingly finding themselves in a dynamic multi-actor situation, in which they attempt to influence decision making by exerting a stronger presence and by participating in rapidly changing networks. In particular, the social acceptability of transport policies is becoming a major issue in many countries. All this implies that now the policy-making process is ‘muddling through’ even more so than it did in the past.

A more recent development is the growing awareness that transport systems are vulnerable to criminality, terrorist attacks and natural disasters. These threats add new dimensions to the design criteria of transport networks: for example, the notion of robustness of transport systems in order to counter the terrorist’s aim to achieve maximum damage. This robustness is also crucial under the chaotic planning circumstances following a major disaster, natural or man-made, when the transport system has to be used in the best possible way for evacuation purposes or the supply of support activities. In this context, the evolution of the complexity of
Policy Analysis of Transport Networks

Transport networks is clearly also dependent on technological information systems, which intensifies the ‘networked’ character of transport systems. Consequently: ‘An understanding of these complexities is imperative for the design of plans and policies that can be used to optimize the efficiency, performance and safety of transportation, telecommunications and other networked systems’ (Reggiani and Schintler, 2005, p. vi).

These issues imply that standard methods of policy analysis in the transport field should be further developed in order to address the current challenges. In particular, we mention the use of analytical methods for evaluating policy in the following main areas:

- Equity and social acceptability;
- Vulnerability due to terrorism and large accidents;
- Uncertainty and risk.

The socio-economic, political and technological trends mentioned above have had strong impacts on the functioning of transport systems and transport policy-making routines. In addition, there have also been important consequences for land use and regional development. Transport and communication serve to increase the accessibility of regions by improving network links: for example, bridging missing links or increasing the speed of flow over existing links and nodes. Telecommunication may compensate for large physical distances and may reduce time-distance to virtually nothing. In this context, the integration of regions is an important theme, including attention to the level of integration and to its impact on the organization of supply chains, the degree of specialization and the economic performance of the companies involved. In addition, in studies on regional and national convergence, progress has been made using new methodologies permitting new perspectives on convergence (for example, Cuadrado-Roura, 2001).

This book brings together a number of papers on these themes. We classify them under two main headings:

I. Policy analysis in the transport field.
II. Transport policies and regional network integration.

Before describing the individual contributions in Section 1.4, first a short review of the themes is provided in Sections 1.2 and 1.3.

1.2 Policy Analysis in the Transport Field

The solution of transport problems is steadily changing in nature because of changes in the underlying technological, economic and political decision-making contexts. In the limited space available here, it is not possible to give an exhaustive
New Trends in Policy Making for Transport and Regional Network Integration

1.2.1 Equity Problems and Transport Policies

Issues of equity and social justice play a role in transport policies in various ways. First, equity problems may be an unintended side effect of policies to address transport problems such as congestion and environmental nuisance. For example, opponents of charging for environmental externalities may claim that this measure has adverse equity effects since it will hurt the poor more than the rich. Second, equity may be the explicit aim of certain transport policies such as the construction of infrastructure in lagging regions, or subsidies to public transport to support the urban poor. In the latter case, equity is more than a side effect: it is the main motivation for a policy.

It is striking that, while efficiency plays a major role in social cost-benefit analysis, equity often receives most attention in the political domain. As a consequence, the outcomes of social cost-benefit analysis are often considered as less relevant in policy-making processes. But as noted, for example, by Viegas (2001), the notion of equity is not unambiguous. Equity concepts may cover horizontal equity (comparable individuals should be treated in a comparable way), level playing field (transport sectors should be treated in a similar way according to taxation, etc.), and the principle that individuals that are negatively affected by policies need to be compensated. Standard cost-benefit analysis is based on adding the net benefits of all winners and losers. But, by doing so, equity issues are ignored. A positive net benefit means that, in principle, the winners can compensate the losers. However, this is only a hypothetical compensation, and therefore a policy alternative with a clearly positive aggregate net benefit may have serious equity consequences. In order to improve the systematic search for, and development of, policy alternatives, there is a need for a tool where, in addition to efficiency concerns as reflected by cost-benefit analysis, equity concerns are also operationalized.

1.2.2 Transport System Performance Under the Threat of Major Accidents and Terrorist Attacks

The threat of major accidents is a consequence partly of natural disasters, such as earthquakes, volcanic eruptions, floods, tsunamis, and partly of man-made disasters. In both cases, transport is a relevant dimension of policies designed to reduce damage. When the accidents can be predicted with some degree of certainty, depending on the type of accident, then evacuation strategies may make sense. It is clear that this solution may easily reveal a lack of capacity to serve the sudden transport need at short notice. In that event, simulations with transport
models may help to predict where the main bottlenecks will be, and whether expanding capacities at critical places can reduce these bottlenecks.

A related problem is the optimal use of transport systems for relief activities after the serious incident. The experience with the 2004 tsunami indicates that there is a need for creative combinations of existing transport modes that make use of waterways and roads, as far as they are still functioning, and air transport in cases where the usual transport modes are no longer operational. This raises questions such as whether and how transport infrastructure should be designed so that it is more robust in the case of natural disasters, and whether reserve capacities should be created to make incident management more effective. After the worst is over, it is necessary to select the best model of policy making for the reconstruction stage. As reconstruction often occurs under time pressure, there is a chance that links with overarching planning aims and principles are forgotten.

Of special importance is the vulnerability of transport systems in the case of criminal activities and terrorist attacks. The recent experiences in this field – the tragic train bombings in Madrid (2004) and London (2005) – make clear that transport is a soft target in both cases, because it is more difficult to protect than other targets. Given the different objectives, it is plausible that criminal activities like theft are mostly related to freight transport, whereas terrorism is more oriented towards passenger transport. The costs of these threats go far beyond the direct costs of criminal acts and terrorist attacks. For example, preventive measures, although necessary, can sometimes lead to delays in aviation schedules, implying an increase in the generalized costs. These changes may result in a decrease in overall travel demand, like in international trade (Nitsch and Schumacher, 2004) and in international tourism (Fleischer and Buccola, 2002).

Even this limited list of examples demonstrates that both natural and man-made accidents have far-reaching consequences for the planning and operation of transport systems that thus deserve due attention from policy makers and researchers during the coming years.

1.2.3 Transport System Planning and Uncertainty

Uncertainty in transport policy and planning is a theme that has attracted a great deal of interest since the 1990s. Failure to reach goals, adverse impacts of policy measures, large budget overruns in transport projects, and forecasts of future transport demand that turn out to be wrong, have all increased attention for uncertainty. Accordingly, it is now realized that transport policy – situated as it is in a dynamic field of actors’ interests, and at the same time attempting to influence systems that are unpredictable due to chaotic dynamics – suffers from uncertainty in many ways. Of course, policy tools already exist to increase insight into the costs and benefits of alternative policy interventions, or to learn about critical conditions and events in the future, as in scenario analysis, but what is new is the recognition of the need for awareness of intrinsic uncertainty and the acceptance of the implications of uncertainty for ways of policy making.
The reason why it is particularly transport policies that face such a great and comprehensive uncertainty stems from the derived character of transport which causes uncertainty in related policy areas, such as regional economics, housing and land-use planning, to spread into the transport field. Moreover, the transport system itself is complicated in nature as it encompasses all types of infrastructure, service provision, maintenance and control, use by passengers and freight, information systems to smooth processes, and an array of institutions that influence all the operations. What adds to the complexity is that, in forecasting exercises, different time-horizons need to be taken into account, ranging from a few minutes and hours to a few decades, not to mention different geographical scales.

If we take a comprehensive view of policy making and transport system behaviour, a wide range of sources of uncertainty can be identified. For example, there is complexity in the transport system itself, including social behaviour encompassing both daily traffic management and long-term planning and policy. In addition, there is complexity in policy making due to the ‘human factor’, including public opinion, emotional reactions to policy measures, value-oriented decision making, and so on. Another class of complexity in policy making is caused by the limited consensus on specific policies; a poor match with policies in adjacent fields, and so on (Friend and Hickling, 1997). There is also overestimation of the ability to design future transport images that are realistic, caused by simplistic conceptualizations of technological development and its impact on society (Geels and Smit, 2000). This limited list of examples of sources serves to demonstrate the widely different origins of uncertainty and its wide presence.

1.3 Transport Policies and Regional Network Integration

A useful tool to analyse the interrelationship between transport systems and regional development is the accessibility concept.

1.3.1 Accessibility

In the emerging European network, as a result of the recent inclusion of the new access countries, the spatial and functional positions of networks (and the related benefits from the use of these networks) are regarded as critical success factors for the development of regions, cities and firms (Martellato and Nijkamp, 1998). In this context, accessibility certainly plays a fundamental role, in investigating both slow dynamics, typical of the network supply side (infrastructure, facilities/locational development) and fast dynamics, characteristic of the user side (demand mobility/communication pattern) (Reggiani, 1998).

From the spatial/regional viewpoint, accessibility can be a useful instrument for exploring the (balanced) distribution of economic activities, the territorial dis-
equilibrium, and the development of the lagging zones: in other words, the growth performance of different regions.

The accessibility concept and its measures have a long tradition in spatial and transport science, starting from the 1960s. In particular, in the accessibility literature (1960–1990), three fundamental perspectives can be identified:

- The accessibility of a node is conceived in terms of its location.
- Accessibility is considered in terms of the opportunities that a person or group has, within a certain zone, to participate in one or more specific activities.
- Accessibility is identified by the benefits accruing to a group from living in a certain region and taking advantage of the available transport systems.

However, the different measures of these three indicators might produce conflicting results. In this context, transport policies would benefit from a synthesis of all the information contained in each of these indicators. In the recent literature, a great deal of attention is therefore given to the issue of a unique global accessibility measure. In this respect, multidimensional methods have been explored, such as Data Envelopment Analysis (Chapter 10) or Principal Component Analysis (Reggiani et al., 2005), with reference to the changes of accessibility in cities/regions generated by the construction of new European infrastructure projects (for example, the Trans-European Transport Network (TEN-T)). This brings us to the issue of spatial convergence, accessibility and network integration.

1.3.2 Spatial Convergence, Accessibility, and Integration

It is interesting to note that the equity theme mentioned earlier in Section 1.2 also has implications for the discussion on accessibility. Transport policies, and investments in infrastructure in particular, will yield benefits that are equally distributed among regions. There is a general fear that large infrastructure investments will reinforce the position of existing core regions to the detriment of peripheral regions. This relates to the theme of regional integration and convergence. The literature on this subject indicates that solutions to this problem of unbalance are not as clear-cut as is often thought (see, for example, Rietveld and Bruinsma, 1998). The point is that the effects on the various regions vary per sector. Some sectors in one region will benefit, whereas other sectors in that same region will shrink. The effects on consumers and producers in each region may well be both positive and negative. In many cases, the net effects are rather small. Of particular importance in the case of infrastructure improvements is that usually the main beneficiaries are found at the nodes connected by a new link, and possibly some other nodes that benefit from the upgraded link, whereas the disadvantages are experienced by the rest of the economy in a rather diffused way. Thus, typically the spatial distribution of benefits of transport infrastructure
investments is more focused than the distribution of the losses due to these investments.

Whereas the term ‘accessibility’ has the connotation of potential opportunities for interaction (for example, Hansen, 1959, in Martellato et al., 1998), the term ‘integration’ refers to actual patterns of interaction and flows of persons, goods and information. Increased accessibility does not automatically mean growing integration. The processes, in reality, may unfold in different ways. For example, economic actors may not be able to respond to the new opportunities, because – with the disappearance of one major accessibility barrier – other barriers to interaction may come to light, such as those caused by historical relations or by different cultures (van Geenhuizen and Ratti, 2001; and see Chapter 14). Of course, overcoming these constraints may simply be a matter of time.

Integration can also be considered in terms of quality or level. Thus, poor connectivity may allow for a certain kind of interaction but prevent other types. This is the ‘selection impact’ of barriers. Currently, selection impacts tend to occur in telecommunication networks. These networks have evolved under the influence of the market, meaning that remote areas – essentially lacking market size – remain disconnected from the national backbones which provide the highest bandwidth, and are excluded from opportunities for highly information-intensive innovative activities. This issue is addressed in Chapter 13. What has received scant attention in transport and communication studies is the level of integration following from improved accessibility or network connectivity. Opening a regional economy may lead to the establishment of dependence relations between actors that are asymmetric in nature. This has often happened, and still happens, in corporate ownership relations, decision structures, and the level of innovativeness of the new economic activities (for example, Taylor and Thrift, 1982). In an extreme case, the regions with improved accessibility become in effect a branch-plant economy and contribute to reinforcing the economic strength of core regions. These kinds of mechanisms and developments contribute to an understanding that improved transport network integration does not automatically lead to the convergence of regional economies.

1.4 Aim, Structure and Content of the Book

1.4.1 Aim and Structure

The aim of this book is to contribute to the understanding of the state of the art and new developments in policy making for transport networks and the regional impacts of network integration. In policy making, evaluation plays a central role as decision support, using \textit{ex ante} and \textit{ex post} approaches. Evaluation may include Cost-Benefit Analysis (CBA) and various other tools to evaluate policy. In addition, attention is paid to tools that analyse the impacts of transport policies on accessibility and spatial integration. This book reviews existing studies and
advances in decision support tools in transport policy and in broader evaluation studies of network integration and regional development (Table 1.1).

Table 1.1 The structure of the book

<table>
<thead>
<tr>
<th>Main Themes</th>
<th>Chapter</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td>2</td>
<td>Rietveld et al.</td>
</tr>
<tr>
<td>Equity and Efficiency</td>
<td>3</td>
<td>Bråthen and Eriksen</td>
</tr>
<tr>
<td>Accident</td>
<td>4</td>
<td>Axensten</td>
</tr>
<tr>
<td>Accident/terrorism</td>
<td>5</td>
<td>Paaswell and Berechman</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>6</td>
<td>van Geenhuizen and Thissen</td>
</tr>
<tr>
<td>Environment and modal choice</td>
<td>7</td>
<td>Givoni</td>
</tr>
<tr>
<td>VTTS</td>
<td>8</td>
<td>Zamparini and Reggiani</td>
</tr>
</tbody>
</table>

Part I: Policy Analysis in the Transport Field

- Equity
- Equity and Efficiency
- Accident
- Accident/terrorism
- Uncertainty
- Environment and modal choice
- VTTS

Part II: Transport Policies and Regional Network Integration

- Accessibility and fixed links (road, rail)
- Accessibility and TEN-T
- Accessibility and multimodality
- Accessibility and aviation
- Accessibility and ICT
- Integration
- Convergence

The book addresses, for example, the incorporation of both efficiency and equity issues in the evaluation of transport policies, and the design of an overall accessibility indicator that combines a number of partial indicators. State-of-the-art work in this book includes a review of studies on the value of travel-time savings (VTTS) due to network integration, and a review of the use of revealed and stated preference models in the location behaviour of companies with reference to infrastructure projects.

1.4.2 Part I: Policy Analysis in the Transport Field

The first part of the book contains seven contributions about new developments in the design and use of decision support tools. The newness stems from, for example, the inclusion of equity issues in evaluation methods of transport policies; a specific focus on ways to identify and map uncertainty in transport policy.
making; and the use of CBA to support decisions on the closure of certain infrastructure.

In Chapter 2, Rietveld, Rouwendal and Van der Vlist address ways to incorporate both efficiency and equity issues in the evaluation of transport policies and infrastructure projects, given the increasing emphasis on social cohesion in the European Union. The authors begin with a discussion of inequality and poverty in the European Union and the concepts and measurement concerned. Next, they review the literature on welfare economics in order to identify approaches that consider both efficiency and equity issues, and this is followed by a discussion of theory concerning compensation measures. The social welfare function seems promising where total welfare equals the product of two factors, one representing the mean value of individual utility and the other representing the inequality between actors. However, various issues need to be solved, such as the explicit consideration of distributional aspects in the reference case, a situation which is different from traditional cost-benefit analysis (CBA). The authors suggest some solutions, inter alia, using insights from compensation measures. Whereas most studies on the costs and benefits of types of infrastructure deal with options for expansion, the study by Bråthen and Eriksen (Chapter 3) focuses on the closing down of particular parts of an infrastructure. The case concerned is a network of 27 existing regional airports in Norway, built between the late 1960s and the mid-1980s. A re-evaluation of the weak parts of this network became urgent for the Norwegian government in the early 2000s as a result of higher airport infrastructure requirements. The analysis focuses on whether each airport is economically viable, compared with the situation in which the airport is closed and some of its passengers are transferred to a neighbouring airport, while other passengers refrain from travelling by air altogether. First, the authors discuss a brief overview of CBA in aviation and present some specific issues in CBA in the context of the closure of airports, such as the change in consumer surplus and aircraft operating costs, and various network effects. Next, the selection of ten candidate airports to include in the CBA is explained. Based on the calculations, including a sensitivity analysis, two categories of airports are then distinguished, that is, clearly unprofitable ones and ones whose unprofitability is uncertain. In a final part, the authors describe the political debate in Norway after the launch of the CBA results, including the need to extend the CBA.

Chapters 4 and 5 deal with transport issues related to accidents. In Chapter 4, Axensten presents the outcomes of a GIS-based system designed to calculate and visualize optimal evacuation routes in the case of a serious nuclear accident, that is, one that involves the release of radioactivity. The investigation concerns the Barents Region with a hypothetical release from the Kola Nuclear Power Plant as a case study (Kola Peninsula, Russia). The problem to be dealt with is to move every person from the affected area to places that can harbour them, while minimizing their exposure to radiation. The approach makes use of a graph model and includes the objective of minimizing flow costs. In the optimal situation, all places exceeding a certain radiation limit are evacuated completely, and there is no
evacuation from other places below this limit. The model is tested in a hypothetical (but realistic) scenario envisaging a release of radioactivity, using one evacuation zone at the accident site and another in the Gulf of Bothnia. In the former location, no evacuation problems are foreseen as most of the population centres are both relatively small and located near the Murmansk-St. Petersburg trunk road. The road network in the latter zone has sufficient capacity, except for saturation of the coastal road. In a final part, the author discusses a few variations of the model.

In Chapter 5, Paaswell and Berechman set out specific policy conditions for the evaluation of promising transit projects in New York City, that is, following the September 11 events in 2001. These tragic events resulted in severe transportation dislocation in lower Manhattan. However, the transit projects that were developed immediately afterwards not only included the rebuilding of what existed before, but also plans for new connections and linkages, increasingly outside the environs of Ground Zero. Thus, the planners began to put a much broader range of projects on the agenda. In this chapter, the authors set out the basic transportation, economic and demographic characteristics of the New York region in order to increase understanding of the environment in which models were developed to evaluate the proposed transport projects. They then briefly discuss the formal and informal planning and decision-making processes, particularly the roles of the planning organizations and the regional transportation agencies. It is notable that none of the projects originated from a single agency and nor were they connected with a regional Master Plan based upon regional overarching objectives. Thus, each single project was meant to impact a specific concern in a localized area. In a more conceptually-oriented Chapter 6, Van Geenhuizen and Thissen address uncertainty in policy making for transport technology in a new way, that is, using a systematic and comprehensive approach in order to identify and qualify different types of uncertainty. On the basis of a systems approach to policy making, they identify various generic classes of uncertainty, such as concerning the definition of the boundaries of the system; the future external factors that are beyond the control of policy makers; and the system response to these external influences. All these uncertainties culminate in uncertainty in policy making, which affects the design of effective policies and the choice of the best policy. The authors proceed with an analysis of the causes of uncertainties. Next, they apply this framework to policy making concerned with the design and implementation of Intelligent Transport Systems. According to the authors, a preferred strategy when dealing with the uncertainty involved combines further knowledge acquisition and learning using an adaptive policy.

In Chapter 7, Givoni estimates the substitution benefits arising from a mode shift between aircraft and high-speed train (HST). The substitution deals with airline and railway integration, that is, the airline offers its services on board the HST (tested on the London Heathrow to Paris route). The airlines benefit from the substitution, in spite of increased operational costs, but these would be compensated by the value of freed airport slots which can then be used for flights to other destinations. The benefits for passengers from this substitution include a
shorter travel time by HST and better travel conditions (a lower disutility), whereas the major benefit for society is a reduction of air pollution. On the methodological side, the author concludes that complexity increases with the consideration of more than one mode within one journey. Also, it appears that the current knowledge is not sufficient to estimate the exact environmental impact of one airline flight or one HST-journey. The methodological recommendations include using financial analysis to evaluate financial benefits to airlines and to use multi-criteria analysis (rather than cost-benefit analysis) in the other cases.

Chapter 8 focuses on an element that is often used in CBA relating to new traffic infrastructure, that is, the value of travel-time savings (VTTS). First, Zamparini and Reggiani discuss the analytical background and basic formula adopted to calculate VTTS. Unlike VTTS in passenger transport that is approached as maximizing a utility function, VTTS in freight transport is approached as maximizing a profit function. In the latter case, VTTS may be part of the profit function of the forwarding firm, the receiving firm or the consumer, a situation that increases the complexity of the measure. The authors proceed with a discussion of the advantages and drawbacks of revealed preference and stated preferences approaches. Because of the strict requirements necessary for a revealed preference study, most researchers are forced to apply stated preference methodologies. Following a review of empirical studies in different countries in the EU, Asia and the US the authors conclude that there is no uniform VTTS, due to the influence of various intervening variables, such as trip length, transport mode, area-specific spatial circumstances, and hidden economic and social factors. However, the freight transport studies in the EU show an average VTTS close to the one obtained in the US. Further, the authors identify important differences between the VTTS in freight transport and the VTTS in passenger transport, and stress the need to combine revealed and stated preference approaches.

1.4.3 Part II: Transport Policies and Regional Network Integration

In Part II, the focus is on the actual (potential) impacts of transport infrastructure policies: for example, accessibility impacts on the economic performance of companies, cities and regions, and on the integration and convergence of regions. Hansen, in Chapter 9, reports on the impacts of the fixed links across the Great Belt and Øresund between Denmark and Sweden. Prior to the implementation of these links, there were two different expectations, that is, an increase in traffic flow due to the elimination of ‘friction’ caused by the ferry connections and an improvement of the planning and efficiency of the logistic organization in the chains involved. First, the author elaborates the concepts of distance, speed, frequency, and time-windows in a logistic frame, and then applies these concepts in an analysis of case studies of transport companies with different positions in the logistic chains. The results of the study indicate that the fixed links (amongst other factors) have contributed to a rise in the freight traffic across the Great Belt and Øresund, mainly due to the ability to organize more frequent deliveries and to
respond better to demands for greater precision in pick-up and delivery. So far, the observed impacts have been on the logistic decision level and the operational level of material and transport flows, not on the level of relocation of companies.

In Chapter 10, Martín, Gutiérrez and Román consider the accessibility impacts of the Trans-European Transport Network (TEN-T) – with special reference to railways – on European cities for the years 1995, 2005 and 2015. In doing so, they perceive accessibility as a multidimensional quality and use a geographic information system (GIS) to calculate four partial accessibility indicators. Next, they present Data Envelopment Analysis (DEA) as a tool to synthesize indicators and provide a multi-criteria decision support tool. The accessibility-DEA index is calculated as the inverse of the maximum proportional output accessibility (potential market and daily accessibility) that can be obtained for the indicated accessibility input (location). It appears that in 1995 Brussels, Lille, London and Paris were the most accessible cities of the EU. However, in the scenarios for 2005 and 2015, London is displaced by the German cities of Frankfurt and Wiesbaden. The DEA-index suggests that connectivity does not guarantee accessibility, as illustrated by some cities in the Iberian Peninsula. In a future-oriented analysis the authors conclude that the TEN-T contributes to increasing regional accessibility disparities in the period 1995 to 2005 and to decreasing such disparities later on.

In Chapter 11, Bruinsma and Rietveld, examine traffic infrastructure in a general way. The focus is on its impact on productivity at the aggregated level (that is, regions) and at the disaggregated level (that is, individual firms), with an emphasis on the latter. In this context, the authors discuss the outcomes of revealed preference models and of stated preference models, and summarize the strength and weaknesses of different types of entrepreneurial surveys. In addition, they present a case study for the Netherlands in which they attempt to overcome some problems that occur with stated preference studies, that is, by estimating trade-offs between location factors. In a pairwise comparison, it appears that location factors with direct financial implications (price of land and investment subsidies) are the most important factors, and that distance to a highway access, to a large city, and to customers and suppliers are next in importance. Also, using logit analysis, the study of trade-offs between several location factors enables the calculation of the cost-effectiveness of various regional policy measures under restricted conditions.

In Chapter 12, Zembri explores changes in airline strategies, following the liberalization of air transport in the EU, as well as the impacts of these changes on the accessibility of the cities in the networks involved. The author observes that, despite the liberalization in the 1990s, Air France was able to maintain its position in the Paris-centred network. In addition, though small carriers were able to gain strong positions in regional hubs in networks bypassing Paris, a few years later they were dominated or acquired by Air France or Swiss Air. Next, the author discusses the concomitant emergence and partial closures of various regional hubs in France, for example, Montpellier and Saint-Etienne, and the emergence of low-cost carriers that primarily set up routes between French regions and foreign countries. In a summary of the developments since 1995, the author concludes that
the many interregional point-to-point connections established during this time have contributed to improving the accessibility of various French cities.

In Chapter 13, *van Geenhuizen* addresses the integration of relatively remote regions in the national economy in the era of modern telecommunications, particularly integration, as witnessed by the emergence of more or less innovative activities in those regions. In exploring this issue, the author uses a multiple-evidence approach from the Netherlands. The findings about the location strategies of highly innovative companies – weak signs of an increased footlooseness – and the findings about the great importance of agglomeration economies for advanced call centres provide no support for the likeliness of a high-order integration of remote regions. However, particular remote regions are able to ‘escape’ the digital divide, by utilizing their remoteness (emptiness) as a positive asset in developing information-intensive research facilities. Thus, the development of facilities for astronomical research (observatories), nuclear research, earth observation, air-traffic guidance, and the like, may be seen as an important strategy to connect remote areas with the highest bandwidth in the national telecommunication network, and to help develop clusters of local research companies in such regions.

In Chapter 14, *Nilsson* identifies the dominant spatial interaction patterns between the city regions in the Baltic Sea Area. It appears that the capital cities of Poland and the Baltic States have increasingly turned towards the Nordic countries and Western Europe at the expense of the Former Soviet Union. Further, it becomes clear that the changing interaction in the Baltic Sea Area takes place within four different but connected subsystems: the Nordic and Baltic countries; Russia; Germany; and Poland. In these subsystems, the leading city regions, such as Frankfurt, Warsaw and Moscow, have an important role in trans-border interaction, but are partly located outside the Baltic Area. In addition, the small Baltic capital cities cannot play an independent role in international networks, and thus undertake internationalization through some larger Nordic regions. The overall impression is one of fragmentation instead of integration. The city regions in the Baltic Sea Area are strongly tied to their national contexts, meaning that there is a mixed structure: a network of city regions where the national city hierarchies have a very large influence.

In the final chapter (Chapter 15) *Percoco, Dall’erba* and *Hewings* present empirical results about the role of national structural changes in convergence tendencies in the EU. In particular, they explore ways in which the changes in structure in one sector or country penetrate the rest of the EU. An empirical analysis of changes in the production structure of five European economies is followed by a description of the model used to evaluate the structural convergence process. The empirical results covering 1965–85 indicate that both sectors and economies are becoming more similar but that sectors at the European level are becoming more similar than the national economies as a whole. However, spatial disaggregation is needed to explore how structural properties manifest themselves in the regional economies involved. In their analysis of transport policies, the authors point to the role of infrastructure investment and deregulation of
transportation industries in stimulating economic convergence by reducing friction due to transport costs. The technical coefficients in the approach used can be seen as functions of the transport costs that determine interaction between economies.

1.5 Future Research

The future research paths that emerge from this volume arise from the increased complexity in transport policy and follow five main directions. The first is of a technical nature concerning a further improvement and testing of quantitative models as decision support tools: for example, to deal with the distributional aspects in the reference case in methods to incorporate equity issues in Cost-Benefit-Analysis (Chapter 2); to determine, for different assumptions, the sensitivity of simulation results on network capacity in short-term evacuation (Chapter 4); and to use advanced meta-analytic approaches in review studies, like the one on travel-time savings (Chapter 8). A second research path is to extend the mapping of uncertainty in transport policy with measurements of different degrees of uncertainty and to include a comparison of different (urban) regions with different policy settings. This connects with a third path that follows from the dynamic multi-actor situation in transport policy. This situation means that potential transport projects need to be evaluated taking into account the interests of opposing stakeholders. New ways of assigning weights in Multi-Criteria Analysis may be helpful, but Data-Envelopment-Analysis also seems promising. However, it is important to note that the political decision-making process may follow a different rationale than the one in decision-support models. Accordingly, there is also a need for systematic studies on the actual use of decision-support outcomes in the policy arena, to identify which other factors play a role in selecting transport infrastructure projects that might lead to cost overrun or wasting money in useless projects (Flyvbjerg et al., 2003; Priemus et al., 2004). A fourth type of possible future research concerns a further elaboration of the relation between accessibility and economic development. Increased accessibility does not automatically lead to economic growth (for example, Vickerman et al., 1999). However, it is not known under which conditions an increase of accessibility leads to positive impacts and which conditions may cause negative impacts. There is a need for further systematic comparative research of different regions, covering core regions and peripheral regions, small and large economies, regions with different population densities and different economic structures, and so on.

Finally, we mention research on transport policy connected with man made or natural hazards. There is a need for studies that assess the match between the capacity of existing traffic infrastructure and traffic flow in an emergency evacuation situation, for example, using simulation studies and practical experiments. This may apply to cities and regions vulnerable to nuclear disasters, volcanic eruption, flooding, and terrorist attacks. Aside from the immediate traffic flow away from the site of the event, there is also the issue of the reconstruction of
the damaged transport infrastructure afterwards (Chapter 5). A major issue is whether the previous infrastructure should be merely restored or whether the tragic events could serve as a springboard to enable major qualitative jumps in the various transport networks.

References


PART I
POLICY ANALYSIS
IN THE TRANSPORT FIELD
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Chapter 2

Equity Issues in the Evaluation of Transport Policies and Transport Infrastructure Projects

Piet Rietveld, Jan Rouwendal and Arno van der Vlist

2.1 Introduction

The main criteria to evaluate transport policies and transport infrastructure projects concern efficiency and equity. Standard Cost-Benefit Analysis (CBA) only addresses the efficiency issue. If equity issues also play a role (for example, the emphasis on social cohesion in EU policies), the question is how this can be evaluated in a joint framework.

An important distinction is between intended and unintended effects on equity. In the first case, projects are proposed with the explicit aim of improving the situation of particular groups of stakeholders (for example, improving the accessibility of peripheral regions by road construction). In the second case, projects are proposed with the aim of improving aggregate social welfare, but where some particular groups of stakeholders may be negatively affected. For example, the construction of a new road to reduce congestion may have adverse environmental effects on the communities living nearby, or it may have an adverse effect on some communities that become less accessible in relative terms.

In both cases, it is important to develop a framework for the joint analysis of efficiency and equity. In the second case, an additional question is how compensatory measures can be developed to alleviate the negative equity effects, while retaining the positive efficiency effects.

The following questions will be addressed in this chapter:

Q1: What is the current practice of measuring efficiency and equity in an EU-wide context?
Q2: How can measure efficiency and equity be measured in a joint welfare-theoretical framework?

These questions will now be dealt with in turn in Sections 2.2 and 2.3 of this chapter. The final aim of this chapter is to arrive at the introduction of equity issues in cost benefit analysis of transport policies in an operational way.
2.2 Inequality and Poverty in the European Union

During the first decades of its existence, the emphasis in the European Community has been on the promotion of free movement of persons and products. By reducing the barriers against this trade and mobility, it was expected that economic efficiency would improve. Equity gradually became more important in the policies of the EC. For example, the year 1975 witnessed the establishment of a European regional development fund. There are at least two reasons for this increasing importance of equity issues. First, there was a growing awareness that free trade might have adverse equity effects, in the sense that some countries would benefit less than other countries, or might even have negative benefits. Second, the gradual expansion of the EC made it more heterogeneous so that equity issues became more urgent.

One way to interpret the EC’s involvement in cohesion policies is that this is just a natural way of solving the bargaining problem of how to redistribute the gains of integration as a result of reducing trade barriers within the common market and enlarging its number of members (see Martin, 1998). However, it is not inevitable that such a bargaining game would arise. For example, in North America, Mexico’s joining of NAFTA did indeed lead to an increase of trade volumes, but not to the introduction of a system of transfers between countries (Boldrin and Canova, 2000).

The aims of the European Union have been formulated and reformulated on various occasions. Some of its documents state that it will have the mission of promoting an harmonious and balanced development of economic activities in the overall community, sustainable growth and a high level of convergence of economic results. In addition, it is stated that EU economic growth cannot be divorced from the need to reinforce the economic and social cohesion and that regional aspects of the problem, in terms of differences in development, require continuous attention (Cuadrado-Roura, 2001).

The cohesion aim of the European Community is broader than just redistributing money. Among the formulated aims of the structural funds are: ‘The promotion of employment, the improvement of living and working conditions, an adequate social protection, social dialogue, the development of the working force to generate a stable and high employment level, and the fighting of social exclusion’ (Boeckh, 1999; Chryssochoou, 1999).

The structural funds that have been developed in the EU during the past decades are rather small when considered from a macro-perspective. For example, compared with the total GDP of the EU, the size of the funds is about 0.5 per cent of annual EU GDP. However, at the level of individual countries, these funds are sometimes substantial. For example, for countries like Portugal, Greece and Ireland, it adds 2 to 4 per cent of total GDP. For the regions concerned, the impact may be even larger since national governments will add money from national sources (see Armstrong and Taylor, 2000). An important part of the structural funds are spent on transport infrastructure, telecommunications and the energy sector. Other parts of the structural funds flow to human resources (education) and
Equity Issues in the Evaluation of Transport Policies

...to industry subsidies. A possible justification for this emphasis on infrastructure is that the regional disparities are greater in terms of infrastructure than in terms of income. An interesting question is, of course: What are the long-run consequences for income levels of the recipient regions?

There are a large number of studies on inequality in the EU (Dunford, 1993; Magrini, 1999; Molle et al., 1980; Sala-i-Martin, 1996). A more recent review is given by Couadrado-Roura (2001). He finds that, during the early phase of the existence of the European Community, convergence of GDP per capita was significant, but that, since the 1980s, the convergence process has slowed down or even come to a halt. That regional inequalities remain at similar levels does not necessarily mean that individual regions remain at the same level. Couadrado-Roura finds that there are a substantial number of regions that experience substantial changes in their relative positions according the GDP/cap level. An interesting finding is that regions within a country tend to have rather similar development patterns. Thus, the national component still appears to dominate regional development patterns in the European Community.

A more recent development in EU policy discussions is the emphasis on poverty and social exclusion. Social exclusion is related to poverty, but it is certainly a broader concept. Poverty can be defined as ‘inadequacy of command over economic resources’. As indicated by Atkinson (2000), it has a static snapshot character, in the sense that someone who is poor this year because they are unemployed may not be poor next year when they find a job. Social exclusion is different in at least two ways: it considers not only a broader range of welfare dimensions than just economic resources, but also dynamic elements.

In this chapter, we will mainly focus on the narrow definition of poverty. Although it may be narrow in its focus, it is more precise, so that it is easier to take into account in the modelling studies. An important element of a poverty definition is the poverty line. Within the EU, poverty is measured in terms of the number of people living in households whose disposable income, adjusted for household size, is less than 60 per cent of the median of the Member State concerned (Atkinson, 2000; Eurostat, 1998). Figures for poverty, as defined above, are presented in Table 2.1. Clearly, the figures in the table depend on various points, such as the choice of the cut-off point of the poverty line (Why 60 per cent and not 50 per cent?). Also the choice of the national median as the reference point (Why not take the EU median, as this would accentuate the differences between countries?) and weighing schemes to adjust for differences in household size and composition have an impact on the figures actually found.

To address poverty issues, governments have many instruments at their disposal. In addition to general policies in the fields of education and employment programmes, regional development policies may also be used to address poverty. In addition, focused measures in the sphere of taxation, welfare payments and pensions may have rather strong impacts on poverty.
Table 2.1 Poverty figures for EU countries (1996)

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage of persons below poverty line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netherlands</td>
<td>10</td>
</tr>
<tr>
<td>Denmark</td>
<td>11</td>
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<tr>
<td>Luxembourg</td>
<td>14</td>
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<tr>
<td>France</td>
<td>16</td>
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<td>Austria</td>
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<td>Belgium</td>
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<td>Germany</td>
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<td>Italy</td>
<td>19</td>
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<tr>
<td>Spain</td>
<td>19</td>
</tr>
<tr>
<td>UK</td>
<td>20</td>
</tr>
<tr>
<td>Ireland</td>
<td>21</td>
</tr>
<tr>
<td>Greece</td>
<td>21</td>
</tr>
<tr>
<td>Portugal</td>
<td>24</td>
</tr>
<tr>
<td>EU average</td>
<td>18</td>
</tr>
</tbody>
</table>


When we consider the measures taken at the EU level to address poverty issues, two main approaches can be distinguished. The first is the use of educational programmes in order to build human capital. Molle (1990) mentions that these programmes did indeed imply a redistribution of European money, but the effects on labour market opportunities of the persons concerned were not convincing. The second is the use of the regional fund with its emphasis on the spatial dimension of poverty.

This is not the place to give an extensive discussion of EU policies which deal with cohesion and social exclusion. In order to make cohesion an integrated dimension of the policies, it is necessary that operational measures are available that are appropriate and can be well understood. The many choices that have to be made to arrive at such measures can be classified as follows.

2.2.1 Inequality of What Variable?

Usually inequality is measured by means of income or GDP per capita data (see Cuadrado-Roura, 2001). But other relevant indicators could also be used such as consumption, unemployment, particular quality of life aspects (environmental quality, supply of public services, life expectancy, accessibility, and so on) For example, Bruinsma and Rietveld (1998) carry out a comparison of European city regions in terms of their international accessibility. In principle, one could also derive aggregates of these welfare dimensions to arrive at total quality of life indicators.
2.2.2 Inequality Measured at What Level of Aggregation?

One might argue that the most appropriate level of aggregation is the individual. However, in some cases, such as income, households seem to be more relevant. Most studies on inequality in the EU relate to larger units of observation, such as regions and countries. One might argue that the regional focus is not fruitful because it is people that matter, not the place where they happen to live. However, interregional and especially international migration within the EU is very low so that the regional element in disparities should not be ignored. This leads to the issue of decomposition of inequality: total inequality is the sum of interregional inequality and intraregional inequality. A general finding is that intraregional inequality by far dominates interregional inequality. For example, Rietveld (1991) finds that, for most relevant welfare indicators in the Netherlands, the interregional share of total inequality is about 1 per cent. On the other hand, at the world level, the within-country inequality appears to be smaller than the between-country inequality (Milanovic, 2001). For the EU, an intermediate result may be expected.

2.2.3 Which Inequality Measure?

As will be explained below, a large set of inequality measures exists. Some well-known examples are the Gini coefficient, the Theil measure, and the coefficient of variation. Given the importance of the decomposition issue, decomposability is an attractive feature. Another issue which deserves attention is whether the measure should address inequality per se or the presence of poverty which implies the introduction of a benchmark.

2.3 Welfare-Based Measures for Efficiency and Equity. A Literature Review

2.3.1 Introduction

This section reviews some aspects of welfare economics that are relevant for operational measurement of efficiency and equity. It does so by formulating a unified theoretical framework in which these measures can be placed. That framework is provided by microeconomic theory.

We first consider interpersonal comparisons of utility and the concept of equivalence scales. We continue with a discussion of the social welfare function. This function is considered as a tool for organizing and developing our thinking about social welfare. It is shown that familiar concepts for measuring efficiency in the context of CBA (such as social surplus and consumer’s surplus) can be derived within this framework. Moreover, popular inequality measures can be placed in the same framework. The social welfare function therefore allows us to address equity and efficiency issues within a single consistent framework. Different concepts of
social welfare are interpreted as different specifications of the social welfare function.

2.3.2 Ordinal Measures for Group Welfare

Here we consider welfare at the level of groups. This means that the question of interpersonal comparability of utility has to be faced. According to the Pareto principle, one situation should be preferred to another if all persons are at least as well off, and at least one is strictly better off. Most people agree with this position. However, the main problem with it is that it is not helpful in many practical situations in which one has to compare situations in which some people gain, but others lose.

Kaldor (1939) has suggested using the sum of the compensating variations as a measure of welfare change. The intuitive interpretation is that a positive sum of compensating variation implies that those who gain from the policy being evaluated can compensate the losers. The project can therefore be transformed to one that implies a strict Pareto improvement by transferring money. Kaldor suggested that compensation should not necessarily take place, and that the potential of a Pareto improvement suggested by a positive sum of compensating variations should be sufficient.

The compensating variation is a strictly ordinal concept. If Kaldor’s criterion is correct, we would therefore have a welfare measure that is compatible with ordinality and that enables something to be carried out that comes very close to interpersonal comparability of welfare changes. However, Sen (1970) and Boadway (1974) have shown that the concept has serious shortcomings and cannot in general be considered to be an adequate welfare measure. Below, we shall see how the sum of the compensating variations can be derived from a social welfare function. However, a social welfare function requires interpersonal comparability of utilities.

We conclude that not much progress is possible if we are unwilling to relax the point of view that interpersonal comparisons of utility are impossible. The main possibility for doing so is to make use of the concept of the social welfare function. The social welfare function has the utilities of the individuals in the group to which it refers as its arguments. The formulation of such a function therefore only makes sense if these utilities can be compared. In the next section, we will discuss one way to look at interpersonal comparability of utility.

2.3.3 Interpersonal Comparisons of Utility and Equivalence Scales

Consider, first, individuals with identical preference orderings. It is conceivable that, despite their similarity in behaviour, they differ enormously in happiness. But is this difference relevant for the purpose of welfare-economic analysis? According to Deaton (1980) it is not:
... I shall take it as axiomatic that for two individuals with identical preferences (that is, identical behavior in all circumstances), the same economic constraints give rise to the same welfare. Even if, in some fundamental sense this is not true, if one individual can extract more welfare from the same consumption than another individual, I believe that practical welfare measurement should be fundamentally based on opportunities rather than their untestable consequences. No government is going to give special treatment to an individual who claims his extra sensibilities require special facilities, at least not without some objective evidence of why money means something different to him than to anyone else (p. 51).

Differences in tastes can be dealt with by relating them to (possibly unobserved) differences in household characteristics. This means that ‘fundamentally, all households are assumed to have the same utility function but this function has as many arguments as are necessary to explain variations in behavior’ (Deaton, 1980, p. 52). This means that equivalence scales should be used in order to compare the utilities of households with different characteristics. Money-metric utility is the basic concept, but it is now extended to deal with differences in household characteristics. Assume that there is a single generic utility function with as argument the vector of goods consumed \( q \) and a vector of household characteristics \( h \):

\[
u = u(q, h). \tag{2.1}
\]

Associated with this utility function are indirect utility and cost functions. The latter gives the minimum amount of money \( x \) that is needed to obtain a utility level \( u \) at given prices \( p \). The cost function can be written as:

\[
x = c(p, u, h). \tag{2.2}
\]

Let us now take an (arbitrary) value of \( h \), say \( h^0 \), as our point of reference. In order to reach a utility level \( u^0 \), a household with reference characteristics should, at the reference prices, have a budget:

\[
x^0 = c(p^R, u^0, h^0). \tag{2.3}
\]

In order to reach the same utility level, a household with characteristics \( h^1 \) should have a budget:

\[
x^1 = c(p^R, u^0, h^1). \tag{2.4}
\]

If we want to use the same measure of money-metric utility for all households, we should therefore adjust for differences in household characteristics. In order to see how this equivalence scale should be defined, consider the following equation:

\[
x^0 = \begin{pmatrix} c(p^R, u^0, h^0) \\ c(p^R, u^0, h^1) \end{pmatrix} x^1. \tag{2.5}
\]
This identity than can be derived easily from the two preceding equations. The first term on the right-hand-side is the appropriate equivalence scale. The equation suggests a way in which one can compare money-metric utilities across households that differ (in composition and therefore) in tastes. Since the utilities as measured by the utility function itself are equal for both households $h_0$ and $h_1$, the corresponding money-metric utilities should also be equal. Income $x_1$ should therefore be transformed by means of the equivalence scale to $x_0$, the income that household $h_0$ (which is our reference case in this context) would have needed to reach the same level of utility. Note that the correction implied by the above equation is intuitive: household $h_1$ needs a higher expenditure level to reach the same level of utility as household $h_0$. Equivalence scales have been widely used in order to correct for differences in household composition, and especially for the effect of children on household welfare.

Some examples might be useful at this point. If preferences are homothetic (see Gravelle and Rees, 1994) the cost function can be written as:

$$c(p, u, h) = ub(p, h).$$  \hspace{1cm} (2.6)

The left-hand-side of this equation gives the amount of money needed to arrive at utility level $u$. One can therefore interpret the term $b(p, h)$ as the ‘price’ of one unit of utility. Since this price depends on household characteristics, the value of the left-hand-side is different for households that differ in composition. If $u$ is equal for two such households, money metric utility is, of course, also equal and the equivalence scale is essentially a way to deflate (or inflate) the expenditure of one household to its money metric utility. Since utility cancels out, the equivalence scale is in this case equal to:

$$\frac{b(p^g, h^g)}{b(p^g, h^1)},$$  \hspace{1cm} (2.7)

which can be interpreted as the ratio of two prices of utility. Homotheticity is a very special characteristic of preference, which has no empirical support. It is therefore useful to see also how this methodology works for less restrictive demand systems. For instance, the well-known almost ideal demand system of Deaton and Muellbauer (1980) has, when household characteristics are taken into account:

$$c(p, u, h) = \exp(a(p, h_1) + ub(p, h_1)),$$  \hspace{1cm} (2.8)

and gives rise to an equivalence scale of the form:

$$\exp\left[a(p^g, h^g) - a(p^g, h^1)\right] + \left[ub(p^g, h^g) - b(p^g, h^1)\right].$$  \hspace{1cm} (2.9)
In this case, the value of the equivalence scale is dependent on the utility level at which the comparison takes place.

2.3.4 Social Welfare Functions: Discussion

There exists no unique social welfare function and the specification of such a function is to some extent arbitrary. However, some general properties that are reasonable can be listed.

- The social welfare function should be non-decreasing in its arguments. This means that social welfare will never decrease if the welfare of one member of the group to which it refers increases.
- The social welfare function should satisfy the Pareto principle.
- The social welfare function should have convex indifference curves.
- The social welfare function should be symmetric. This means that the value of the social welfare function depends only on the welfare of its members, but not on which household has which welfare level. (For this to be a reasonable requirement, it is necessary that corrections for differences in household characteristics have been made.)
- The social welfare function should satisfy the ‘principle of transfers’ which says that transferring money-metric utility from a rich to a poor individual (without changing their relative positions) will always increase social welfare.

The social welfare function can be specified in many ways, and we will discuss some examples in the following subsections. These examples do not possess all the properties that have been listed (for instance, the Benthamite function does not have strictly convex indifference curves).

In what follows, we shall always assume that money-metric utilities have already been made comparable by means of equivalence scales.

2.3.5 The Sum of Individual Utilities and Social Surplus

In this and the following sections, we discuss various possibilities for specifying a social welfare function. We start with perhaps the easiest specification: social welfare may be considered to be the sum of the individual utilities. Maximization of social welfare implies maximization of the sum of individual utilities. For this reason, this social welfare function is often called Benthamite, after Jeremy Bentham, who proposed the ‘greatest happiness of the greatest number’ as the purpose of social policy. Consider the following welfare function:

\[ W = \sum_{i} x_i / N = \mu. \]  \hspace{1cm} (2.10)
Here \( N \) denotes the number of individuals in the group, and the symbol \( \mu \) (denoting average money metric utility) has been introduced for later reference. Social welfare, according to this specification, equal to the average value of the money-metric utilities. This social welfare function has as a special characteristic that its value depends only on the sum of the individual money-metric utilities and not on the way it is distributed. For instance, if income is redistributed in such a way that the utility of all but one members of the group is equal to zero, and that of the remaining individual is equal to the sum of all original utilities, social welfare would remain unchanged. Alternatively, the welfare function can be interpreted as stressing the total value of money-metric utility. It might therefore be expected that this specification of the welfare function has some relationship with the measures for individual welfare that were discussed in the previous section. In that section, we briefly discussed consumer’s surplus as a possible measure of welfare change at an individual level. One of its practical advantages is that aggregation across individuals is easy: the consumer surplus as measured under the aggregate demand curves is equal to the sum of the consumer’s surpluses measured under the individual demand curves. The shortcomings of consumer’s surplus can be avoided by using the compensating or equivalent variation, and Kaldor (1939) has proposed the use of the sum of the compensating variations as a measure for aggregate welfare change. In the first part of this section, it was mentioned that the sum of the compensating variations cannot be regarded as an ordinal concept of group utility. Now we will see how it can be interpreted in the context of an analysis that uses a Benthamite social welfare function. We want to compare two situations, denoted with superscripts 0 and 1, respectively. In the two situations, prices are different. The difference in welfare associated with that in the prices is:

\[
\Delta W = \sum_i \left( c(p^1_i, u^1_i) - c(p^0_i, u^0_i) \right) \\
= \sum_i \left( [(c(p^1_i, u^1_i) - c(p^1_i, u^0_i)) + (c(p^1_i, u^0_i) - c(p^0_i, u^0_i))] \right) \\
= \sum_i (\Delta \nu_i + cv_i) 
\]

The change in welfare is thus equal to the sum of the changes in real expenditure evaluated at \( p^1 \), denoted as \( \Delta \nu_i \), and the compensating variations, with \( p^0 \) as the reference prices. This sum is often referred to as the ‘social surplus’ and is much used in theoretical as well as empirical analyses (see, for example, Tirole and Laffont, 1993). The change in welfare would be equal to the sum of the compensating variations if, for all households, expenditure remained unchanged. Even though the explicit use of a social welfare function provides a solid welfare economic foundation for cost benefit analysis, it should be noted that discussion on the use of this method continues (see, for instance, Brekke, 1997, 1998; and Johansson, 1998).
2.3.6 Measures of Poverty

An important aspect of welfare is poverty, and it might be asked whether the social welfare function is able to deal with this issue. Since poverty has to do with income, it would be expected that this is the case. It is first necessary to deal with the measurement of poverty. The simplest and most common way to do this is to define a poverty line. The poverty line can be considered to be the critical income level that is on the boundary between poor and non-poor households. Since we have already dealt with differences in household composition, we can assume that the poverty line refers to a single level of money-metric utility. An often-used measure of poverty is the head-count ratio, which measures the fraction of the households with an income below the poverty line. We can define welfare as:

\[ W = \sum_i d(x_i) / N, \]  

(2.12)

with \( d(.) \) a function that is equal to 1 if the household is not poor and equal to 0 otherwise. If we denote the poverty line as \( x^p \), we have:

\[ d = \begin{cases} 0 & \text{if } x_i < x^p \\ 1 & \text{otherwise} \end{cases} \]  

(2.13)

The head-count ratio is the share of the population with income/utility below the poverty line. According to the function given above, social welfare is equal to 1 minus the head-count ratio. On the measurement of poverty lines, see Ravallion (1998). The head-count ratio has some drawbacks as a measure of poverty. For instance, it is insensitive to the difference between actual income (or utility) and the critical value given by the poverty line. This implies that the poverty measure remains unchanged if all the poor households experience a decrease in income. This is counterintuitive, and other welfare measures have been proposed (see, for example, Sen, 1976). A social welfare function that expresses an extreme concern with the least well off was proposed by John Rawls (1974). The measure proposed by him can, in the present context, be considered as a social welfare function that identifies welfare with the lowest money-metric utility.

2.3.7 Homogeneous Welfare Functions and Income Inequality Measures

Now assume that the welfare function is homogeneous of degree 1 in utilities. This means that multiplication of all utilities by the same positive constant \( k \) results in multiplication of the value of the welfare function by the same constant. This implies that we may write:
\[ W(x_1, ..., x_n) = k W \left( \frac{x_1}{k}, ..., \frac{x_n}{k} \right). \]  

If we choose \( k \) to be equal to the mean value of utility \( \mu \), this implies:

\[ W(x_1, ..., x_n) = \mu W \left( \frac{x_1}{\mu}, ..., \frac{x_n}{\mu} \right). \]  

We can always scale the function \( W \) in such a way that \( W(1, ..., 1) = 1 \). Under general conditions, 1 is also the maximum value of this function. The reformulation of the homogenous welfare function has an interesting interpretation. The first term on the right-hand-side is the Benthamite welfare function of the previous subsection, which can be interpreted as an indicator of efficiency (social surplus). The second term on the right-hand side measures the equality of the distribution of the individual utilities and can therefore be considered as addressing equity issues. Since indicators of inequality are more common than indicators of equality, the welfare function may be rewritten as:

\[ W(x_1, ..., x_n) = \mu \left( 1 - I \left( \frac{x_1}{\mu}, ..., \frac{x_n}{\mu} \right) \right), \]  

where \( I \) is an inequality measure.

An example of the approach outlined above is the welfare function proposed by Atkinson (1970):

\[ W = \left( \sum_i \frac{x_i}{1 - \varepsilon} \right)^{1-\varepsilon}. \]  

Two properties of the social welfare function are important for the measurement of inequality. First, it is homogeneous of degree 1. Second it satisfies Dalton’s principle of transfers, which says that social welfare should increase if income is transferred from a rich to a poor households (provided their relative positions remain unchanged). If we denote mean income as \( \mu \), we may rewrite social welfare as:

\[ W = \mu \left( \sum_i \left( \frac{x_i}{\mu} \right)^{-\varepsilon} \right)^{1-\varepsilon} \]  

If all incomes are equal to the mean value, social welfare is equal to \( \mu \). The second term on the right-hand side would then be equal to 1. If some or all incomes differ from the mean, this second term will be smaller than 1, because of the
principle of transfers. The smaller this term is, the more unequal is the income distribution. It seems, therefore, natural to use as a measure of income inequality:

$$A = 1 - \left( \sum_i \frac{(x_i / \mu)^\epsilon}{1 - \epsilon} \right)^\frac{1}{\epsilon - 1},$$

(2.19)
as was done by Atkinson. The coefficient $\epsilon$ can be interpreted as the degree of inequality aversion. If it is equal to zero, we arrive at the Benthamite social welfare function.

If we have a measure of inequality that takes on a value between 0 and 1, we can always regard it as being derived from a homogeneous welfare function. An example is the Gini-coefficient. This inequality measure is equal to:

$$G = \frac{1}{2N^2 \mu^2} \sum_i \sum_j |y_i - y_j|.$$

(2.20)

This is the sum of the absolute differences between all pairs of incomes, divided by twice the squared number of individuals multiplied by the mean income. From the familiar graphical illustration of the Gini-coefficient, it is clear that its value is always between 0 and 1.

An interesting feature of the homogeneous social welfare functions is that they allow for a separation between efficiency and equity issues. The former are incorporated in average utility $\mu$, the latter in the inequality measure $I$. As a first order approximation, we may always write the welfare effects of a policy measure as:

$$dW = d\mu - (Id\mu + \mu dI).$$

(2.21)
The first term on the right-hand-side represents the change in social surplus, which is conventionally measured in CBA. If we do not take into account equity issues, the project is considered as beneficial to society if this first term is positive. The above equation adds a second consideration. If social surplus is increased and inequality decreases, the product is always beneficial. If social surplus increases, but inequality increases, the two effects have to be weighted. If a project does not pass the conventional cost-benefit test, it may still be beneficial to society if it decreases inequality. The trade-off between efficiency and equity is implicitly incorporated in the definition of the inequality measure that we use. For instance, if this is Atkinson’s measure $\epsilon$, then the coefficient that indicates risk aversion, also indicates the weight attached to equity issues.

2.3.8 Other Inequality Measures and Social Welfare Functions

In this subsection, we briefly mention other measures of inequality that are often used: the coefficient of variation of (the logarithms of) incomes, and Theil’s
entropy measure. The coefficient of variation is defined as the ‘ratio of the standard deviation and the mean of a distribution’. This measure is often used in research on regional inequalities. However, it has no upper bound, and therefore it cannot be considered to be derived from a homogeneous welfare function. If we divide Theil’s measure by its maximum value (ln N), we derive an inequality measure that can be linked to a homogeneous welfare function.

2.3.9 Countries and Regions

Efficiency and equity issues can be discussed and analysed at various levels (countries, provinces, municipalities). It would, of course, be useful if all these measures could be placed in a consistent framework. It is well known that Theil’s inequality measure can be used to decompose total inequality into inequality between groups and inequality within groups (see Theil, 1967). Another measure that shares this attractive property is the coefficient of variation. However, as noted above, this measure has the disadvantage that it cannot be derived from a utility function. Other inequality measures do not have this convenient property of decomposition. However, it may be noted that a number of social welfare functions (notably the Benthamite and homogeneous ones) can be interpreted as indicating the welfare of an individual that is representative for the group. If this group is part of a larger group, we can therefore define the welfare of this larger group as a function of the welfare of the smaller group. In this way, we can nest the welfare functions at a number of aggregation levels.

2.4 Discussion

In this contribution we have surveyed a number of approaches to address equity issues in CBA of transport policies. A promising approach is the use of the social welfare function in Section 2.3. This leads to the formulation where total welfare equals the product of two factors, one representing the mean value of individual utility, and the other representing the inequality between actors, written as:

\[ W(x_1, \ldots, x_N) = \mu \left[ 1 - I \left( \frac{x_1}{\mu}, \ldots, \frac{x_N}{\mu} \right) \right]. \tag{2.22} \]

This formulation implies that an inequality index \( I \) has to be formulated. Possible candidates for such an index are the Gini, Theil, or Atkinson index, as explained in Section 2.3. These indices may give rise to different outcomes when they are applied to a particular empirical case. As long as there is no firm basis to prefer one inequality indicator above another, the obvious choice is to present results for the various indices simultaneously.

A more difficult issue is the formulation of the meaning of the \( x_1, \ldots, x_N \). The formula can be applied to any partial indicator of welfare. For example, if one
wants to measure $x_n$ as disposable income of individual $n$, the formula can immediately be applied. In a similar way, the formula can be applied to any other partial indicator of welfare, such as the accessibility of public services, environmental quality, or leisure time. This is certainly a useful exercise, since it generates explicit information on equity issues according to various relevant dimensions. Note, however, that correlation coefficients between these utility components may well be negative: people living in densely populated regions may earn high incomes but may have fewer environmental amenities available to them compared with residents of rural areas. Thus, from an integrated welfare perspective it may well be that high inequalities in one domain can be compensated by a high inequality in another domain. For the aggregation of these partial equity issues, it is not possible to do without the specification of an overall underlying utility function. This brings us to the next option.

If the aim is for an integrated view of welfare, taking into account the various underlying components of utility these components of utility, have to be aggregated to arrive at money-metric utility values. This is similar to the computation of a ‘green national product’ where various quality of life aspects have been taken into account, but now at the individual level. For example, contingent valuation approaches can be used to arrive at the money-metric valuation of changes in environmental endowments. In a similar way, value of time studies can be used to arrive at money-metric valuations of travel time. Such valuations are part of many standard CBAs. Note that standard applications of cost benefit analysis are formulated in terms of differences in money-metric utility between a particular alternative and a reference alternative. The point is that the absolute values (that is, the money-metric levels of aggregate utility) of the reference case and the other alternatives do not matter in standard cost benefit analysis: the change in total welfare is just equal to the sum of the changes in individual welfare. However, in the case of the more general welfare indicator, where equity is taken into account, the utility values in the reference case become important. The point is that, in order to compute $\Delta W$, the difference in welfare between two alternatives, it is not necessary to have information on $\Delta x$ but also on the level of the $W$ function itself.

This is an important result because it implies that the distributional aspects in the reference case have to be considered explicitly. Consider, for example, two alternatives that lead to an equal outcome for average utility. If the first alternative leads to a less extreme distribution of net changes compared with the latter, one might be tempted to state that the first alternative should be preferred. However, without information on the distribution of welfare in the reference case, such a conclusion is not warranted. For example, it is particularly welfare-improving when a project leads to large positive effects for individuals that have low values in the reference case. Thus, depending on the situation in the reference case, it might well be that the first alternative leads to a less equal welfare distribution than the second alternative.

Thus, for an ideal approach one would need an indicator of money-metric utility which takes into account all relevant utility determinants. A possible way to arrive
at this result would be a *linear approximation of the welfare function*. This would imply a function where $\Delta W$ can be written as the weighted sum of changes in $x_n$. The weights will depend on the value of the money-metric utility level of individuals $x_n$. Thus, again the issue of determining the levels of total money-metric utility at the individual level cannot be avoided. Given the social welfare function $W(x_1, \ldots, x_N)$ it follows that:

$$\Delta W = \left(\frac{dW}{dx_1}\right)\Delta x_1 + \ldots + \left(\frac{dW}{dx_N}\right)\Delta x_N. \quad (2.23)$$

To make this operational, the values of $x_n$ and $\Delta x_n$ have to be determined. Thus, in addition to income, ideally other welfare relevant aspects are also considered such as the valuation of accessibility and of environmental quality. This expression for $\Delta W$ is essentially a linear welfare function where weights $w_n: \left(\frac{dW}{dx_n}\right)$ vary among actors. Note, however, that this only yields meaningful results for small changes, otherwise the weights can no longer be assumed to be constant. An issue that needs further consideration is the derivation of the weights on the basis of the various specifications of the welfare functions considered.

Another approach found in the literature and in policy practice is to consider the reference case (status quo) as a neutral starting point. An often-observed view in policy analysis in the transport field is that policy should improve overall efficiency, and that if welfare changes are distributed in an uneven way among the actors, this is a point that has to be accommodated if possible. Thus, this approach considers equity effects as an unintended side effect of transport policies.

Another issue in the analysis of equity in transport policies concerns the unit of measurement. The ideal would be to use data on individual welfare effects. A next-best alternative is to have data on homogeneous groups. In the context of the present chapter, the regional dimension is particularly relevant. We have observed in Section 2.2 that the large inequalities in Europe are intraregional in nature, the share of interregional inequality being much smaller. The use of spatially-decomposable inequality measures is recommended to address this issue in an adequate way. This makes the Theil inequality index an attractive measure.

We conclude that the introduction of equity considerations into policy analysis of transport policies and of transport infrastructure projects does not make things easier. It is a complex issue that nevertheless has to be addressed to improve the relevance of CBA for policy-making processes.

**Note**

1 This chapter is partly based on the contribution of the authors to the EU IASON project.
References


Chapter 3

Economic Impact Assessment for Analysing the Viability of Regional Airports in Norway

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3.1 Introduction

The Norwegian regional airport system consists of 27 airports. They are mainly served by operators under public service obligation (PSO). According to EU regulations, PSO routes are subject to competitive tendering for periods of three years. This chapter reports the method and results from an economic impact assessment of parts of this airport system, which is illustrated in Figure 3.1.

The regional airport network (the smallest dots) is relatively dense, especially along the western and northern coastline. These airports were mainly built between 1968 and 1986, to serve community centres with poor surface transport. The travel time to a neighbouring airport could easily amount to 3 hours. The initial aircraft type was STOL aircraft (Short Take-Off and Landing), mainly the Fokker DHC-6 (Twin Otter, 19 seats). The runway lengths are approximately 800 m, with only a few exceptions. The airports that are analysed in this chapter lie within the ellipses.

Most of the regional airports were established in terrain that offers serious limitations to expansion. The possibilities of taking future changes in operational rules and safety standards into account are thus in many cases limited. This may constitute a problem, since no adequate STOL-aircrafts are manufactured today. They are now being replaced with larger aircrafts like de Havilland DHC-8 (Dash 8, 37 seats) and the ATR 42 (42 seats), but only a few upgrades of the runway infrastructure have been made. The local communities previously owned the regional airports, but from 1998 the state, represented by the Norwegian Air Transport and Airport Management (NATAM), took over the ownership of all PSO airports.

NATAM’s successor, AVINOR1 is a fully state-owned company and responsible for its own financial viability through revenues from user charges and other commercial activities. At the same time, AVINOR’s role in the Norwegian transport sector calls for a broader economic appraisal of projects within its jurisdiction, as supplementary to AVINOR’s financial assessment. AVINOR has
on several occasions claimed that the revenues from airport charges are not sufficient to cover the necessary improvements of the regional airport network.

Figure 3.1 The Norwegian airport network

In cooperation with the Ministry of Transportation, AVINOR therefore decided to perform a study, applying Cost-Benefit Analysis (CBA) techniques in order to provide information about the economic viability of the weaker parts of the regional airport network. Together with information about operating conditions, CBA should support decisions with respect to whether any of the regional airports should be closed. Molde Research Institute and the Institute of Transport Economics were appointed to carry out this study.
Consequently, there are three main reasons why the government wanted to assess whether all parts of the network were viable for future operations:

- In general, larger aircraft have higher requirements connected to airport infrastructure, like runway length, runway end safety areas (RESA), and unrestricted terrain near the airport.
- Over the years, improved surface transport has reduced air transport’s comparative advantage. Today, for many airports the travel time to a neighbouring airport has been reduced by 1 to 1.5 hours.
- The financial deficits from the regional airports call for more comprehensive CBA in addition to the financial assessments, to check whether the retention of the airports in question is desirable when the full economic effects are considered, and as a basis for the political debate.

The analysis that will be presented in this chapter focuses on whether a particular airport is economically viable compared with the situation where that airport is closed and the passengers transferred to a neighbouring airport. The rest of the chapter is organized as follows. In Sections 3.2 and 3.3, brief discussions of the applied CBA method and data are provided. The selection of airports for the CBA is made, and the results are presented and discussed. A short discussion of the decision-making process is provided in Section 3.4, before conclusions are made in Section 3.5.

### 3.2 Cost-Benefit Analysis (CBA)

#### 3.2.1 CBA in Aviation – An Overview

The main purpose of CBA is to provide a basis for the choice and the ranking of projects. Thus, it is important that the analyses are comparable across different projects. CBA gives the net changes in the use of real resources, measured in monetary terms. The most important economic effects to be analysed within the aviation sector are:

- Changes in generalized travel costs, often in terms of changes in time costs. If present, changes in air ticket costs and transport costs to/from airports should also be taken into consideration.
- Environmental effects, like noise and emissions.
- Effects on safety.
- Investments and operating costs.

Network effects are relevant when flight corridors and routes are affected. These include effects on the generalized travel costs for passengers in other parts
of the network, as well as for different operators. The method is thoroughly described in Bråthen et al. (2001).

A CBA should be considered because, most often, changes in air ticket prices will not be able to internalize the changes in consumer surplus that is caused by the project. Presumably, the most complex part of the analysis is to identify the impacts in terms of real costs and benefits for each alternative. The real costs are adjusted for fiscal taxes and external costs like emission and noise nuisance costs are included. For a discussion of the concept of external costs, see, for example, Button (1993).

One of the main assumptions in CBA is that prices are determined in a competitive environment. However, within aviation, taxes are levied for various reasons, which violates this assumption. Like most other aviation authorities in Europe (Fewings et al., 1998), AVINOR has a financial responsibility for its own activities. The cost structure within important parts of the aviation system (for example, uncongested airport infrastructure and air traffic management systems) is characterized by increasing returns to scale (IRS). Figure 3.2 shows the possible pricing strategies with IRS.

For a monopolist, profit-maximizing behaviour gives the price $P_m$ and the corresponding traffic volume $X_m$. According to the theory of monopolistic behaviour, the profit-maximizing price is determined where the marginal revenue (MR) equals marginal costs (MC). Normally, to ensure cost coverage the
monopolist is subject to regulations which aim at a pricing regime where the price equals average costs \( (P_a) \). Price \( P_c \) equals marginal cost, which maximizes economic efficiency, but leaves a financial deficit equal to the shaded area \( P_{SDC} \).

For the aviation authorities, in most cases the air charges are submitted to the Ministry of Transport for approval, and the principle of \( P_a = AC \) is applied. In a case with elastic demand, the dead weight loss from deterred traffic is the area ECF in Figure 3.2, which is reduced to the area EGF with a less elastic demand. In practice, the air charges are differentiated among aircraft categories, but not for each airport or leg (non-stop flight distance). There are thus reasons to believe that the air ticket costs used in the CBA are biased compared with using the marginal cost principle. This bias may go both ways, as long as congestion charges are not levied.

In general, it is well known that, if prices exceed marginal costs, a CBA will underestimate social benefits, and, conversely, if prices are lower than marginal costs (Mohring, 1993). If average cost pricing is common for the PSO airports it means prices higher than marginal cost. On the other hand, external costs like pollution, noise and congestion may not be reflected correctly in AVINOR’s charges. Further investigations should be done to check whether there is a tendency to underestimate social benefits in the PSO network.

AVINOR’s charges are levied on the basis of average cost pricing for a network of airports, where these costs also comprise a mark-up to cover the costs of investments within a given time period, as shown in Figure 3.2. Even if the pricing regime varies among the European countries according to the way the civil aviation is organized (Fewings et al., 1998), there is a significant element of governmental price control based on some kind of average cost pricing.

If the air charges can be currently adjusted to internalize the user benefits correctly, then the changes in air ticket prices will reflect the change in economic welfare, and a financial analysis will be sufficient. Likewise, if environmental effects like noise and emissions are correctly valued, a corresponding change in air ticket revenues will internalize the value of these effects. For example, if the costs of implementing damage-reducing measures, say noise abatement, are internalized in the air charges, then the WTP (willingness to pay) can be used directly to calculate whether the noise abatement expenses are being covered.

3.2.2 CBA for Regional Airports

3.2.2.1 Change in consumer surplus When the effects of airport closure are considered, there are reasons to believe that a large share of the passengers will use a neighbouring airport. Some others will refrain from travelling altogether because of the increase in total travel costs. This is the opposite effect of traffic generated from, for example, new road projects. The economic loss from air traffic deterrence is calculated correspondingly, as shown in Figure 3.3.
Figure 3.3 shows the change in consumer surplus (CS) from an airport closure. The difference in generalized travel costs together with the deterred traffic ($X_0 - X_1$ in the figure) and the traffic that will use the neighbouring airport ($X_1$) is used to calculate the black and crosshatched area. The black area is the loss in consumer surplus for those who will still go from the neighbouring airport, while the crosshatched area is the loss for those who are completely deterred because of the higher travel costs. The value of the reduction in CS discounted over 25 years is:

$$NT = \sum_{i=1}^{25} \frac{X_{1i} + X_{0i}}{2} (G_1 - G_0)(1 + r)^{-i},$$

where:
- $NT$ = Net present value of the CS loss, 25 years;
- $X_{1i}$ = Traffic that will use neighbouring airport, year $i$;
- $X_{0i}$ = Traffic at the existing airport, year $i$;
- $G_1$ = Generalized travel costs by going from neighbouring airport;
- $G_0$ = Generalized travel costs by going from the airport that is assessed with respect to possible closure;
- $r$ = Discount rate (here 7 per cent).

3.2.2.2 Aircraft operating costs In these analyses, aircraft costs are one of the most important factors. Assumptions with respect to aircraft operations before and after the airport closure may have significant impacts on the CBA results.
As the point of departure, the economic cost of air services should reflect the marginal use of real resources that is needed for this specific trip. The economic theory of welfare provides relatively straightforward pricing rules:

- The passengers should pay for the use of real resources (in addition to the person’s own costs, such as time costs, and so on), that is, the price should cover the marginal cost of the trip. In second-best situations with, for example, financial constraints (maximum deficits on PSO routes) a mark-up towards average cost pricing may be necessary.
- When an air service supply is correctly dimensioned (optimized), the utility of the marginal unit of supply should be greater than or equal to the marginal cost of supplying that unit.

This may call for a differentiated assessment of the costs of air services. If the costs of air services are to be assessed by CBA, there may be two main categories of assessment:

1. The marginal extension or reduction of air services, which entails only a change in the number of passengers. If this causes no more than a change in load factor on the existing capacity, then the marginal costs are mainly connected to a slight change in the fuel consumption due to variations in the payload and the cost of in-cabin service.
2. The marginal expansion or reduction of air services in terms of the number of routes and the number of departures per route, thereby affecting the number of departures and/or even the number of aircraft.

Thus, one important question concerns in which of the two categories a marginal change in the supply of air services will fall. The models that can assign aircraft capacity within an airline network will probably be needed to answer this question to its full extent. In practice, there is a mixture of the two categories, depending on whether there is excess capacity in the affected parts of the network or not.

The cost structure of an airline can be considered in different time-scales such as day, week, month, year, dependent on the purpose of the analysis. In this project, annual costs are considered. It can be shown that airline costs have a stepwise upward sloping curve, where the steps are caused by aircraft capacity expansion. Airline costs are thoroughly discussed in Bronger et al. (2001).

As a practical approximation to these costs, Janic (1999) has estimated a regression model to quantify the average costs per flight, depending on the aircraft size-capacity and non-stop route length, as follows:

\[ C(n,d) = 7.934n^{0.603}d^{0.656}, \]  

(3.2)
where $C(n, d)$ is average costs per flight; $n$ is aircraft seating capacity; and $d$ is route length.

The properties of the model seem appealing, in the sense that it incorporates the scale effects of flight length and aircraft size, and because it gives a reasonable fit to the data for actual route costs. The model is used in the calculation of changes in aircraft operating costs, as a reasonable approach when assessing changes in the airport network. The changes are mainly connected to airport closures. In most cases, this means that the costs will be connected to reduced numbers of departures and landings in addition to reduced leg length.

3.2.2.3 Supply of capacity with and without airport closure The applied route cost model demands that the route and the number of flights are determined exogenously. When airport closure is assessed, the number of flights and the destinations in actual operation is the point of departure. We assume that, when the annual average aircraft load factor exceeds 60 per cent, one additional flight is needed. The assumption is based on experiences from current practice within the regional airport network, according to information from the Ministry of Transport and Communications. When passengers are transferred to neighbouring airports because of an airport closure, we consider the need for expanded seat capacity at this airport.

There is, however, one important factor that has to be carefully considered. If the actual aircraft load factor is low at the airports in question and the number of flights is above a minimum service level, we have to use an estimated adjusted number of flights in the model. The number of flights is reduced in the model to reach an aircraft load factor of between 55 and 60 per cent. This is done to put the ten airports on an approximately equal level. Before closing down an airport with great overcapacity, it is better to adjust down the supply of seats to an ‘optimal’ number, if not in reality, at least in the model. However, the adjustments cannot be of such a magnitude that the minimum service level is not maintained. These adjustments have to be made both at the airport that is assessed with respect to closure, and at the neighbouring airport that receives the transferred traffic. In the 25-year time span, the number of flights is increased when the estimated traffic growth gives a load factor above 60 per cent as an annual average.

The adjustment of initial supplied capacity is carried out when constructing a reference level for a ‘lean’ air service in the existing airport network. This is done so as to be able to compare the true route cost difference when an airport is closed and the majority of the passengers are transferred to an adjacent airport (which leads to an increase in number of departures there). If these corrections are not made in cases with low load factors, then the situation will be that the cost savings will be overestimated. In such an unadjusted case, we normally get route cost savings as the dominant benefit of an airport closure, and closure will most likely turn out as profitable.

In the Norwegian PSO air network, the load factor may be as low as around 30 per cent. What is actually done when making the described adjustments is to separate the airport closure route cost savings from cost savings related to
improved air service efficiency. The latter may be achieved through, for example, reduced capacity and hence a higher aircraft load factor, independent of the closure. It is, however, worth noting that the determination of departure frequencies in the PSO network is a part of a policy for regional balance.

The approach concerning the determination of route costs has a number of shortcomings. One is that a significant decrease in the number of departures may cause traffic deterrence in itself, which is not taken into account in the CBA. Another weakness is that the overall network effects are only intuitively considered. As long as there is one dominating airline in the PSO network, there may also be scale effects which we have not been able to capture.

3.2.2.4 Network effects Ideally, it is important to assess more than just pairs of regional airports in a joint analysis. Because even if the number of passengers is not very large, there are several network factors that cause several airports to be mutually dependent, concerning both demand and supply. The most important of these network or network-related effects are:

- In cases where routes have multiple stopovers closure of one airport may lead to reduced travel time for passengers who use neighbouring airports within the same route area.
- Supply is scaled to an ‘optimum’ level in the calculations, as described above. This is done to calculate the true cost of closing an airport and will affect all airports within a route area.  
- Closure of more than one of several airports in a region may have additional network effects.
- Closure may lead to higher frequencies at neighbouring airports, which in turn reduces waiting time and increases benefits for all passengers in the region.
- Scale effects due to indivisibility of aircrafts and utilization of manpower may appear when the supply situation in a route area is changed.

We have not managed to include the last two of these effects in our analyses because of insufficient methods and data. The first three effects, however, are to a fair extent accounted for, as it should appear from earlier sections.

3.3 Application of CBA to the Norwegian Regional Airports

3.3.1 Selection of Airports for the Analysis

The regional airport network serves important functions for major parts of the population in the catchment areas. There is no doubt, however, that the regional airports are more important for local society in some districts than in others. In particular, where there is no practicable alternative transport mode, the regional air
network ensures that these communities obtain a minimum acceptable transport standard. Some airports play a key role in the oil and gas offshore industry. Others have high passenger numbers due to their proximity to hospitals or regional administration centres.

These factors are naturally of great importance in selecting candidate airports for the cost-benefit analysis (CBA). Thus, some of the 27 airports are considered as ‘fixed’ in the sense that they are indisputably a prerequisite for different important functions that need to be served. Hence, these airports are not subject to any further economic viability test in this project. After excluding these airports, ten airports remained as candidates for the CBA. These airports were selected by means of a package of factors like weather conditions, operational conditions, expansion possibilities, the distance to the nearest airport, and expected traffic development. These factors are explained in more detail below.

The reasons for selecting the ten candidates are briefly presented in Table 3.1.

Table 3.1  Factors important for selecting candidate airports for the CBA

<table>
<thead>
<tr>
<th></th>
<th>General weather conditions</th>
<th>Turbulence, cross-wind, etc</th>
<th>Operational limitations</th>
<th>Limited developing space</th>
<th>Short distance to neighbouring airport</th>
<th>Large traffic diffusion to neighbouring airport</th>
<th>Little travelling activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fagernes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Forde</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sandane</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>X</td>
<td>x</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td>Hovden</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>X</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Namsos</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Mosjøen</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Narvik</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Svolvær</td>
<td>-</td>
<td>x</td>
<td>X</td>
<td>X</td>
<td>x</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Honningsvåg</td>
<td>x</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vardø</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Here x means ‘important factor’, and X means ‘very important factor’. The explanation of the factors displayed in the table is as follows:

- **General weather conditions**: accessibility of airport for general meteorological reasons.
- **Turbulence, crosswinds, and so on**: frequency of special weather conditions like turbulence and crosswind.
- **Operational limitations**: terrain limitations and special landing procedures and dispensations due to terrain, turbulence, and so on.
- **Limited developing space**: lack of expansion possibilities due to proximity to sea, mountains or other terrain obstacles.
Short distance to neighbouring airport: mainly less than 1.5 hours travelling to the nearest airport, sometimes substantially less.

Large traffic diffusion to neighbouring airport: occurs when the inhabitants or visitors to the municipality hosting the airport mainly prefer using a neighbouring airport.

Small travelling activity: occurs when the number of passengers using the airport is very low both in absolute figures and relative to population in the catchment area.

Table 3.2 Passengers on arrivals and departures in 2001

<table>
<thead>
<tr>
<th>Airport</th>
<th>Pax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fagernes, Leirin</td>
<td>1,953</td>
</tr>
<tr>
<td>Førde</td>
<td>53,782</td>
</tr>
<tr>
<td>Sandane, Anda</td>
<td>23,949</td>
</tr>
<tr>
<td>Ørsta-Volda, Hovden</td>
<td>27,452</td>
</tr>
<tr>
<td>Namsos</td>
<td>19,623</td>
</tr>
<tr>
<td>Mosjøen, Kjærstad</td>
<td>48,933</td>
</tr>
<tr>
<td>Svolvær, Helle</td>
<td>63,870</td>
</tr>
<tr>
<td>Narvik, Framnes</td>
<td>33,009</td>
</tr>
<tr>
<td>Honningsvåg, Valan</td>
<td>12,720</td>
</tr>
<tr>
<td>Vardø, Svartnes</td>
<td>12,563</td>
</tr>
<tr>
<td>Sum of analysed airports</td>
<td>297,854</td>
</tr>
<tr>
<td>All regional/local airports</td>
<td>1,334,649</td>
</tr>
<tr>
<td>Main airports</td>
<td>16,550,453</td>
</tr>
<tr>
<td>Total</td>
<td>17,885,102</td>
</tr>
</tbody>
</table>

Notes: * Pax = Passengers arrived + departed.


As can be seen from Table 3.1, the general weather conditions are unfavourable for six of the ten airports. In addition, seven of the airports are affected by special weather conditions like crosswinds and turbulence. Meteorological conditions are, of course, part of the operational limitations to which six of the airports are subjected. Actually, some of them have special landing procedures that are approved for the airline(s) serving the airport. Operating conditions are frequently characterized by limited space for future development of the airport – mainly for aviation safety reasons, but also for the possible use of larger aircraft. When establishing the regional network of STOL airports, it was underlined that the International Civil Aviation Organization’s (ICAO) recommendation of a
minimum of 95 percent accessibility on average over the year should be met. Most of the regional airports have been located in mountainous areas where the wind conditions are often problematic with crosswind and turbulence. The operative assessments and updated meteorological calculations that have been made for this study show that accessibility has had a decreasing tendency all the time since the establishment of the network. It is possible to include the economic value of the reduced regularity (the ability to avoid delays). Calculations have shown that reduced regularity has a minor impact on the economic profitability of the airports (Bronger et al., 2001).

The decision on which airports should be on the final list for economic impact assessment was taken by AVINOR, and based on the information in Table 3.1. In addition to the assessment of the ten airports, it has been necessary to assess several of the other airports that are situated in the same regions as the airports on the list in order to have appropriate standards of reference. Thus, for some of these other airports separate CBAs have been carried out for reference purposes. These CBAs, however, are not fully documented in the report (Bronger et al., 2001). Traffic figures for the airports in question are displayed in Table 3.2 above.

3.3.2 Input Data

The net present value of the loss of consumer surplus due to an airport closure is calculated for business travel and leisure travel separately, and the results are summarized. The traffic forecasts are made by AVINOR, and the annual growth rate lies between 1 and 3 per cent for most of the airports. The values of travel time (VOT) are based on the Norwegian VOT study, where the VOT for business travel amounted to €27/hour while VOT for leisure travel amounted to €24/hour. The social discount rate is 7 per cent, and reflects the risk to which the project is exposed. Air transport is exposed to systematic risk such as macroeconomic fluctuations (not controllable by the aviation authorities), hence the risk premium should be relatively high. The determination of the correct interest rate level is quite complex, and this topic will not be further elaborated here.

A demand elasticity of –0.8 is used as a reasonable approximation when doing traffic assessments. This means that, when total (generalized) travel costs increase by 10 per cent, we get an 8 per cent reduction in the number of the passengers. For most of the airports in this study, the traffic reduction is modest (between 7 and 10 per cent) because the travel costs are initially high. The additional travel cost connected to the use of an alternative airport is not high enough to give substantial deterrence effects.

A couple of points are worth noting. First, if other transport modes are used instead of the alternative airport, then the actual cost increase of airport closure is even lower than the costs of using an adjacent airport. If the other mode does not entail significant negative externalities such as noise, emissions or congestion, then the net reduction in CS will be lower than is calculated in this study. Second, if the demand elasticity is higher, then the traffic deterrence would have been larger and the reduction in consumer surplus would have been smaller. In Figure 3.3, this
would have produced a larger triangle, at the expense of the size of the black rectangle. The effects of using different demand elasticities are, however, small. If we study the effects of using a demand elasticity of \(-2\) instead of \(-0.8\), the difference in consumer surplus reduction will be around 6 per cent. The demand elasticity and the eventual use of alternative transport modes are not thoroughly analysed in these CBAs. However, a few simulations were carried out, and they suggest that the results are fairly insensitive with respect to these factors. Third, the closure of one airport may lead to improved frequency services for the neighbouring airport, from which **all** travellers, also those originally using this airport, will benefit. This effect may be substantial, but is not taken into account in this CBA because of insufficient methods.

The black and the hatched areas in Figure 3.3 can also be considered as the benefits of continuing the operations at the airport in question. These benefits are then compared with the operating costs for AVINOR and the airline, in order to assess whether the actual airport closure is feasible or not.

As can be seen from Equation (3.2), the model indicates the existence of economies of scale both with respect to route length and aircraft size. Data from 21 Western European airlines are used, and the model explains nearly 90 per cent of the variations. The statistical diagnosis suggests that the equation and the coefficients are significant at the 5 per cent and 1 per cent levels. The coefficients, which are less than unity, indicate that there are economies of scale both with respect to aircraft size and route length. Figure 3.4 shows the economies of scale with respect to route length for different aircraft, for flight distances up to 400 km. The figure also indicates the economies of scale related to aircraft size.

![Figure 3.4 Aircraft costs per supplied seat related to aircraft size, from Equation (3.2)](image)

The model (with an adjusted constant) is compared with the Norwegian cost data from the winners of the last competitive tendering process. The comparison
comprises 19 of the PSO routes. The model results deviate by 2 per cent for the 19 routes in total, in the sense that the costs are slightly overestimated in the model. The model results are mainly within ±20 percent at the route level, compared with the reported route costs from the competitive tendering process. There are, however, a few larger deviations.

There are reasons to be cautious about the interpretations based on these comparisons. One reason may be that, even if the model seems statistically robust, the only explanatory variables are seating capacity and route (leg) length. Hence, it does not capture local conditions that may affect the route costs.

Another reason for caution is that there may be strategic biases considering the costs reported from this tendering process. One bias may be the occurrence of the ‘winner’s curse’ which means that the actual route costs turn out to be higher than the cost estimates in the tender, resulting in a deficiency. One of the major deviations at the route level may be explained by this kind of bias, where the model calculates significantly higher costs than the ones that were actually given in the tendering process. Here, the airline actually did enter negotiations on cutting the number of departures. Another bias that goes the other way may be caused by ‘route packages’ allowed by the regulator. These may weaken the competitive environment and hence allow for larger airfare increases. We have, however, no robust evidence whether this may explain a couple of larger deviations where the model underestimated the costs significantly.

3.3.3 Main Results

The economic evaluation of the ten selected airports was carried out according to AVINOR’s handbook for CBA (Bråthen et al., 1999), where the reduction in consumer surplus from airport closure is held against cost savings for AVINOR and the airlines. In addition, accident and emission costs are included. All unit costs of market and non-market goods were valued according to the same principles in the CBA handbooks of the main transport sectors in Norway, to ensure compatibility with analyses done in other parts of the sector. Non-market factors are mainly value of time and external costs such as environment (noise and emissions to air) and transport safety costs. The results are given as present values discounted over a 25-year period. The discount rate is 7 percent per annum based on guidelines from the Ministry of Finance.

According to these calculations, an important element of the CBA is the increase in the passengers’ travelling costs in the case of airport closure. These include time costs as well as vehicle costs. These cost elements originate mainly from travelling to/from the airport (feeding time), waiting time, time airborne and transit/transfer time. All these elements may be subject to substantial changes in the case of airport closure. In these cases, changes in feeding time are the most important element. Other important elements are the airline’s route costs and AVINOR’s investment and maintenance costs.

The calculations were carried out for two, and in some cases three, alternatives that were compared with the net value of closing down the airport. Alternative 0 is
the ‘do minimum’ alternative where a minimum standard of operations with De Havilland DHC 8 or the like is maintained. Only strictly necessary investments are made to maintain this standard. Alternative 1 is a partial upgrading of standards, and Alternative 2 is full upgrading to modern ATC equipment and a 1,200 m runway. The two latter alternatives turned out in all ten cases out to be less profitable than Alternative 0, and they are therefore omitted from this presentation. The reason for this is that the benefit from this upgrading is by and large negligible when it comes to consumer benefits.

The results are presented in Table 3.3. The net result to society is the net result for all the stakeholders. The table includes the net result for the airlines, for the Ministry of Transport and for AVINOR, which represent some of the stakeholders involved. In addition to the Ministry of Transport and AVINOR, the Treasury also benefits from fiscal passenger charges. All these parties are, however, representatives of the state. Thus, columns 3, 4 and 5 do not add up to column 2. The costs and benefits to each stakeholder may differ considerably from the total costs or benefits to society.

Table 3.3  Net present value (in million €) to society and to selected stakeholders (€1 ≈ NOK8.3)

<table>
<thead>
<tr>
<th>Airport</th>
<th>Net benefit to society (NPV) from airport closure (2)</th>
<th>Airlines: reduced operation costs (3)</th>
<th>Ministry of Transport: reduced government subsidies (4)</th>
<th>AVINOR: net reduced costs (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Førde</td>
<td>8.2</td>
<td>7.1</td>
<td>2.9</td>
<td>21.6</td>
</tr>
<tr>
<td>Sandane</td>
<td>14.5</td>
<td>7.6</td>
<td>5.5</td>
<td>17.7</td>
</tr>
<tr>
<td>Hovden</td>
<td>5.5</td>
<td>8.2</td>
<td>2.4/8.4†</td>
<td>18.0</td>
</tr>
<tr>
<td>Namsos</td>
<td>24.5</td>
<td>10.8</td>
<td>10.6</td>
<td>18.9</td>
</tr>
<tr>
<td>Mosjøen</td>
<td>6.6</td>
<td>11.7</td>
<td>0.6</td>
<td>20.4</td>
</tr>
<tr>
<td>Svolvær</td>
<td>9.4</td>
<td>18.7</td>
<td>6.0</td>
<td>18.7</td>
</tr>
<tr>
<td>Narvik</td>
<td>30.2</td>
<td>21.7</td>
<td>17.5</td>
<td>17.2</td>
</tr>
<tr>
<td>Honningsvåg</td>
<td>2.4</td>
<td>2.2</td>
<td>0.8</td>
<td>21.8</td>
</tr>
<tr>
<td>Vardo</td>
<td>27.2</td>
<td>8.2</td>
<td>6.6</td>
<td>19.9</td>
</tr>
<tr>
<td>Fagernes</td>
<td>29.9</td>
<td>15.2</td>
<td>15.1</td>
<td>14.0</td>
</tr>
</tbody>
</table>

Note: † With or without transfer of passengers to non-subsidized routes.

The close interdependence of airports on the western coast has made it necessary to take into account the effects of closing one, two, or all three of the airports Førde, Sandane or Hovden. Separate calculations have been carried out to account for this. These calculations are not presented here, but the benefits of closing more than one of these airports are reduced only by a modest increase in
travelling costs for the users. The conclusions shown below are, however, not altered. From the calculations shown in the table and the sensitivity analyses that are carried out, it is apparent that the airports fall into two categories concerning the economic profitability of closure. The closure of five airports is economically favourable to society with a robust margin. For the other half of the airports, closure is also profitable, but with some degree of uncertainty.

The two categories are:

- **Category 1: Clearly unprofitable:**
  Fagernes, Sandane, Namsos, Narvik and Vardø. The present value of closing these airports varies from around €14 to 30 million.

- **Category 2: Unprofitable, but with uncertainty:**
  Førde, Hovden, Mosjøen, Svolvær and Honningsvåg. Closing these airports has a present value varying from around €2.5 to 9.5 million.

An airport that has been closed down is costly to reopen, and under certain circumstances such a decision may be irreversible. On the other hand, even a running airport may still be closed at every point of time in the future. This gives reasons to draw careful conclusions about which airports that are socially unprofitable (the present value of closing the airport is positive). Uncertainty about the future route network, departure frequencies and hence the route costs are among the factors that call for careful conclusions regarding Category 2. We cannot fully exclude the possibility that some of the five airports in Category 2 might be economically profitable. This view is also supported by the sensitivity analyses.

### 3.3.4 Sensitivity Analysis

A sensitivity analysis has been carried out, where the traffic growth rates, the discount rate and the costs for AVINOR and the airlines have been assessed with respect to reasonable variations. In addition, the value of time for business travel (€27/hour) has been doubled. This test was carried out because in the handbook VOT is given in national averages, and the possibility of local variations cannot be excluded. None of the tests were able to alter the conclusions given above.

### 3.4 Consequences

In order to improve the CBA framework to support political decisions, attention should be paid to the political debate following the launch of CBA reports. The examination presented here rests on the assessment of regional airports presented above. But the way the report was received by the public seems to be illustrative of what appears to be a quite common situation when an assessment report on a controversial project or topic is submitted:
The local community and the decision makers called for a more comprehensive assessment.

In connection with this, the local community strongly advocated the airports’ vital role in keeping up the local economic activity.

3.4.1 The ex-post Political Debate

The conclusions from the CBA led to an intense political debate before the Norwegian Parliament (NP) made its decision. The arguments embraced a wide variety of concerns:

- Lack of confidence regarding the appropriateness of the CBA method, in particular a suspected lack of ability to include an adequate range of impacts.
- A genuine fear of losing jobs and activities in the local communities. Remote airports are perceived to be of great importance to local communities. People and the industry worry about the very existence of their community, loss of jobs, reduced tourist traffic and so on. Mobility and the option value of mobility are important in a modern community.
- Disagreement with respect to the description of travel costs with and without the local airport, that is, disagreement with the description of the basic realities.
- Discontent with a closed planning process, represented by statements like: ‘As a point of departure, the views of the local community were not a part of the picture’.
- The benefits of a better route network with more frequent departures, when concentrating the activities at fewer airports, do not appeal to the local communities at all.

On behalf of the Government, The Minister of Transport and Communications proposed to close down three of the airports on the Category 1 list: namely, Fagernes, Narvik and Vardo. Those were among the ones where the Government considered alternative means of transport as fair. This view was in accordance with the CBA results, where these three airports ended up as the most profitable candidates for closure.

The government proposal was, however, turned down by the NP, which decided that possible closures should be seen in connection with the National Transport Plan (2006–15), where the airports’ role in rural transport should be assessed as part of the basis for future decisions. In addition, more information was needed. The following statement in the Ministry’s interpretation of the NP resolution is of particular interest in the context of this chapter (translated by its authors):

The assessments of airport viability in the Government proposal were to a large extent based on CBAs. The Ministry reads that the NP resolution points out the
need for more information regarding the distributive consequences for the industry, employment, and the residents around the airports in question. These assessments should be made if restructuring of the airport network is proposed at a later stage, and they should be carried out as complementary to the CBA.

The statement suggests that the economic efficiency perspective is not considered as sufficient to make a public project selection of this kind. Even if there is a fair consensus on using CBA for economic efficiency assessments (see, for example, Little and Mirrlees, 1995), the need for information on the distributive consequences is clearly articulated. According to Sager (1990), if the NP resolution had been made in accordance with a CBA veto against future airport operations, then this would have illustrated that the decision makers would have attended to the macroeconomic interests or productivity interests, supported by CBA as the individual preferences aggregation device. A local consensus against the closure may then be overruled. One reason why the local community is against airport closure has to do with economic incentives. Another reason is that overall economic efficiency as the decision-making criterion is not always in accordance with the interests of the local community. These aspects are briefly discussed below.

3.4.2 Reasons Why the Different Viewpoints Were Articulated

Why do the aforementioned points end up as the main summary of the political debate? The answer may be found in the following considerations:

- The route and airport services are serving as a ‘local public good’. The Ministry and AVINOR are responsible for the financial side through PSO routes and airport services. Better air services (or keeping up thin routes and inadequate airports) can be demanded from the local communities at virtually no costs.

- There is a strong belief in air transport as important for regional development. There is also a fear of losing the airport in a ‘critical mass’ perspective. A negative circular and cumulative development is suspected because activities may move or locate elsewhere. Figure 3.5 illustrates the problem.

- Figure 3.5 shows possible causes and effects if an airport closure severely affects the conditions for local industry. An airport closure may make firms relocate, which, in turn, reduces the demand for labour and capital. There are four main loops that describe the circular and cumulative effects. First, relocation of firms decreases the population and hence the local supply of skilled labour. Second, the reduction of local employment and population makes capital and firms move to serve the demand for goods and services elsewhere. Third, the secondary industries may disappear or reduce their activities because of a diminishing market. Both the second and the third loop may support the reduction of external economies for existing
enterprises. The external economies evolve from a larger number of interacting economic agents. The dotted line from infrastructure to external economies indicates the infrastructure’s role in reducing ‘the costs of interaction’ between agents. The fourth loop illustrates how the reduced economic activity cuts the public sector revenues, which again may make location in the area less favourable. However, one of the main unsolved empirical issues is, in general, related to the ‘critical mass problem’, that is, the level of economic activity that has to be present to maintain local communities. Another issue is related to what extent airport closures are leading to such adverse effects. The increased travel time is relatively modest in many cases, and the possibility of more frequent route services at neighbouring airports may partly outweigh the inconveniences. This trade-off between airport closure and the economics of density in the route network is not analysed here. The CBA did not, however, take the benefits of increased departure frequency at the neighbouring airport into consideration, which supports the conclusion that the benefit of airport closure is not overestimated.

Figure 3.5 Adverse circular and cumulative effects of an airport closure

- It is important to examine the situation for local industry, even if a closure seems profitable. At one of the airports in particular, one larger multinational enterprise (a world leading pulp and paper factory) claimed the local airport as a prerequisite for the location of its head office. There are good reasons to examine such situations more closely. A potential ethical problem with the application of the Kaldor-Hicks criterion in CBA
is ‘the tyranny of the majority’. On can think of situations where small benefits to the many (the taxpayers in the case of profitable airport closures) may outweigh severe losses for the few.

• There is a lack of confidence in whether CBAs cover the true benefits and costs to society. Even if it is practically unavoidable that the interpretation of findings will be coloured by the position of the different stakeholders, there are, nevertheless, good reasons to be aware of this fact when presenting the findings and the results. This issue was, however, thoroughly handled in the presentation of the assessments for the ten airports. This goes together with the next point, namely that

• The politicians’ job at the local level is to maximize the benefits for the local communities. It is important to have this in mind when trying to make sense of a CBA to the local community. CBA takes the efficiency of the whole economy into consideration, while the local politicians’ focus is at the local level. The first bullet point above (p. 68) gives the economic rationale for such behaviour.

• Another important lesson to be learned is that it may be wise for the authorities to have an *ex ante* apprehension of compensatory measures that may be offered in the case of an airport closure. Examples of such measures are:
  - Improved air transport at neighbouring airports, in terms of higher departure frequencies, easier access to a larger set of destinations than before.
  - Lower fare level at the neighbouring airport. Maximum fares can be regulated in a PSO system. This measure is not necessarily proposed from an economic efficiency point of view, but as a golden mean alternative between current inefficient operations and the economically efficient but politically unacceptable alternative (closure without compensation).
  - Diverting measures like road or transit improvements to the neighbouring airport or to improvements of competing transport modes.

• A dialogue with the local communities was almost non-existent during the planning period. In the future, there may be good reasons to strengthen this kind of dialogue, to ensure a kind of participatory planning and local confidence with respect to the outcome of the analytical work. In two earlier airport assessments in Norway, this approach contributed to a more convergent local view regarding the outcome of the economic assessments. These aspects will be further commented on below. The main difference, however, between these two assessments and the ten airports under consideration here is that the two earlier appraisals assessed new airports. From economic welfare theory, it is reasonable to expect a substantial difference in local commitment to something that may be perceived as a ‘right’ to have (for example, to maintain the existing airport services)
compared with getting benefits that were not present in the first place. One may consider the difference between the willingness-to-accept (WTA) and willingness-to-pay (WTP) consumer surplus measures. If one considers the size of the loss in consumer surplus when asking people about the minimum amount of money that is necessary to offset the reduced welfare from airport closure (WTA), one may get a different (and higher) amount compared with asking them about their maximum willingness to pay (WTP) for having a new airport in the area (given that there was no airport there in the first place). This difference influences the true value of travel time (VOT) in the areas under consideration. In the CBA of the ten airports, this aspect was covered fairly well in a sensitivity analysis where a doubling of the VOT was tested.

3.4.3 How Can a More Comprehensive Planning Approach Be Designed?

This chapter has presented the CBAs that were carried out to assess the viability of the weaker parts of Norwegian regional airport network. The main arguments that were put forward in the decision-making process are shown, and their rationale is briefly discussed. Various categories of impacts were also examined, where the main distinction was between the real impacts (‘productivity effects’) included in the CBA and the distributive impacts (that is, how the various stakeholders are affected by a given action in terms of localization effects for firms and households, changes in local employment, and so forth). The distributive impacts are often the main elements of public concern, especially in the affected local communities, but they are not explicitly a part of a CBA. As noted above, the productivity effects of, for example, relocations are mainly taken care of in the CBA.

Sager (2002) examines various aspects of democratic planning and social choice dilemmas, showing that it is a complex task to unite the need for dialogue with the need for economic efficiency in the planning process. Sager points to dilemmas where one ‘cannot have it both ways’. Public participation has its costs. As examples, he points out that ‘… the democratization of institutions has its costs as it gets in the way of the achievement of other goals, like more stable and non-arbitrary decisions. … . And aiming for decentralization with more protected spheres will increasingly conflict with planning for the public interest in the sense of respecting unanimity.’

Sager suggests that the planning system will have to live with such difficult dilemmas. Even though it is clear that the institutions of planning and social decision making are not going to be perfect, it does not follow that practice cannot be improved. It might be possible to find trade-offs between the need for, for example, non-arbitrary decisions resting on, for example, CBA outcomes, and the need for participation from the local communities.
3.5 Conclusions

An important element in CBA of airport closures is the increase in the passengers’ travelling costs. These include time costs as well as vehicle costs. These cost elements originate mainly from travelling to/from the airport (feeding time), waiting time, time airborne and transit/transfer time. All these elements may be subject to substantial changes in the case of airport closure. In all the cases presented above, changes in feeding time are the most important element. Other important elements are the airline’s route costs and AVINOR’s investment and maintenance costs. It is important to have a critical view on the input data, particularly with respect to changes in route operating costs and the value of changes in travel time.

In order to improve the CBA framework to support political decisions, attention should be paid to the political debate following the launch of CBA reports. In the present case, the way the report was received by the public seems to be illustrative of what appears to be quite a common situation when an assessment report on a controversial project or topic is submitted:

- The local community and the decision makers call for a more comprehensive assessment.
- In connection with this, the local community strongly advocate the airports’ vital role in maintaining local economic activity.

We consider CBA to be an appropriate means for project ranking with respect to economic profitability. In this respect, the Government proposal to close three airports seemed justified, given the priority of economic efficiency. CBA should, however, be supplemented by addressing specific topics that are perceived as important to the local community.

Notes

1 AVINOR will also be used in cases concerning its predecessor NATAM.
2 There are certain problems with the regulation of monopolies that will not be discussed in detail. These are connected to the level of production costs where asymmetric information between the monopolist and the regulator gives limited possibilities to control the amount of resources that is actually needed for a given level of production. For a discussion, see Tirole (1990).
3 Since these route optimizations are not likely to happen in real life, these effects are network related only in the calculations.
4 Interestingly, the politicians often ask for economic impact analyses, but the results are rarely reflected in the selection of projects (Odeck 1996).
5 CBA still has weaknesses. Many of them are of an empirical kind and connected to the use of the method. The method may, for example, invite planners to use average values of important elements (such as the value of time, and construction costs), where local conditions may call for a closer assessment.
References


Modelling the Short-Term Impact of a Nuclear Accident on Transportation Flows

Peder Axensten

4.1 Introduction

The Kola Peninsula constitutes the largest source of nuclear risk in the Barents Region. The peninsula has the highest concentration of nuclear reactors in the world. Currently, there are reactors aboard submarines, cruisers and icebreakers – some are based along the northern coast while others are decommissioned and stored in the berth at naval bases and shipyards awaiting removal of their reactors. However, the greatest risk is associated with the Kola Nuclear Power Plant (KNPP), located at Polyarnye Zori. The plant has four reactors, two of which are of an older type that lack secure containment, have limited emergency core cooling capability, and little redundancy and separation of safety equipment. Moreover, observers have reported that the plant has deficient instrumentation and control systems as well as serious deficiencies in its fire protection system (Bergman and Baklanov, 1998; Nilsen et al., 1996).

A nuclear accident at the plant would be disastrous for Russia and possibly for Finland too. Simulations have shown that Sweden too runs a 25 per cent risk of being affected, although the resulting deposition on Swedish soil would rarely be such that an evacuation would be necessary even from the most affected areas. There are cases, however, when meteorological conditions are such that the release is transported by strong winds straight to the Gulf of Bothnia and deposited in this area by rain. In these cases, radiation levels could in a very short time, as little as 18 hours, become so high that an evacuation of the local population should be considered (Figure 4.1) (Lundström, 1999).

From the point of view of the Swedish nuclear security authorities, this represents a serious risk and various measures to reduce the risk have been proposed. One such action to this end is that, in the event of a release from a nuclear power plant, information on the circumstances would be given so that forecasts of the release’s consequences could be calculated. These forecasts need to be distributed and often amalgamated with other information: the number of people affected, location of rescue organizations’ resources, and so on. They also need to
be processed so as to obtain further information, for example evacuation or escape flows, capacity constraints, and travel times in the road system. The geographical nature of the information makes it natural to use a Geographical Information System (GIS).

Notes: The simulated release was 1 PBq of $^{137}$Cs from the Kola Nuclear Power Plant to an altitude of 70–130 m at a radius of 60 m. The particles were 0.1–1 μm and 2.8 kg/dm$^3$. The simulation was made with PELLO (Lindqvist, 1995). Each reactor at KNPP contains 180 PBq $^{137}$Cs. Some 3–30 per cent, maybe more, of it could be released in a serious accident. During the Chernobyl accident 20–40 per cent of the $^{137}$Cs content was released, or about 1 per cent of the total radioactivity released—most of the released radioactivity was in the form of short-lived isotopes, such as $^{133}$Xe, $^{131}$I (about one order of magnitude more than $^{137}$Cs), $^{132}$Te and so on (Bergman, 2000; Lundström, 1999).

Figure 4.1 A hypothetical scenario based on the weather conditions of 26 August 1998

The chapter presents an integrated system to calculate and visualize the short-term impact that an evacuation would have on a road network in the event of a serious radiation release. A number of issues related to evacuation planning can be studied with the model, for instance: the identification of areas with capacity problems in the road network; how optimal routes depend on the time available for the evacuation, and so on. The model approach is to formulate a Minimum Cost Flow Problem, where cost is measured by the risk exposure on a link. Thus, routes are calculated so as to avoid areas of high risk. Specifically, the Barents Region is studied and a hypothetical release from the Kola Nuclear Power Plant is used as a case study.

The chapter also proposes directions to improve the formulation of the presented model, as well as indicating how societal factors could be included. A big problem has been the heterogeneous character and incompleteness of the available information, especially in the Russian part of the region studied. This is the principal obstacle against introducing human factors in the model. The Barents Region has a great cultural variation and the efficiency of authorities, as well as people’s trust in them, vary accordingly.
4.2 Methodology

The optimization problem can be easily formulated: move everyone from the dangerous area to places that can harbour them – and do this while exposing them to as little radiation as possible. Mathematically, the problem of finding optimal evacuation flows is a graph problem (Figure 4.2), where the roads constitute the links and population points and intersections are the nodes. Given a directed graph comprising node set $N$ and link set $L \subseteq N \times N$, we would like to find $x_{ij}, \forall (ij) \in L$, so as to solve:

$$
\min \left( \sum_{(i,j) \in L} a_{ij} x_{ij} \right), \quad (4.1)
$$

$$
0 \leq x_{ij} \leq c_{ij}, \forall (ij) \in L, \quad (4.1a)
$$

$$
0 = \sum_{i \in N} \left( \sum_{(i,j) \in L, j \rightarrow i} x_{ij} - \sum_{(j,i) \in L, j \rightarrow i} x_{ji} \right), \quad (4.1b)
$$

$$
x_i = \sum_{(i,j) \in L, j \rightarrow i} x_{ij} - \sum_{(j,i) \in L, j \rightarrow i} x_{ji}, \{ \forall i \in N \mid s_i \geq 0 \}, \quad (4.1c)
$$

$$
s_i \leq \sum_{(i,j) \in L, j \rightarrow i} x_{ij} - \sum_{(j,i) \in L, j \rightarrow i} x_{ji}, \{ \forall i \in N \mid s_i < 0 \}, \quad (4.1d)
$$

where $a_{ij} < 0$ is the level of radiation exposure from using link $(i, j)$ as calculated by Equation (4.5) below, $x_{ij}$ is the number of people using $(i, j)$, and $s_i$ is the number of people to be evacuated from source $i$ ($s_i > 0$) or the harbouring capacity of sink $i$ ($s_i < 0$). The constraints are: the number of people on a link is never less than zero or greater than its capacity $c_{ij}$ (Equation 4.1a); everyone starting from a source will reach a sink (Equation 4.1b); all sources must be emptied (Equation 4.1c); and sinks can not be more than filled (Equation 4.1d). In other words, we want to empty all sources to whatever sinks with a minimum of transportation cost.

The problem can easily be reformulated as a Minimum Cost Flow Problem (MCFP). Equations (4.1b,c,d) taken together state that the number of sources, $n_s$, must be smaller or equal to the number of destinations, $n_d$ – that is, the number of evacuees is smaller or equal to the number of harbouring places. But MCFP requires the number of destinations to be equal to the number of sources. A source $f$ of size $s_f$ equal to the difference $n_d - n_s$, solves this if it does not influence the transportation costs in any way. Thus a node $f$ of source $s_f$ is connected to all nodes of $N$ by one-way links $\{(j,f), \forall j \in N\}$ of sufficient capacity $c_{jf} \geq s_f$ and of cost $a_{jf} = 0.8$, $\forall j \in N$. We reformulate the problem:

$$
\min \left( \sum_{(i,j) \in L} a_{ij} x_{ij} \right), \quad (4.2)
$$

$$
0 \leq x_{ij} \leq c_{ij}, \forall (ij) \in L_f, \quad (4.2a)
$$
Notes: Arrows depict one-way links; the grey arrows depict virtual links with zero cost and unlimited capacity. Sources are indicated by ‘+’ and sinks by ‘–’ followed by the quantity. The grey node is the virtual source.

**Figure 4.2 Using a fictitious source to equal the sum of sources and the sum of sinks**

\[
s_i = \sum_{\{j \mid (i,j) \in L_r\}} x_j - \sum_{\{j \mid (j,i) \in L_r\}} x_j, \quad \forall i \in N_f, \tag{4.2b}
\]

where

\[
N_f = N \cup f, \quad L_f = L \cup \{(f, j), \forall j \in N\}, \tag{4.2c}
\]

\[
s_g = -\sum_{i \in g} s_i. \tag{4.2d}
\]

Now the problem can be solved directly by TransCAD (Caliper Corporation, www.caliper.com), a GIS program with an MCFP solver.

### 4.3 Data Preparation

#### 4.3.1 The Population Points

The decisive factor as to whether a place \( i \in N \) should be evacuated – or if it is suitable as a harbour for evacuees – is whether the node related cost, \( a_i \), is high – or low – enough. The cost, \( a_i \), is set to the level of radiation, \( v_i \), at this place \( i \). Radiation data calculated by PELLO (Lindqvist, 1995) was used during the development of the model. This data comes in the form of a text file containing a list of the coordinates and the values – it would not be difficult to adapt the system to use other sources of radiation data. Linear interpolation is used to calculate the radiation level, using values \((v_i' - v'_j)\) from the four closest points in the radiation data file:
In the model, very simple criteria are used to decide what places are evacuated and what places are to be safe havens. If $a_i$ exceeds a limit $r_{\text{max}}$, then $i$ is evacuated. If $a_i$ does not exceed a limit $r_{\text{min}}$, then $i$ may harbour a number of evacuees, the number being proportional to the original population of the place. Let $s_{ij} \in N$ signify the number of people moving out of ($s_{ij} > 0$) or into ($s_{ij} < 0$) a node $i$, $h$ the harbouring capacity expressed as a fraction of its population, and $x_i$ the number of people living in $i$:

$$s_{ij} = \begin{cases} -hx_i, & a_i \leq r_{\text{min}} \\ 0, & r_{\text{min}} < a_i \leq r_{\text{max}}, \forall i \in N. \\ x_i, & r_{\text{max}} < a_i \end{cases}$$

(4.4)

### 4.3.2 The Road Network

#### 4.3.2.1 The cost

As the objective of the evacuation is to limit people’s exposure to radiation, it is of interest to choose routes in a fashion that minimizes exposure. The cost of traversing a certain route will be the amount of exposure to radiation to which the travellers will be subjected, $a_{ij}$. A link ($i, j$) is geographically actually a polyline drawn by its points $P_m, m = 1, 2, \ldots, k$, and the radiation level of the link is calculated as the average of the radiation levels at these points:

$$a_{ij} = z + l_{ij} \frac{1}{k} \sum_{m=1}^{k} v_m, \forall (i, j) \in L.$$  

(4.5)

Here $l_{ij}$ is the length in metres of polyline $(i, j)$, and $v_m$ is the radiation level of point $P_m$ of the polyline, calculated in the same manner as $v_i$ in Equation (4.3). The parameter $z$ is the cost for travelling a link, irrespective of its length and contamination. It determines the size of the detour around a contaminated area – a small $z$ could result in large detours, a larger $z$ would encourage shortcuts through areas with negligible (but not zero) radiation. Furthermore, a $z > 0$ removes the small circular zero-cost flows that otherwise arise due to the algorithm.

There is no time factor in Equation (4.5). The length of the link is as good a factor, if not even better, as the time spent on the link. In an emergency situation, it can be assumed that people would feel free to drive at whatever speed the local situation would allow, and there is no obvious way to estimate this speed. Furthermore, driving through areas of radiation with closed windows and the AC
off, whether 10 minutes are spent in the area or 15 is not considered to be a big
factor. However, not driving unnecessarily long distances in polluted areas is an
issue, since the car will pick up particles that will contaminate it (Bergman, 2000).

4.3.3.2 Capacity The choice of digital geographical data was limited: there is only
one set of data that covers the Barents Region in a consistent manner: The Barents
Geographic Data Base (BGDB) (Metria, www.metria.com/metria). There is no
information on road capacities in the database, so the capacity $c'_y$ of link $(i, j)$ is
calculated as:

$$
c'_y = [\text{base}]_y [\text{lanes}]_y [\text{surface}]_y \text{ passengers}, \quad \forall (i, j) \in L, 
$$

(4.6)

where the value of passengers is set to three people per vehicle and the values of
$\text{base}_y$, $\text{lanes}_y$, and $\text{surface}_y$ are defined in Table 4.1. The unit of $c'_y$ is people per
hour.

**Table 4.1** Vehicles per hour based upon the class field in the road layer of the
BGDB

<table>
<thead>
<tr>
<th>Class</th>
<th>Width (assumed)</th>
<th>$[\text{base}]_y$</th>
<th>Lanes</th>
<th>$[\text{lanes}]_y$</th>
<th>Surface</th>
<th>$[\text{surface}]_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>main</td>
<td>13 m</td>
<td>3000</td>
<td>2</td>
<td>1.8</td>
<td>paved</td>
<td>1.0</td>
</tr>
<tr>
<td>regional</td>
<td>9 m</td>
<td>2600</td>
<td>1</td>
<td>1.0</td>
<td>unpaved</td>
<td>0.3</td>
</tr>
<tr>
<td>local</td>
<td>7 m</td>
<td>2500</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

*Notes*: Values from the Swedish Road Administration (2001, Chapter 3.3). The effect of
road width (left), double lane traffic (middle), and the surface (right).

The amount of people that a link can accommodate during the time $t$ available
for evacuation is then expressed as:

$$
c_y = c'_y t, \quad \forall (i, j) \in L. 
$$

(4.7)

The capacities are calculated according to Equation (4.6) in a scenario-independent
way. If the time available in a given scenario is not long enough, obviously no
solution will be found because of the lack of time or capacity – there is a trade-off
between $t$ and $c'_y$. On the other hand, if $t$ is large, only the least contaminated
roads need to be used, as shown in Figure 4.3.
Modelling the Short-Term Impact of a Nuclear Accident on Transportation Flows

Notes: In the case to the left, \( t \) is too small and the network capacity does not suffice. In the middle, \( t \) has a good value and all links are used. To the right the value is too high and only the cheapest path is used.

Figure 4.3 The importance of giving \( t \), of Equation (4.7), a good value

If no \( t \) is given, the shortest time needed, \( t_{\text{min}} \), can be evaluated for a given scenario. The location of the highest quotient of needed capacity divided by available capacity must be identified. Often such weak spots are found at the exits of the population points, so a good estimation is obtained by the following rule:

\[
    t_{\text{min}} = \max_{\{ i \in N; x_i > 0 \}} \frac{x_i}{\sum_{(a,b) \in L} c_{ab}},
\]

where \( x_i \) is the population of \( i \).

4.4 Results for a Test Scenario: 26 August 1998

The test scenario (Figure 4.1) is a hypothetical situation based on real conditions – the accident could have happened. The presumptions of the scenario are a release of 1 PBq at 00.00 hours, 26 August 1998 from the KNPP. The final deposition calculations were made using PELLO (Lindqvist, 1995).

All populated places with a radiation level exceeding 12 kBq/m² were chosen as sources, and all populated places with no radiation were chosen as sinks, with a harbouring capacity \( h \) set to 20 per cent of the population. A value of 12 kBq/m² on a release of 1 PBq corresponds to 216 kBq/m² on a release of 10 per cent of one of KNPP reactor’s contents of \(^{137}\text{Cs}\). The size of \( S_y \) was then calculated (Table 4.2).
Table 4.2 The test scenario

<table>
<thead>
<tr>
<th>Sources or sinks</th>
<th>Their total size (in m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources (r_{max} = 12,000), Gulf of Bothnia area</td>
<td>17</td>
</tr>
<tr>
<td>Sources (r_{max} = 12,000), Polyarnye Zori area</td>
<td>17</td>
</tr>
<tr>
<td>Sinks (r_{min} = 0 and h = 0.2)</td>
<td>1950</td>
</tr>
<tr>
<td>Calculated virtual source, s_f</td>
<td>1</td>
</tr>
</tbody>
</table>

Two evacuation zones are identified, one at the Gulf of Bothnia (due to heavy rains just as the radiation ‘cloud’ passes), and one by the accident site at Polyarnye Zori. By studying the zones, it is not difficult to localize the bottleneck. The Gulf of Bothnia has a large number of high capacity roads facilitating the evacuation, whereas there is only one through-road in the relatively densely populated area of Polyarnye Zori-Kandalaksha, the main road between Murmansk and St. Petersburg. By dividing the number of evacuees in this area by the base capacity of the road, it is found that a value of t of about 4 hours suffices. Using these values, the problem was solved and the result is illustrated in Figure 4.4.

4.4.1 Gulf of Bothnia

In this area (Figure 4.5A), the road network is rather extensive and has sufficient capacity in relation to the population – with one exception: the coastal route is saturated some 10 km South-East of Kemi. The 1,600 people travelling North from Kemi and possibly some of the 4,800 people living north of Kemi would have been better off going South.

4.4.2 The Polyarnye Zori Area

This area (Figure 4.5B) has a sparse road network. It consists of the Murmansk–St. Petersburg trunk-road passing through in a North–South direction and the branches to the population points along it. Most other roads in this area are gravel tracks of dubious quality, and their capacity is probably significantly lower than indicated by the BGDB (see Section 4.3.3.2), for example, the road used by 6,000 people in the upper-left corner of Figure 4.5B. However, in this scenario all population centres are both relatively small and located near the trunk-road. Kovdor has a radiation level of 8 kBq/m² and is therefore not evacuated, its evacuation would have added 30,000 people. Only 4,400 people cross the Russian border in the optimal solution to this scenario, so in practice the evacuation could have been done with no transborder flow.
Modelling the Short-Term Impact of a Nuclear Accident on Transportation Flows

Notes: Scenario is illustrated in Figure 4.1, as calculated by the model. Details of the two evacuation zones (A and B), as well as the legend are illustrated in Figure 4.5.

Figure 4.4 Resulting evacuation flows based on the final radioactive deposition of the 26 August scenario
Note: All maps use the same legend.

Figure 4.5 Details of Figure 4.4: the evacuation zone along the Bothnia Gulf (A) and the evacuation zone by the accident site itself, at Polyarnye Zori (B)
4.5 Possible Model Extensions

4.5.1 A More Generalized Optimization

As the optimization problem is formulated in this chapter, the choice of what places to evacuate is made in a blunt way: all places with a radiation level higher than a given limit are evacuated completely and from no other places is there any evacuation. It would be interesting to include the decision of who is to be evacuated into the optimization. Maybe, due to different sheltering possibilities and so on, different areas ought to be evacuated at different radiation levels? By reformulating the goal function in Equation (4.1), we could introduce a cost of staying:

\[
\sum_{i \in N} a_i n_i + \sum_{(i,j) \in L} a_{ij} x_{ij},
\]

(4.9)

where \(a_i\) is the cost of staying at \(i\), \(n_i\) is the number of people staying in node \(i\), \(a_{ij}\) is the cost of travelling \((i, j)\), and \(x_{ij}\) is the number of people travelling to it. It is easy to reformulate Equation (4.9) to an MCFP. A fictitious node, a ‘stay’ node \(q\), is added to \(N\) and one-way links are added from all nodes of \(N\) to \(q\) (see Figure 4.6):

Notes: Grey indicates node \(q\) and the one-way links to it. Sources are indicated by ‘+’ and sinks by ‘−’, followed by the quantity.

Figure 4.6 Using a fictitious ‘stay’ node \(q\)

\[
\min \left( \sum_{(i,j) \in L_q} a_{ij} x_{ij} \right),
\]

(4.10)

\[
0 \leq x_{ij} \leq c_{ij}, \quad \forall (i, j) \in L_q,
\]

(4.10a)

\[
s_q = \sum_{j \in N_q} x_{jq} - \sum_{j \in N_q \setminus \{q\}} x_{ij}, \quad \forall i \in N_q,
\]

(4.10b)

where:

\[
N_q = N \cup \{q, L_q = L \cup (i, q), \quad \forall i \in N,\}
\]

(4.10c)
We now have the same kind of problem as in Equation (4.2), if we substitute node \( f \) with node \( q \) in all its occurrences. In this solution, the people in link \((i, q)\), \( i \in N \), are actually staying in \( i \), so \( x_{iq} \) is the number of people staying in \( i \) and \( c_{iq} \) is the limit of how many people can stay in \( i \). By adjusting the value of \( z \) in Equation (4.5), it is possible to influence the radiation level at which places should be evacuated.

This model has another great advantage. It is now possible to experiment with values of \( t \) that are not sufficient to complete the evacuation, as the problem now has solutions for all \( t \leq 1/(1+h) \). Examining a node \( n' \) with high radiation, we find the number of people that could not be evacuated from \( n' \) by looking at the usage of the link \((n', q)\).

### 4.5.2 When to Evacuate – If at All?

In areas with more than 200–300 kBq/m\(^2\), the situation needs to be examined as to whether measures are needed. If it is decided to evacuate an area, it is also crucial to determine when to start the evacuation. During the Chernobyl accident, the short-lived isotopes contributed to about 90 per cent of the total radiation released, so it is thought that, during a radiation release accident, there will be an initial peak of higher radiation, due to the short-lived isotopes, that levels out as the long-lived isotopes begin to dominate (Figure 4.7). The optimal way of evacuating a place would be to evacuate people before the radioactive particles from the accident arrive, let the remaining people take cover during the radiation peak, and then resume the evacuation. In practice, there is probably often too little time before the radioactive matter arrives to organize and start an evacuation. The system presented in this chapter does not take any variations of the radiation level into account, so it is well suited to be used once past the radiation peak. It could also be used to optimize the number of people evacuated before the peak. It can not, however, optimize the whole process by determining the optimal times of interruption and resumption of the evacuation.

The presented system lets the cost of a node equal the contamination at this place, \( a_i = v_i \), but local factors may vary and a function could be used that takes this into account. Do people live predominantly in thick-walled houses made of concrete or in wooden cottages?
Notes: Assumed exponential depth distribution with relaxation length 0.01 m. (Edvarson, 1991).

Figure 4.7 Open-air effective dose equivalent rate in the city of Umeå, Sweden, during the year following the Chernobyl accident

In the same way a rather simple cost function is used for the links: the cost of a link equals the average contamination along it multiplied by its length. This assumes a linear relationship between the radiation level outside the vehicle and the occupants’ exposure inside it, more probably there is a time factor involved, dependent on the inflow of particles into the vehicle.

4.5.3 Evacuation by Water or Rail

Since many of the greater population points within the Barents Region are located by the sea at the end of the road network, an evacuation of these places by road only, would be time-consuming – the use of ships and trains would greatly reduce the evacuation time. The system presented in this chapter only deals with transport along roads, but it would not be difficult to include waterways and railroads as long as their capacity and cost can be determined.

4.5.4 Data Issues

Naturally, there are imperfections in how the data depicts the reality. To give an example, you can comfortably and rather speedily travel along a Swedish gravel road, whereas many Russian ‘gravel’ roads require off-road vehicles – but nonetheless all these roads get the same capacity values. One way of improving the capacity values would be to differentiate the values between the countries. Another
way would be to use actual values from the proper authorities of respective country instead of Equation (4.6).

4.5.5 Adaptation to Other Use

The basic functionality of the system is that of a GIS using a data set of the Barents Region and with the capability to include spatial radiological information. The system uses this to calculate evacuation routes that minimize people’s exposure to radiation, but other uses can be envisaged. Given spatial soil and vegetation information, for example, the duration of the radioactive matter, as well as its biological effects, can be calculated and visualized in an integrated manner. Given other kinds of spatial information, economic, social, societal, and other effects of the radioactive deposition can be visualized.

The model approach, where cost is measured by risk exposure on a link, could be used in other contexts, as long as the risk can be estimated quantitatively. For example, to check for road network capacity problems during an evacuation in case of volcanic eruption or hurricanes, various scenarios of lava flows or hurricane paths could be tested by the model.

4.6 Reflections on the Model Versus a Social Context

Apart from population distribution, network capacity, the time available, and so on, there are human and societal aspects of evacuation. Some people will refuse to leave. Some people in areas that do not really need to be evacuated will leave anyway. Queues will form and accidents will occur, temporarily changing the capacity of roads. People’s reaction to orders from the authorities might be unexpected. For instance, some people will check if their children really have been evacuated from the kindergarten. The issue of confidence is particularly important in Russia, where people’s trust in the authorities is especially complex (Tønnesen, 2001). There might also be other kinds of capacity restrictions, such as fuel availability.

On the other hand, a well-organized society might be able to use collective transport systems effectively, and thus lower the load on the road system. A variation of Equation (4.7) is proposed:

\[ c_{ij} = c'_{ij} t \eta_{ij}, \quad \forall (i,j) \in L, \tag{4.11} \]

where \( \eta_{ij} > 0 \) is a measurement of the local society’s efficiency in terms of effectuating an evacuation. A low value of \( \eta_{ij} \) would, for example, reflect a weak trust in authorities and a generally disorganized society.

The model could be used as a tool by policy makers both when ranking the seriousness of different accident scenarios and when designing evacuation plans. Since the model is implemented with a GIS program, it is easy to amalgamate
information from many sources and still have an overview of the whole picture. Since this information is handled in a consistent manner using fairly standard formats, it would not be difficult to envisage a system where many users could work with the same set of information. That all players have the same information is important for communicating not only within and between the authorities but also with the public.

Note

1 The North-Western part of Russia together with the northern parts of Finland, Norway, and Sweden.

References


5.1 Introduction

The tragic events of 11 September 2001 (9/11) resulted in severe transportation dislocations in lower Manhattan. Nearly 250,000 daily transit trips were impacted; all auto traffic in lower Manhattan was disrupted and even pedestrian thoroughfares were shut down. Restoration of accessibility became an immediate highest priority. Because this restoration implied high levels of capital investment, restoration plans ranged from simple rebuilding of what existed on 10 September 2001 to bold initiatives for new types of connections and linkages. But the planning did not stop at the environs of Ground Zero. Lacking any real transit capacity additions in the last four decades in an increasingly congested part of the New York Region, planners began to put a much broader range of projects on the table, many of which were not related to Lower Manhattan. Some projects had decades-old lifetimes of advocacy; others came to mind through an examination of New York’s status as a Global City in the Year 2001. Each project had its own stakeholders and advocates. None, except for those replacing terrorist-damaged infrastructure had any immediate source of dedicated funding. What then should be built, and how should any or all of the projects be funded? This debate has triggered the fundamental planning exercise of project evaluation, while simultaneously triggering the civic exercise of political advocacy building.

The urgency to rebuild New York was coupled with the inability of many stakeholder groups to prioritize among a worthy, but large set of candidate investments. The authors were commissioned by one prominent stakeholder business group to develop models to assist in their evaluation of the most promising projects. As part of this work, the authors interacted with a wide range of stakeholders, ranging from the agencies that proposed specific projects to developers to institutional interests to local businesses and firms. In addition, the authors interacted with regional transportation peers. But it should be noted clearly that, while the work of the authors was used to inform influential stakeholder groups, it was not part of the regulated and formal, public agency driven planning process. As will be discussed below, the inability of the region to address planning
Policy Analysis of Transport Networks

in a strategic, text book sense has led to a type of ad-hoc planning, but a type not atypical of mega-project planning in the largest US cities (Altshuler, 2003).

This chapter discusses the transportation project proposal and decision process post-11 September 2001 in the context of both the author’s analytic framework and regional decision making during this post-11 September 2001 (9/11) period. The chapter sets the stage for understanding the environment in which this work was carried out. Basic transportation, economic and demographic characteristics and trends of the region are presented in order that an understanding of investment needs can be made. The authors describe the formal and informal planning and decision-making processes and the roles of the planning organizations and of the regional transportation agencies. Similarly, the role and the power of the elected leadership, the Governor and Congressional representatives are also defined, as they have great impact on final project selection and funding.

The authors then present the approach they took to inform key stakeholders of the relative values of the candidate projects. They developed a model to calculate transportation benefits and economic development benefits for eight of the most prominent proposed regional rail transit projects (with an investment value of over $30 billion or €23 billion). The models were developed to inform the stakeholder on ways to assess the various major infrastructure proposals being considered by several regional transportation agencies. (Berechman and Paaswell, 2005). The authors present the scope and findings of their work and assess these findings against the current public strategies for investment. Finally, they conclude that both the stakeholders and the projects they endorse have influenced current actions (May 2004) being taken in the region to advance specific projects.

5.2 Transportation Issues: 10 September 2001 and 12 September 2001

The New York City metropolitan region is a region of superlatives. That is both good and bad news. The good news is that the population and its workforce create a world class economic engine. The bad news is that, as a consequence of this economic activity, the costs of doing business in a world capital that is congested, and growing more so, are substantial.

This metropolitan region is home to about to 20 million residents, more than 600,000 business establishments, more than 1.3 million registered trucks, and more than 8.8 million employees. The region is one of the largest and densest in the world, with an average of 17,600 persons per square mile. Every year, more than 67 million trucks cross the toll facilities administered by the various transportation agencies (NYMTC, 1999). One-third of the nation’s transit commuters are in this metropolis; one-tenth of all national vehicle miles travelled on expressways are within this metropolis (Paaswell and Zupan, 1998).

The entire metropolitan region surrounding Manhattan covers a land area of more than 8,300 square miles, yielding a regional average density of 2,300 persons per sq. mi. This is misleading: the Central City, New York City has 8,000,000 residents living in 360 sq.mi. (22,000 persons/sq.mi.). The distribution of jobs
reflects this distribution of densities: one quarter of the 9,000,000 regional jobs are in an area of Manhattan, called the core (the area of Manhattan south of 60th Street), giving an employment density of nearly 80,000 persons/sq.mi.

The core of Manhattan has Global Prestige, a factor that is influential in infrastructure investment decisions. It is the place where financial, media, fashion, entertainment and arts leaders want and need to be. In an area that has grown through agglomerations since the 1600s, the psychology of ‘being in ‘the city’ pervades planning rationales. We will show later in the chapter that business leaders have stronger input into new projects than does a rational planning process. This reflects the entrepreneurial characteristic of the region.

To meet the needs of the population, public transportation provides nearly 8 million daily trips. Eighty per cent of the trips into the core are – by necessity – taken on public transportation. But the majority of the more than 6 million jobs outside the core use motor vehicles; there are 240 million vehicle miles per day. In these cases New York City shows a type of schizophrenia. It supports, on the one hand, public transit, similar to dense European and Asian Cities, and, on the other, the auto, similar to sprawled US cities, such as Los Angeles. Both roads and public transit must be supported through maintenance and reinvestment and system expansion.

Lower Manhattan, defined as the area South of Houston Street, famous for its World Trade Centre Skyline, was a vibrant, still expanding area of jobs, housing and related commercial enterprises on 10 September 2001. On 12 September 2001, 120,000 jobs had been abruptly displaced; and 80,000 trips per day by various modes of public transportation had to be relocated. The 9/11 tragedy destroyed two transit stations, a major commuter rail station and essentially disrupted all transportation, not only at the site, but in lower Manhattan (in Figure 5.1 – South of the line from the Holland Tunnel to the Williamsburg Bridge). Figure 5.1 illustrates the level of these dislocations.

On 12 September 2001 New York City was faced with one immediate task – to make lower New York whole and vital again. The energies of the regional transportation agencies, providers and planners were focused upon a relatively small area in Lower Manhattan. The issues of how to proceed were addressed by Paaswell (2002), who recommended strategic thinking as the order of the day. The recovery of Lower Manhattan was seen to take place over three time periods: immediate, short-term, and long-term. The long-term projects were the high capital projects necessary to restore destroyed transit facilities or invest in facilities to meet the needs of an, as yet at the time, undefined lower Manhattan. While the details of the work to be done are far beyond the scope of this chapter, several issues that came to the planning table formed the basis for the surge in proposals for major infrastructure investments for New York City since 11 September 2001. The issues identified were:
Figure 5.1 Estimated peak period 6–10 am transportation ridership coming to and from Manhattan

- Quality of life: the events that precipitated the need to plan now for lower Manhattan are events that greatly impacted the quality of life and all the attributes that entails for hundreds of thousands of people. Restoring a quality of life that involves safety and security, as well as being able to carry out normal daily activities, is a priority objective.
• **Economic growth**: New York City had gone through a period of unprecedented economic growth during the last decade (1990–2000). This growth was slowing, yet it established lower Manhattan as the Centre of the World economy, bringing together, finance, real estate, commerce and the businesses and services that supported them in a dense, stimulating and highly entrepreneurial environment. A planning question is: Can and should this level of activity – a level that made the average income of those in this area 50 per cent higher than the average in the rest of NYC – be recreated? What will be the roles of high-tech and information technology in the restructuring of this local (yet global) economy? What economic stimuli and levels of finance are necessary to hit economic development targets?

• **Dispersion vs. centralization**: A major debate concerning the previously existing high concentration of activities has become part of the planning process. The thrust towards dispersion of businesses is a natural response to the WTC destruction. In fact, dispersion is necessary now in order for businesses to be sustained. But the underlying rationale for centralization and agglomeration will remain. How close do deal-makers wish to be to each other? To sustain a financial industry as inventive, competitive and ahead of the curve as New York’s has been raises the question of what type and magnitude of commercial clusters must be in place.

• **Connectivity (enhanced accessibility)**: The WTC site represents a significant, but far from majority portion of the economic activity of the region. There are layers of reconnections that must take place, but these must take place understanding the pressures for economic growth in adjacent and competitive locations – the other boroughs, New Jersey, and Connecticut. These layers which begin with lower Manhattan, reach through complementary and competing locations and end with necessary global connections through the region’s airports and seaport. Connectivity leads to understanding the role of infrastructure. How do investments restore or simulate connectivity? At what levels do such levels of connectivity support – or conflict with – other regional growth plans? A fundamental question that is at the core of all the proposed investments is: ‘How will this help New York’s need to remain globally competitive?’ Simultaneously, how will new investment assure New Yorkers that they can have easy access to work, home and all of the activities they need at personal costs they can afford?

After 11 September 2001, the focus of development and infrastructure investment was clearly on lower Manhattan and the World Trade Centre Site and its environs. This focus and resulting activities were reinforced by the allocation of Federal Emergency Funds to rebuild destroyed transit facilities. However, the regulations that accompanied these funds stipulated the replacement of destroyed or damaged facility in kind and were not available for speculative new investments for facilities still at the planning stage. A difficult and parallel issue was to identify the types of structures or memorials or other land uses that will replace the
destroyed World Trade Centre. Perhaps, a better way of stating the issue that has surrounded all regional discussion of lower Manhattan since 11 September 2001 is: ‘What will lower Manhattan become?’ Translated into planning language, this debate centres on how many commercial square metres and how many residential square metres shall be built (or rebuilt) and what set of activities, including a national memorial should there be. In an area already well served by public transit, what well-planned changes or additions are needed to meet the goals of rebuilding? This process has been quite dynamic. In 2001, it centred upon the boundaries of the WTC site. By late 2002, lower Manhattan had become the focus for redevelopment. At the time of writing (May 2004), competition for resources for new infrastructure projects occurs across the five New York City Boroughs. While the trauma of 11 September 2001 is always in the background of development, coupled with respect for those who perished and for those who live in lower Manhattan, the planning focus that has emerged has broadened its geographic scale.

5.3 Transportation Policy and Stakeholders: Planning in a Complex Region

There is a presumed and an actual process to guide major transportation infrastructure projects. The presumed – the rational transportation planning process (Institute of Transportation Engineers – ITE, 1999) is based upon the systems approach. Starting with a well defined set of regional goals and objectives, the process, which uses an analysis to evaluate alternative solutions arrives at projects that meet financial constraints. This process works, generally on a small scale, but in a large complex city such as New York, Boston or Los Angeles, the actual steps from project identification through implementation often take a far different course. Recently, Altshuler (Altshuler and Luberoff, 2003) discussed the political and social impacts on project implementation and impacts, observing how ‘mega-projects’ take on a life of their own and are seen as above or outside the traditional and mandated planning process. While it is well beyond the scope of this brief chapter to discuss examples of mega-projects and their initiation in any detail, the following should be noted:

- There is a federally-mandated transportation planning process (ITE, 1999) that specifies the need for long-term (capital) planning. The process has been carried out in each US City over 50,000 population by a Metropolitan Planning Organization (MPO). The MPO is structured by the Governor of the State in which it resides and is made up of regional transportation providers and managers.
- Because the US is so large and so diverse, there are numerous models of MPOs and numerous models of planning and decision making (Paaswell, 1998). The national goals relating to planning are general enough to ensure that local objectives are paramount in project selection.
The difficulties that MPOs have when arriving at local consensus occur when members are particularly strong local agencies or governments and can, in fact, make or influence decisions extra-organization. In fact, Altshuler (2003) discusses such actions, but notes that powerful organizations do get the projects they desire implemented. This is the case in New York and Boston.

Finally, and this is a major difference between the US and European infrastructure initiatives: in the US, it is often a public body or agency that plans and implements transportation infrastructure projects. But land uses, whether for the project or impacted by the project are controlled at the smallest level of local government. This alone has the potential to create conflict arising from local and regional differences, and does little to diminish intra-regional competition, especially for economic development.

In a rational transportation planning process, a public planning group, such as a Metropolitan Planning Organization (MPO), would have responsibility for undertaking the steps beginning with the formulation of regional goals and objectives and culminating with a recommended set of projects. These projects would be based on discussions with stakeholder groups, on assessments of regional economic and demographic changes, on regional strategies for growth or other specific desired objectives, and on knowledge of regional agency ability to deliver specific types of projects. In metropolitan New York, this type of procedure has become unworkable. First, the MPO does not possess the real power to carry out such a process. They do work on the mandated Long Range Plans and the Transportation Improvement Program, but these are outcomes of a negotiated process among powerful stakeholders. Second, individual public agencies have extraordinary powers and specific legislated areas of interest and responsibility, thus rendering them difficult negotiating partners. Third, there are a number of persons or assemblies who are the decision makers; often, they are unable to come to a consensus on specific regional projects that have emerged from a rational planning process. Many times, this leads to projects being formally evaluated and tested against Federal Regulations after they have been selected for implementation. Paaswell (1999) describes how significant rational regional plans went without a client, mainly because of the inability of powerful local agencies to agree on issues such as turf, project control and, most important, allocation of funds. Table 5.1a gives abbreviations commonly used for these agencies throughout the chapter. Table 5.1b illustrates the Transportation Agencies and their spans of control and responsibility. Table 5.2 describes the nature and power of elected decision makers in the New York Region.

An example of the use of such powers was seen Post September 11, 2001 in Lower Manhattan. In early 2002, the Governor of New York State established the Lower Manhattan Development Corporation (LMDC), a new public body, whose role was, and remains, the rebuilding of infrastructure and development in Lower Manhattan. The LMDC Board is controlled by the Governor. While rebuilding of specific damaged infrastructure was the responsibility of the operating agencies
(reopening of MTA transit stations and rebuilding the PANY&NJ PATH station at the World Trade Centre), the integration of these facilities and design approaches to new infrastructure is the responsibility of LMDC. They were given unique powers of planning and building that would have been the purview of existing agencies and authorities.

Table 5.1a Agency abbreviations

<table>
<thead>
<tr>
<th>Agency</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metropolitan Transportation Authority</td>
<td>MTA</td>
</tr>
<tr>
<td>Port Authority of New York and New Jersey</td>
<td>PANYNJ</td>
</tr>
<tr>
<td>Port Authority Trans Hudson</td>
<td>PATH</td>
</tr>
<tr>
<td>New York State Department of Transportation</td>
<td>NYSDOT</td>
</tr>
<tr>
<td>New Jersey Department of Transportation</td>
<td>NJDOT</td>
</tr>
<tr>
<td>New Jersey Transit</td>
<td>NJT</td>
</tr>
<tr>
<td>New York Metropolitan Transportation Commission (MPO)</td>
<td>NYMTC (MPO)</td>
</tr>
</tbody>
</table>

Table 5.1b Regional agencies influential in transportation investments in New York City

<table>
<thead>
<tr>
<th>Agency</th>
<th>Responsibilities</th>
<th>Source of Capital Funds for transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTA</td>
<td>Operates rail rapid and bus service within NYC; commuter rail in suburbs to Manhattan core; some toll facilities</td>
<td>Federal Gov., State, local gov., issuance of debt, tax revenues</td>
</tr>
<tr>
<td>PANYNJ</td>
<td>Operates commuter rail from adjacent New Jersey to core of Manhattan; operates toll facilities between NYC and NJ; operates major regional airports and the Port of NY/NJ</td>
<td>Issuance of debt; cross subsidy from bridge and tunnel tolls</td>
</tr>
<tr>
<td>NYSDOT</td>
<td>Maintains selected roadways within region</td>
<td>Federal and State govs</td>
</tr>
<tr>
<td>NJT</td>
<td>Operates commuter rail and commuter bus from NJ to Manhattan</td>
<td>Federal and State govs; issuance of debt</td>
</tr>
<tr>
<td>AMTRAK</td>
<td>Intercity rail; heart of the NE Corridor; operates from Penn Station in Manhattan, the busiest station in the nation</td>
<td>Fares; federal and state subsidies</td>
</tr>
</tbody>
</table>
Table 5.2 Regional transportation decision makers

<table>
<thead>
<tr>
<th>Decision Maker</th>
<th>Powers</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Governor</td>
<td>Suggests projects; appoints major Public Authority Boards – including MTA and PANY&amp;NJ; Has Budget veto power; Appoints DOT Commissioners; Structures MPO</td>
</tr>
<tr>
<td>State Legislatures</td>
<td>Develops State Budgets and Budget special items; must have adequate majority to over ride a Gubernatorial veto</td>
</tr>
<tr>
<td>Mayor of City of NY</td>
<td>Suggests budget; suggests programs and projects; appoints members to, but does not control, major Transportation Boards</td>
</tr>
<tr>
<td>US Senators, Congressmen</td>
<td>Can specify local projects in Federal Budgets</td>
</tr>
</tbody>
</table>

5.4 Policy Makers and their Level of Decision Making

The complexity of the institutional structure described above originates from the legislation and purposes for establishing each agency. A number of special purpose governments, some of them created at the beginning of the 20th century, have played a prominent role in the economic development and in building the region’s transportation system. The Port Authority of New York and New Jersey (founded in 1921 as the Port of New York Authority), the Triboro Bridge Authority (founded in 1933 and later merged as part of the Metropolitan Transportation Authority), the Metropolitan Transit Authority (created in 1968), the New York State Thruway Authority, and the New Jersey Turnpike Authority are all examples of special governments that are given powers to design, build and operate transportation facilities, as well as (important) special powers to collect tolls and fees, and issue debt. But the State Transportation Departments, by law receive and utilize federal road funds. The purpose of these funds was, initially, to build roads for a rapidly expanding (in terms of mobility) country. While State DOTs still plan, build and maintain roads, they are changing to multi-modal agencies, adding to the mix of regional players in the transportation field.

Federal Law requires the establishment of Metropolitan Planning Organizations (since 1975). But while the MPOs plan the expenditure of funds, the other agencies (most frequently DOTs) are the recipients of funds and have a strong influence on their expenditures.

Each mega-agency (See Tables 5.1 and 5.2 above) controls a different facet of the transportation system while maintaining some independence from the others. While many of the agencies have the power to be multi-modal and modally integrated, the history and institutional framework have led them to concentrate on single modes. And, in fact, while the special purpose authorities provide service
(operate transit systems, ports, bridges and tunnels, expressways), the State DOTs plan, build and maintain highway infrastructure, but operate no transit systems or expressways. However, the infrastructure they build must serve the needs of passengers and freight; simultaneously, these people and goods also move over the portions of the transportation network controlled by the special purpose authorities. In 2004, these agencies controlled tens of billions of dollars of annual expenditures, employed tens of thousands of persons, and worked hard to maintain their own uniqueness and long-standing missions.

5.5 Candidate Projects: Post 11 September 2001

The period following September 11, 2001 sustained a focus on rebuilding Lower Manhattan as described above. But, because of the focus on obtaining Federal support for high Capital projects, advocates of a number of other important Capital investments began to be heard. Many came to the table out of fear that, without strong immediate advocacy and a claim to Federal support, they would again fall off of the table. These projects shown in Figure 5.2 are listed in Table 5.3.

The individual transportation projects listed in Table 5.3 have come to the planning table – whether bottom-up or top-down – because of pressing, cross-cutting issues, summarized as acute transportation operational problems and network problems. A major activity of transportation planners is to identify acute transportation needs, which require capital investments for upgrading existing facilities or constructing new ones. Jammed highways at specific intersections, insufficient rail capacity at river crossings, and highly congested bus or subway terminals are examples of such critical needs. In these cases projects are evaluated and selected on the basis of how well they are capable of answering these needs, given their costs.

The pressure to build new infrastructure often competes with the understanding and need to sustain and operate that which is already in place. An ongoing, and cost-sensitive part of operation problems is the maintenance and modernization (upgrading) of existing components of the transit system or roadway system. As a matter of practice, a large proportion of regional transportation budgets are devoted to maintenance and upgrading activities. Keeping the transportation capital stock in a state of good repair is the single greatest major need that cannot be sidestepped for long – and in fact is at the heart of the 5-Year Capital Programs of the regional transit agencies (MTA, NJT and PATH). New revenue sources must be developed. These include new types of taxes, utilization of Tax Increment Financing (TIF), establishment of transit impact zones, innovative real estate – transit deals and dedicated, long-term sources of State Capital, PATH. Project evaluation mainly aims at finding the best investment alternative for reaching engineering standards of State of Good Repair.
### Table 5.3 List of projects

<table>
<thead>
<tr>
<th>Category</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rebuild Lower Manhattan:</strong></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Fulton Transit Centre and Permanent PATH Station – connecting a number of separate subway lines and PATH in a substantially more accessible mega-terminal</td>
</tr>
<tr>
<td>B</td>
<td>West Street Tunnel – improving vehicle and pedestrian access within lower Manhattan</td>
</tr>
<tr>
<td><strong>Improving New York City Connection:</strong></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Second Avenue Subway (SAS) – a new line along the full East Side of Manhattan, to relieve congestion on one subway line and upgrade access to and within the East Side</td>
</tr>
<tr>
<td>D</td>
<td>No. 7 Subway Extension to extend the subway from Times Square (7th Avenue) to 11th Avenue, promoting access to major development for the far West Side (at midtown) of Manhattan</td>
</tr>
<tr>
<td><strong>Connecting the City and the Region:</strong></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Access to the Region’s Core (NJ Hudson Tunnel &amp; connection to Grand Central) – building a new tunnel from New Jersey to Penn Station to improve capacity into midtown from the rapidly growing labour force from New Jersey</td>
</tr>
<tr>
<td>F</td>
<td>East Side Access -LIRR Connection to Grand Central, allowing those commuters to have an East Side destination in addition to the West Side destination at Penn Station</td>
</tr>
<tr>
<td><strong>Connecting to Other Regions and Global Economy:</strong></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>LIRR and/or JFK Access to Lower Manhattan – improved access to lower Manhattan. The belief is that access to lower Manhattan suffers from the two mid-town terminals, Penn Station and Grand Central Terminal</td>
</tr>
<tr>
<td>H</td>
<td>Farley Post Office – an expansion of Penn Station to allow for additional capacity</td>
</tr>
<tr>
<td>I</td>
<td>PATH Extension to Newark Airport – improved airport rail access</td>
</tr>
</tbody>
</table>
The competing new projects – all quite different in scope, size and area of impact could be examined in terms of the following dimensions:

- **Total project capital costs:** Not all projects can be accomplished with current projected availability of funds. Some projects – very limited in lower Manhattan – can be funded with Federal Emergency Management Agency (FEMA) funds. The remainder needs more traditional, extremely competitive sources of State and Federal funds. The 2nd Avenue subway at $12.5 billion costs more than double the East Side Connector. The remaining projects varied in cost from $4 billion to under $1 billion. Finding funds for one project may cut off availability of funds for other – equally important – projects.

- **Some projects may generate capital to ‘pay their own way.’** New revenue sources must be developed. These include new types of taxes, utilization of Tax Increment Financing (TIF), establishment of transit impact zones,
innovative real-estate-transit deals and dedicated, long-term sources of State Capital, may all be used in place of traditional debt financing. This is the approach for the No. 7 Line extension, a project needed for economic development and expansion in Mid-Manhattan.

- **Transportation benefits**: While the 2nd Avenue subway costs significantly more than other projects, it generates significantly greater transportation benefits than any other project. However, unless 2nd Avenue is staged, these benefits will not be realized for 20 years. Both the 2nd Avenue subway and East Side Access have generated the greatest travel time savings; this improvement in accessibility would have an impact on business location decisions.

- **Benefits per passenger**: The downtown hub (Fulton St superstation) needs the fewest benefits per ride to break even; most of these can be realized as direct transportation benefits. Improvements to Penn Station and the No. 7 line extension also share these characteristics.

- **Time of construction**: The downtown hub, Penn Station improvements and the No 7 extension can all be constructed within a 5-year time period; this allows benefits to be realized in the short term. The 2nd Avenue subway, while taking almost 20 years to be completed, would have a great long term regional impact on both travel and development. However, the No. 7 line extension benefits come only if new West Side development occurs simultaneously, generating demand for the new service.

- **The demand for ancillary projects**: Each project will need associated bus route rationalization, changes in street networks, new fare or toll policies. Some projects – NJ tunnel, Penn Station, No. 7 line extension, Airport access – will require vigorous and intense multi-Agency, multi-State cooperation. Such cooperation – with a regional perspective – has yet to be shown.

Lastly, the final criteria for project needs and impacts must be established by the stakeholder community including businesses and firms, developers and real estate interests and, of course, the ultimate system users.

In New York, there is, first, a tremendous need to sustain the huge investment in existing infrastructure that underpins the regional economy. The Agencies that plan and operate the systems invest through three types of Capital Programs: (1) State of Good Repair (SGR) – bringing systems to a standard of most efficient performance; (2) Normal Replacement (NR) – replacement of rolling stock, signals, tracks, power sources at specified intervals; and (3) System Expansion, adding system elements to meet current or anticipated capacity needs. The same pot of capital supports all three thrusts; this leads to competition among programs, and a sustained problem of delaying or underfunding many program elements. While no one understands SGR and NR better than the operating agencies, the call for new initiatives and the political impacts that new Capital initiatives creates causes these programs to be balanced in an arena supported by a diverse set of
stakeholders. While some of these new projects might emerge from a public planning process, many emerge because of stakeholder advocacy.

5.6 The Role of Stakeholders

The growth of Stakeholder Organizations and their impact on project advocacy is in direct response to the likelihood of gaining significant Federal and State funds to implement major projects. The projects being rebuilt as a result of September 11, 2001 and the advocacy to add additional projects in Manhattan present the greatest opportunity for such investments in more than 45 years. The stakes are high; the stakeholders are well organized. Stakeholder groups who have been most prominent in this cycle of rebuilding are noted below. One, the Civic Alliance was organized to influence 9/11 rebuilding, through an open, citizen led effort. The Empire State Transportation Alliance is a 6-year-old organization that had its genesis in attempting to influence the Capital Programs of the MTA. The Partnership for the City of New York – a very high powered group of civic leaders (primarily business people) has a focus on influencing major quality of life issues in the City – education, housing and, most recently, transportation. The Regional Plan Association has had a history of providing vision and planning from an NGO perspective. Their strong influence post-9/11 was the formation of the Civic Alliance – a process that enabled thousands of New Yorkers to be heard post-9/11 concerning issues of planning and priority setting for rebuilding and for overall high visibility planning issues. All have members who have had positions of leadership and respect in the local community, either through roles in government or the private sector. While there are many other stakeholder groups working alongside government, these have had the most visibility and reached the greatest audiences since 11 September 2001. Hence, all have access to the media and to the ultimate decision makers, the Governor of New York State and the Mayor. Because the Governor and Mayor control applications for project funding and control the Boards of the implementing transportation agencies, they are the ones who need to be persuaded that projects should go forward.

5.7 Stakeholders

Descriptions for the following stakeholders are taken from their current (May 2004) web pages. They are quotes as displayed. These stakeholders are not government agencies. They are groups of business and civic leaders who value the role that transportation plays in New York City’s economic health. While they have a diverse set of political interests, they converge in wanting to ensure that transportation investments meet regional – and their members – needs. These groups have played a major role in moving the Region and its political leaders to define projects in terms of their ability to meet needed objectives. The prominent
and most articulate stakeholder groups concerning rebuilding lower Manhattan and making transportation investments are:

- **Partnership for the City of New York (NYCP):** ‘The Partnership is a nonprofit membership organization comprised of a select group of two hundred CEOs – its Partners – from New York City’s top corporate, investment and entrepreneurial firms. It is a Network of Business Leaders Partners are committed to working in partnership with government, labour and the nonprofit sector to enhance the economy and maintain New York City’s position as the global centre of commerce, culture and innovation.’

- **Empire State Transportation Alliance (ESTA):** ‘RPA [Regional Plan Association], working in partnership with the Council on Transportation (COT), has convened the Empire State Transportation Alliance (ESTA) to assist the Metropolitan Transportation Authority (MTA) and New York State Department of Transportation in developing five-year capital programs that continue the progress that has been made in restoring New York’s mobility infrastructure. ESTA draws members from a wide range of civic, business, labour, and environmental interest groups and is operating as an ad-hoc organization, co-chaired by ... the ... Executive Director of RPA, and ... the ... Director of COT. Three subcommittees have been organized to address education and outreach, capital needs, and finance. The ESTA research effort has recently completed its own assessment of the capital needs of the MTA, and is working to develop assessments and needs of NYSDOT and the rest of the State. ESTA is also working to identify potential investment scenarios and crafting an effective education and outreach campaign that increases public understanding of the issues and the urgent need for a resolution. ESTA expects to build a compelling and publicly supported campaign that results in the passage of a transportation investment program that sustains New York’s economic growth and preserves environmental quality. This capital program will be sustainable and thus leave the State in a solid financial position for future investments.’

- **Regional Plan Association (RPA):** ‘RPA is an independent, not-for-profit regional planning organization that improves the quality of life and the economic competitiveness of the 31-county New York-New Jersey-Connecticut region through research, planning, and advocacy. For more than 80 years, RPA has been shaping transportation systems, protecting open spaces, and promoting better community design for the region’s continued growth. We anticipate the challenges the region will face in the years to come, and we mobilize the region’s civic, business, and government sectors to take action.’

- **Civic Alliance:** ‘In a partnership with New School University, New York University and Pratt Institute, Regional Plan Association has convened The Civic Alliance to Rebuild Downtown New York to develop strategies for the redevelopment of Lower Manhattan in the aftermath of the September
11 attack on the World Trade Centre. The Civic Alliance is a coalition of more than 75 business, community and environmental groups representing a cross-section of New York and the Region that is providing a broad ‘umbrella’ for civic planning and advocacy efforts in support of the rebuilding of Downtown New York. The Alliance is working closely with the Lower Manhattan Development Corporation, the Empire State Development Corporation, the Port Authority of New York and New Jersey, and the City of New York to create a bold vision for a revitalized downtown.

The Civic Alliance, RPA and ESTA were on record as strong advocates of the SAS. In conclusion, the stakeholder groups promoted advocacy for several of the projects listed above, while remained tentative about the others. But the selling of the projects started and ended with the case being made to the ultimate decision makers. What remains consistent within the stakeholder groups is that all are advocates for new large projects; each is seen to have substantial impact on a target area or activities advocated by the Stakeholders. However, none of the stakeholder groups shows concern for maintaining State of Good Repair. In fact, a number believe that SGR can be drawn out to support new construction. This is a debate that is to take place in a broad budget negotiation later in 2004 and 2005. In Section 5.8 below, the authors describe their work for the NYCP in developing a model to discriminate among the candidate projects. The idea of SGR – while compelling – was not to be examined against new projects. The projects that ultimately moved will be discussed in a later section.

5.8 The Partnership Evaluation

The NYCP commissioned the authors to conduct a study to assist its members in discriminating among the various projects noted above. The purpose of the study was to define the projects, to calculate both transportation and economic benefits, and to array the projects by potential impact. NYCP is an important stakeholder group, described above, whose business leaders have influence on the media and on public officials. The authors were asked to develop quantitative tools to assist prominent local stakeholders in the understanding of these projects and to provide a means to discriminate among them. The objective of that work was to assist rational and systematic choices based on economic and transportation grounds. While the evaluation methodology developed incorporates acceptable transportation economic methods, the discussions surrounding the methods could not be divorced from key underlying institutional and political factors.

NYCP proposed a set of projects for which they wanted answers to seemingly simple questions. Are these projects worth doing? Are any ‘better’ than the others? The authors defined a somewhat rigorous response to the client and, in doing so, changed somewhat the tenor of those questions. Our response was that projects can be evaluated and that these evaluations should be conducted through careful
definition of the variables used to measure costs and benefits and through the cost-
benefit methodology itself. We noted that this would raise many issues as the
evaluation proceeded. Among these are:

- the projects will be evaluated independently – yet, may make better sense if evaluated in clusters,
- they will be constructed over widely varying time periods,
- the projects have each arisen because they meet specific but diverse local/regional objectives: for example, relieving congestion, creating access, stimulating real estate development, and so on,
- sources of capital funding for the projects differ, and they are not all competitive for funding.

The overall structure of the study and the analytic methods are described in a companion paper of the authors (Berechman and Paaswell, 2005). The authors used a Goals Achievement Matrix, to evaluate transportation benefits and economic development benefits. For more details on the quantitative analysis and numerical results, the reader is directed to the paper cited (Berechman and Paaswell, 2005). The analysis scored the projects on the basis of these benefits and project life-cycle costs. However, the analysis was constrained by the factors noted above.

5.9 How the Model Worked

The methodology used in the analysis is composed of two major parts: computation of the overall benefits from each project, and, subsequently, the ranking of these projects. Benefits were assumed to comprise direct transportation benefits, in terms of travel time savings and increased ridership and economic development benefits, mainly in terms of additional real-estate development and job creation. The computation of net transportation benefits, while accounting for the value of the invested resources, shows that the projects cannot be justified on the basis of these benefits alone. On the other hand, most of the projects generate positive net economic development benefits. This reality of negative net transportation benefits and positive net economic development benefits raises theoretical and practical questions regarding the acceptance of transportation projects. Should transportation investments be carried out if the expected transportation benefits are insufficient to cover the costs involved, even if other non-transportation benefits are substantial? On the practical level, if we do accept projects that engender inadequate net transportation benefits on the basis of their external benefits, in the decision-making process, should the latter benefits receive the same weight as the former ones do? For the policy sciences theorist under these conditions – why transportation? Why not education, health care, housing, and so on?
Related to the use of more refined economic development methods is the issue of the regional distribution of benefits and costs from transportation projects. Little attention was given in this study, as well as in the decision-making circles, to this question. Yet, at time of implementation, various population segments, which may regard themselves as ‘losers’ relative to the distribution of costs and benefits, could delay the investment by many years to come, adding substantially to its already very high costs. As with the economic development impacts, at present, tools for assessing the distribution of costs and benefits from transportation investment projects are unsophisticated and insensitive to socio-economic and spatial variables. Nonetheless, a clear understanding of this question is essential for successful project completion.

Another issue that this study raises is the role of public sector planning organizations. That is, transportation investment decision-making processes have always been political, balancing political stakeholder demands, equity and resources availability. These are all strong dimensions – or forces, not readily modelled. What then is the role of professional public planning agencies in the project selection process? Forty to fifty years ago, models and techniques used for project evaluation and planning were technically rather crude, quite restricted and largely inaccurate, leaving plenty of room for fuzzy decision-making processes, where rough estimates, conjectures and even personal values, played a major role. The advancement of computation and data storage capabilities along with highly sophisticated mathematical, GIS and economics models and techniques, render planning and evaluation schemes quite versatile, highly accurate and, most importantly, available for routine use by planning professionals and stakeholders alike. Public agencies, which have evolved since the post-WW2 period, have adopted a fortress-like attitude towards their methods, data collection and sharing, and ultimate decision making. Some of this attitude is reflexive – especially in an environment such as New York. For every agency-proposed project, other groups propose alternatives – many as antagonistic alternatives. Agencies though are the ultimate decision makers for the expenditure of resources, and that is the source of much internal regional conflict. Agencies become reticent to share information, making public evaluation of mega-projects and their alternatives difficult and often contentious. This, of course, raises the difficult – but pressing question, ‘What is the relationship of planning to project realization in the early 21st Century?’

5.10 Project Evaluation

Of the three projects which received the highest goals-achievement scores relative to their contribution to transportation and economic development benefits, two are essentially hub facilities. These are the Fulton Transit Centre and permanent PATH Station and the Penn Station and Farley Post Office. This finding is quite significant as it reflects the present structure and needs of the NY transportation system. Thus, save for Penn Station and Grand Central Station, both located in the mid-Town area, there are no major hub facilities for the entire rail, bus and subway...
networks, where users can expediently transfer within and between modes. The lack of hub facilities, in part, is also responsible for the poor East-West accessibility in Manhattan. The third highest scoring project, the No. 7 Subway Extension, aims at linking the borough of Queens with Manhattan’s west side via Penn Station.

Another key result that characterizes the ‘best’ projects is that they scored highest on both scales: transportation benefits and economic development benefits. While above we have observed that the analysis of the economic development benefits is not directly linked with the projects’ level of accessibility, nevertheless, significant economic development impacts are apparently associated with high-level transportation impacts.

Surprisingly, the Second Avenue Subway (SAS) project, which has been on the drawing board for many years in NY (actually, for over the past 40 years) and thus has received much attention in the public and among planning agencies and has strong local advocacy, is not ranked among the three top projects. This is due to its massive capital needs ($12.5 billion, exclusive of debt service) and long construction period (17 years). In addition, the project is located in the midst of one of the most well-developed areas in the city, with major construction implications for everyday life. This raises an interesting planning question. In a world characterized by severe limitations on public resources and rapid technological changes, can such a massive project actually be implemented? Apparently, funding issues, (not accounting for costs overruns), traffic and urban activity disruptions, inability to forecast future technological developments in communication and transportation and lack of political stability during the construction period, are likely to render a project of this magnitude rather unfeasible. SAS is a very high priority of the RPA and ESTA, but became a low priority of the NYCP.

Some major projects examined have emerged from, and are strongly advocated by, the private sector. Such a project, Airport access to JFK International Airport from lower Manhattan is promoted by powerful real estate and financial organizations (members of the NYCP). The project would underpin the desire to see more economic growth, that is, square metres of office construction, in lower Manhattan. This transportation-planning phenomena and attempt to tip the scales in favour of project funding is absolutely legitimate and one that should be encouraged. However, as done in the analysis, it should still be treated as a public project relative to its contribution to economic social welfare. The Airport Access Project has gained significant strength due to support from the Governor and one U.S Senator from New York. It retains support from the NYCP.

5.11 Back to Realities: Funding Issues

Since the late 1970s, finding ample financial support for both maintaining and renewing infrastructure in the US has been a major national issue. The availability of capital for infrastructure investments has strong influence over local project
Policy Analysis of Transport Networks

selection. Rather than starting with the fundamental planning question: ‘What project – or combination of projects – is good for the region?’ Too often the starting influence is: ‘What projects are immediately eligible for funding.’ Capital comes from a number of sources. The sources are US DOT and State governments for subsidies, State and local governments for the issuance of debt, in rare instances from the fare box, and occasionally from the private sector in some joint venture. For all of the projects studied here, some source of Federal Subsidy would be needed; without the possibility of such subsidy, project planning would be delayed or foregone. The projects located in Lower Manhattan are eligible for FEMA funding – funding as ‘insurance’ for September 11. But again, FEMA funds are too scarce to meet all of the proposed projects. So planning becomes confounded over the issue of multiple agencies with competing proposals and multiple funding sources that are not fungible.

5.12 Implementing Projects

Ultimately, project decision making comes from political strength. The Governor of New York appoints board members to two of the strongest regional agencies, namely the Metropolitan Transportation Authority (MTA) and the Port Authority of New York/New Jersey. The New York Federal Legislators also suggest or earmark projects to be implemented by these agencies, based upon availability of funds. The projects, of course, have merits; projects that reach the open discussion and subsequently the planning phase have developed strength through addressing a problem for which political help is appropriate. But the projects ultimately selected might be suboptimal. No one has asked the open question: ‘What does the New York region need from new transportation investments in order to remain globally competitive, culturally diverse, the capital of entertainment or any of a number of appropriate goals?’ Then the question asked would be, for each project: ‘Does this move us to that goal?’ To some extent, this is a failure of regional planning, that is, the engagement of the set of regional players in setting a vision and choosing strategies to implement this vision. But stakeholders also have impact; they do so by lobbying the Governor and Mayor, individually or through representation of important civic interests. The SAS, while questioned in its cost and time estimates by some professionals had strong stakeholder support and has found a Governor responsive to their interests. The No. 7 line extension, with strong advocacy from the Mayor is under review, but not now competing for Federal Funds.

At the time of writing (May 2004), the following projects have emerged with initial funding or strong political pressure to receive funding. They are the ‘winners’ from the long list of important regional transportation investment projects.

- 2nd Avenue Subway (SAS): On the ‘books’ for 40 years, the SAS represents a negotiation among the Governor, the State legislator and influential stakeholders. While funds are not presently available for the full-
length system, a short initial segment has been committed to and may see the start of construction by the end of 2005.

- **East Side Access**: Bringing the Long Island Railroad to Grand Central Terminal – an East Side location has been prominent on the wish list of those who commute to the core of the city from Long Island. The champion of this project was a former US Senator who arranged for funds to commence this project over 4 years ago. The project is now in early construction.

- **Airport Access from lower Manhattan**: This is a ‘prestige’ project, one that cements New York City in its role as a Global Capital. Desired by business leaders, with few other supporters, the project has the strong support of the Governor who announced that it would go into preliminary design this year.

- **9/11-related projects**: The Fulton Street super station is planned to provide significant access improvements by connecting a number of now poorly-connected rapid transit lines in the vicinity of the World Trade Centre. It will also improve connection from a New Jersey-based commuter rail line (PATH) and serve as a gateway to the rebuilt lower Manhattan. It had the support of all groups and all political leaders. Many 9/11 projects are supported by post-9/11 funding unavailable to the other large scale projects.

### 5.13 Conclusions

The driving force for this work was the simple question by local stakeholders: ‘Are these good investments?’ The basic problem that arises when such an analysis has been done is that project comparisons, while made in a consistent manner, are not consistent in objective. All of the projects being compared did not originate from a single agency. Of greater importance, the projects did not originate from a regional Master Plan based upon the achievement of regional overarching objectives – whether economic, equity, environmental or other objectives. Each is simply a transportation project meant to impact specific concern in a rather localized area.

In fact, a traditional formal Benefit-Cost analysis of the type carried out by the authors showed clearly that transportation benefits alone needed to be supplemented by economic development benefits to justify project investments. Decision makers often prefer to emphasize economic development and jobs, and often overlook transportation benefits; transportation planners and policy analysts understand that in a world where all dollars are competitive, transportation projects should be built for transportation reasons.

In all of the formal analyses by the agencies and the discussions by the stakeholders, the focus has been limited to single projects. In fact, these projects were often posed as competitive, the competition arising from limited funding sources. There has been, and continues to be, no discussion on examining the projects on a regional scale, collectively or in reinforcing groups. This task, actually a requirement of the Metropolitan Planning Organization (MPO), has been
neglected so that advocates of singular projects could sustain focus on those projects. The assumption – often stated by top planning officials is that ‘projects do not conflict.’ That assumption has not been tested for either transportation or more general impacts.

In one sense, 9/11 created a need to examine the regional context of investment in terms of local projects. The focus was on lower Manhattan and getting back to an even better ‘normal’. But this has evolved into a Manhattan-centric exercise, where each project is being supported on justifiable benefits. The competitive aspect comes from stakeholders attempting to maximize very local benefits. The work here is a start, a rationale for a more balanced and coherent discussion.

Acknowledgements

The authors thank Todd Goldman and Herbert Levinson for their work on the NYCP Project and their assistance in this chapter.

Notes

1 The Metro Region covers parts of three states, Southeast New York, Northern New Jersey and Southern Connecticut. New York City, consists of five Boroughs, and is totally contained in New York State. When many writers discuss New York City, they usually refer to the core of one of the Boroughs, Manhattan – below 60th Street.

2 In a number of focus group meetings with business leaders, Global Prestige was identified as an important factor in head office location. How these leaders are seen by the group they consider to be their peers has a strong influence on where they choose to locate. Extremely high real estate prices reinforce this attribute. These business leaders are also influential in local investment decision making resulting from their economic importance to the region.

3 In fact, The Federal Reserve Bank recommends that financial institutions disperse many of their activities and even develop redundant activities to avoid dislocations due to catastrophic events. At the time of writing (May 2004) this is still their policy.

4 From the Federal Emergency Management Agency (FEMA).

5 The MPOs have been required for every major Metropolitan Area in the US since 1975. Made up of local transportation providers and governments, they have the purported responsibility of certifying that regional plans emerge from a rational planning process. That they are not always successful is the subject of much greater discussion beyond the scope of this chapter (Paaswell, 1998).

6 In fact, Federal Law requires every Metropolitan Region, through its MPO to establish Long Range Plans and Yearly Programs of Projects to meet regional goals. That there are no teeth in the Federal Law is clearly seen in the emergence of major Capital Projects through a political as opposed to a ’rational’ process.

7 A seminal report on the value of infrastructure and its costs was presented to Congress in 1988 (National Council on Public Works Improvement, 1988). This report is based on extensive research and hearings on the condition of the trillions of dollars of public works investments in the US since the early 1900s. This wake-up call has had marginal
impact, as short-term, rather than long-term funding solutions have remained the order of the day.

For the No. 7 line extension, the initial thought was to finance the entire capital costs through tax increment financing (TIF). This was shown to be unfeasible so more traditional, that is, Federal and State subsidies will be needed.

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Chapter 6

A Framework for Identifying and Qualifying Uncertainty in Policy Making: The Case of Intelligent Transport Systems

Marina van Geenhuizen and Wil Thissen

6.1 Setting the Scene

There is increasing concern about the impact of uncertainty in policy making. Policy decisions often do not lead to the realization of policy aims and may even cause adverse impacts, and such developments seem to be occurring more frequently in recent times. There are various reasons for this situation. The world subject to policy making is becoming increasingly complex and fast changing. We mention the quick advancement in new technologies, the integration of the global economy, the increased environmental burden of economic activities, and the increased differentiation in needs and interests between categories of the population. Particularly the growing awareness of stakeholders about their (power) position in pursuing their interests and swift changes in these positions make the design and implementation of policies inherently more complex. Accordingly, policy decisions are made without a full understanding of the present situations and developments, and this is even more true for the future. For this reason, in rational models of policy making an extensive use of decision support tools and methods is suggested, like cost-benefit analysis, risk assessment, and more advanced computerized support tools. However, although policy makers are aware of various kinds of uncertainty, little attention has been paid to a systematic approach in the identification and evaluation of uncertainty. Only a few policy studies consider the comprehensive character of uncertainty in policy making in view of improved decisions (see, for example, van Asselt, 2000; Funtowicz and Ravetz, 1990; van Geenhuizen and Thissen, 2002; Khisty and Arslan, 2005; Walker et al., 2003).

Uncertainty is particularly evident in the field of policy making on future transport and communication technology (for example, van Geenhuizen et al., 1998; Geels and Smit, 2000). This situation stems from the fact that transport is a derived activity and the transport system is interconnected with a range of widely different other systems of, for example, production and consumption, living and
working and recreation. The transport system also comprises various subsystems such as infrastructures and vehicles (for example, car, rail and plane), and various (sub)systems according to the geographical scale. In addition, there are high costs involved in supporting the introduction of new transport technology (for example, hydrogen-fuelled vehicles and a concomitant fuelling infrastructure, advanced driver assistance systems, and magnetic levitation trains), but the demand reactions of consumers, reduction of road congestion and environmental burden and the emergence of unwanted side-effects, are poorly predictable (for example, van Geenhuizen and Nijkamp, 2003). Since the impacts of present policy options are poorly predictable, any choice made may lead to failure. What then is a wise course to follow in selecting the technologies to be supported, the strategies to test and improve these technologies, and the instruments to advance market introduction once the technology is mature?

Uncertainty is difficult to define because it touches upon many different aspects. Uncertainty in a broad sense refers to all we do not know and all we do not know to a full extent (for example, Rowe, 1994; Wynne, 1992). Rowe (1994) in a broad approach elaborates uncertainty as the ‘absence of information’ and makes a division into four related dimensions, that is, concerning: 1) the past and future states of the system under study; 2) the quality of the models that represent reality and are used in explanation and prediction; 3) the quality of measurement of the model relations, and so on, in reality, including issues like precision and accuracy (validity); and 4) communication and interpretation of results of analysis and modelling in a policy context. The first three dimensions comply to a large extent with what is termed ‘model uncertainty’ and its causes (see Section 6.2). It needs to be mentioned that the term risk is closely related with uncertainty. Risk may refer to specific situations in which the behaviour of the system under study is basically well known and chances of different outcomes can be defined and quantified by an analysis of mechanisms and probabilities, whereas in most uncertainty the system behaviour is not well known (for example, Wynne, 1992). We consider risk as a sub-set of the much broader set of uncertainties.

Instead of adopting a broad perspective on uncertainty, attention in policy making may be limited to those missing elements of knowledge that matter in taking the right decisions. This holds for the system being studied and subject to policy measures, including unexpected behaviour of stakeholders. Uncertainty may therefore be defined as the gap between what we know and what we think we need to know in policy making. In practice, uncertainty is not an objective phenomenon; what is perceived as uncertainty is dependent upon the satisfaction with existing knowledge and this is ‘coloured’ by various underlying values and perspectives, and the specific context (for example, Khisty and Arslan, 2005; Stough and Rietveld, 1997).

The purpose of this chapter is to develop a broad framework to identify various types and sources of uncertainty that surround policies on new transport technology and ways in which different types of uncertainty can be handled. Further, we apply our framework to the case of intelligent transport systems and evaluate the results in the context of a larger applicability. Accordingly, we
perceive new transport technology in a multi-actor situation by recognizing the influence of different stakeholders and their fast-changing positions. Our diagnostic framework is expected to match the following design rules: 1) to be sufficiently generic to serve a broad range of policy making situations in transport and similar complicated systems and to be adaptable to specific technology situations; 2) to be sufficiently comprehensive to cover a large variation of uncertainty aspects, and 3) to yield a sufficient transparency to improve understanding of different sources of uncertainty and to select the best mix of ways of dealing with uncertainty (see Walker et al., 2003). This leads to a focus on:

- the factors and system behaviour about which uncertainty exists
- the nature of this uncertainty in terms of sources and severity of impacts on policy making
- the ways to deal with uncertainty.

These aspects will be discussed in a theoretical way in the next two sections, and this is followed by an application to intelligent transport systems.

6.2 Conceptual Framework and Classes of Uncertainty

In our approach to identify uncertainty, we make the assumption that policy makers contemplate policy choices referring to a specific part of reality and that their decisions are based on means-ends rationality. This implies that policy makers are looking for knowledge that enables them to select those interventions that will contribute most to bringing policy goals nearer. In our attempt to structure uncertainty, the relevant part of reality may be conceptualized as a simplified system (Figure 6.1). The system model represents the set of cause-effects relationships characteristic of the behaviour of a system. A critical decision in this conceptualization is the definition of the system’s boundaries. This decision determines the framing of issues and formulation of problems (for example, broad or narrow), particularly the identification of external factors that influence the problem and the scope of alternatives considered.

We distinguish two broad types of factors as an input to the system, that is, external factors and policy factors. External factors may significantly impact on the system but are beyond the control of the policymaker. Policy factors are those factors through which a policymaker can influence the system. We may also distinguish output factors; these indicate those characteristics of the system performance that represent wanted and also unwanted outcomes, and, accordingly, are considered relevant criteria for the evaluation of the success of policy measures (van Geenhuizen and Thissen, 2002).
Figure 6.1 A system-based policy framework to identify uncertainty

The conceptualization described above provides various classes of factors that potentially cause relevant uncertainty (Figure 6.1): 1) the boundaries of the system; 2) future relevant external inputs; 3) system properties and performance and system responses to the various inputs; and 4) valuation of policy results based on a set of values. These different classes of uncertainty lead to an ‘overall’ uncertainty in making the right policy choices. We present details about the relevant uncertainty and sources of uncertainty as follows (van Geenhuizen and Thissen, 2002; van Geenhuizen et al., 2003; Walker et al., 2003):

1) Ambiguity in the definition of the system’s boundaries may lead to an unclear framing of issues and formulation of problems. Stakeholders often have different perceptions of reality, related to their different views of the world and their different interests. If important stakeholders are excluded from defining what the issue is, policy makers will then develop a biased framing of the context and system view, potentially leading to confusion, delay and ultimately additional uncertainty in policy outcomes. The same holds true for the view on external factors. If the system is defined too narrowly, particular factors that might be influenced by the policy concerned are seen as external and beyond control.

2) Uncertainty about future external inputs includes those factors considered to be beyond the control of policymakers. Factors beyond control in the field of transport may significantly influence the system, such as dead-ends in technology research and diminishing economic growth determining shrinkage of public budgets for research and, maybe – depending on how the boundaries are drawn – urban sprawl of living and working causing a thinning of traffic flow to different degrees on different geographical scales. Policies from other departments that are beyond control of transport
policy, like those in spatial planning, may also be viewed as external factors (for example, Friend and Hickling, 1997).

3) Uncertainty about system properties and performance in terms of response to external inputs can have different causes, most of which relate to a lack of an adequate theory about system behaviour and to problems with the specification of empirical values, given a theory. System behaviour in this context refers to transport systems. As expectations about system behaviour are generally based upon a model of the system, uncertainty in this respect is often termed model uncertainty. It refers mainly to the nature of the impacts of transport policy (and of lack of such policy) and to the irreversibility and scale of such impacts. There are three major causes of model uncertainty. First, there is uncertainty about the relevant model components and the key relations that determine system behaviour, termed structural uncertainty by Rowe (1994). Secondly, given model components and relations, there may be uncertainty in the exact specifications of these relations. In modelling terms, this is called parameter uncertainty. Particular mechanisms, mainly unknown to date, may lead to unpredictable results due to non-linear and irregular (chaotic) behaviour. In addition, the lack of appropriate data can be an important cause of model uncertainty, referred to by Rowe (1994) as metrical uncertainty. Further, what might happen is that a policy (project) is not feasible based on model outcomes but that, nevertheless, a positive policy decision is taken, due to specific interpretations of the outcomes and other data, for example, demand estimations and assessments of costs. This is an example of what Rowe (1994) refers to as translational uncertainty. Large projects in transport infrastructure that are subject to cost overrun and remarkably optimistic traffic forecasts illustrate this particular type of uncertainty. The often large differences between forecast and actual costs and demand cannot be explained primarily by structural and metrical uncertainty. By being strongly consistent and one-sided the uncertainty that has entered follows from the strategic behaviour of stakeholders.

4) Uncertainty about the valuation of the policy outputs is mainly concerned with the importance given to (future) system outcomes based on different value sets. It makes sense to distinguish between core values that are relatively stable over time and norms and standards at lower levels of abstraction. What causes uncertainty is a weak link between core values and practical standards, such as that between freedom and responsibility of individuals to drive their own vehicle as a core value and standards relating to a certain degree of central guidance concerning driving vehicles; this situation leads to confusion about what should, and what should not, be respected. In addition, in a multi-actor situation, there is pressure on norms and standards from different sides of stakeholders, sometimes leading to unexpected shifts in norms and standards in the evaluation of policy outcomes.
Uncertainty in valuation of policy outcomes contributes to uncertainty in making the right policy decisions. In fact, all previously indicated uncertainty contributes to uncertainty in making the right policy choices that could influence the system (policy factors), potentially leading to not achieving the intended effects. For example, uncertainty in the coordination of liaisons, in setting the agenda, and in taking policy measures may be caused by ambiguity in the delineation of the system and uncertainty in system properties and performance (Friend and Hickling, 1997).

We will now briefly address the severity issue. It is difficult in general to assess which of the above classes of uncertainty is most worrisome in a policy making context, because the context may vary from situation to situation. It can be stated that, in general, apart from ignorance (Dror, 1988), the most serious forms of uncertainty are the external influences beyond control and structural uncertainty about the system itself. The reason is that these uncertainties may have the greatest impacts in terms of expected policy outcomes that are wrong, while relatively little can be done to reduce their influence without strong research efforts (and high investments). Dealing with uncertainty will be discussed in more detail in the next section.

6.3 Dealing with Uncertainty by Policy Makers

There are different strategies to deal with the types of uncertainty described above and these may vary between governments depending on their wish to be involved to certain degrees and to bear risks, and depending on the type of prevailing uncertainty. The strategies listed below may not exclude each other; some of them are in fact complementary and depend on each other (van Geenhuizen et al., 1998; van Geenhuizen and Thissen, 2002):

- To **ignore** uncertainty, take policy measures and see what will happen. In fact, this means accepting the risk of great uncertainty in policy outcomes and serious policy failures by the wrong (or incomplete) selection of measures.
- To **identify** and, if possible, **specify** uncertainty. This enables the policy maker to act consciously in the presence of uncertainty, mainly uncertainty about future external factors and system performance response to these factors. Methods to identify and specify uncertainties include, for example, scenario analysis (van der Heijden et al., 2002; Nijkamp et al., 1997; von Reibnitz, 1998; Schwartz, 1991), case-based reasoning using retrospective analysis on past failures and success (Khattak and Kanafani, 1996), and sensitivity analysis using the development of alternative system models.
- To **reduce** uncertainty. Like the previous strategy, this mainly applies to uncertainty from external factors and related system performance responses. First, a reduction of uncertainty can be achieved by additional research and/or a better integration of existing knowledge. Additional
research may cover improved data collection and the application of advanced methods of integrated modelling, using notions derived from chaos theory and evolutionary models (Reggiani and Nijkamp, 2002). Note that modelling results enable the policy maker to distinguish more clearly between possible and impossible developments, and to identify critical events and bottlenecks (exploratory modelling). Also, uncertainty about external factors and system performance may be reduced by negotiating with stakeholders whose behaviour is uncertain.

- To accept uncertainty and act consciously in its presence. Here, too, different strategies are possible, and these can be applied to all major classes of uncertainty. A robust policy may be selected, that is, a policy expected to do well in most possible future circumstances. Or, a flexible or adaptive policy can be designed, such as a policy (choice) that is adaptable to the future course of events or new valuations of such events (for example, Walker et al., 2001). The latter policy requires an extensive monitoring of system behaviour and policy outcomes.

- To see uncertainty as an opportunity to creatively shape the future. This strategy holds mainly for the overall uncertainty in making the right policy choices. Rather than emphasizing a choice for a presently available policy option, this approach calls for the development of a broad vision that provides the guiding principles for present and future action, allowing for experimentation and small-step learning (for example, Stacey, 1992).

We now move our attention to uncertainty in policy making relating to intelligent transport systems, and apply our framework to identify and qualify uncertainty in this particular area.

### 6.4 Intelligent Transport Systems

#### 6.4.1 Introduction

Intelligent Transport Systems (ITS) is a broad category of innovative systems that aim to smooth traffic flow and differences in density. ITS include advanced traveller information systems in public transport and private cars, route guiding (navigation) systems, advanced tracing systems of goods and automated guidance of vehicles. We limit our discussion here to the subclass of automated guided vehicles (AGV), and focus on uncertainties that are of concern in policy making for the adoption of this technology. The technology is attracting increased attention due to the assumed improvement of traffic flow, avoiding of congestion, and reduction of the environmental burden and numbers (severity) of accidents (for example, Bekiaris and Stevens, 2005; Bose and Ioannou, 2003; van der Heijden and Marchau, 2002; Ioannou, 1997; Lu et al., 2005 and Marchau et al., 2000).

There is a wide variety of AGV systems: some are quite similar to current systems and others are entirely different and surrounded by a manifold uncertainty.
In this context, it is useful to distinguish between various technology dimensions and positions. These technology dimensions are the nature of the drivers’ tasks, the type of drivers’ support, and the degree of mixing with established transport systems (for example, Levine and Underwood, 1996; Lu et al., 2005 and Marchau et al., 2000). With regard to the first dimension, the drivers’ tasks, a distinction can be made between vehicle control (speed and direction), manoeuvre control (lateral and longitudinal positioning vis-à-vis other vehicles) and route control (navigation). The second dimension – type and degree of drivers’ support – refers to the use of information to support drivers’ decisions (warning, advising), automated control of a limited number of tasks, including the possibility for drivers to overrule this control and autonomous automated control without drivers’ interference. With regard to the third dimension – the degree of mix – there is the theoretical possibility of a totally integrated implementation of AGV technology in particular regions, but also of different mixes with current systems, for example, limited to highways or even to specific lanes on highways. The more comprehensive the guiding system and the greater the differences with the current situation, the greater the uncertainty. For example, semi-automated vehicles equipped with forward-looking sensors are expected to be deployed in the near future, but less is known about the introduction of more advanced and complicated intelligence in vehicles and infrastructures.

There are quite high expectations about AGVs. These are supposed to increase transport efficiency and to improve the quality of the environment (Nijkamp et al., 1996). Traffic management systems and new types of cruise control (distance control) improve the efficiency of the flow of goods and persons. Efficiency gains contribute to a reduction of congestion and to a reduction of fuel consumption and emission per unit of goods and persons. Furthermore, new driver systems, such as collision warning systems, automatic speed adaptation and the comprehensive personal auto-pilot including the function of monitoring drivers’ behaviour, are expected to contribute to the prevention of fatalities or reduce the severity of accidents (Lu et al., 2005 and Marchau et al., 2004). Systems in which equipped vehicles are grouped to move automatically may also contribute to the reduction of emissions and to a decrease in the use of energy. However, efficiency gains in terms of road use seem to be the largest benefits from this use of intelligence in vehicles and infrastructures. In the next part of this section we analyse uncertainties in the adoption of AGV including indications of the severity of the uncertainty concerned. A summary is given in Table 6.1.
Table 6.1 Uncertainties of relevance to policy making for AGV

<table>
<thead>
<tr>
<th>Class of uncertainty</th>
<th>Specification of uncertainty</th>
<th>Sources of uncertainty</th>
<th>Severity*</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Boundaries</td>
<td>• Unclear problem definition</td>
<td>Lack of knowledge</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• Fragmented or wrong problem view and view on causalities</td>
<td>Desire to ‘keep things simple’</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inherent complexity of transport system and subsystems, and relations with other systems</td>
<td></td>
</tr>
<tr>
<td>Future External Inputs (beyond control)</td>
<td>• Changing needs and attitudes in driving and travel behaviour</td>
<td>Long-term nature of implementation of AGV</td>
<td>XX</td>
</tr>
<tr>
<td></td>
<td>• Influence of the legal system (liability)</td>
<td>Inherent poor predictability of most of these factors in the long term</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Future urban sprawl</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Future technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Future culture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Performance and Responses</td>
<td>• Impacts of AGV on traffic safety, emissions and efficiency</td>
<td>Poorly-known key relations and mechanisms determining system behaviour, due to:</td>
<td>XX</td>
</tr>
<tr>
<td></td>
<td>• Interference of AGV with other transport goals</td>
<td>lack of research with an integrated approach and focus on causality;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Type and time of indirect impacts (for example, in residential areas)</td>
<td>lack of a clear specification of the structure of AGV in practice</td>
<td></td>
</tr>
<tr>
<td>Valuation of Policy Outputs</td>
<td>• No clear vision on which core values need to be respected</td>
<td>Passive role and ignorance of policy makers</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>• Shifting values and standards in judging policy impacts</td>
<td>Occurrence of disasters that work as a ‘catalyst’</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Long-term nature of implementation of AGV</td>
<td></td>
</tr>
</tbody>
</table>

Notes: * X = medium severity, XX = great severity.
6.4.2 Uncertainties

We first consider uncertainties related to the choice of system boundaries. It is important to note that changes in one part of the transport system may impact on other parts or (sub)systems. If the various relations between the subsystems within the transport system (that is, infrastructure, vehicle movements, persons and goods transported, and spatial and temporal configurations of living and working activity) are disregarded, unexpected policy outcomes may be the result. Changes, such as new intelligence in the vehicle subsystem, may directly and indirectly affect all subsystems and their stakeholders, ranging from driving behaviour on roads to decisions of the population on (re)location of places of residence. It is unclear what the direct effects of implementing certain technologies will be, and uncertainty is increased because changes in one subsystem of the transport system may have impacts throughout the system. There is little insight so far regarding these indirect effects, not least because they occur in different subsystems with diverse time-lags. In addition, there may be unexpected but undesirable effects, such as adverse consequences for safety or the attraction of more traffic, which undo the direct reduction in environmental impacts. This situation illustrates the crucial importance of drawing adequate system boundaries.

With regard to relevant external inputs beyond the control of transport policymakers, we identify unknown developments in human needs and attitudes in driving and travelling, such as the need for individual freedom, the need for taking certain limited risks, and the need for a certain (fixed) travel-time per day, including time to ‘disconnect’ work from home. An external factor that also causes uncertainty is how the legal system (liability) concerning AGV applications will develop, particularly where automated control and individual decision making interfere (for example, van der Heijden and van Wees, 2001). In studies where the system boundaries are taken narrowly, the future sprawl of living centres and work centres are often addressed as important external factors. A certain density of traffic flow appears to be a condition for the feasibility of particular systems of AGV. Despite such analysis, there remains a lack of understanding of future spatial patterns and their impacts. In a similar vein, the directions of technology development and cultural changes as independent influences are little known. Most of these external uncertainties can be attributed to the fact that the external environment is many-sided (different sectors and actors) and often turbulent (rapid changes), and therefore inherently difficult to predict.

Major uncertainty exists about system performance and responses, that is, the way the system will develop in reaction to the various inputs. There is significant uncertainty about the key mechanisms that determine system behaviour (structural uncertainty). This manifests itself, for example, in a lack of knowledge about gains in flow rate, density and time, although knowledge is now increasing about changes in mixed (semi-automated and manual) traffic (Bose and Ioannou, 2003). Little is known about the relationships among specific technological functions, such as cruise control in vehicles, routing information systems, tracing of goods and in-car communication about congestion. There is even lack of knowledge
about individual technological functions. For example, understanding user acceptance and the implications of adaptive cruise control is of great importance to network operators in charge of improving the capacity and safety of the road network, but the knowledge in this field so far is relatively poor (for example, Marsden et al., 2001). Further, an important point of uncertainty concerns the reliability and applicability of the technology in practice (for example, Bekiaris and Stevens, 2005). There may be a rapid increase in the vulnerability of AGV systems as a result of interference (for example, atmospherics, electromagnetics) and failure (for example, in sensor registration), particularly when a large number of partial applications are implemented simultaneously. Of course, fear of such failures affects market acceptance of systems in which drivers cannot overrule commands from automated control. A further point of uncertainty is how different types of drivers will appreciate different types of AGV applications. It seems that standard classifications using gender, age, education, and so on, are not adequate with regard to the propensity to accept the new applications. In addition, there is a limited knowledge about real-life influences on individual behaviour in the various transport subsystems, for example, persons’ and logistics firms’ driving, their use of infrastructure, their travelling behaviour, their activity patterns, and their location behaviour.

Knowledge about how AGV applications will affect the transport system is limited, in the first place, because it is almost uncharted territory: because of the novelty of the technology, no prior research was possible, except for experiments that implied a limited real-world validity. Another important cause of the limited knowledge is that new knowledge is gathered in a fragmented way, with many separate pieces that have not yet been connected in a systematic way. This situation follows from the nature of the market for AGV applications and the passive role of governments. Producers of new applications face good market opportunities in separate areas, such as drivers’ support in personal cars and tracing of freight. As a consequence, no attention is paid to compatibility and functional links with larger systems. In this context it should also be noted that there is no single specification of what an AGV system will look like (Marchau, 2000). Will the AGV technology be mainly connected with the vehicle or with the infrastructure? What will be the level of automation in terms of transfer of drivers’ tasks? It is clear that this lack of images of what AGV might look in practice is a chicken-and-egg problem: because of the prevailing uncertainties, decision makers and developers are hesitant to make clear choices and, as a result of that, there is no clear insight into probable system configurations, their impacts and acceptance. Note, however, that, most recently, knowledge is increasing about the specification of safety systems and road traffic efficiency systems that are almost ready to enter the market (Marchau and Walker, 2003).

As a consequence of the uncertainties in system surroundings and in system behaviour, there is a great deal of uncertainty about valuation of the policy outputs, particularly in terms of achieving the policy goals and how this is evaluated. It is often taken for granted that AGV serve to increase efficiency in infrastructure use, help to reduce emissions, and increase traffic safety. However, most information is
based on theoretical reasoning and small-scale experiments under strictly controlled conditions. Estimates about the impacts on the increase in road efficiency vary from as high as 100 per cent to as low as 20 per cent (Geels and Smit, 2000). The previous situation means a great uncertainty not only in reaching policy aims but also a great uncertainty about possible unintended or even adverse effects. The latter can be illustrated with the following examples. ICT-based efficiency gains in road freight transport may compensate for the increased price of gasoline, a policy measure taken in the context of advancing modal shift. Similarly, increasing efficiency in flow may lead to shorter travel times and lower consumer costs, which, however, may make mobility more attractive and ultimately cause longer commuting distances and an increase of energy use rather than a decrease. There is a clear uncertainty concerning the values (importance) given to various impacts likely to be produced by AGV. What is evident is that the generally accepted core value of individual freedom to make choices as a driver (traveller) is challenged by particular types of AGV, but the repercussions of this situation for the practical implementation of AGV are largely unknown.

As a result of all the above uncertainties it is not clear which new types of AGV are to be preferred, meaning that policy makers lack a sound basis for choosing measures with respect to AGV that will help reach their transport policy goals. Uncertainty about external influences beyond control and uncertainty about system performance and responses seem the most serious types of uncertainty contributing to this situation.

6.5 Coping with Uncertainties

Given the causes of the most important uncertainties identified in the previous section, traditional risk analysis type of approaches based on probabilities are not useful. Uncertainty about future developments in the external factors is partly unknowable, and may at best be partly specified. Most uncertainty about system responses is structural. From the possible strategies identified in Section 6.3, the ‘do nothing’ option seems to have been the most popular so far with most governments, not because of the conviction that the interplay of societal forces will automatically result in the best system, but because of lack of a vision in the face of the immense uncertainties. One of the results is a fragmentation of approaches and of knowledge build-up, which in turn does not help reduce uncertainties at a more comprehensive level. However, some of the other strategies seem to be more promising.

First, uncertainties in the external factors could at least partly be identified by developing a set of possible scenarios. Such a scenario-analysis may also help to increase policy makers’ alertness with respect to the relevance of external factors. Scenarios of the future also provide support in designing robust policies, that is, those that produce favourable outcomes under most of the different scenarios. However, a crucial need in scenario development for AGV is to include serious trend-breaks, but these are difficult to identify. Perhaps there will be a series of
serious collision accidents, maybe a merger between important manufacturers of equipment leading to scale economies and a fall in consumer prices? Secondly, several of the approaches to reduce uncertainty could be exploited, such as:

- Additional research and a better integration of existing knowledge about AGV implementation and its impacts. Additional research should depict the new applications in a real-life situation or its simulation, cover a sufficiently long time period to identify impacts in the different subsystems, and should reveal important links among different applications.
- Research on uncertain external factors, to gain, for instance, a clearer picture of legal issues (for example, product liability aspects of the systems) and how they may be resolved (van der Heijden and van Wees, 2001).
- Reduction of the number of possible system configurations and development paths by systematic feasibility analysis. This would lead to the elimination of technically improbable or impossible system configurations and reduce the set of possible ones to a more manageable size (Marchau et al., 2000). Exploratory modelling (Bankes, 1993; Walker et al., 2001) may also help in mapping out the possible development patterns.
- For each of the specific AGV applications, identifying uncertainties in adjacent policy fields like spatial planning and, where possible, improving coordination with policy makers in such fields.
- With regard to user acceptance and behavioural response in driving, increasing insights from social psychology, particularly in identifying relevant categories of users.
- Regarding the implementation of specific applications, granting the possibility of participation of relevant individuals and groups in policy making. For example, trucking company owners, drivers and highway police officers would be involved in selecting technologies for traffic monitoring and lane assignment. Such an approach fits current policy-making cultures in Western Europe.

A third strategy to deal with uncertainty is to develop smart policies in the presence of inevitable uncertainties. This would not mean investing in all feasible technologies and development paths. Rather, a flexible or adaptive policy is preferred, which is adaptable to the future course of events and can fully exploit the lessons of experiments and research that will become available as time proceeds (Marchau and Walker, 2003). This would imply combining policy actions that are time urgent and policy actions that preserve needed flexibility in view of future adaptations. A specific kind of adaptive policies is the one that has a focus on real options, meaning the design of a broad policy which leaves open various realistic options that can be used immediately if it becomes apparent that they are attractive. This may be true for specific provisions in new road infrastructure and for new safety measures concerning the technical conditions of cars, the latter anticipating a large-scale adoption of in-car sensor systems. The real-options
approach allows for the valuation of risky projects, while accounting for the contribution of active management or flexibility, as in terminating projects that are not working out and expanding those that perform well (Neely and de Neufville, 2001). The operationalization of the previous adaptive policies may be easier if specific visions are developed for specific AGV applications in specific subsystems of the transport system, provided that possible interactions among the subsystems are monitored in the implementation and adaptation process (van der Heijden and Marchau, 2002). A vision should also include normative choices; for example, with regard to the distribution of costs and benefits and the extent to which there should be interference in individuals’ driving behaviour in terms of freedom and responsibility.

6.6 Implications for Policy on ITS

Policy makers so far have adopted a mostly passive role, but there are many good reasons to become more active in view of the potential contributions of ITS to overall transport policy goals. In the light of uncertainty, any policy adopted should be a flexible and adaptive one. Important elements of developing and implementing such a policy include:

- Development of a vision of the policy goals to be achieved by the implementation of ITS, both at the level of individual applications and at the overall system level (including relevant core values).
- Development of scenarios to identify key uncertain factors in the system’s surroundings as a basis for coordination with adjacent policy fields and for the specification of factors to be monitored as time proceeds.
- Analysis of possible ITS configurations and development paths, the results of which will also help to identify critical assumptions and thus contribute to the specification of factors to be monitored.
- Research into the impacts of both isolated ITS applications and integrated ITS systems, with a particular emphasis on building up integrated knowledge and on indirect effects, taking into account the full complexity of the transport system and its interrelated subsystems.
- Research on specific topics such as liability issues and factors influencing user acceptance and user perceptions of failure of the technical systems.
- Selection of small-scale experiments in real-life settings that allow for learning, and in which the major stakeholders are involved.
- Development of an understanding of vulnerabilities of the policy and the design of monitoring of key manifestations of these vulnerabilities.
- Development of guidelines for policy adaptation or other corrective actions, that is, indications of what steps to take next, given specific experimentation outcomes, research findings and monitoring results.
In this set-up, the policy makers’ responsibility is rather different from the traditional model in which they make or finalize key choices regarding the system of concern. Rather, policy makers should, first, develop the normative vision and subsequently guide the experimentation and adaptation process, and stimulate knowledge creation, knowledge availability and knowledge integration.

6.7 Concluding Remarks

We believe that the approach and typology of uncertainty set out here will be helpful to both practitioners and researchers in policy analysis for identifying uncertainties and dealing with them in the context of transport technology. The typology provides a broad diagnostic tool for examining the nature and causes of uncertainty, using a basic systems input-output model. Four important classes of uncertainty can be summarized according to their relation with the system: 1) system boundaries; 2) external inputs to the system; 3) performance and response of the system to external factors – all three leading to uncertainty about the relevant system outcomes; and 4) valuation of the policy outputs. As a result, choosing the right policy option to reach policy goals often lacks a sound basis.

In this chapter, we have demonstrated how the typology of uncertainties and of possible ways to deal with them can provide guidance to identify the key relevant uncertainties, their sources, and the most appropriate policy strategies in view of those uncertainties and stakeholders’ preferences. We do not claim that our typology is better than the others, but we argue that a typology in the context of policy analysis needs to be clear and systematic in terms of causal structure of the uncertainties, and needs to provide solid ground for generating strategies to deal with these uncertainties. The framework also seems sufficiently generic to be applicable to many other policy issues than new transport technology, on the condition that a systems approach is used. The AGV example illustrates a more general phenomenon: namely, that the key uncertainties involved in many strategic policy issues are structural, and cannot be dealt with using classical, mostly quantitative methods, such as those developed in risk analysis. Rather, a combination of further knowledge acquisition using more qualitative approaches and learning with flexible, adaptive policies, is often needed.

In particular, we would like to address future research on uncertainty from the perspective of the stakeholders. The framework developed in this chapter uses the perspective of the policy maker. An equally important perspective in arriving at the best policy results is that of the major stakeholders in the field. There is an increased dynamics in stakeholder importance and in shifts in their positions. Thus, it is highly relevant to know how different stakeholders deal with uncertainty, for example their perceptions of system boundaries and problem perceptions, interpretations of model outcomes and valuations of (potential) policy results.
Notes

1 As uncertainty in making the right policy decisions follows from all other classes of uncertainty, this type of uncertainty is not regarded as a separate class.
2 With regard to the identification and assessment of uncertainty in the practice of implementation, we refer to Bekiaris and Stevens (2005).

References


Chapter 7

An Evaluation of Benefits from Aircraft and High-Speed Train Substitution

Moshe Givoni

7.1 Introduction

Substitution of trains for planes on airlines’ short-haul services is considered desirable for different reasons, but mainly for environmental reasons. The EU in its White Paper on transport called for cooperation between the modes and stated that ‘network planning should therefore seek to take advantage of the ability of high speed trains to replace air transport and encourage rail companies, airlines and airport managers not just to compete, but also to cooperate’ (CEC, 2001, p. 53, emphasize in original text). The White Paper also states that ‘we can no longer think of maintaining air links to destinations for where there is a competitive high-speed rail alternative’ (CEC, 2001, p. 38).

Evidence from routes where both aircraft and High Speed Train (HST) services exist suggest that the airlines and Train Operating Companies (TOCs) compete against each other. ‘This might even create more pressure for slots at airports as the airlines remaining on the routes would have to compete with rail on frequency’ (Caves and Gosling, 1999, p. 59), and will probably lead to greater environmental impact from air services, greater congestion at airports, and will prevent potential benefits from aircraft and HST substitution. Therefore, benefits from shifting passengers to the HST from the aircraft are expected only when airlines will be the one to initiate the change of mode used. For this, the HST service must originate from the airport (and not the city centre, as is usually the case) in order to allow quick connection between aircraft services (which cannot be served by HST) and the HST service. This requires that the airport will be connected to the HST network.

For the reasons stated above, aircraft and HST substitution is considered here in the context of a model of airline and railway integration. That is aircraft and HST substitution, where the HST service is offered by the airline, but operated by the TOC, from the airport. Under airline and railway integration, the HST service replaces the aircraft service offered by the airline (and not adding to it, as might be the case when there is no integration between the airline and the railway).

Under airline and railway integration the airline cooperates with the rail company in order to offer some of its services on board the HST. For the
passenger, it is assumed, there is no change in the journey experience other than the change in the mode used. In the general model of airline and railway integration, passengers fly to a hub airport, and at the hub airport transfer to a HST service instead of to another aircraft service. The transfer at the hub airport between the aircraft and the HST is assumed to be similar to the transfer experience when passengers transfer between two aircraft. This means that passengers do not need to purchase a new ticket, or carry their luggage as they change from the aircraft service to the HST service.

Using the model of airline and railway integration described above (and in Figure 7.1), the benefits from aircraft and HST substitution are evaluated. The main objectives of this chapter are to empirically measure the benefits from mode substitution and, at the same time, empirically examine the use of current evaluation methodologies and suggest ways to improve them. In addition, the implications of the results for policy makers are emphasized.

Notes: LHR = London Heathrow; HST = High Speed Train.

Figure 7.1 Two options of travel on the LHR to Paris route: by air and by HST

The remainder of this chapter is structured as follows. Section 7.2 provides details on the methodology used to evaluate the benefits from mode substitution. Sections 7.3, 7.4 and 7.5 describe the benefits from substitution to airlines, passengers and society respectively. Section 7.6 sums the benefits, and Section 7.7 concludes the chapter and discusses the policy implications of the results.

7.2 The Evaluation Framework

The case study chosen for the analysis is the London Heathrow (LHR) airport to Paris city-centre route. The model of aircraft and HST substitution under airline
An Evaluation of Benefits from Aircraft and High-Speed Train Substitution

LHR is the journey origin since this is where airlines offer their aircraft services. It is assumed that passengers benefiting from aircraft and HST substitution are passengers arriving at the airport in order to transfer between flights, or otherwise, passengers who prefer, for various reasons, the airport over the HST station in the city-centre. In order to evaluate the benefits from mode substitution, two options of travel are compared. In the first option, the air journey, the passenger arrives at LHR by a flight and then transfers to another flight that takes him to Paris Charles de Gaulle (CDG) airport. At CDG the passenger transfers again, this time to a surface mode, to complete the journey to Paris city-centre. In the other travel option, the HST journey, the passenger arrives at LHR by a flight and transfers to an HST service that takes him directly to Paris city-centre.

The comparison of benefits between the two travel options is made with respect to three categories of benefits: benefits to airlines, to passengers, and to society. Benefits to airlines are expected in the form of reduced operating costs (OCs) when the aircraft services are replaced by HST services; benefits to passengers are expected in the form of reduced travel time; and benefits to society are expected in the form of reduced Local Air Pollution (LAP) and climate change when the HST journey from LHR to central Paris replaces the aircraft journey from LHR to CDG (which includes the surface journey from CDG to Paris city-centre).

The benefits described above are the direct benefits from operating HST and aircraft substitution. There are other benefits expected as well. For example, airlines can benefit from the valuable freed slots, and airports can benefit from the connections to the HST network. However, such benefits are considered as indirect benefits and are not considered here. In addition, the costs associated with, for example, connecting the airport to the HST network are also not considered here. Before advocating aircraft and HST substitution, and specifically airline and railway integration, it is important to evaluate if direct benefits, that is, benefits from mode substitution on the operational level, do exist.

For the evaluation purpose, it is assumed that the HST service is identical in all aspects, from the passenger point of view, to that provided by the aircraft except for the difference in mode used. Therefore, on the revenue side, the initial assumption is that there will be no difference from shifting services to the HST. The base unit for comparison between the options of travel is the seat, since this allows comparison of vehicles with different capacities. The seat unit was also preferred over the passenger unit, because the research is concerned with the supply side of aircraft and HST services, and because the impact of mode substitution is more affected by the capacity offered than by the number of passengers using this capacity. In other words, the impact of a flight on the environment or on an airline’s OCs directly depends on the capacity offered and not on the service load factor. In addition, since the distance the aircraft and the HST cover on a specific route is relatively fixed and is often different for the two modes, it is important to analyse substitution taking into consideration the distance each mode has to cover. For this reason seat-per-route units are used, and not the common seat per km units.
The evaluation of the benefits is made using Multi-Criteria Analysis (MCA) and Cost-Benefit Analysis (CBA) frameworks. To compare between different categories of benefits and in order to sum them up they must be measured in the same (monetary) units. However, the practice of converting different benefits, and especially travel time savings and reduced environmental pollution, into monetary units has many limitations, and therefore MCA is used to support the CBA. Furthermore, to measure the benefits in monetary units, they must first be measured in other units (for example, in minutes, before the value of travel time is measured) and this is done using the MCA framework.

7.3 Evaluating Benefits to Airlines from Aircraft and HST Substitution

Whether to substitute the aircraft by HST is mainly the airlines’ decision (provided the infrastructure is available), and in a deregulated aviation market such a decision is to a great extent determined by financial considerations, hence the importance of evaluating potential financial benefits to airlines from mode substitution. In line with the assumptions made, the financial analysis is restricted to the potential operating cost (OC) savings for airlines from substituting the aircraft by HST on the case study route. The cost of operating the service by each mode is evaluated and then compared.

A company’s OCs, the costs required for the company to produce and provide its main products, are usually divided between direct and indirect OCs. In the case of an airline or a TOC, the direct OCs are all the costs that can be easily traced to a specific flight (such as the cost of fuel consumed), or to a specific train journey (such as the cost of maintenance required after each journey), and these costs change in relation to the number of services supplied. The indirect OCs are all the other costs required to offer flights or train services; for example administration costs, ticketing and distribution costs, advertisement costs, and so on.

An airline that considers the use of HST services to replace the aircraft should compare the aircraft direct OCs with the HST direct OCs. Airlines’ ticketing, sales and promotion costs are not linked to the mode used, and therefore will not change if the airline shifts services to the HST. Furthermore, the costs required to provide the seat capacity should be distinguished from the costs required to serve the passengers, such as catering and service personnel (ground and air stewards), since costs required to serve the passengers are assumed not to change when the mode used is changed, and therefore are of no concern in this analysis.

To estimate the OC of an HST service from LHR to Paris, a profit and loss statement for the HST services of a TOC was used. The data available was sufficiently detailed to be able to recognize, and exclude from the analysis, cost components that are unique for this specific company. To estimate the direct OCs of a flight from LHR to CDG, OCs per block hour of a Boeing 737-300 (henceforth B737) were used, assuming the flight takes 65 minutes (gate to gate). To this estimate, the different charges imposed on a flight from LHR to CDG were calculated and added.
Table 7.1 shows the base comparison between the modes. OC per seat-km are usually the basis for comparison between different modes, because it compares the modes in the same capacity and distance units. Using these units, operating an HST rather than an aircraft service is financially better. However, because the route distance is fixed (to a large degree even for the aircraft) and different for each mode, the comparison should be made in units of seat-per-route, taking into account the distance each mode has to cover on a journey from LHR to Paris. When taking into account that the HST route is 525 km and the aircraft route is 348 km it becomes cheaper to operate the B737 on the route by €3.43 for each seat offered (OCs per seat in Table 7.1). If, however, an airline had to cover the indirect as well the direct OCs of the HST, it would not be financially viable to replace the aircraft with the HST, no matter which units of comparison are used.

Table 7.1 Comparison of HST and aircraft Operation Costs (OCs) on the LHR to Paris route (in euros)

<table>
<thead>
<tr>
<th></th>
<th>HST direct + indirect OCs</th>
<th>HST Direct OCs</th>
<th>B737-300 Direct OCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCs per service</td>
<td>37,203</td>
<td>22,896</td>
<td>3,469</td>
</tr>
<tr>
<td>OCs per seat</td>
<td>49.60</td>
<td>30.53</td>
<td>27.10</td>
</tr>
<tr>
<td>OCs per seat-km</td>
<td>0.094</td>
<td>0.058</td>
<td>0.078</td>
</tr>
</tbody>
</table>

The results were tested for changes in route distance, journey time, type of mode, and delays to the service. Such changes will not affect the HST OCs in this analysis since they are not related to journey time (and therefore are not sensitive to delays), or type of train used, and the distance is fixed. Changes in the above variables when using the aircraft (Table 7.2) show that the aircraft is still cheaper to operate, on the basis of OCs per seat offered between LHR and CDG, when the distance is increased by 25 per cent, or when the journey time increased by 5 minutes. If the type of aircraft is changed from the B737 to the Airbus A320 the aircraft advantage over the HST increases. The B737 was chosen for the analysis since in 2000 it was the most common narrow body aircraft (aircraft typically used on short-haul flights) in the world, more than 30 per cent of the world’s total narrow body aircraft flying in 2000 (IATA, 2001). If the OCs of a low-cost airline are applied together with the typical seat capacity on board a B737 operated by such an airline, then the OCs are reduced by almost 40 per cent. It is only when the aircraft service is delayed by 15 minutes, which increases the journey time to 80 minutes (15 + 65 minutes), and assuming that delays occur during flight, that it becomes cheaper to operate HST services on the route, by €1.22 per seat.

Concern with the environmental impact imposed on society by the operation of transport services results in the suggestion to ‘make the polluters pay’ for the environmental damage they cause. Although the operation of both aircraft and train services result in environmental damage, it is air services that are more likely to
face some kind of environmental charges in the future. The EU proposes a Kerosene tax of €245 per 1,000 litres of fuel consumed by aircraft (CEC, 1999). Adding a Kerosene tax to the aircraft OCs and assuming that a B737 consumes 1,561 kg of fuel on a flight from LHR to CDG (based on Archer (1993)), increases the OCs per seat by 11 per cent to €30.09, still lower than the OCs per seat of the HST (Table 7.3). Another way to take account of the environmental costs imposed by a flight and an HST service is to use the results of the analysis on the cost of Low Air Pollution (LAP)\(^8\) and climate change presented below. Adding the cost estimates for LAP and climate change impacts from aircraft and HST operation to the aircraft and HST OCs per seat shows that the aircraft is still cheaper to operate despite its greater impact on the environment (Table 7.3).

### Table 7.2 Flight Operation Costs (OCs) on the LHR to CDG route under different assumptions (in euros)

<table>
<thead>
<tr>
<th>Route distance(^a)</th>
<th>Journey time(^b)</th>
<th>Delays(^c)</th>
<th>Aircraft(^d)</th>
<th>Low cost(^e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCs per seat</td>
<td>OCs per seat-km</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(30.53)</td>
<td>(0.058)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base-</td>
<td>Base-</td>
<td>Route</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HST</td>
<td>B737</td>
<td>distance(^a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27.10</td>
<td>27.62</td>
<td>28.65</td>
<td>31.75</td>
<td>25.05</td>
</tr>
<tr>
<td>Delays(^c)</td>
<td>Aircraft(^d)</td>
<td>Low cost(^e)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 minutes delay</td>
<td>Operating Airbus A320 aircraft (base case).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OCs per seat</td>
<td>OCs per seat-km</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(30.53)</td>
<td>(0.058)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base-</td>
<td>Base-</td>
<td>Route</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HST</td>
<td>B737</td>
<td>distance(^a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27.10</td>
<td>27.62</td>
<td>28.65</td>
<td>31.75</td>
<td>25.05</td>
</tr>
<tr>
<td>Delays(^c)</td>
<td>Aircraft(^d)</td>
<td>Low cost(^e)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 minutes delay</td>
<td>Operating Airbus A320 aircraft (base case).</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
\(^{a}\) 25 per cent increase in route distance to 435 km.  
\(^{b}\) 5 minutes increase in journey time to 70 minutes.  
\(^{c}\) 15 minutes delay to aircraft while flying results in journey time of 80 minutes.  
\(^{d}\) Operating Airbus A320 aircraft (base case).  
\(^{e}\) Assuming OCs and seat capacity of a low cost airline (base case).

### Table 7.3 Comparison of HST and flight Operation Costs (OCs), including environmental costs, on the LHR to Paris route (in euros)

<table>
<thead>
<tr>
<th>OCs per seat</th>
<th>OCs per seat-km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct (Base(^c))</td>
<td>Direct + Env.(^a)</td>
</tr>
<tr>
<td>HST OC</td>
<td>B737-300 OC</td>
</tr>
<tr>
<td>30.53</td>
<td>31.34</td>
</tr>
<tr>
<td>0.058</td>
<td>0.060</td>
</tr>
</tbody>
</table>

Notes:
\(^{a}\) Environmental charge: assuming the cost of environmental impact estimated below.  
\(^{b}\) Environmental charge: assuming a Kerosene tax of €245 per 1,000 litres.  
\(^{c}\) Base-line values for the route are in italic.
The OC comparison between the HST and the aircraft revealed that when the aircraft and the HST routes cover the same distance there is a financial incentive for mode substitution. However, on the case study route, airlines are financially better when operating aircraft and not HST services. At present, an airline’s decision on whether to adopt mode substitution is almost independent of the environmental benefits that substitution might yield. Nevertheless, even if the airlines did consider their environmental impact, the introduction of some form of environmental charges, the analysis shows that there is still no financial case to substitute the aircraft by HST, even if only the aircraft is taxed for the environmental impact it causes. The advantage shifts to the HST, however, if the flight is delayed for 15 minutes or more.

The financial analysis shows that there is currently no reason for airlines to adopt mode substitution on the case study route unless they can expect other financial benefits from airline and railway integration which will offset the OC losses. Such benefits could be the benefits of reduced delays, or the possible use of the free slots from mode substitution for use of long haul services. Alternatively, if the benefits to other stakeholder groups from mode substitution are large enough to compensate the airlines for their OC losses, airlines would have an incentive to consider substitution. This adds importance to the evaluation of benefits to other stakeholder groups. The benefits to passengers are analysed next.

### 7.4 Evaluating Benefits to Passengers from Aircraft and HST Substitution

Passengers on board an airline’s HST service that has been offered hitherto by aircraft are expected to benefit from shorter journey time when their destination is the city centre of the destination city. Those benefits are measured, to begin with, in units of time. They are then transformed into monetary units by using estimates of the Value of Time (VOT), which allows the inclusion of travel time savings in CBA. In addition to travel time savings, the different characteristics of an aircraft and a HST journey can also lead to benefits to passengers from mode substitution, and they are considered as well. Accordingly, this section is divided between monetary and non-monetary benefits to passengers, starting with the latter.

LHR is not connected to the HST network, and therefore travel time from LHR to Paris had to be estimated based on the London to Paris HST journey time. The Frankfurt (FRA) airport to Stuttgart (city centre) route was added to the analysis since, on this route, airline and railway integration, in the way described above, already takes place (FRA and Stuttgart representing LHR and Paris in Figure 7.1, respectively), and can therefore serve as a benchmark for mode substitution.

#### 7.4.1 Non-Monetary Benefits to Passengers from Aircraft and HST Substitution

Passengers affected by airline and railway integration are mainly passengers arriving by air at a hub airport where they are transferred to an HST service to complete their journey, instead of being transferred to another flight. This means
that the comparison between a rail and a plane journey is on the second leg of the passenger journey and should start once the passengers disembark from the plane on arrival at the hub airport (LHR in Figure 7.1). In order to use real data of the transfer time between aircraft at the hub airport, it is assumed that, on the LHR to Paris route, the passenger origin is New York (JFK airport) and on the FRA to Stuttgart route, the passenger origin is Madrid. For aircraft to HST transfer time, data is available for the FRA to Stuttgart route only and it stands at 45 minutes between arriving plane and departing HST (LH, 2003). Accordingly, at LHR transfer time between the aircraft and the HST was assumed to be 45 minutes to represent the benchmark transfer time achieved at FRA. Without integration, the transfer time between the aircraft and the train at the destination airport (CDG in Figure 7.1) is assumed to be 60 minutes, which means that the transfer time is 15 minutes faster under airline and railway integration than when there is no integration. In part, this is due to the fact that the passenger does not need to wait for his luggage or wait to buy the train tickets while transferring between the integrated aircraft and HST service.

The time-based analysis (Table 7.4) shows that when the conditions at LHR allow airline and railway integration to take place, including 45 minutes transfer time from plane to train and a high-speed line from LHR all the way to Paris, passengers will save 15 minutes of travel time compared with current air services. On the FRA-Stuttgart route, passengers using the train and not the plane from FRA already enjoy 54 minutes shorter journey time to Stuttgart city centre. However, currently passengers who arrive at LHR and want to use the HST to Paris (from Waterloo) will increase their journey time by 74 minutes. If we assume the ‘potentially fastest’ travel time for both modes, the journey by aircraft from LHR has a 30-minute advantage over the HST. Considering congestion at major airports and on major routes, and specifically on the LHR to CDG route (see CODA, 2002, 2003), ‘potentially fastest’ travel time conditions are more likely for the HST than for the aircraft. Specifically, a 45-minutes transfer time seems more likely for aircraft to HST transfer than for aircraft to aircraft at LHR.

Other than travel time savings, the differences between the modes in terms of the actual travelling experience might also lead to benefits from aircraft and HST substitution. Travel time is usually considered as wasted time, hence the benefits from reducing the time travelled. Yet, different activities that can be undertaken during travel reduce the extent to which travel time is a wasted time (see for example Mokhtarian and Salomon, 2001). Therefore, passengers faced with two options of travel with the same travel time will prefer, according to the theory, the option that offers greater ability to engage in different activities while travelling. ‘The “cost” to the individual of travel time is reduced as travel time is converted into activity time ... encouraging greater use of modes that best enable en-route activities to be undertaken’ (Lyons, 2003, p. 6).
Table 7.4  Travel time comparison between aircraft and HST journeys (in minutes)

<table>
<thead>
<tr>
<th>Route</th>
<th>(New York-) LHR-Paris</th>
<th>(Madrid-) FRA-Stuttgart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Air</td>
<td>Rail</td>
</tr>
<tr>
<td>Fastest available*a</td>
<td>220</td>
<td>294</td>
</tr>
<tr>
<td>Potentially fastest*b</td>
<td>175</td>
<td>205</td>
</tr>
<tr>
<td>Air: current rail: fastest*c</td>
<td>220</td>
<td>205</td>
</tr>
<tr>
<td>Direct flight*d</td>
<td>505</td>
<td>625</td>
</tr>
</tbody>
</table>

Notes:

*a Using the fastest available transfer time and flight time combination for the air travel, and fastest available train connection from hub airport to destination city.

*b Using the shortest schedule flying time for aircraft; assuming direct HST from hub airport to destination city centre, and assuming 45 minutes transfer time between modes.

*c Air journey: assuming ‘Fastest available’; HST journey: assuming ‘Potentially fastest’.

*d Comparing direct flight, for example, from NY to Paris with the NY to Paris via LHR journey using the HST.

*e Time savings by rail.

The ‘opportunity to engage in other activities while travelling’ (Mokhtarian and Salomon, 2001, p. 7) by aircraft and by HST depends on many factors such as the smoothness of the journey, the variety of on-board services, safety perception, and seat pitch. However, the most important factor seems to be the amount of time available during the journey to engage in such activities. Two categories represent this journey characteristic in the analysis: first, is the number of transfers required (or number of journey segments); and, second, the duration of the journey’s longest segment. The higher VOT assigned to time spent transferring between services (see below) is an indication of the disutility that passengers experience from having to interrupt their journey and change the vehicle they travel in. The HST, therefore, has an advantage over the aircraft, from the passenger point of view, due to the need to transfer once and not twice on the routes analysed, or because the HST journey consists of three segments compared with the five segments of the aircraft journey (Table 7.5).
Table 7.5 Comparison between aircraft and HST journey characteristics

<table>
<thead>
<tr>
<th>Route</th>
<th>(New York-) LHR-Paris</th>
<th>(Madrid-) FRA-Stuttgart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Air</td>
<td>Rail</td>
</tr>
<tr>
<td>Transfers (segments(^a))</td>
<td>2 (5)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Longest segment duration (minutes(^b))</td>
<td>85</td>
<td>160</td>
</tr>
<tr>
<td>Spent in/during:</td>
<td>Aircraft</td>
<td>HST</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transfer</td>
</tr>
</tbody>
</table>

Notes:
\(^a\) Transfer between services is considered as a (time) segment.
\(^b\) The flight from origin to the hub airport (from New York to LHR, or from Madrid to FRA) is not included.

The HST also has an advantage with respect to the duration of the longest segment. On the routes analysed, the HST option of travel provides longer uninterrupted journey time which means more opportunities to engage in activities that will reduce the disutility of travelling. On the LHR to Paris route, the difference between the aircraft and the HST longest segment is 1h15m.

7.4.2 The Value of Travel Time Savings to Passengers from Aircraft and HST Substitution

In order to compare the benefits of travel time savings to other categories of benefits, a monetary value must be assigned to the time saved. While there is an agreement concerning the theory of the VOT, its empirical application still faces many difficulties.

Empirical research show that people assign different values for time spent travelling depending on the journey characteristics and two main attributes, the mode used and the purpose of travelling. There are further subcategories of journey attributes, such as distance travelled, time of travel and the traveller’s income. The more precise the definition of the value, the more accurate the value will be in representing the true VOT, but this comes at the price of a smaller sample, reduced statistical significance, and less possibility to use the value in other studies.

To measure the value of the 15 minutes travel time savings when using the HST (‘Air: current’, and ‘Rail: fastest’ category in Table 7.4), different sets of VOT estimates are used, in line with different empirical practices and according to best available data from other empirical studies. The first set of VOT estimates applied is the one recommended by the EU (EUNET, 1998), representing the base case. The recommendations are to use a single VOT estimate for time spent travelling for non-work purposes, regardless of the mode used, and differentiation by mode when time spent travelling is during working time. The transfer time between the modes should be valued at 1.6 the value of time spent travelling. Using this set of
values results in a €4.31 VOT saving for passengers travelling by HST and not by aircraft for non-working (leisure) purposes. The corresponding value for journeys made during work time (business) is €65.63 (Table 7.6, row 1).

Table 7.6 Value of Time comparison between aircraft and HST journey (in euros)

<table>
<thead>
<tr>
<th>Different Types of VOT</th>
<th>(New York-) LHR-Paris</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Air</td>
</tr>
<tr>
<td>1) Base case: EU recommended VOT</td>
<td></td>
</tr>
<tr>
<td>Leisure</td>
<td>22.83</td>
</tr>
<tr>
<td>Business</td>
<td>159.01</td>
</tr>
<tr>
<td>2) Adding 17.61 minutes ‘transfer penalty’</td>
<td></td>
</tr>
<tr>
<td>Leisure</td>
<td>27.33</td>
</tr>
<tr>
<td>Business</td>
<td>189.10</td>
</tr>
<tr>
<td>3) Using the UK VOT estimates for each mode</td>
<td></td>
</tr>
<tr>
<td>Leisure</td>
<td>194.54</td>
</tr>
<tr>
<td>Business</td>
<td>237.27</td>
</tr>
<tr>
<td>4) Using the Swedish VOT for flight and UK VOT for rail</td>
<td></td>
</tr>
<tr>
<td>Leisure</td>
<td>73.15</td>
</tr>
<tr>
<td>Business</td>
<td>108.57</td>
</tr>
<tr>
<td>5) Using the average of the VOT estimates found</td>
<td></td>
</tr>
<tr>
<td>Leisure</td>
<td>104.94</td>
</tr>
<tr>
<td>Business</td>
<td>134.20</td>
</tr>
</tbody>
</table>

*Note: ^* Value of travel time.

Wardman (2001a) estimates an interchange penalty of 17.6 minutes representing the ‘disutility of having to change over and above that associated with the time spent waiting for or transferring between trains’ (Wardman, 2001a, p. 112). When this estimate is applied to leisure and business journeys by plane and by train from LHR to Paris the advantage of using the train amounts to €6.56 and €85.03, respectively (Table 7.6, row 2).

The EU favours the same VOT for all modes when the journey is not during work time, because of the ‘practical benefits of using a single value [VOT]: in particular, the clear impression of comparability between appraisals of infrastructure investment in different modes. In addition ... adoption of a single non-working value of time helps to overcome the equity problems’ (EUNET, 1998, article 2.6.1). Such approach ignores the fact that there are likely to be differences in the VOT for different modes. In addition, in this research the same people ‘choose’ between the two options of travel, and therefore there is no problem of equity. Furthermore, the time spent on different modes is valued differently by the EU for journeys during work time because ‘differences exist between modes in terms of the ability to work in transit’ (EUNET, 1998, article 3.2.7), and those differences might also be valued by passengers travelling for non-work purposes. Therefore, it is appropriate to use mode-specific values for non-work journeys as
well. Furuichi and Koppelman (1994), for example, found in a study on access to airports that the same people do value rail and plane differently on the same journey.

Once it is decided that mode-specific VOT estimates should be used the problem is which estimates to use. The analysis begins with the UK VOT estimates for air travel, Intercity rail travel (for the HST journey), and ‘Urban’ rail (for the journey CDG to Paris) of, respectively, €1.11, €0.18, and €0.09 per minute for leisure travel and, respectively, €1.24, €0.44, and €0.27 per minute for business travel (Wardman, 2001b). When using these estimates, and a transfer value as recommended by the EU, the value of the 15 minutes saved from using the HST and not the aircraft is €152.78 for non-work journeys and €135.19 for work journeys (Table 7.6, row 3).

The above values seem to be too high and unrealistic. Therefore a different set of estimates is used (Table 7.6, row 4). The flying VOT is changed to €0.37 and €0.46 per minute for leisure and business travel, respectively. These values, estimated in Sweden (Bråthen et al., 2000), are used since they are closer to the VOT used for the HST (under airline and railway integration there is no reason to assume a big difference in the aircraft and the HST VOT). In addition, estimates of VOT specifically estimated by rail passengers (as opposed to estimation by the general population of travellers), according to distance, were used to complete this set of estimates. The VOT of rail passengers for journeys of 16 km (Urban rail category) is €0.10 and €0.27 per minute for leisure and business travel, respectively, and €0.23 and €0.61 per minute for leisure and business travel, respectively, for journeys of 320 km (HST category) (Wardman, 2001b). Applying this set of values results in a positive value of time savings for leisure passengers who travel with the HST, of €19.79, but business passengers who chose the HST over the aircraft lose €32.95 (Table 7.6, row 4), a result that contradicts the VOT theory.

The last set of VOT estimates used was the average VOT across the different estimates found for each category. Using this set of results in €70.14 and €71.56 VOT saved for leisure and business passengers travelling between LHR and Paris by HST and not aircraft (Table 7.6, row 5).

Assigning a monetary value to the travel time saved as a result of mode substitution on the case study route was found to be problematic and led to varying results, some of which are not consistent with the theory, although the analysis was based on common practices in the appraisal of transportation projects, and robust academic research. Each set of VOT estimates chosen for the analysis can be justified for use in this research, yet the different sets of VOT results in a significantly different monetary value for saving the same 15 minutes. The VOT saved for leisure passengers, for example, ranges from €4.31 to €152.78. These results represent the difficulty in applying the theory of VOT to empirical research, especially when an inter-modal journey is considered, and when the passengers are of an international nature. The analysis also underlined the limitations in applying estimates from different studies to a specific, but different, project or study.
In general, it was not possible to find ‘best practice’ for this study, partly because governments and the EU support the use of a single value for different modes but empirical evidence suggests that passengers do value differently the travel time on different modes. The best solution in the context of this research is to conduct a survey designed specifically to evaluate the appropriate VOT. However, the international characteristics of the journey and the passengers creates problems in performing such a survey, even if other obstacles are overcome, since each passenger (whether travelling for business or leisure purposes) is likely to have different values depending on his country of origin.

However, it is still essential to assign a monetary value to the travel time savings in order to compare benefits to passengers with other benefits. Using the set of estimates recommended by the EU (Table 7.6, row 1) seems to be the least unfavourable and was therefore adopted. It was justified in part due to the international characteristics of the route.

In conclusion, the analysis showed that, under favourable conditions for the HST at LHR (45 minutes transfer from the aircraft, and HST track throughout the route), and current conditions for the aircraft (which are not likely to change in the future), passengers will save 15 minutes following mode substitution. In addition, the analysis showed that passengers would benefit from improved journey characteristics which allow better opportunities to engage in different activities while travelling.

The analysis suggests that time-based analysis is the most robust way to assess the benefits to passengers from mode substitution, and that, if travel time savings occur, it can be concluded that passengers will benefit from it. However, in the absence of travel time savings, it is not possible to determine if better journey characteristics are enough for passengers to benefit from mode substitution. This calls for appraisal practices to be improved to account for, and put a value on, these characteristics. Finally, one of the implications of the above analysis is that efforts to reduce travel time should be concentrated on reducing the transfer time and on reducing the inconvenience associated with the transfer and the need to interrupt the journey since these are valued the most by passengers.

### 7.5 Evaluating Benefits to Society of Reduced Environmental Impact as a Result of Aircraft and HST Substitution

Many studies consider that the substitution of trains for planes results in reduced environmental impact from aircraft operation (for example, AEF, 2000; IPCC, 1999; Whitelegg et al., 2001). A study by the Royal Commission on Environmental Pollution (RCEP) also supports a shift from air to rail, which could ‘reap considerable environmental benefits’ (RCEP, 2002, p. 33). Therefore, benefits to society from reduced environmental pollution are expected as a result of aircraft and HST substitution. The main environmental effects from rail and aircraft operation can be divided into three groups: Local Air Pollution (LAP), climate change, and noise. Except for climate change, the effect is of local
magnitude, but since most major airports are located in, or close to, densely populated areas it affects many.

Comparisons of aircraft and HST noise pollution are normally made with regard to the overall operations and not to a single flight or a single train service. The units used are usually the number of people around airports and under the aircraft flight path who are exposed to aircraft noise compared with the number of people along the rail route who are exposed to train noise. However, since not all aircraft services are expected to be transferred to the HST, the noise impact of one flight needs to be compared with the noise impact from one HST service. Evaluating the differences in noise pollution around an airport if one flight is transferred to the HST is almost impossible and is outside the scope of this research. In addition, ‘research on noise annoyance caused by railroad traffic is relatively underdeveloped’ (Brons et al., 2003, p. 169), which means there is also lack of data to allow comparison of the modes. Therefore, evaluation of benefits from reduction in noise pollution following mode substitution was not carried out in this research and only reductions in LAP and climate change were considered.

The evaluation of environmental benefits from mode substitution is made by comparing the modes on three levels. On the first level, comparison of emissions in units of emission per seat per route is made, but because of the different effect each gas has on LAP and climate change, just summing the total emission across the different gases has no meaning. Instead, the impact of each gas is considered at the second level of comparison. For the analysis of the impact of LAP, the toxicity factor of the gases, used by Quinet (1994), is considered as the common denominator that enables us to sum the effects of the different pollutants emitted during the journey and allows a meaningful comparison of the modes. For the climate change analysis, units of CO₂ equivalent are considered as the common denominator. On the third level, the cost of damage caused by emissions, which occur during the journey, is compared. Dings et al. (2002) collected and compared monetary values assigned to the damage caused by emission of pollutants from different recent studies. On the basis of these studies, they then calculated an average cost of damage which is used to evaluate LAP and climate change from HST and aircraft operation. It is important to note that, as we move from comparison of emission to comparison in terms of impact, and finally in terms of cost, we encounter decreasing scientific understanding and increasing subjectivity due to the many assumptions required when moving from one level to the other.¹⁵ This is important to acknowledge when assessing the results.

For the analysis of LAP, aircraft emissions were estimated based on EPA (1999) data for the B737-300. Aircraft operation impact on LAP occurs as long as the aircraft is within the Landing and Take-Off (LTO) cycle area, the mixing zone,¹⁶ which is set at 915 m according to the ICAO estimation (Archer, 1993; EPA, 1999). For the HST journey, emission estimates for the French TGV (Quinet, 1994) and the British West Coast Main Line (WCML) (CfIT, 2001) are averaged. As well as providing a mix of specific HST estimates and more up-to-date estimates (which are not specific for HST), the two sources represent the mix of energy used in each country to generate the electricity for the HST. The results
show that the journey by air results in more emissions of HC, CO, NO\textsubscript{x} and PM\textsubscript{10} but less SO\textsubscript{2} than the journey by HST. Since each gas has a different impact on LAP summing emissions across all gases is meaningless, and therefore it was not possible to conclude which travel option is better.

On the second level, and by using the toxicity factor of the gases as an indicator of the impact each gas causes, a comparison between the modes is possible. The results show the HST is a much better option since it results in 5,882 units of toxicity for every seat offered on the route compared with 10,924 units of toxicity when using the aircraft (Table 7.7). About 14 per cent (or 1,558 toxicity units) from the air journey are associated with the surface journey from CDG to Paris city centre, and the remainder with the flight. Comparing the modes in terms of the social cost of LAP, the third level, also indicates that the journey by aircraft leads to more damage from LAP. The cost of damage from LAP caused by the aircraft option of travel and the HST option of travel is estimated at €1.00 and €0.52 per seat per route, respectively.

Table 7.7  Summary of Local Air Pollution (LAP) and climate change analysis for the LHR to Paris route (seat per route)

<table>
<thead>
<tr>
<th></th>
<th>Aircraft Journey (65 min)</th>
<th>HST journey (525 km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local air pollution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emission (gram) *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxicity factor (units)</td>
<td>10,924</td>
<td>5,882</td>
</tr>
<tr>
<td>Cost (Euro)</td>
<td>1.00</td>
<td>0.52</td>
</tr>
<tr>
<td>Climate change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO\textsubscript{x} emission (grams)</td>
<td>330.79</td>
<td>17.57</td>
</tr>
<tr>
<td>CO\textsubscript{2} emission (grams)</td>
<td>39,014</td>
<td>7,194</td>
</tr>
<tr>
<td>CO\textsubscript{2} equivalent (units)</td>
<td>126,090</td>
<td>7,247</td>
</tr>
<tr>
<td>Cost (euros)</td>
<td>2.49</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Note: * With regard to some gases, the journey by aircraft results in more emissions, in others the HST journey. Therefore, summing total emission across pollutants is meaningless, as explained above.

HST might also have an advantage over the aircraft in terms of LAP since the sources of emission of gases from HST operation (assumed to be the same as electricity power plants) are usually further away from densely populated areas than aircraft sources of emissions (from the engines, while the aircraft is moving on the ground or flying under 915 m). Furthermore, in countries where much of the electricity is supplied from ‘clean’ sources (such as hydroelectric power plants), the HST will have an advantage over the aircraft which always uses Kerosene fuel. However, in countries where electricity generation relies on coal, which is responsible for high levels of SO\textsubscript{x} emissions, aircraft operation might lead to less LAP.
In the case of climate change, the analysis shows that for both the gases analysed, NO\textsubscript{x} and CO\textsubscript{2},\textsuperscript{17} the journey by air results in substantially more emissions. While this leads to the conclusion that a journey by HST has less impact on climate change, it does not enable us to say by how much, since emissions of NO\textsubscript{x} and CO\textsubscript{2} have a different effect on climate change. CO\textsubscript{2} emissions are directly related to fuel consumption, and the effect of CO\textsubscript{2} emissions on climate change is not related to where, or at which altitude, emissions occur, but this is not the case with other gases, and especially with NO\textsubscript{x}. In fact, emission of NO\textsubscript{x} is believed to have a greater impact on climate change than the same amount of CO\textsubscript{2} emission, and furthermore, NO\textsubscript{x} emissions at high altitude (at the troposphere) is believed to have more effect on climate change than emission of NO\textsubscript{x} at ground level (Archer, 1993). Measuring the total impact on climate change from both gases, using CO\textsubscript{2} equivalent units estimates given by Archer (1993),\textsuperscript{18} it was found that the HST journey results in 118,843 gr less CO\textsubscript{2} equivalent units than the aircraft journey for each seat supplied on the route. As in the first and second level of the analysis, the social cost comparison also shows a clear advantage of using the HST compared with the aircraft in terms of the effect on climate change (Table 7.7).

In conclusion, the foregoing analysis confirms the claims in the literature that substitution of aircraft by HST would lead to environmental benefits, at least in terms of LAP and climate change. However, the analysis also underlined the difficulties in empirically trying to quantify environmental benefits, because of the present lack of scientific understanding of the relations, processes and reactions between fuel consumption, level of emissions, and the impact on LAP and climate change. These difficulties suggest that the results obtained should be considered as an indication rather than a precise result. Nevertheless, the conclusions reached are considered robust and provide a realistic indication of the magnitude of benefits that can be expected from mode substitution on the case study route.

Although the third level of comparison, the cost of environmental damage, is considered the least robust, it is the only one which makes it possible to sum up different environmental benefits. At this level, the analysis shows that even when the HST route covers a considerably longer distance, mode substitution (under airline and railway integration) yields environmental benefits which amount to €2.68 per seat. Most of these benefits, over 80 per cent, are the result of reduced climate change, while the remaining benefits are from reduction in LAP. However, the significance of the benefits from reduced LAP increases since these benefits would be felt locally, while climate change benefits will not necessarily be felt in either France or the UK (or in Paris and London). It is also interesting to note that once mode substitution takes place the HST services themselves contribute more to LAP than to climate change impact.

Following this analysis, policy makers should note the following. First, the reduction in environmental pollution following mode substitution is attributed to reduction in all the gases/pollutants considered,\textsuperscript{19} except SO\textsubscript{2}. Therefore, in order to increase the environmental benefits from mode substitution, efforts should be focused on reduction of SO\textsubscript{2} emissions associated with HST operation. Second, most of the benefits (€1.74, or 65 per cent of the benefits), or most of the
environmental impact from aircraft operation on short-haul flights, come from emissions of NO\textsubscript{x}. Hence, attempts to reduce the impact of aircraft operation on the environment must be focused on reducing NO\textsubscript{x} emissions from aircraft operation as much as the focus is currently on reducing CO\textsubscript{2} emissions. This is even before taking into consideration the higher impact on climate change from NO\textsubscript{x} emissions at high altitude.\textsuperscript{20} Third, despite the high uncertainties associated with the impact of aircraft NO\textsubscript{x} emission on climate change, the analysis shows that an evaluation that yields a robust indication can be made. Therefore, there is no reason to exclude NO\textsubscript{x} emission from the discussion on climate change, or limit the reference to it, as often is the case, and focus solely or mainly on CO\textsubscript{2} emissions (see, for example, RCEP, 2002; CfIT, 2003; HM Treasury and DfT, 2003; Environmental Audit Committee, 2003). Fourth, the benefits from eliminating the egress air journey, following mode substitution, are not insignificant. However, the magnitude and the nature of the environmental impact of the access/egress journeys to airports suggest that it is probably better dealt with outside the context of mode substitution. This is also supported by the CfIT (2003).

7.6 Overall Benefits from Aircraft and HST Substitution

Most appraisals of transportation projects are done using CBA, mainly because the results of the CBA are very easy to understand and to interpret. Furthermore, the results provide clear and unambiguous evidence of the project outcome in units that are clear to everyone. In practice, however, the CBA results might be misleading and not robust due to the uncertainty and subjectivity associated with estimating the monetary value of products, such as time saved, for which there is no market. In this analysis, assigning a monetary value to the benefits of reduced environmental pollution and to travel time savings showed the limitations of such practices. In addition, the variety of cost estimates from different studies in different countries and periods of time, which were not inflated to present prices and were converted to euros using an illustrative exchange rate, further adds some limitations to the results. Nevertheless, after acknowledging and accepting the limitations of using a CBA framework, it remains the best way to provide an estimate of the net benefits from operating airline and railway integration, and to put these benefits in context. Table 7.8 summarizes the monetary benefits from mode substitution on the case study route. The difference in the ‘cost’ between the aircraft journey and the HST journey in each category is the benefit from mode substitution.\textsuperscript{21}

Overall, the evaluation shows net benefits of €29.13 per seat transferred from the aircraft to the HST on the case study route, which include €3.43 OC losses to airlines. Passengers benefit the most from airline and railway integration, €29.88 per seat.\textsuperscript{22} Most of these benefits (87 per cent) are enjoyed by business passengers. Society is also expected to benefit, €2.68 per seat, mainly through reduction in the adverse effects of climate change, but also from reduction in LAP (Table 7.8).
### Table 7.8 Benefits from substitution of aircraft services with HST services on the LHR to Paris route using CBA (in euros per seat per route)

<table>
<thead>
<tr>
<th>Category</th>
<th>Costs per seat per route (Euro)</th>
<th>Costs per seat per route (Euro)</th>
<th>Costs per seat per route (Euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Air journey (a)</td>
<td>HST journey (b)</td>
<td>Benefits from substitution (a – b)</td>
</tr>
<tr>
<td>Airline benefits</td>
<td>27.10</td>
<td>30.53</td>
<td>-3.43</td>
</tr>
<tr>
<td>Passenger benefits*</td>
<td>54.11</td>
<td>24.23</td>
<td>29.88</td>
</tr>
<tr>
<td>Environmental benefits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local air pollution</td>
<td>1.00</td>
<td>0.52</td>
<td>0.48</td>
</tr>
<tr>
<td>Climate change</td>
<td>2.49</td>
<td>0.29</td>
<td>2.20</td>
</tr>
<tr>
<td>Total</td>
<td>84.69</td>
<td>55.57</td>
<td>29.13</td>
</tr>
</tbody>
</table>

Note: *To include benefits to passengers in the CBA, the VOT per passenger was converted to VOT per seat using a load factor estimate of 70 per cent for the aircraft and 50 per cent for the HST, and assuming 60 per cent of air passengers are leisure passengers with the remaining travelling for business purposes.

Net benefits from mode substitution mean that, overall, it should take place, provided the infrastructure is in place, for the benefit of society and the users of the service. Net benefits also mean that the airlines can be compensated for their losses. However, the environmental benefits found are not enough to compensate the airlines for their losses. Perhaps surprisingly, it is the users who benefit the most from mode substitution on the case study route. Although these benefits were sensitive to the assumptions on the modes’ load factor and the mix of business and leisure passengers, under all the realistic assumptions tested these benefits were large enough to yield net benefits from mode substitution. The benefits to passengers were also sensitive to the VOT estimates used, but under a different set of estimates (from the ones recommended by the EU) the benefits would in fact increase (see Table 7.6). These benefits, at least in theory, are easy for the airlines to capture through the fare mechanism in order to recover their OC losses (meaning through higher fares for the airline’s HST service) and still leave the passengers with benefits from the reduction in travel time. Alternatively, if airlines have other financial benefits from mode substitution, which would compensate for their OC losses, then mode substitution is beneficial based only on the expected environmental benefits, as long as passengers did not experience travel time losses.

To give a better impression of the magnitude of benefits (and disbenefits) from mode substitution, one year’s operation on the route is considered. During 2001, 21,815 flights were operated between LHR and CDG airports (CODA, 2002). Assuming that all the airlines that operated on the route in 2001 adopted mode substitution, and consequently all the passengers (that is, those who transferred at LHR and those who originated at LHR) switch from the aircraft to the HST, the
yearly net benefits of mode substitution amounts to over €80 million (assuming all the airlines used B737 with a capacity of 128 seats). However, for the airlines such substitution would result in a loss of almost €10 million. Although not all airlines might adopt mode substitution\(^23\) and although the size of the transfer traffic market on the route is not clear, the above analysis provides an indication for the potential yearly benefits.

In many cases, MCA is used only after monetization of all the effects within a CBA has been considered and been judged inappropriate or not robust. As stated, despite the limitations in using CBA, there is no good alternative that can provide similar information. However, presenting the benefits from mode substitution using an MCA framework provides a mean to judge the robustness of the CBA. Since the MCA results are the basis for assigning monetary values to impacts/effects, and thus the basis for the CBA, it is by definition more robust. Nevertheless, it is still based on many assumptions and depends on the quality of data available.

The results of the MCA (Table 7.9) present a similar picture to that emerging from the CBA, that is, mode substitution is beneficial for society and passengers but not for the airlines. This increases the confidence in the CBA results with regard to their conclusions (that passengers and society would benefit, but airlines would lose), although this does not make the estimate of the benefits/disbenefits more accurate.

<table>
<thead>
<tr>
<th>Category</th>
<th>Air journey (a)</th>
<th>HST journey (b)</th>
<th>Benefits from substitution (a – b)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Airline benefits</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating cost savings (euros)</td>
<td>27.10</td>
<td>30.53</td>
<td>No (–3.43)</td>
</tr>
<tr>
<td><strong>Passenger benefits</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel time (minutes)</td>
<td>220</td>
<td>205</td>
<td>Yes (15)</td>
</tr>
<tr>
<td>Longest segment duration (minutes)</td>
<td>85</td>
<td>160</td>
<td>Yes (75)</td>
</tr>
<tr>
<td>Number of Transfers</td>
<td>2</td>
<td>1</td>
<td>Yes (1)</td>
</tr>
<tr>
<td><strong>Environmental benefits</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local air pollution (Toxicity units)</td>
<td>10,924</td>
<td>5882</td>
<td>Yes (5,042)</td>
</tr>
<tr>
<td>Climate change: NO(_x) emission (grams)</td>
<td>330.79</td>
<td>17.57</td>
<td>Yes (313.22)</td>
</tr>
<tr>
<td>Climate change: CO(_2) emission (grams)</td>
<td>39,014</td>
<td>7194</td>
<td>Yes (31,820)</td>
</tr>
<tr>
<td>Climate change: CO(_2) equivalent (units)</td>
<td>126,090</td>
<td>7247</td>
<td>Yes (118,843)</td>
</tr>
</tbody>
</table>
7.7 Conclusions and Policy Implications

Soon after the inauguration of the modern HST, in 1964, it became apparent that HST can be a substitute for the aircraft on some routes. Years later, the immense growth in air transport, together with the forecasts for continuous rapid growth in demand for air services has led to increased support for the idea of mode substitution, including as a solution to the congestion faced by the air transport industry. The idea also gained many supporters in light of increasing concerns about aircraft operation impact on the environment. However, to date, mode substitution has mainly led to competition between the modes, which means that an HST service does not necessarily substitute for an existing aircraft service. For real mode substitution to take place, when an existing flight is substituted by an existing HST service, the airlines themselves need to initiate and support mode substitution. This can happen under the model of airline and railway integration, in which the airport is connected to the HST network and allows the airline to integrate its services with the HST service. The HST service is provided by the airline but is operated by the TOC.

Under the assumption that the infrastructure for airline and railway integration exists, the benefits to airlines, passengers and society from the operation of mode substitution by means of airline and railway integration were evaluated. The focus on the operation of airline and railway integration was also due to the methodological challenges in empirically measuring such benefits, and the level of analysis required in order to make a valuable contribution to the discourse on aircraft and HST substitution.

The evaluation clearly shows that airlines have no operational incentive to adopt mode substitution on the case study route since this will lead to OC losses. This is an important finding, since it is the airlines’ decision whether to substitute the aircraft with the HST. However, there are likely to be other benefits to airlines from mode substitution which will compensate for the OC losses, such as the value of the freed slots and the network economics from adding (rail) destinations (see Givoni, 2005). If airlines adopt mode substitution on the LHR to Paris route, the evaluation showed that passengers would benefit from shorter travel time and favourable journey conditions which will allow them to engage in different activities while travelling, and thus reduce the disutility from having to travel. In terms of environmental impact, mode substitution will lead to a reduction in the impact of climate change and LAP from aircraft operation, to the benefit of society.

The methodology used and the way the results are presented allows us to estimate the benefits from mode substitution on other routes, and expand the discussion to more general cases and different aspects of mode substitution, as discussed below.

Routes where mode substitution, and airline and railway integration, as likely to be considered have relatively similar characteristics in terms of route distance, and travel time by train and plane. Therefore, the results described above are a good indication for other routes as well. Alternatively, converting the results from seat-
per-route to seat-km units can enable transfer of the results to other routes (however, care must be taken when doing this to acknowledge differences between routes, such as the landing charges at different airports which affect the OCs). Thus, on routes where the HST covers a similar distance between origin and destination to the one covered by the aircraft, airlines can actually expect OC savings following mode substitution. Regarding the environmental impact, it can be expected that on all routes where mode substitution seems plausible, environmental benefits would occur. Their extent (including in monetary value) could probably be predicted on the basis of the results presented above.

Most of the studies evaluating the effects of transport operation choose to use passenger units over seat units. The foregoing analysis can be translated to passenger units to account for the differences between the modes with respect to this characteristic, and to allow comparison with findings in other studies. Considering a 70 per cent load factor for the aircraft and 50 per cent for the HST, the CBA shows net benefits from mode substitution of only €9.84. However, when the HST load factor is assumed to be 45 per cent (an assumption which is as realistic) mode substitution results in net losses. This highlights the efficiency of the airlines in using their aircraft and the inefficiency of the railways in using the HST. One of the possibilities for the railways to increase their service load factor is through cooperation with the airlines, and specifically through airline and railway integration as proposed here.

Currently, mode substitution mainly leads to competition between the modes on the city-centre to city-centre market. The above analysis can also be used to show the impact of mode substitution on this market (central London to central Paris market, where currently the HST services compete with the airlines). Assuming the distance and the travel time from London city centre to LHR are similar to the ones from CDG to Paris city centre, then the findings for the egress journey (CDG to Paris) should be doubled to account for the access journey (London to LHR). This would increase (and almost guarantee) travel time savings from mode substitution and would increase the environmental benefits (by €0.14 per seat, the impact from the egress journey).

Because the analysis was based on the supply of aircraft and HST services and, in general, did not consider the demand for them (an important aspect of mode substitution which requires a separate and further analysis) a few issues must be highlighted.

First, it was assumed that the passengers view the two modes as perfect substitutes, although this was not analysed and is not necessarily the case. However, the analysis actually indicated that the HST might be preferred by passengers over the aircraft, which increase the scope for substitution, because of the better travel conditions it provides. In addition, it is assumed that the extent to which (aircraft) passengers will view the modes as substitutes depends on the level of integration achieved between the modes. Under full integration (including integration of the reservations, ticketing, customer service, timetables, and so on), there is no reason to assume the modes are not (almost) perfect substitutes.
Second, although the analysis clearly showed that mode substitution will lead to environmental benefits, the actual benefits depend on the extent to which integration is used as a means to meet current demand rather than meeting new demand for air services. Using mode substitution to meet more demand for air services will lead, overall, to an increase in environmental impact.

Third, the model of integration envisaged relies on the transfer traffic market, that is, on passengers who arrive at LHR by aircraft in order to transfer to another aircraft. Because of commercial confidentiality, it was not possible to obtain data on the actual size of this market on the case study route. What is known is that in the leading European airports the proportion of transfer passengers in the airports’ overall passenger volume is very significant. During 2000, for example, 58 per cent (27.9 million) of the passengers at CDG were transfer passengers, at FRA this was 50 per cent (24.5 million), at Amsterdam airport 41 per cent (16.1 million), and at LHR 34 per cent (21.9 million) (Doganis, 2002). In addition, evidence shows that the HST has already gained about two-thirds of the London-Paris market, and that airlines operating on the route from LHR have only around 10 per cent of the market (Eurostar, 2004). Nevertheless, those airlines still operate almost 60 flights per day on the route (Innovata, 2004). Furthermore, evidence suggests that European short-haul services operated by the major network airlines are not profitable (see, for example, López-Pita, 2003; Doganis, 2002). Therefore, it is reasonable to assume that the transfer traffic market on the case study route is, at least, not insignificant, and, in addition, important to the airlines at the network level, though not necessarily at the route level.

On the methodological aspect, the analysis showed the extra complexity introduced by the consideration of more than one mode within one journey. It made it more difficult and less robust to use monetary values to estimate the benefits of reduced travel time, an otherwise common practice in the evaluation of transport projects. The environmental analysis provided evidence that the current knowledge of the way the environment is altered by transport operation, and mainly aircraft operation, is not sufficient to accurately estimate the impact of one flight, or one HST journey, on the environment. The methodological recommendations following the evaluation presented above are that the results of a CBA should be supported with MCA to ensure that the CBA is at least robust even if not accurate. For example, if the CBA shows a positive value of travel time savings but the MCA does not, then the CBA result is not valid.

The overall conclusion from this detailed analysis is that in airports where the infrastructure for airline and railway integration is provided, mode substitution is beneficial. Whether these benefits compensate for the costs required to provide the infrastructure requires further evaluation. Such evaluation, however, must consider the benefits from mode substitution which are not directly related to its operation, as well as the benefits from improving rail access to airports.
Acknowledgments

The analysis and the results presented here are part of the research for a PhD undertaken at The Bartlett School of Planning, University College London. The research was supervised by Professor David Banister and Professor Sir Peter Hall, and the author would like to gratefully acknowledge the supervisors’ valuable guidance, comments and support throughout the research. The author would also like to thank two anonymous referees for their useful comments. The content of this chapter, however, remains the author’s own responsibility.

Notes

1 There are different definitions of what is included in each category (see, for example, Atkinson et al., 1997).
2 The data available is a forecast of the profit and loss statement for the year 2002. For reasons of commercial confidentiality, the name of the company cannot be revealed.
3 Based on estimates published in Air Transport World (2002).
4 The costs of operating the surface journey from CDG to Paris were not included in the analysis since they are not borne by the airline.
5 The great circle distance between LHR and CDG.
6 It can be assumed that, if delays to HST services occur while the train is not running, the effect of these delays on the OCs is marginal.
7 Southwest airline’s OCs are 44 per cent lower than Delta airlines’ OCs, and the seat capacity on board Southwest B737-300 is 137 seats (Doganis, 2001, p. 131) compared with 128 seats assumed in the analysis. The reduction in OCs applies to the block hour OCs only and not to the different charges.
8 Often referred to as Local Air Quality (LAQ).
9 Often referred to as the Value of Travel Time Savings (VTTS).
10 Assumed to be 2:40 hours once the Channel Tunnel Rail Link (CTRL) is opened in 2007 (2:20 for the London St. Pancras to Paris route (Union Railways, 2000).
11 Although this probably holds for any passenger on any journey, it is important to note that passengers faced with the two options of travel, as described in this chapter, chose a flight through a hub airport in preference to the direct flight (for example New-York to Paris), suggesting that perhaps these passengers have, on average, a lower disutility from the need to transfer.
12 The EU non-working VOT for the UK is €0.065 per minute and for Sweden is €0.063 per minute (EUNET, 1998), suggesting the Swedish values can be a good estimate for the UK values.
13 Air journey: €0.57 and €0.63 per minute for leisure and business travel respectively; HST journey: €0.15 and €0.30 per minute for leisure and business travel respectively; Surface journey from destination airport to city-centre: €0.09 and €0.25 per minute for leisure and business travel, respectively.
14 Also referred to as global warming.
15 For more information on the methodology used to evaluate the environmental impact from aircraft and HST operation, see Givoni (2005).
16 ‘The layer of the earth’s atmosphere where chemical reactions of pollutants can ultimately affect ground level pollutant concentrations’ (EPA, 1999, pp. 2–8).
Found to be the relevant gases for comparison of the impact of HST and short-haul aircraft journeys on climate change (Givoni, 2005).

The estimates used in the analysis: the only estimates found that differentiate between NOx emissions at ground level and at high altitude are: 1 gr NOx at ground level equals 3 gr CO2, and 1 gr NOx emitted at high altitude equals 335 gr CO2 (Archer, 1993). Using other estimates would have produced smaller differences between the modes compared with the ones presented in Table 7.7.

These include HC, CO, NOx, PM10 and CO2.

Evaluating the monetary value of the impact of climate change using the CO2 equivalent units, which account for differences in impact from NOx emissions at ground level and at high altitude, would further increase the environmental benefits from reduction of NOx emissions.

This can be regarded as a form of Total Cost Analysis (TCA), which is a form of CBA. ‘In the TCA approach, benefits involving “cost savings” are automatically considered on the ‘cost’ side of the equation, instead of separately as “benefits”’ (DeCorla-Souza et al., 1997, p. 108).

To compare benefits to passengers with other categories, it was necessary to convert the benefits to seat units. This was done using the following estimates: 70 per cent load factor for the aircraft, 50 per cent load factor for the HST, 60 per cent leisure passengers, and 40 per cent business passengers (Button (2004) notes that, on both sides of the Atlantic, business travel accounts for somewhat over 40 per cent).

Even on routes where the HST is considered to have ‘won’ the competition, for example Brussels to Paris, some airlines still operate aircraft services.

The differences in the check-in time for the aircraft and HST services should also be accounted for, and this will further increase the travel time savings.

In the two largest airports in the world (in terms of passenger volume), Atlanta and Chicago, 63 per cent (51 million), and 53 per cent (38 million), respectively, of the passengers were transfer passengers during 2000 (Doganis 2002).

It was not possible to determine how many of British Airways’ services on the route are from LHR and how many are from Gatwick.

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Chapter 8

The Value of Travel Time in Passenger and Freight Transport: An Overview

Luca Zamparini and Aura Reggiani

8.1 Introduction

The past decades have witnessed the passage from simple transport activities to integrated logistic chains and the increasing need to rationalize the public expenses related to transport infrastructures. The value of travel time savings (VTTS), considered as the monetary value that is attached to the possibility to save a determined amount of time, has thus emerged as a key variable both for private economic actors and for public administration choices among different alternatives leading to different travel times. When household’s or firm’s behaviour is taken into account, VTTS is related to the monetary value related to the possibility to save a determined amount of travel time, considered as a scarce resource, that can be reallocated to other activities, both productive and unproductive. In the case of public administrations, VTTS can be one of the most important benefit categories in cost-benefit analyses aimed at justifying the investments in a transport infrastructure that can allow people to save travel time (see, among others, Wardman, 2001).

The relevance of VTTS has been demonstrated in several economic studies, which provide both an analytical and an empirical framework for VTTS. Starting from the above observations, this chapter aims presents an overview – from both the analytical and empirical viewpoint – of the recent results concerning studies and applications on VTTS. It is structured as follows. The theoretical literature is analysed in Section 8.2. Section 8.3 deals with the problem of data collection, while the empirical analysis is explored in Section 8.4. The theoretical survey is devoted to pinpointing the main similarities and differences in terms of formal models and of the identification of the VTTS in passenger and in freight transport. The review of the empirical studies first highlights the problem of data collection, and the related use of revealed preference and stated preference methodologies. Secondly, it presents the estimates of VTTS obtained both for passenger and for freight transport, emphasizing its change over time and space. The chapter concludes by synthesizing the results outlined in the literature and proposing possible future directions of research which may include meta-analytic estimations of the VTTS.
8.2 Determining the Value of Travel Time Savings in Passenger and Freight Transport: Analytical Framework

8.2.1 Preface

This section aims at introducing and discussing the basic formulas that have been adopted to calculate the VTTS for these two types of transport. The seminal work by Becker (1965) introduced and discussed the basic formulas that were subsequently adopted to calculate VTTS both in passenger and in freight transport. Since then, several authors have proposed various modifications and refinements. However, it is quite remarkable that, despite the different theoretical frameworks and settings, there is an analytical equivalence of VTTS for passenger and for freight transport.

It is important to emphasize that, for both freight and passenger transport, the formulation of VTTS emerges from a maximization problem, based on micro-economic theory, which has recently focused on behavioural models of discrete choice theory. In particular, for freight transport, firms maximize a profit function and not a utility function (as in the case of passengers). Moreover, in the case of freight transport, there is a methodological problem arising from the difficulty in identifying the economic actor whose profit function has to be maximized (which is clearly not the parcel of goods). Even though the decision about the mode of transport and route is adopted by the shipping firm, VTTS might be part of the profit function of the firm which is sending the goods, as well as of the firm or consumer that is to receive them. This is particularly relevant in the case where the focus of the analysis is centred on integrated logistics processes.

8.2.2 Benchmark Model of VTTS in the Case of Freight Transport

This subsection first discusses the issues related to VTTS in freight transport and then it introduces the basic formulas used to calculate it.

First, as previously outlined, it is important to emphasize that, in the case of freight transport, the function to maximize is a profit function and not an utility function. Further, in the case of freight transport, there is a methodological problem given by the difficulty of identifying the economic actor whose profit function has to be maximized. Even though the decision about the mode of transport and route is made by the shipping firm, it is the case that travel time savings might be part of the profit function of the firm which is sending the goods as well as of the firm or consumer that is to receive them. This is particularly relevant in the case in which the focus of the analysis is centred on integrated logistics processes.

The analytical framework adopted to describe the VTTS is linked to the constrained maximization of a profit function which is normally based on Winston’s approach (Winston, 1979). Here we will describe the adaptation of Winston’s analysis which is present in Bergkvist (2001). The profit maximization function of a shipping firm is described as:
Max $P(p, w, Z, S)$. (8.1)

In the objective function (Equation 8.1), $P$ is the profit, $p$ is the price of the good which is shipped, $w$ is the row vector of the costs related to the production factors, $Z$ is a vector of transport-related attributes and $S$ is the vector of observed and unobserved company characteristics. In a situation in which a firm can choose among several alternative modes $i$ of transport ($i = 1, \ldots, j, \ldots, I$), $z_{i}^{t}$ and $z_{i}^{c}$ are related, respectively, to the time and cost attributes of alternative $i$. Consequently, the company will prefer transport mode $i$ to the alternative $j$ if:

$$\pi(p, w, z_{i}^{t}, z_{i}^{c}, S) > \pi(p, w, z_{j}^{t}, z_{j}^{c}, S).$$ (8.2)

Assuming a first-order Taylor expansion of $p, w, S$ and $Z$ around a base level (b), we will obtain an approximate profit function. The relation in Equation (8.3) shows how profit depends on mode attribute changes in a linear way:

$$\pi = \pi(p^b, w^b, S^b, Z^b) + (d\pi / dp)(p - p^b) + (d\pi / dw)(w - w^b) + (d\pi / dS)(S - S^b) + (d\pi / dZ)(Z - Z^b) + R.$$ (8.3)

The available data obtained from transport managers are then focused on the choice concerning $Z$ (the vector of transport-related attributes). It is an open question to what extent the manager captures all the indirect effects on profit of infrastructure in the prices of products and inputs, or even of the availability of production factors and the technology of the production function. Further, by setting up the difference in profit between two transport choice alternatives $i$ and $j$, it is possible to estimate $dP / dZ$, and, from this, to calculate VTTS:

$$VTTS = \partial P / \partial z_{i} / \partial P / \partial z_{c}.$$ (8.4)

Equation (8.4) states that the VTTS in the case of freight transport is equal to the marginal rate of substitution between time and money (that is, the monetary value that firms attach to the possibility to save a determined amount of time).

### 8.2.3 Benchmark Model of VTTS in the Case of Passenger Transport

Contrary to the case of freight transport, the economic actor whose utility $U$ is being maximized is unambiguous when passenger transport is considered. An interesting survey on the main maximization models concerning travellers – derived from consumer theory – is given by Jara-Diaz (2000). Within this framework, further economic concepts of the value of time are: a) the value of time as resource; b) the value of time as commodity; c) the value of saving time in a certain activity. In general, the fundamental definition of VTTS emerges from discrete choice theory as ‘the amount the individual is willing to pay in order to
Policy Analysis of Transport Networks

reduce his or her travel time by one unit'. One of the related models is the following (Jara-Diaz, 2000). The passenger utility function $U$ that has to be maximized is:

$$\max U(G, L, W, t),$$  

(8.5)

subject to: an income constraint (Equation 8.6), which states that aggregate consumption and travel costs must equal the total wage of the individual; the constraint (Equation 8.7) that total available time equals the sum of leisure time, working time and travel time; and the constraint (Equation 8.8) that leisure time must be lengthier than the time which is needed to consume the goods and services which have been purchased. Moreover, there has to be the possibility (Equation 8.9) to choose among several different transport modes:

$$G + c_i = wW,$$  

(8.6)

$$L + W + t_i = \tau,$$  

(8.7)

$$L \geq \alpha G,$$  

(8.8)

$$i \in M,$$  

(8.9)

where $G$ is aggregate consumption; $L$ is leisure time; $W$ is working time; $t$ is exogenous travel time; $c_i$ is travel cost; $w$ is wage rate; $t_i$ time assigned to travel; $\tau$ is total time available; $\alpha$ is consumption time per unit $G$; and $M$ is the set of available modes $i (i=1, \ldots, M)$.

The solution of this constrained maximization problem (where $\theta$ is the Lagrange multiplier associated with the time constraint $\tau$) enables us to obtain the following VTTS:

$$VTTS_i = w + \frac{\partial U / \partial W}{\partial U / \partial G - \alpha \theta} \frac{\partial U / \partial t_i}{\partial U / \partial G - \alpha \theta} = (\partial U_i / \partial t_i) / (\partial U_i / \partial c_i) = \partial c_i / \partial t_i,$$  

(8.10)

proof of which can be found in Jara-Diaz (1996). In Equation (8.10) we can identify the main concept lying behind the VTTS, via the willingness to pay, which can be expressed as the amount that an economic agent is willing to pay to reduce his travel time of one unit.²

Equation (8.10) states that the ratio between travel cost and travel time gives a measure of the difference between leisure and travel time in direct utility. Remarkably, as mentioned in the Preface to this section, despite the different settings (in terms of the function to maximize and of the constraints to be taken into account), the formulas obtained for both passengers and freight VTTS are analytically analogous. Accordingly, heterogeneities between VTTS in freight and passenger transport should be linked to different sets of preferences of the economic agents whose utility has to be maximized, or to other attributes related to travel, or to both these factors. Concerning VTTS in passenger transport, it is difficult to elicit a few key factors which can give an exhaustive explanation of VTTS, even though income, journey purpose, and travel mode seem the most
important ones. Finally, while passenger VTTS is often expressed in terms of money units per minute, freight VTTS is more practically expressed in terms of money units per hour, given the longer average transport time in freight transport.

8.3 The Problem of Data Collection: Stated Preferences vs. Revealed Preferences

8.3.1 Preface

When data collection is taken into account in order to determine VTTS in both freight and passenger transport, the methodologies usually adopted can be classified as either revealed preference (RP) or stated preference (SP). The main difference between these two types of methodologies is given by the fact that RP studies take into account the actual behaviour of persons or firms, while SP studies try to investigate the preferences of economic actors among alternatives which are only hypothetical. Consequently, when long-run VTTS is taken into account, SP is the only possible methodology which can be adopted. The next subsections provide a description of the two methodologies, emphasizing their differences and comparing their respective advantages and drawbacks.

8.3.2 Revealed Preference Studies

Revealed preference studies can be divided into aggregate and disaggregate studies. In the aggregate studies, the modal share for different regions in a country is compared, while in the case of disaggregate studies, the decisions of a sample of shipping firms is considered. The former studies can be divided into aggregate modal-split models (Blauwens and van de Voorde, 1988), and neoclassical aggregate models (Oum, 1989). Among the disaggregate models, a distinction can be drawn between behavioural models and inventory models. Concerning behavioural models, the methodology commonly used is the logit model. With respect to the inventory models, a shortcoming in the indirect calculations of VTTS in freight transport follows from the consideration that the inventory value of shipped goods is not a reliable measure when time losses are considered. This is because the related estimates do not take into account all the consequences that a travel delay can generate in all the interdependent sectors of the supply chain of a shipping firm.

The requirements that must be met in order to have the possibility to conduct an RP study are the following (Monsere, 1996): a) alternative routes or modes must be available to the user; b) the possibility of a real choice exists; c) the variance in the distribution of relevant parameters of the alternative trips must be sufficient to enable a meaningful estimation of VTTS. These requirements grant a high degree of explanatory power to the studies conducted using RP. On the other hand, it is often difficult to meet all of them. Consequently, researchers have normally opted for SP studies, which will be described in the following subsection.
8.3.3 Stated Preference Studies

SP is the only available method when the situation under analysis is a hypothetical one. In this case, passengers or firms are required to give a response with respect to modal choice (or route choice) which might not be actually available. This is an advantage of the SP method, as well as a possible drawback. It is an advantage in all the cases where it is difficult to collect actual data or when the situation under analysis cannot be observed. It is a drawback, since the hypothetical situation can hinge on the reliability of the data obtained, unless the context of the surveyed situation is carefully described and framed. Moreover, SP studies have the following further advantages, which have driven researchers to adopt this methodology in most of the cases:

- the time to collect data by means of the SP method is shorter than when using an RP method;
- by using SP data it is possible to know in advance if a transportation infrastructure project deserves to be financed;
- in SP methods, surveys can be organized in order to eliminate the problems caused by correlation;
- respondents can be allowed to answer questions which will provide a more interesting range of trade-offs than RP studies;
- the questions allow respondents the opportunity to either rank or give a rating of their responses.

As mentioned above, all the advantages which pertain to SP studies have led researchers to adopt this methodology in most of the cases. Nonetheless, the consideration that the results obtained are only hypothetical suggests that the results and relationships obtained need to be carefully interpreted. However, Jovicic (1998) and Gunn (2000) outlined that RP and SP studies may obtain comparable results. Further comparative analyses on this issue could constitute an interesting stream of research. All the above-mentioned considerations are pivotal when interpreting the results that will be introduced in the following sections, as they might explain part of the heterogeneity which characterizes the studies related to VTTS.

8.4 Value of Travel Time Savings Applications: an Overview

8.4.1 Preface

Given the importance of VTTS for passengers, firms, and public administrations, several studies have tried to estimate it quantitatively since the mid-1960s. The first studies were related to passenger transport but, by the mid-1980s, researchers also paid attention to the case of freight transport. The next two subsections survey
the estimates of VTTS obtained, respectively, for freight and for passenger transport, with the aim of analysing the historical evolution of VTTS. In this context, the similarities and differences between the VTTS values obtained in the European Union and those gathered in other countries – mainly US and Australia – will be particularly considered. Moreover, in the case of freight transport, the data collection methods and the estimation techniques will be compared and discussed.

8.4.2 VTTS Evidence in Freight Transport

Table 8.1 below surveys some of the most relevant studies related to VTTS in freight transport by road, in the period 1986 to 2001 and with respect to 12 different countries. Out of 19 studies, 15 were conducted in Northern Europe countries, while the others related to France, to Switzerland and Italy, to US and to Australia.

A comparative analysis enables us to draw several preliminary considerations. First, SP seems to be the most commonly used method to gather relevant data. This can be related to the consideration that many situations exist in which RP techniques cannot be used (see Section 8.3). In this framework, it is interesting to note that Jovicic (1998) used a combination of SP and RP data for freight transport in Denmark, trying to combine the realism of RP data with the good statistical properties of SP data.

The method of analysis is the logit regression in 17 cases out of 19. The remaining two studies (McKinsey and Co., 1986; NEA, 1991) used the factor cost method. Moreover the study by Bergkvist (2001) used the neural network approach in parallel with the logit analysis.

Comparing the results obtained in the European Union and in the United States with respect to goods transport by road (Table 8.1 and Figure 8.1), it is possible to stress that, in general, the quantitative values related to the EU studies are rather heterogeneous. However, it should be noted that, if the subset of central European countries (Germany, The Netherlands and France) is taken into account, an average VTTS of 30.16 (with a standard deviation of 8.08) emerges, a value which is comparable to those obtained in the US study (23.4–26.8).3

On the other hand, the values obtained for Scandinavian countries vary significantly depending on the study that has analysed the VTTS issue; for example, in Sweden, VTTS ranges from 1.53 to 97 which is quite similar to the range obtained in Norway (0–69). It seems worthwhile to carry out further research in different spatial contexts, given the relevance of the VTTS for freight transport. In this respect, it would also be interesting to be able to use more sophisticated techniques of analysis capable of integrating the findings of different independent research results, such as meta-analysis, in a quantitative and rigorous way (Rosenthal, 1991).
Table 8.1  VTTS in freight transport by road (in 1999 SUS per shipment per hour)

<table>
<thead>
<tr>
<th>Country</th>
<th>Author(s)</th>
<th>Data used</th>
<th>Method</th>
<th>VTTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>Kurri et al. (2000)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>1.53</td>
</tr>
<tr>
<td>Sweden</td>
<td>Transek (1990)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>2.25</td>
</tr>
<tr>
<td>Sweden</td>
<td>Widlert and Bradley (1992)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>7</td>
</tr>
<tr>
<td>Sweden</td>
<td>Bergkvist and Johansson (1997)</td>
<td>Stated preference</td>
<td>Logit, WAD, bootstrap</td>
<td>3–7</td>
</tr>
<tr>
<td>Sweden</td>
<td>Bergkvist (2001)</td>
<td>Stated preference</td>
<td>Logit, neural networks</td>
<td>0–97</td>
</tr>
<tr>
<td>Norway</td>
<td>Fridstrom and Madslien (1994)</td>
<td>Stated preference</td>
<td>Box-Cox logit</td>
<td>0–69</td>
</tr>
<tr>
<td>Denmark</td>
<td>Fosgerau (1996)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>31–71</td>
</tr>
<tr>
<td>Denmark</td>
<td>Jovicic (1998)</td>
<td>Stated preference and revealed preference</td>
<td>Hierarchical logit</td>
<td>1.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.54</td>
</tr>
<tr>
<td>Netherlands</td>
<td>NEA (1991)</td>
<td>Fuel cost, wage rates</td>
<td>Factor cost</td>
<td>26</td>
</tr>
<tr>
<td>Netherlands</td>
<td>De Jong et al. (1992)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>43</td>
</tr>
<tr>
<td>Netherlands</td>
<td>De Jong et al. (1995)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>40–43</td>
</tr>
<tr>
<td>Germany</td>
<td>De Jong et al. (1995)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>33</td>
</tr>
<tr>
<td>Germany and Denmark</td>
<td>Fehmarn Belt Traffic Consortium (1999)</td>
<td>Stated preference and revealed preference</td>
<td>Logit</td>
<td>21</td>
</tr>
<tr>
<td>UK</td>
<td>De Jong et al. (1995)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>36–48</td>
</tr>
<tr>
<td>France</td>
<td>De Jong et al. (1995)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>34</td>
</tr>
<tr>
<td>Switzerland and Italy</td>
<td>Bolis and Maggi (2001)</td>
<td>Stated preference</td>
<td>Tobit</td>
<td>10.78–19.4</td>
</tr>
<tr>
<td>Australia</td>
<td>Wigan et al. (2000)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>0.33–0.20</td>
</tr>
</tbody>
</table>

Source: Adapted from de Jong (2000) and Bergkvist (2001).
The studies related to freight transport by rail (Table 8.2) were conducted between 1991 and 2000 and do not show remarkable differences among the majority of EU countries. The VTTS ranges from 0.1 to 1.29 1999 US$ per ton per hour. There is only one noteworthy exception represented by France (2.32–9.97). In parallel, the US study conducted in 1992 obtained a value of 0.69 1999 US$ per ton per hour. All the studies conducted in the EU countries opted to collect data by means of SP and to analyse them by means of a logit function. The study conducted in the US combined the SP and the RP methods, and made use of a logistic cost function to calculate the VTTS.

Table 8.2 VTTS in freight transport by rail (in 1999 $US per ton per hour)

<table>
<thead>
<tr>
<th>Country</th>
<th>Author(s)</th>
<th>Data used</th>
<th>Method</th>
<th>VTTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>Kurri et al. (2000)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>0.1</td>
</tr>
<tr>
<td>Sweden</td>
<td>Widlert and Bradley (1992)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>0.03</td>
</tr>
<tr>
<td>Netherlands</td>
<td>de Jong et al. (1992)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>0.86</td>
</tr>
<tr>
<td>UK</td>
<td>Fowkes et al. (1991)</td>
<td>Stated preference</td>
<td>Logit</td>
<td>0.09–1.29</td>
</tr>
<tr>
<td>US</td>
<td>Vieira (1992)</td>
<td>Stated preference, revealed preference</td>
<td>Logistic cost function</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Source: Adapted from de Jong (2000).
8.4.3 VTTS Evidence in Passenger Transport

The empirical research on VTTS related to passenger transport has been conducted since 1965 and has taken into account all possible modes of transport. A comparative analysis of the results which emerged from a survey of the economic literature, is given in Table 8.3. VTTS is calculated as a percentage of the wage rate. It must be noted that the most recent studies tend to calculate VTTS as a nominal monetary value. In this chapter, we have decided to normalize all the data in terms of the wage rate – by means of the International Labour Office statistics – in order to have comparable results.

Table 8.3  VTTS in passenger transport by road (as a percentage of the average wage)

<table>
<thead>
<tr>
<th>Country</th>
<th>Author(s)</th>
<th>VTTS as % of wage rate</th>
<th>Trip Purpose</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>Algers et al. (1974)*</td>
<td>21</td>
<td>Commuting</td>
<td>-</td>
</tr>
<tr>
<td>Sweden</td>
<td>Algers and Wildert (1985)*</td>
<td>52.5</td>
<td>Commuting</td>
<td>Taxi, Bus</td>
</tr>
<tr>
<td>Sweden</td>
<td>Algers et al. (1998)</td>
<td>43</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ireland</td>
<td>O’Farrel and Markham (1975)*</td>
<td>86</td>
<td>Interurban</td>
<td>Bus</td>
</tr>
<tr>
<td>UK</td>
<td>Beesley (1965)*</td>
<td>33–50</td>
<td>Commuting</td>
<td>Car</td>
</tr>
<tr>
<td>UK</td>
<td>Quarmby (1967)*</td>
<td>20–25</td>
<td>Commuting</td>
<td>Car</td>
</tr>
<tr>
<td>UK</td>
<td>Lee and Dalvi (1969)</td>
<td>30</td>
<td>Commuting</td>
<td>Bus</td>
</tr>
<tr>
<td>UK</td>
<td>Lee and Dalvi (1971)*</td>
<td>40</td>
<td>Commuting</td>
<td>Car</td>
</tr>
<tr>
<td>UK</td>
<td>Fowkes (1986)*</td>
<td>59</td>
<td>Commuting</td>
<td>Bus, Car</td>
</tr>
<tr>
<td>UK</td>
<td>Bates et al. (1987)* (route choice)</td>
<td>68</td>
<td>Interurban</td>
<td>Car</td>
</tr>
<tr>
<td>UK</td>
<td>Bates et al. (1987)* (survey)</td>
<td>62</td>
<td>Interurban</td>
<td>Car</td>
</tr>
<tr>
<td>UK</td>
<td>Transprice (1997)</td>
<td>39</td>
<td>-</td>
<td>Car</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Gunn (2000)</td>
<td>42 (Business men), 27 (Commuters), 18 (Others)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Netherlands</td>
<td>van Exel and Rietveld (2004)</td>
<td>40</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Italy</td>
<td>Dawson and Everall (1972)*</td>
<td>60–89</td>
<td>Interurban</td>
<td>-</td>
</tr>
<tr>
<td>Israel</td>
<td>Guttman and Menashe (1986)*</td>
<td>105</td>
<td>Commuting</td>
<td>Car</td>
</tr>
</tbody>
</table>
Table 8.3 (cont.)

<table>
<thead>
<tr>
<th>Country</th>
<th>Study</th>
<th>Year</th>
<th>Type</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>Becker (1965)</td>
<td>42</td>
<td>Commuting</td>
<td>Car</td>
</tr>
<tr>
<td>US</td>
<td>Lave (1968)</td>
<td>42</td>
<td>Commuting</td>
<td>Bus, Car</td>
</tr>
<tr>
<td>US</td>
<td>Oort (1969)</td>
<td>33</td>
<td>Commuting</td>
<td>Car</td>
</tr>
<tr>
<td>US</td>
<td>Kraft and Kraft (1974)</td>
<td>38</td>
<td></td>
<td>Interurban</td>
</tr>
<tr>
<td>US</td>
<td>McFadden (1975)</td>
<td>28</td>
<td></td>
<td>Car</td>
</tr>
<tr>
<td>US</td>
<td>McDonald (1975)</td>
<td>45–78</td>
<td>Interurban</td>
<td>Car</td>
</tr>
<tr>
<td>US</td>
<td>Calfee and Winston (1998)</td>
<td>30</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>US</td>
<td>Small (2001)</td>
<td>117,83</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>US</td>
<td>Lam and Small (2001)</td>
<td>159</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Canada</td>
<td>Cole Sherman (1990)</td>
<td>170</td>
<td>Commuting</td>
<td>Car</td>
</tr>
<tr>
<td>Canada</td>
<td>Bhat (1995)</td>
<td>61</td>
<td></td>
<td>Car</td>
</tr>
<tr>
<td>Australia</td>
<td>Hensher and Hotchkiss (1974)</td>
<td>2.7</td>
<td>Commuting</td>
<td>Car</td>
</tr>
<tr>
<td>Australia</td>
<td>Hensher and McLeod (1975)</td>
<td>20</td>
<td>Leisure</td>
<td>Car</td>
</tr>
<tr>
<td>Australia</td>
<td>Hensher (1977)</td>
<td>39</td>
<td>Commuting</td>
<td>Car</td>
</tr>
<tr>
<td>Australia</td>
<td>Hensher (1982, cited in 1989)</td>
<td>46</td>
<td>Commuting</td>
<td>Car</td>
</tr>
<tr>
<td>Australia</td>
<td>Hensher and Truong (1985)</td>
<td>52–254</td>
<td>Leisure</td>
<td>Car</td>
</tr>
<tr>
<td>Australia</td>
<td>Hensher (1989)</td>
<td>36</td>
<td>Commuting</td>
<td>Car</td>
</tr>
<tr>
<td>Australia</td>
<td>Hensher (1990)</td>
<td>34</td>
<td>Commuting</td>
<td>Car</td>
</tr>
<tr>
<td>Australia</td>
<td>Hensher (1999)</td>
<td>36</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Australia</td>
<td>Hensher (2001)</td>
<td>36</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Kenya</td>
<td>Howe (1971)</td>
<td>102</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Japan</td>
<td>Edmonds (1983)</td>
<td>67–101</td>
<td>Commuting</td>
<td>Subway</td>
</tr>
<tr>
<td>Malaysia</td>
<td>Thomas (1983)</td>
<td>42–49</td>
<td>Commuting</td>
<td>Car, Bus</td>
</tr>
<tr>
<td>Singapore</td>
<td>Mohring et al. (1987)</td>
<td>60–120</td>
<td>Commuting</td>
<td>Bus</td>
</tr>
</tbody>
</table>

Source: Waters II (1995) for starred studies (*). Details of the other authors’ contributions may be found in the References.

Table 8.3 shows that there is a high degree of heterogeneity in the VTTS among the considered studies. Most of the cases related to Europe consider Northern countries; only one study deals with one Mediterranean country (Italy). The VTTS
has the highest variance in Australia, where it ranges from 2.7 per cent to 254 per cent of the wage rate, by showing an almost 100-fold variation. When the studies conducted in the EU are considered, VTTS varies from a minimum of 21 (Sweden) to a maximum of 89 (Italy). In the US, it shows a range of 28–78, which is very close to that obtained for the EU countries. On the contrary, for Canada and Israel the value is rather high (from 105 to 170).

While part of the variability could be due to random components, several differences might be explained by specific characteristics which underlie each particular VTTS study, such as traveller and/or trip characteristics, commuting vs. leisure travel, congested vs. uncongested routes, economic, social, political and spatial conditions.

In 25 out of the 32 studies surveyed until 1990, the analysis concerns passengers travelling by car, that is, a private mode, while in the other studies public transport is considered. When the studies conducted since the mid-1990s are considered, the VTTS has a lower average than the one obtained in earlier empirical estimations. More precisely, in Europe, after the 90s, the VTTS range is 18 to 43. Three values are due to the study by Gunn (2000), who points out the different VTTS between businessmen, commuters, and others, by showing a higher VTTS for business-men compared with commuters. In US, the studies by Calfee and Winston (1998) and Lam and Small (2001) give very different values, albeit higher than the European ones. Both studies have been conducted in California; their heterogeneity is given by the fact that the study by Calfee and Winston (1998) took into account a congested metropolitan area, and the related VTTS represents the average of values from different scenarios (no-tolls road, tolled road, flat traffic, rapid traffic, and so on), while the study of Lam and Small (2001) has been conducted on a single State Route. In Canada and Australia, the range of values (36–61) is closer to the European one. Concerning the methodology adopted, almost all the studies used the logit model (or its variations, such as probit, nested, mixed, H-probit) to analyse the data.

The following Figures 8.2–8.5 are based on the results surveyed in the preceding table.

![Figure 8.2](image_url)  
**Figure 8.2** Evolution of passenger transport by road VTTS in the UK (as a percentage of the wage rate)
Figure 8.3  Evolution of passenger transport by road VTTS in the US (as a percentage of the wage rate)

Figure 8.4  Evolution of passenger transport by road VTTS in Sweden (as a percentage of the wage rate)

Figure 8.5  Evolution of passenger transport by road VTTS in Australia (as a percentage of the wage rate)
Figures 8.2–5 attempt to provide an intertemporal comparison of the VTTS with respect to passenger transport in the countries (UK, Sweden, US and Australia) where the most of the studies were conducted.

First, it should be noted that VTTS in the UK shows a steady growth trajectory from 1969 to 1987, followed by a decay in the 1990s. In particular, the surveys conducted in the United Kingdom display clearly that between the early 1970s and the mid-1980s, the VTTS has increased significantly, moving from an average of 35 per cent of the wage rate to an average of 63 per cent. Since then, it has decreased to 39 per cent in 1997. The VTTS in the US and in Sweden shows a similar evolution between 1974 and 1998 (in the case of the US, the VTTS was 28 per cent of the wage rate in 1975, 46 per cent in 1985, and 39 per cent in 1998, while, in Sweden, the VTTS ranged from 21 per cent in 1974, to 52.5 per cent in 1985, and to 43 per cent in 1998). The Australian VTTS does not show a clear pattern (see Figure 8.5) if the entire time span is considered. However, since 1989, a VTTS close to 35 per cent of the wage rate marks all the studies conducted in this country.

8.5 Concluding Remarks

The aim of this concluding section is to stress the most relevant findings related to VTTS and to propose possible directions for future research.

From the analytical viewpoint, the main problem is the use of logit models in freight transport. A common problem is the maximization of the utility of the decision maker, since in this case the decision maker is clearly not the single piece of good. In addition, the single pieces of good are certainly not independent (in contrast with the passenger case, where the decision maker is the user). In this framework, it is still not clear in which way this problem might be overcome (see, for example, the studies using logit models as quoted in Tables 8.1 and 8.2).

The theoretical analysis in Section 8.2 shows that, under the condition of exogenous working time, the VTTS for private trips cannot be constant nor equal to the wage rate, but it should be affected by various factors including travel time, travel fees, and others. Accordingly, the main point about VTTS is that it is quite hard to have a unique VTTS. On the other hand, the surveyed freight transport studies conducted in the EU countries showed, in principle, an average value close to that obtained in the US. Several variables might influence VTTS: the length of the trip, the type of transport, the area where the transport occurs, plus hidden economic, social and spatial variables, which are difficult to control.

Some national transport agencies have tried to solve this problem by giving an average VTTS for each area or jurisdiction of their country (Waters II, 1995). However, a satisfactory value could not be achieved.

Remarkable differences exist between VTTS in freight and in passenger transport:
Mean freight transportation time is longer than passengers transportation, because of different transportation modes, longer distances and typical additional operations in freight transport. This is the reason why freight VTTS is calculated per hour and not per minute.

Heterogeneity in freight transport is more evident than in passenger transport, as quoted by De Jong (2000, p. 554): ‘[T]he value of a truckload of sand is vastly different from a load of gold blocks, the size of the shipment may vary from a parcel delivered by a courier to the contents of an oil tanker.’

Different economic actors exist and so a profit function is considered in freight VTTS formula, while a utility function is used in passenger VTTS formula.

Concerning data collection, Section 8.3 summarized the differences between SP and RP methods, concluding that, in most of the instances, the researchers are compelled to use SP methods instead of RP methods. This is mainly because of the possibility of: a) considering hypothetical alternatives, b) evaluating/assessing in advance a transport infrastructure project, c) obtaining data in a shorter period of time.

From the empirical viewpoint, the variance in the results of empirical analysis related to freight transport (see again Tables 8.1 and 8.2) requires a richer set of studies with a more differentiated spatial framework, in order to extrapolate the generalization of results. Moreover, to reach more reliable results for VTTS, it could be worthwhile to combine, where possible, the two data collection methods. In this way it is possible to take advantage of both the greater realism of the RP data and the better statistical properties of the SP data.

There appears to be a need to have more sophisticated techniques of analysis capable of integrating the findings of different independent research results in a quantitative and rigorous way (for example, by using meta-analytic techniques). In conclusion, from the analytical viewpoint, further research should address dynamic and stochastic issues, while – from the empirical viewpoint – more research is needed at a wider spatial scale (such as that of the Mediterranean countries in Europe and other regions).

Notes

1 See, for example, the Handbook of Transport Modelling (Hensher and Button, 2000), which contains five articles dealing with VTTS.
2 This is the main reason why some authors (Gunn, 2000; Jara-Diaz, 2000) sometimes prefer to call VTTS ‘SVTT’ (Subjective Value of Travel Time).
3 However, it would be necessary to extend the survey with respect to other studies conducted in the US in order to obtain a clearer comparison between the EU and the US.
References


Fehmarn Belt Traffic Consortium (1999), Fehmarn Belt Traffic Demand Study, Danish and German Ministries of Transport, FTC Final Report, Copenhagen.


The Value of Travel Time in Passenger and Freight Transport: An Overview


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PART II
TRANSPORT POLICIES
AND REGIONAL NETWORK INTEGRATION
Chapter 9

Less Friction and More Traffic?
Examples of the Impact of the Fixed Links of the Great Belt and Øresund on Danish Firms’ Organization of Transport and Logistics

Leif Gjesing Hansen

9.1 Introduction

The opening of the fixed links across the straits of the Great Belt and Øresund (see Figure 9.1) within the last six years has been anticipated in both Denmark and Sweden with great expectations of radical changes in the traffic and transport patterns, regional development, changes in firm’s organization, trading patterns, and so on. This chapter is based on some of the results of the research project Infrastructures, transport and the environment – fixed links and the logistical map of Denmark. The aim of the project was to study what kind of influence the newly established fixed links across the Great Belt and Øresund have on selected types of firms and their organization of logistics and transport. The research has been funded by the former Danish Transport Council and was carried out by a research team from the Centre for Transport Research, at Roskilde University in Denmark.

The expectations as to what would be the influence of the fixed links were manifold and even contradictory. On the one hand, the worry has been that the fixed links would increase the traffic flows due to the elimination of the ‘friction’ caused by the ferries. On the other hand, the expectations reflected a desire to improve the planning, coordination and consolidation of the freight transport, and thereby not necessarily produce an increase in the traffic flows. However, there has been a lack of studies on the produced effects of the fixed links on firms’ organization of logistics and transport.
Notes: The 18 km-long Great Belt link opened for rail traffic in 1997 and for road traffic in 1998. The 16 km-long Øresund link opened for both rail and road traffic in 2000.

Source: The author.

Figure 9.1 The location of the Great Belt and Øresund
These considerations formed the basis for a study among selected examples of firms' within manufacturing, transport and distribution. These examples served as cases focused upon changes in the firm's location, trading relations, organization of product and transport flows, and the organization of transport activities.

Previous studies on the logistical effects of the fixed links across the Great Belt and Øresund have mainly focused on impacts on manufacturing and service-related firms or on surveys of industrial sectors (Füssel & Skjott-Larsen, 1990; Björnland, 1997; The Great Belt, 1999). In the present study, however, the intention has been to look at specific examples of firms and also to include the outermost link in the logistical chain – the transport firms.

In this chapter, it is argued that the most significant impacts of the new fixed links can already be identified among transport firms. Hitherto, the effects on the activities among manufacturing and distribution firms included in the study have been limited. The impact on the logistical decisions-levels such as location and organization of trading relations (supplier and customer links) has been very limited or even absent. But a greater impact has been registered on the organization of material flows and transport resources. A major conclusion that the study makes is therefore that the freight traffic growth in Denmark seems to be supported by the newly established fixed links, while more deeply-sealed changes in the firm’s logistical organization have so far been absent.

Section 9.2 presents an analytical approach that served as the starting point for the present study and which offers an understanding of the underlying driving forces in postmodern society that tend to affect more specific parameters related to transport and logistics. Section 9.3 discusses what kind of significance is attributed to the actors within the transport sector in studies of the impact of newly-established traffic infrastructures on firms' transport and logistics. On the basis of the actors' capabilities to affect the organization of logistics and transport, the themes of the case studies are outlined in Section 9.4. Section 9.5 presents examples from the case studies of firms' possible – or lack of – changes in their organization of logistics and transport on the basis of the newly established fixed links across the Great Belt and Øresund straits. In Section 9.6, the implications for national and European transport policy are discussed. Finally, the main conclusions from the study are summarized and discussed in Section 9.7.

9.2 The Effect of New Traffic Infrastructures on Transport and Production Systems

9.2.1 Three Driving Forces

New traffic infrastructures are not isolated phenomena, which are established independently of their contemporary context – political, economic, social, and so on. Thus, the newly established fixed links can also be seen in the context of underlying structures and tendencies embedded in postmodern society. First, postmodernity in a socio-spatial sense can be characterized by the compression of
time and space (Harvey, 1990), which is a state caused by – among other things – the development of new communication and transport technologies, and networks. Communication and transport networks can be perceived as intermediaries of new forms of industrial organization – both in a literal and a conceptual sense. Three main characteristics in the theoretical discourse of the postmodern society can be related to the conceptualization of postmodern transport and logistics. The concepts reflect a development, where distance and time are perceived in new ways caused by the instantaneous connectedness of information, product and transport flows (Beckmann, 1999; Nielsen and Oldrup, 2001).

The development of transport and information technologies has the consequence that distances between localities and individuals are perceived to be shrinking. This can, first, be conceptualized as spatial compression (Harvey, 1990). A second, closely connected, tendency in postmodern society is the time compression that similarly is contingent on – among other things – the technological development of transport and communication. The effects are reflected in the way that activities, to a greater extent than previously, are coordinated independently of geographical distances. One can therefore conceptualize this development as a change in the perception of time from ‘scheduled time’ to ‘instantaneous time’ (Urry, 2000). The third characteristic of postmodern society that affects the manifest transport and mobility is the flow network. This characteristic reflects a change in the relations among individuals, organizations, firms, and so on. Information and products thereby have a greater tendency to flow continuously among firms than previously, a tendency that has to be understood in connection with the trends of spatial and time compression (Castells, 1997).

These three characteristics or driving forces of postmodern society function as preconditions for the analytical coupling of general societal changes and corresponding changes within logistics and transport. This coupling should not be perceived as a simple cause-effect relationship, where changes on the societal level directly result in changes on the more specific levels of firms, organizations and individuals. Instead, these relationships should be seen as mutually affecting each other and thereby treating changes in transport and material flows as capable of affecting the spatial, time and relational structures within society.

9.2.2 Mediating Concepts of Transport Logistics

The meta-concepts from the theoretical discourse concerning postmodern society discussed above cannot directly be the subject of empirical analysis on transport and logistics. In the study of transport logistical effects of the newly established fixed links, it has therefore been necessary to apply four mediating concepts, which more directly and specifically reflect the transport logistical themes of the three meta-concepts (Nielsen et al., 2003): distance; speed; frequency; and time-windows. These concepts have been used to develop an analytical framework based upon themes that are often included in logistical analysis (see, for example, Cooper et al., 1994; McKinnon, 1998).
Distance – how far? There is a tendency for firms to sell their products and buy their supplies at ever more distant locations. The transport distance of materials often becomes longer when production processes are centralized or when new supplies and markets are expanded worldwide. This spread of activities takes place on local, regional, national and international levels.

Speed – how fast? The demands for speedy delivery of goods have been increased resulting from the expectation of customers that lead-time should be continuously reduced. The demands for quick delivery result in the use of faster means of transport, which affects the customer’s choice of transport modes, the ability to optimize load capacity and the environmental impacts of transport.

Frequency – how often? Both manufacturing and retail firms require more frequent deliveries. This demand can, for example, be motivated by the reduction or elimination of internal warehousing. The growth of more frequent deliveries can result in a less efficient transport in terms of load capacity and a growth in traffic volumes that – among other things – generate a negative environmental impact.

Time-windows – when? When demands for delivery are heading towards greater precision and smaller time-margins, then it becomes more challenging to plan and coordinate distribution, and utilize transport and human resources efficiently. The demand for more tight delivery schedules is – among other things – a result of logistical set-ups like just-in-time, which requires continuous material flows to and from the firms.

The concepts described above can be perceived as reflecting underlying tendencies, which affect the decision making of firms concerning their organization of logistics and transport. New traffic infrastructures can possibly change or enforce the significance of these underlying tendencies concerning compression of time and space. But, it is worth noting that it could also be the case that the general tendencies within industrial and logistics organization marginalize the effects of new traffic infrastructures on firms’ organization of transport and logistics.

9.3 The Transport Sector – A Neglected System of Actors?

Freight transport is an activity that is derived from – among other things – firms’ decisions concerning location and organization of production and distribution. Firms are embedded in systems or networks of supplier and customer relations, which consist of a flow of raw materials, sub-supplies and end-products. Distance to and accessibility between the individual firms in a production system is of central importance. Furthermore, the location and quality of the traffic infrastructures are considered to be as essential factors for how firms and production systems evolve and succeed. However, the freight transport among Danish and European firms is often outsourced to external transport and forwarding firms. In Denmark, approximately 70 per cent of the road-based freight transport is organized by hauling and forwarding firms (Bjerregaard et al., 1995; Hansen, 2000). This gives the transport firms a mediating role between, on the one
hand, the firms buying transport services and, on the other hand, traffic infrastructures (see Figure 9.2).

Figure 9.2 illustrates a frame of reference of the functional relations among manufacturing/distribution, transport and infrastructure systems. The first layer represents the organization of production and distribution firms: the logistical organization of material flows between firms in production systems results in a transport demand. The second layer reflects transport activities, which entails the handling of material flows between shippers, recipients and loading terminals. The transport flows consist of vehicles, trailers, containers, and so on. These transport flows generate a demand for traffic capacity. The third layer represents traffic infrastructures, which establish the supply of traffic capacity for the traffic flows in the form of roads, bridges, tunnels, and so on.


Figure 9.2 Systems of actors and activities, which are central in the relationships among firms transport and infrastructures

As shown in the framework presented in Figure 9.2, there is a causally-established relationship between demand for transport and the corresponding transport services offered. It is also explicitly illustrated that the traffic infrastructures affect which routes the material flows – between firms and their
suppliers and customers – can follow. The transport firms are situated in the middle of these two systems and have a capability to affect how the transport of goods actually takes place and which routes are actually followed. Transport firms thereby represent a more or less central coordinating function for the material flow in production systems – depending on the competencies of the transport firms (Hansen, 2000; Hansen, 2002).

Studies on the relationships between new traffic infrastructures and the economic development among firms and regions tend to include effect analysis only on production and distribution firms. The results of these studies and analyses have primarily identified a limited effect of traffic infrastructures on firms’ organization and economic development. These studies provide examples from Denmark, the rest of Europe and North America, where the supply of traffic infrastructure is, in general, of a high quality and dense (Forslund and Karlsson, 1991; Hjalager, 1993; AKF, 1993; Maskell, 1994; McKinnon, 1997, Burmeister and Colletis-Wahl, 1998; Standing Advisory Committee on Trunk Road Assessment, 1999). On the other hand, in countries and regions with a generally low accessibility, new traffic infrastructures can of course still be identified as main drivers in the economic development of countries, regions and firms (Hoyle and Smith, 1992).

The absence of significant and radical effects of new traffic infrastructures on the economic performance and development of firms might therefore be due to the presence of an already well-functioning traffic infrastructure system. Another plausible explanation might be that studies of effects tend to focus narrowly on manufacturing and service industries. The mediators of the material flows – transport and forwarding firms – are often excluded from this type of study. The relevance of including transport and forwarding firms in such studies can be found in the ongoing tendency within these firms to expand their activities to include third-party logistics services for their customers – for example, warehousing, packaging, logistical management, and so on.

Based on the findings and tendencies discussed above, it seems relevant when undertaking studies of effects of new traffic infrastructures to apply a transport logistical chain perspective (Nielsen et al., 1999). The effects of the newly established fixed links across the Great Belt and Øresund on firms’ organization of transport and logistics may therefore, it is argued here, depend on which types of logistical chains they are part of, and which function they exert in the chain. In the next section, the design of the study is presented, together with the kind of research themes that structured the analysis of the empirical findings.

9.4 Research Design and Methodology

On the basis of empirical findings and experience from previous research projects on freight transport, this study applied a transport logistical chain perspective. Six firms from three different positions in logistics and transport chains agreed to take
part in an interview-based study of their organization of logistics and transport of in- and outgoing material flows.

The firms represented activities within manufacturing, distribution and transport:

- Two SMEs within the furniture manufacturing industry (referred to in this chapter as M1 and M2).
- Two large distribution firms within the retailing sector and wholesaling plants sector (referred to in this chapter as D1 and D2).
- Two medium-sized road haulage firms (referred to in this chapter as T1 and T2).

Geographically, the firms are located in different regions of Denmark (Jutland, Fuen and Zealand), and they also represent different sizes of firms in terms of number of employees and turnover. The selection criterion of the firms was to pick examples of different types of functions in transport and logistical chains, and not representatives of different branches (see Figure 9.3). It was also the intention to include both firms that were, and firms that were not, affected by the fixed links. Thus the objective of the study was not only to identify and document changes in the organization of the transport and logistics of these firms, but also to increase the knowledge of how this type of traffic infrastructures affects different types of firms in the logistical chain.

![Diagram of distribution, transport, and manufacturing firms]

**Figure 9.3 Focus on three types of firms in a transport and logistics chain perspective: manufacturing, transport, and distribution firms**

Qualitative interviews with managers were used in the six cases to find out how the firms organized their ingoing and outgoing transport and logistics, and in this connection to what extent there had been major changes within the last 5–10 years. In relation to this, we asked the managers what kind of circumstances – including the new fixed links – had caused these organizational changes.

Seen from the individual firm’s point of view, decisions concerning actions relating to transport and logistics can take place on many organizational levels – from the management’s decision to open or close a firm’s activities to the driver who makes the route decisions concerning the deliveries. On this basis, Allan McKinnon (1998) developed a hierarchy of logistical decision levels that reflects...
important spaces where decision making affecting the transport and logistics of firms takes place. These are:

- **Logistical structures**: for example, number and location of factories, warehouses, administration and terminals.
- **Pattern of trading relations**: location of suppliers and customers that constitute a manifest network of material and transport flows.
- **Scheduling of product flow**: planning and implementation of production and distribution activities, which are transformed to specific material and transport flows to and from a firm.
- **Management of transport resources**: for example, the use of own or external transport modes, route choice, transshipment via terminals and capacity utilization.

These four levels formed the basis for the themes in the interviews, and thereby structured the findings that were collected from the six case studies of selected firms. These findings were afterwards qualitatively interpreted and refined by using the intermediary analytical concepts from the theoretical discourse of time-space dimensions in postmodernity as illustrated in Table 9.1 (Kvale, 1996; Flick, 1998).

**Table 9.1 The analytical framework**

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<thead>
<tr>
<th>Time-Space dimensions</th>
<th>Levels of logistical decision-making</th>
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<td>Intermediary analytical concepts</td>
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<td>Point in time</td>
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*Notes: On the left side, the two headings refer to intermediary and empirical concepts of time-space. On the top-right side, the column headings refer to empirical concepts of logistical decision making on different levels.*
9.5 The Impact of the Fixed Links on Selected Types of Firms

This section presents examples from the six firms. These examples illustrate effects, or the lack of effects, due to the new fixed links across the Great Belt and Øresund on the firm’s organization of logistics and transport.

9.5.1 Logistical Structures

The interviews indicate that changes in the firm’s physical location of activities (production, warehouses, administration, and terminals) are relatively resistant to immediate changes in the accessibility for in- and out-going transport flows. None of the firms interviewed were able to identify changes in the firm’s logistical structures which had taken place during the last five to ten years as a result of the new fixed links.

Examples of conditions that to a greater extent affect the firm’s location of their own activities were – among other things – decisions concerning in- and outsourcing of activities. For the interviewed manufacturing firms (within furniture production), this was exemplified by the issue of production of low or high value furniture to a standardized mass market or order-specific customers. In the latter example, the furniture firm reduced its own physical facilities by out-sourcing activities to dedicated and specialized suppliers. One of the road haulage firms did establish a warehouse which could serve as an intermediate storage and distribution facility for its major customers. These decisions that are related to the firm’s physical location of its own facilities were affected by other circumstances than the newly established fixed links.

Nevertheless, it is also necessary to consider the decisions related to logistical structures in a time perspective. This was illustrated in an interview at one of the road haulage firms, where it was stated:

... that the future will cause changes on this issue – that is within five to ten years. When future warehouses and logistical centres are to be located, then the existence of the new Øresund link will be taken into consideration. But, because the investments [in new terminals and warehouses] are huge it means that existing facilities are not abandoned in the short run. ... Zealand is facing a great future as logistical centre for the Nordic countries, because a large number of consumers and customers can be reached from this region. Similarly, Swedish companies will in the future, to a larger extent, locate in the vicinity of Malmö rather than Gothenburg or Stockholm, because there are better possibilities for transport by ship, lorry and plane (Interview, T1).

Thus the transport firms point to the fact that time represents a kind of inertia in terms of sunken investments in existing logistical structures. This could result in more significant changes in the long time-perspective of the logistical structures through relocations caused by the new fixed links.
As a result, the logistic structure of the firms had so far not been affected in terms of changes in the transport logistics indicators due to the opening of the fixed links.

9.5.2 Pattern of Trading Links

None of the interviewed firms could identify changes in the location of suppliers and customers as a consequence of the fixed links across the Great Belt and Øresund.

At the two manufacturing firms in the study – M1 and M2 – the choice of suppliers has not been affected by the fixed links, for example in the form of increased accessibility to alternative suppliers. The most important parameters for choice of suppliers among these firms are their competencies and qualifications in relation to the complete furniture product, while transport costs do not play any role in the choice of Danish suppliers. The character of the customer relations have also been unaffected by the fixed links. But, interestingly, one of the furniture producers did notice that furniture retailers and wholesalers on Zealand – as a consequence of the fixed link across the Great Belt – today operated to an increased extent West of the Great Belt than previously. This could indicate that the immediate effects of the fixed links on the logistical chains are felt more significantly in the retail and distribution parts than in the manufacturing parts of the chain.

It was also stated by the two retail and distribution firms in the study that the fixed links had not produced any changes in the location of suppliers and customers. Nevertheless, there were indications that the present location of suppliers and customers in the near future could be changed. At one of the distribution firms – D1 located on Fuen – this was primarily due to a possible reorganization of existing terminals on the island of Fuen and in Jutland. This reorganization will lead to centralization, in terms of a single terminal, of the firm’s distribution activities concerning the transport of potted plants from the market gardens in Denmark to customers in Denmark and Europe. This centralization and thereby possible change in the supplier and customer network, was caused by a strategic desire to make a more distinct division of activities within a large company’s sub-division in Fuen and Jutland, respectively.

For D2 located near Greater Copenhagen – a regional division of one of the leading retail companies in Denmark (with a market share of approximately 40 per cent) – the fixed links had not affected the inward bound transport to the warehouses and terminals through changed locations of suppliers or customers. The ‘customers’ of D2 are the grocery stores of its parent company on Zealand, and it has therefore not been affected by the fixed links. The parent company’s grocery stores in the Western parts of Denmark (mainly on Fuen and in Jutland) are supplied from two regional terminals in Jutland. This regionalization, into an Eastern and a Western distribution network, is divided by the Great Belt and the fixed link has not affected this division:
The regional terminal at D2 [in Zealand] delivers goods to 400 grocery shops on Zealand. In relation to the fixed link across the Great Belt, we have tested the possibilities of also distributing to our grocery shops on the Eastern part of Fuen [on the Western part of the Great Belt], but because of the price of using the [fixed] link, the costs proved to be too high – even though [the parent company] was offered a discount on account of the traffic volumes. If the price was lowered considerably, the distribution from the terminal on Zealand to shops on Fuen would probably be profitable (Interview, D2).

In the cases of the two freight haulage firms in the study, it was not possible to identify examples of changes in the location of suppliers or customers as a consequence of the fixed links. However, it is likely that particularly transport firms’ supplier and customer relations could be subject to changes, because transport firms often have far more changeable and short-lived relations than manufacturing and distribution firms.

9.5.3 Scheduling of Product Flow

Among the interviewed firms, there was a distinct differentiation of how directly the new fixed links have affected their organization of material and transport flows, as illustrated in Table 9.2 below.

<table>
<thead>
<tr>
<th>Types of firms</th>
<th>Distance</th>
<th>Speed</th>
<th>Frequency</th>
<th>Point in time</th>
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<tbody>
<tr>
<td>Manufacturing firms</td>
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<tr>
<td>Distribution firms</td>
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<td>Transport firms</td>
<td>++</td>
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Notes: ++ strong change; + change; – none or weak change.

The interviewed manufacturing firms had in general not experienced any impacts from the fixed links on their organization of material flows to and from their firms. Other factors played a greater role on how the firms plan and organize their internal and external logistics. At the furniture-producing firm M2, a critical element in the logistical planning is the co-ordination between the inward and outward bound material flows. Sofas and chairs are order-produced and the minimization of the internal storage of the finished furniture is a central strategy.
The consequence is that the lead-time – for example, the time it takes from when the order is confirmed to actual delivery at a customer – is three to four weeks. But this lead-time is furthermore extended by including the time used for planning the co-ordination of inbound material flows of raw materials and unspecialized components. M2 is therefore obliged to operate with a considerable storage capacity of a variety of standardized components that often require a delivery time far beyond the three to four weeks of finally-produced furniture. Hence, the potential time savings of the new fixed links in minutes and hours are in this context without any significance for the firm.

Among the distribution firms, the effects of the fixed links are more significant. However, a number of other factors are, in general, of greater significance for the firm’s decision making concerning their organization of inward and outward bound material flows.

At D2, the fixed link across the Great Belt had affected the organization of the transports of fresh goods between the regional terminals of the retail chain in particular:

There has been a rise in the number of these transportations and the time saved from the new fixed link across the Great Belt has increased the flexibility in organizing these transportations. However, the external road haulage firms still often use the ferry link between East-Jutland and West-Zealand to transport dry goods between the terminals of Greater Copenhagen [on Zealand] and Aalborg [in Jutland] (Interview, D2).

Other factors have played a far more significant role in generating a growth in the traffic flow of D2 and its parent company than the above-mentioned higher frequency of internal material and transport flows between regional terminals in the East and West of Denmark. Examples include new concepts such as ‘Fresh Milk’, a strategy for milk delivery from farmers to the grocery stores within 24 hours – which increases the throughput for milk products, a concept that is beginning to spread to other types of fresh goods. The ‘Fresh Milk’ strategy is also an attempt to reduce the import of milk from Germany and the Netherlands, because imported milk cannot be distributed within twenty-four hours to Danish grocery stores and shops. This distribution concept has lead to an increase in the frequencies of deliveries from the regional terminals of D2’s parent company to its grocery stores:

[On account of the volumes involved,] the road haulage, firms have to distribute to the stores twice a day … even though the terminals storage capacities are big, there is simply no space for it. If all [the grocery stores] have to wait for fresh milk, then it also becomes a space problem for them, because the volumes are so enormous (Interview, D2).

Consequently, the time-pressure that the ‘Fresh Milk’ concept generates results in a need for more frequent distribution between regional terminals and the grocery
stores. This also happens because the road haulage firms do not want to increase
the number of vehicles in order to distribute all the milk in one delivery round, but
instead use the same lorries for at least two trips per day with fresh milk
distribution: ‘If they [the transport firms] are forced to use a lot more lorries, which
have to run for a shorter period – then they become unhappy and want more
compensation for their transport services’ (Interview, D2).

The development of an increased time-pressure on the organization of material
and transport flows is also a well-known phenomenon at the pot-plant wholesaling
firm D1 located on the island of Fuen. This is partly because of the changed
expectations among the customers regarding shorter delivery time, but also partly
due to the effect of the fixed link across the Great Belt. The wholesaling firm packs
and distributes pot plants from greenhouse gardens on Fuen mainly to the retailing
sector in Denmark. A large part of the deliveries are ordered on the same day of
delivery. This means that the greenhouse farmers typically receive the orders
directly from the retailers between 8 and 11 a.m., and thereafter the pot plants are
collected and transported to the wholesaler’s terminal for final packaging. Finally,
the consignments of pot plants are distributed to the customers late in the
afternoon.

Even though the new fixed links across the Great Belt and Øresund have
increased the time-pressure in the logistical chain, this has not had any direct
consequences for the organization of storage and packaging – a core-activity at the
wholesaling firm. The impacts have primarily been visible in the transport
planning activities: for example the fixed links have broadened the scope for
scheduling deliveries due to the improved stability in crossing the Great Belt and
Øresund by bridge/tunnel instead of ferries. Furthermore, the customers of the pot-
plant wholesaling firm are eager to take advantage of the new opportunities:
previously the customers were obliged to order their goods the day before delivery,
but this lead-time has been reduced substantially to delivery within the same day of
ordering.

For a distributing firm like D1, the fixed link across the Great Belt has had an
ambiguous impact on the logistics organization: On the one hand, the replacement
of the ferry link has eliminated a transfer point, which represented an uncertainty
in relation to planning of departures and arrivals of deliveries. The time-tables of
the ferries functioned as time-windows, which the deliveries from D1 to their
customers had to match precisely. On the other hand, the fixed link has amplified
the development of new time-windows at other stages of the logistical chain. The
transit time from D1 to bigger customers on Zealand, for instance, was reduced by
approximately 1 hour. Due to the short lead-time, the transit time plays a relatively
more significant role than in the logistical organization of the furniture firms
referred to above. This results in a tighter coordinated transport and logistical chain
that includes more narrow time-windows at the big customers – for example, the
time margin for delivery that is acceptable for the customer. Typically, this means
that if a lorry arrives outside these time-windows, then the haulage firms or the
suppliers (for example D1) are penalized by the customer with an extra cost.
Even though the effects of the fixed links among the studied examples of manufacturing and distribution firms seem limited or non-existent, the effects proved to be more significant at the outermost link of the logistical chain – the freight haulage firms.

At the freight haulage firm T1, near Greater Copenhagen, the transport flows have significantly been affected in terms of increased speed, increased frequency and precision, and through a growth in the transported distance. For the haulage firm, the Great Belt link has contributed to a reduction in uncertainty in the planning of transport flows by a better regularity of the trips between Denmark and, for example, France. A major market for the firm is transport of airfreight between Copenhagen Airport and other Northern European airports – a transport market where the time factor is of crucial importance.

The establishment of the fixed Øresund link has led to an increase in the firms’ departures from a terminal in Malmö (Sweden) to Copenhagen Airport – from three to nine departures. Today the firm uses smaller lorries because the freight volumes have not increased similarly. The reason for the increased frequency is that the firm tries to solve a capacity problem, that previously meant that extra lorries had to be sent off with rather small consignments:

The reason for increasing the number of departures has been that previously – when, late in the evening, we discovered that we needed more loading capacity than four flight-pallets, then we had to take the risk of sending the extra flight-pallet with an extra lorry, because it definitely had to be at Copenhagen the following morning. These situations are, today, handled more flexibly by an increase in frequencies (Interview, T1).

However, it has not been possible to avoid a certain number of trips, where the loading factor has been very low: ‘… Approximately three to four times a week the transported volumes are far below the actual loading capacity of our lorries’ (Interview, T1). This statement can be seen in the general ongoing process that was already set into motion before the opening of the fixed link across Øresund: the rising demand for very frequent transport connections due to the expectations among transport customers for departures and arrivals of trips to be as flexible as possible. A transport demand, which reflects the conceptualization of just-in-time logistics.

At the second road freight haulage firm in the study, T2, located in the middle of Jutland, the establishment of the fixed Great Belt link has resulted in one less time-window to consider in the daily planning of transport and distribution activities. Thus the establishment of the fixed link has resulted in more flexibly organized transport systems across the Great Belt and the trip planning has improved because of the replacement of the ferries:

We can organize the trips without considering the weather conditions as a pre-condition for punctual delivery. And the time-margin that we have to plan for trips between Fuen and Jutland to Copenhagen, in order to calculate the exact
time for arrival of a consignment, has changed significantly. If we didn’t catch a ferry [before the opening of the fixed link], then we had to wait for three-quarters to one hour before we could take the next ferry – if this was not overbooked (Interview, T2).

According to the road freight haulage firm, the establishment of the fixed link has lowered the costs of crossing the Great Belt, but this cost-reduction has been transferred to the transport customers. When the prices for crossing the fixed link were published, the contracts with the largest customers of the road freight haulage firm were renegotiated – on demand of the customers. Before the establishment of the Great Belt Link, the ferry cost for road freight haulage was approximately €148. After the opening of the Great Belt Link, the price-level was lowered to approximately €87.

The road freight haulage firm experienced a greater pressure to optimize the utility of the loading capacity before the opening of the fixed link. The high capacity utilization was primarily reached by consolidating return loads. Today, where costs of crossing the Great Belt have been reduced, the pressure for high capacity utilization has changed.

For the road haulage firm, T2, the Great Belt Link has resulted in more frequent trips on some of its routes. The Great Belt Link has also led to an increased use of express deliveries at short notice and therefore the haulage firm has invested in a number of small lorries and vans. The transit-time has been compressed after the opening of the fixed link across the Great Belt. This seems to be due to a perception among the transport buyers that the transport distance has been reduced by the Great Belt Link, and also that the transport costs have been lowered for transport between the East and West of Denmark: ‘… we have felt that [the customers] do not speculate on the costs the same way as before. It is easier to send some goods to Zealand today [from the peninsula of Jutland]. Transport buyers know that there is a different time-horizon. There is another cost-structure’ (Interview, T2). It is therefore not only the supply of capacity in the transport system that generates more transport, but also due to the increased transport demand facilitated by expectations among transport buyers, the transport is managed more frequently, faster and cheaper than before the fixed links were established.

9.5.4 Management of Transport Resources

The establishment of the fixed links has affected the way the studied firms organize their transport resources differently, as shown in Table 9.3 below. The manufacturing firms did not perceive any changes in the way their in- and out-bound transports were organized after the opening of the fixed links. According to the furniture-producing firm M1, the Great Belt Link has not generated a greater flexibility in the logistical planning within the firm – even though today the transport firms are not restrained by the fixed schedules of the former ferries. However, the frequent time-schedule of the former ferry link is also given as a
reason by the firm as to why no remarkable change in the transport quality due to
the fixed links has been noticed. The firm has neither experienced a greater
pressure for quicker deliveries in the last five to ten years nor put a greater pressure
on their transport providers for faster and cheaper transport services. According to
M1, this is mainly due to the firm’s high-value products, which serve a market
where customers rank product quality higher than a low lead-time. The total lead-
time for producing the furniture products usually amounts to four to six weeks
(from receiving the order to it being ready for delivery), and therefore the time-
saving of 1 hour from the fixed link across the Great Belt does not play any
significant role for the furniture producer’s own logistical organization. The
absence of changes in the organization of in- and out-bound transports is probably
due to the fact that this firm – like the majority of Danish manufacturing firms – is
not directly involved in the coordination and execution of the actual transport. As
described above, most manufacturing firms use external transport firms for
coordinating and handling their in- and outbound transport and often also logistics
activities. The effects of changes experienced in the organization of transport
routes, choice of transport modes, reloading and consolidation of goods, are often
located at the two other types of firms involved in this study – distribution and
transport firms. It is among these firms that the effects on their organization of
transport resources were more significant.

Table 9.3 Influence of the new fixed links on the management of transport
resources via changes in transport logistics for different types of
firms

<table>
<thead>
<tr>
<th>Management of transport resources</th>
<th>Distance</th>
<th>Speed</th>
<th>Frequency</th>
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<tr>
<td>Types of firms</td>
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<td>Transport firms</td>
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Notes: ++ strong change; + change; – no or weak change.

The wholesaling firm D1 expected – before the opening of the Øresund link –
that this link would become the preferred distribution channel to customers in
Sweden. The actual transport pattern has so far been very different:

... with the pricing policy so far, it has not been interesting and much too
expensive. In short, this means that all goods destined for customers in
Helsingborg and further north are still transported via the ferries [Helsingor-
Helsingborg. … this is due to the price of the fixed link. The ferries take 20 minutes and sail very regularly. Previously, there was a lot of waiting-time at the ferries, but this is rare now. There is no incentive to use the fixed link. If you drive from Malmö towards Stockholm, then you have to drive via Helsingborg anyway. It gives you 60 km extra driving to reach customers north of Helsingborg, if you use the fixed link instead of the ferries (Interview, D1).

According to the wholesaling firm, a transfer of transport from the ferries to the fixed link will depend on a lowering of the prices. Current rules on resting-time for drivers have also a great influence on the choice of transport channel. Transport to destinations such as Oslo and Stockholm can be achieved by using only one driver, because the maximum time-limit for driving (ten hours) is not exceeded when the drivers choose the ferry-link.

Among the road haulage firms in the study, the establishment of the fixed link across Øresund has only had significant influence for the distribution and picking-up of goods in the Malmö area. This is especially the case for T1, which transports, among other things, air cargo between Copenhagen Airport and a freight terminal in Malmö. For both the studied road haulage firms, it is not profitable to drive to destinations north of Malmö via the fixed link. Therefore, both firms use the ferries for these destinations.

In general, several of the studied firms pointed to the fact that the fixed Great Belt Link replaced a ferry link in an already existing and heavily used transport corridor between the Eastern and Western parts of Denmark. Therefore, the establishment of this fixed link has not had any significant consequences for the route choice among transport and distribution firms’ organization of transport flows. On the contrary, the fixed Øresund link represents a new corridor for road and rail transport between Denmark and Sweden, since it mainly replaced existing passenger ferries between Copenhagen and Malmö. Therefore, more dramatic changes could be anticipated in the route choice for transports across Øresund – from the still-existing ferry link to the new fixed link. But, this is not the case, as indicated in this study and also verified by current statistics on the transport flows across Øresund.

9.6 Policy Implications

The Great Belt link is primarily considered as a traffic infrastructure project of national interest, while the Øresund link also has an international dimension. Not only did the Øresund link connect Denmark and Sweden, but, since the late 1980s, it has also been considered as an important link between Northern Scandinavia and the European continent, and has officially been one of a number of prioritized infrastructure projects in the transport policy of the EU (Scandinavian Link, 1987; European Commission, 1993). A missing link in this European context is the Fehmarn Belt between the south of Denmark and Germany (see Figure 9.1 above), and it has now been identified as one of a number of new prioritized infrastructure
projects of importance for the mobility in the European market (European Commission, 2001). This European policy context is the key to understanding the differences in traffic flows and their related spatial impact on the transport logistics activities in Denmark. The fixed Great Belt link replaced an existing and heavily-used ferry-based link, which was part of the major East-West traffic corridor in Denmark. The conditions for coordinating economic activities between different locations in Denmark was therefore already pretty good even before the opening of the fixed link across the Great Belt, which may add to the explanation of why the link so far primarily has had an impact on the traffic flow but to a lesser extent on relocation and scheduling of product flow.

The opening of the fixed Øresund link has added further traffic volumes to the Great Belt link in terms of transit traffic between Sweden and the European Continent. All rail freight transport between Sweden and the Continent is being channelled through this traffic corridor. This may change in the future if, or when, the establishment of a Fehmarn Belt link is realized. If traffic to the Continent in the future is redirected from the Great Belt link to a Fehmarn Belt link, then it could cause serious implications for the existing economic foundation of the Great Belt link. The link is based on user charges and these have been set on a level defined politically. Direct competition in prices between the Great Belt and Fehmarn Belt links could lead to a major reduction in fare prices and change the prevalent location of economic activities and the scheduling of product flow dramatically.

Apart from the strategic future of the Great Belt and Øresund links, it can be recognized that the links impose some spatial and structural implications for different cities and regions in Denmark.

In a survey conducted by the Consortium of the Great Belt in 1999, it was confirmed, that the immediate impact from the fixed link of the Great Belt was identified among firms located in counties within the traffic corridor from Greater Copenhagen, across the island of Fuen, through the Southern part of Jutland to the German border as illustrated in Figure 9.4 (Sund & Bælt, 1999).

The regions of Greater Copenhagen and Mid-East Jutland have a high number of firms within transport and logistics activities (haulers, forwarders, terminals, warehouses and consultancies). In contrast, firms in the counties in the North of Jutland were relatively unaffected by the Great Belt fixed link (Sund & Bælt, 1999). These results are, however, open to contradictory interpretations, since they could indicate either that there is a tendency towards an economic weakening of these Northern regions of Denmark or that the firms already use alternative and satisfactory transport corridors.
The transport policies in national and European terms have so far primarily been driven by providing infrastructure supply, and less on traffic and transport management, in order to enhance efficient use of existing infrastructure capacity (see Figure 9.2 in Section 9.3 above). In the latest EU-policy document on transport in Europe, not only are missing infrastructure links listed but also the congestion and environmental problems due to the rise in traffic volumes are discussed as a serious issue (European Commission, 2001). It seems to be a challenge for national and European policymakers to connect ‘the missing links’ between the provision of new infrastructure and its more efficient use in order to decouple improved accessibility from a parallel growth in traffic volumes.

9.7 Conclusions

The results of this study should be seen in relation to the expectations concerning whether the new fixed links would generate an increase in traffic volume due to the
elimination of the ferry links, or whether the fixed links would lead to improvements in firms’ logistics organization for coordinating and optimizing their transport activities.

In the study, there are indications that the fixed links have supported a dramatic rise in the freight traffic on the roads across the Great Belt and Øresund. However, factors other than the fixed links have also had an influence on this growth – for example, a general tendency in the firms’ organization of internal and external logistics that reduces the storage capacity at manufacturing firms, and thereby increases the demand for frequent in- and out-bound transport flows. The fixed links seem to be contributing to the growth in the traffic volume, but not necessarily to a similar growth in transported goods. Among the road haulage and distribution firms it was stressed that the fixed links have improved the ability to organize the transport with more frequent deliveries. The transport firms also experienced that transport buyers in general expected greater precision in the pick-up and delivery of consignments after the establishment of the fixed links. On the one hand, and seen from the perspective of the individual transport buyer, this represents a clear improvement in the transport quality. On the other hand, it also makes it difficult for the road haulage firms to coordinate and optimize the capacity utilization.

The study has contributed knowledge on how the new fixed links across the Great Belt and Øresund affect different types of firms’ logistical decision making. The fixed links are primarily affecting the transport firms and partly the distribution firms. In contrast, firms in the counties in the North of Jutland were relatively unaffected due to the fixed links. Neither have they experienced any changes in their scheduling of product flow or management of transport resources. Instead, other factors were mentioned as being more significant than the time-savings and route choices now made possible by the new fixed links. Among the transport and distribution firms, it was stressed that the fixed links enabled more flexible trip planning that is often a core activity within these types of firms. However, these firms also experienced a tendency among their customers to tighten the existing time-windows for picking-up and deliveries, as a result of expectations for faster and more accurate transport. Thus it seems the increased flexibility enabled by the fixed links has ambiguous effects on the ability to organize transport and logistics in an efficient way.

In relation to the above-mentioned results, the study also clearly reveals that it is primarily the logistical decision levels closest to the actual and operational organization of material and transport flows that have been affected by the fixed links. In contrast, it seems that logistical decisions related to relocation of firms’ own activities or relocation of suppliers and customers have not been affected by the new fixed links. It is, however, important to note that a study over a longer period of time could probably show more significant effects on relocation of firms. Factories, storage, terminals, and so on, represent sunken investments that in a short-term perspective can not easily be relocated.

From this and other ex post studies of impacts from new traffic infrastructures on firms’ logistical decision making, it would appear that infrastructures are only
one of many factors of influence. However, it is reasonable to expect that location of new firms and not only relocation of existing firms, will increase in the future within the traffic corridor of the Great Belt and Øresund relative to other locations in Denmark. The ability to generalize from this study is, therefore, limited to logistical decision making, including relocation, of firms within a 5-year period after the establishment of the fixed links. The study aimed at a broad geographical scope including firms from different parts of Denmark in order to gain knowledge of effects on centrally- as well as peripherally-located firms in relation to the Great Belt and Øresund fixed links. Thereby, the study excluded a more narrow and in-depth look at different types of firms within the same traffic corridor, and how improvements, such as a fixed link, would affect them. Another promising approach could have been to follow particular transport logistical chains or product chains in order to assess more precisely whether impacts from a new infrastructure affect firms, connected in the same chain, differently.

It is possibly the case that including manufacturing firms more time-sensitive in their lead-time cycle could have proved to be more responsive to new major infrastructures like a fixed link. However, as the distribution and retailing firms included in the study illustrate, a number of factors other than refined infrastructures seem to be more or equally critical in their logistical management. In general terms, the study shows that time and distance matters for logistical decision making, but it is the position in the transport logistical chain – geographically and organizationally – that determines how fast and to what extent the single firm can gain benefits from new traffic infrastructure like the fixed links of the Great Belt and Øresund.

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Chapter 10

Accessibility Impacts of the Trans-European Railway Network

Juan Carlos Martín, Javier Gutiérrez and Concepción Román

10.1 Introduction

The European Union (EU) has an uneven distribution of the stock of public capital in infrastructures between the Member States. As a result, the peripheral countries are demanding an investment policy in order to achieve social cohesion for countries that must compete in a single market. The European Commission considers that the improvement of transport infrastructure plays an important role in the reduction of social disparities within the EU.\(^1\) In this sense, the Commission is promoting the development of the Trans-European Transport Network (TEN-T). However, the development of TEN-Ts may, in certain circumstances, widen rather than reduce the differences in both accessibility and economic opportunities of regions (Vickerman et al., 1999).

In 1990, the European Commission proposed an initial outline plan for high-speed railway lines (COM, 1991). In 1994, a list of 14 priority projects was adopted by the Essen Council and the European Parliament. In 1996, the European Parliament and the Council adopted the guidelines for the development of the TEN-T. Since this landmark in the recent history of EU, the European Commission has been required to submit a report every five years adapting the guidelines to take account of ‘economic development and technological developments in the field of transport, in particular in rail transport’.

The relationship between infrastructure and economic growth has been quantified by economists using different econometric models. Infrastructure has a positive impact on production, private investment and employment (Biehl, 1986; Aschauer, 1989, 1990; Stern, 1991; Munnell, 1992). However, the explanation of changes in economic indicators by transport investment or changes in accessibility has been less successful (Fullerton and Gillespie, 1988; Rietveld and Nijkamp, 1993). As transport in general can be viewed as an important input in the production process, an improvement of the transport infrastructure would help less developed regions to grow closer to more developed ones. But, even when infrastructure investments has increased the rate of growth this is not sufficient to conclude that further investment would product the same effect. Therefore, although the results of the different models seem to confirm the relationship
between these two variables, the direction of the causality is not clear and still subject to much debate. Better infrastructure will reduce transportation cost, and not only provides poorer regions better access to markets of more developed areas but also makes it easier for firms in richer regions to supply less developed ones, which reduces the development opportunities of the latter (see, for example, Puga, 2000; and Vickerman et al., 1999).

The TEN-T is one of the basic policy instruments applied in the EU to achieve growth, competitiveness and employment. European transport policy has always called for an integrated approach combining inter alia measures to revitalize the rail sector, and special emphasis has been dedicated to the development of High Speed Train (HST) corridors, in particular the cross-border corridors (COM, 2001). The major cross-border projects of the last decade, such as the Channel Tunnel, the high-speed line between Brussels and Paris and the bridge/tunnel between Sweden and Denmark, send out signals to the citizens of the EU that European integration is progressing. The TEN-T is also a key instrument for the achievement of economic, social and territorial cohesion. In this sense, the HST PBCAL² (Paris-Brussels-Cologne-Amsterdam-London) corridor is a key element in this policy, an consciously borrowed from the Japanese Shinkansen. This corridor comprises two HST networks, Eurostar and Thalys, and it allows trips of dense flows of passengers at speeds of 300 km/hr between the principal cities of the EU. It has already effectively taken virtually all traffic away from air in the Paris-Brussels sector with a travel time of only 1 hour 25 minutes.

Nowadays, there is a growing tendency to evaluate policy options, such as investments in transport infrastructures, by combining classical Cost-Benefit Analysis (CBA) with more indicators that can be used in Multi-Criteria Analysis (MCA). In this sense, it is usually common to assess transport investments, by taking into consideration different indicators, such as economic, environmental, social and cost indicators. Within the category of social indicators, accessibility has become quite a popular area of study since the application of Geographical Information Systems (GIS). Accessibility has usually been measured by different indicators, and good previous references include Vickerman (1974), Morris et al. (1978), Pirie (1979), Jones (1981), Geertman and Ritsema van Eck (1995), Bruinsma and Rietveld (1993) and Reggiani (1998).

Vickerman (1995) studied how accessibility measures can be nested into wider studies that attempt to link the role of transport infrastructure in regional economic development. So, accessibility only offers a partial vision of all the possible economic impacts that transport investments may induce in regional economic development. It would also be necessary to establish a further connection, linking changes in accessibility with changes in economic development, regional cohesion or even spatial reallocation of economic activities. However, this connection is beyond the scope of this chapter. Readers may refer to some papers of new economic geography models that try to fill this gap, such as Gasiorrek and Venables (1997), Puga and Venables (1997), and Fujita and Mori (1997).

In this chapter, we study the accessibility impacts of the railway TENs for three different periods of time: the years 1995, 2005 and 2015. Section 10.2 presents a
literature review of accessibility and discusses the intrinsic nature of distinct partial accessibility indicators. Section 10.3 shows the results of the impacts of the railway TENs on accessibility using a partial approach for three different periods. The results are obtained with the use of a GIS (ARC/INFO). Section 10.4 introduces our Data Envelopment Analysis (DEA) proposal to synthesize the partial accessibility information in a sensible way, and presents the results of this new global approach. Section 10.5 analyses the accessibility disparities in the EU for the three scenarios, and discusses the evolution of European accessibility disparities. Finally, Section 10.6 concludes.

10.2 Accessibility Indicators

Accessibility is a complex concept that has been traditionally studied using different indicators. Van Wee et al. (2001) classify accessibility indicators into three different groups: infrastructure-related; activity-related; and mixed measures. Infrastructure indicators are based on the main characteristics of the infrastructure and its use: for example, speeds on motorways, travel times by train, density of the networks in some specific area, such as municipalities or regions, and so forth. The first group of indicators are only related to the infrastructure supply. The second group, activity indicators, are related to the different activities that individuals can carry out in a certain period of time, for example, the number of jobs that may be reached from a zone within 45 minutes by car, or the number of different shopping centres that may be reached from a zone within 1 hour by public transport. The third group includes indicators that relate the infrastructure use with the activities. Examples are the distances between households and bus stops, schools, hospitals or airports.

In this section, we present four different indicators which respond to different conceptualizations of accessibility and offer complementary information with respect to the question we are trying to study: the accessibility impacts of transport infrastructure. As we will see, the partial accessibility indicators include: 1) aspects related to interaction, such as population and GDP; 2) difficulties of the interaction between zones, such as travel times or distances; 3) features of location, such as accessibility considered from one place to other places or from several places to other places; and, finally, 4) daily accessibility which is characterized by the population that can be reached in a threshold value of 4 hours.

The revision of the definition of all partial accessibility indicators will be done taking into consideration some relevant previous references that have employed these or other similar indicators to study accessibility impacts.

10.2.1 The Location Indicator

This indicator represents the average weighted travel time between each node and all the cities in the set of urban agglomerations according to the following expression:
\[
L_i = \frac{\sum_{j=1}^{n} t_{ij}GDP_j}{\sum_{j=1}^{n} GDP_j}, \tag{10.1}
\]

where \(L_i\) is the location indicator of node \(i\); \(t_{ij}\) is the travel time by the minimum-time route in the network between node \(i\) and urban agglomeration \(j\) (in minutes); and \(GDP_j\) is the GDP of the urban agglomeration \(j\). The GDP of the urban agglomeration is used to weight the minimal-time routes in order of importance (Gutiérrez and Urbano, 1996; Gutiérrez et al., 1996). This indicator reflects quite well central and peripheral locations of the demarcation area with respect to the cities included in the set of the centres of economic activity. The programmed investments in TEN-Ts will modify this location indicator by reducing travel times to the urban agglomerations if the minimum-time route includes some link that has been upgraded or constructed.

10.2.2 The Relative Network Efficiency Indicator

This indicator offers an accessibility measure in terms of the relative ease of access according to the network efficiency in each of the scenarios analysed: for the years 1995, 2005 and 2015. The aforementioned location index classifies peripheral locations as low accessibility locations, and, as a consequence, these nodes have a high probability of being potential receptors of new investments in transport infrastructures, even though these locations could already possess an adequate provision of transport infrastructure. Transport planners have to be cautious about the serious limitations that location indices present, and need to incorporate another kind of index into the study of changes in accessibility that correct these biases. The relative network efficiency indicator neutralizes the effect of geographical location, and the ordinary notion of costs is replaced by the ease of access in relative terms (network efficiency), as follows:

\[
A_i = \frac{\sum_{j=1}^{n} \hat{t}_{ij}GDP_j}{\sum_{j=1}^{n} GDP_j}, \tag{10.2}
\]

where \(A_i\) measures the accessibility of node \(i\) according to this network efficiency indicator; \(t_{ij}\) and \(GDP_j\) are defined as above; and \(\hat{t}_{ij}\) is the ideal time spent between the nodes \(i\) and \(j\), assuming the hypothetical existence of an HST link of 350 km/h in a straight line (Euclidean impedance). This indicator is based on a measure known as the route or circuitry factor, which is usually used to calculate the extra
distance incurred by some individual link with respect to a hypothetical straight line link (Chapman, 1979; Chorley and Haggett, 1969).

The weighted average of the ratio $t_i/\hat{t}_i$ is calculated according to the GDP of the economic centres in the destination city $j$. This ratio expresses the relative ease of access in each city-pair in comparison with the Euclidean impedance of all the economic centres. This index does not take into account real transport demand in each city-pair, but the network efficiency for the multiple connections.

### 10.2.3 The Economic or Potential Market Indicator

This index is a gravity-based measure that has been extensively used in accessibility studies (see, for example, Harris, 1954; Keeble et al., 1988; Linneker and Spence, 1992; Smith and Gibb, 1993; Spence and Linneker, 1994). It measures the closeness of potential economic activity to a particular node. This index uses a decay-distance function as a plausible weight for each city-pair in order to take into consideration the possible interaction between the nodes. Its classical mathematical expression is as follows:

$$
P_i = \sum_{j=1}^{n} \frac{GDP_j}{d_{ij}^x},
$$

where $P_i$ is the accessibility potential market indicator of node $i$, $GDP_j$ is the GDP of the economic centre $j$, $d_{ij}$ is the distance between the cities $i$ and $j$ (a proxy of transportation costs), and $x$ is a parameter that reflects the effect of the distance decay function.

In this chapter (as in the majority of accessibility studies), the value of the parameter $x$ is 1. If $x$ is greater than 1, it means that more weight is given to short distances. In this case, we are analysing an HST network, and it is necessary to remark that this type of infrastructure presents a comparative advantage over medium distances, so it does not seem adequate to consider a parameter $x$ greater than 1. The parameter $x$ can also have a big influence in the problem known as ‘self-potential’ (see Frost and Spence, 1995; Bruinsma and Rietveld, 1998).

### 10.2.4 The Daily Accessibility Indicator

This indicator calculates the amount of population or economic activity that can be reached from each node within a certain limit of travel time. The threshold figure is usually established between 3 and 4 hours, so that it is possible to go and return within the day and carry out some activity at the destination city (Lutter et al., 1992). In this chapter, we calculate this indicator as the number of inhabitants that can be reached within 4 hours. Its mathematical expression is as follows:

$$
DA_i = \sum_{j=1}^{n} P_i \delta_{ij}
$$

(10.4)
where $DA_i$ is the daily accessibility indicator of node $i$; $P_j$ is the number of inhabitants of the economic centre $j$; and $\delta_{ij}$ takes the value of 1 if $t_{ij}$ is less than 4 hours, and 0 otherwise. This index can be viewed as an extreme case of a potential market indicator, because the distance decay function takes the discontinuous form of all or nothing, depending on the threshold of travel time considered.

The indicators presented above provide complementary information and emphasize some cost or attraction attributes in a different way. Table 10.1 shows the main characteristics of each indicator concerning at different issues, such as the number of economic centres that are included in the estimation, the type of distance interaction, their units, and their basic interpretation.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Economic centres included in the calculation</th>
<th>Distance decay function</th>
<th>Units</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>All</td>
<td>No</td>
<td>Time in minutes</td>
<td>Decreasing function</td>
</tr>
<tr>
<td>Network efficiency</td>
<td>All</td>
<td>No</td>
<td>Unit-less</td>
<td>Decreasing function</td>
</tr>
<tr>
<td>Potential market</td>
<td>All</td>
<td>Yes</td>
<td>Monetary terms</td>
<td>Increasing function</td>
</tr>
<tr>
<td>Daily accessibility</td>
<td>Discrimination function</td>
<td>No</td>
<td>Inhabitants</td>
<td>Increasing function</td>
</tr>
</tbody>
</table>

For example, the location indicator includes all the economic centres without any decay function measuring the distance interaction. It is a measure of the weighted time to all the economic centres included as the set of reference, and its basic interpretation is as follows: lower indicators are related to better accessibility.

10.2.5 A Discussion on Accessibility Indicators

Although the selected indicators analyse the impact of new infrastructure under a different perspective they are not exempt from possible drawbacks. Bruinsma and Rietveld (1998) showed that the internal accessibility of a city does not have significant influence on the calculation of indicators with no distance decay function, but may have a substantial impact on the final outcome in the case of gravity type models. This problem is known as ‘self-potential’ bias in gravity models, that is, if the contribution of the potential of an individual city itself to the total potential market is important then the results of economic potential indicators will be distorted each of the cities’ own size included in the set of reference. For example, the relationship Paris-Paris distorts this indicator but the demand is not important in this context (Gutiérrez et al., 1996). If accessibility indicators do not
employ a distance decay function, the calculations depend very much on the geographical area of study that is chosen. For this reason, Bruinsma and Rietveld (1998) argue that the area needs to be chosen carefully, and suggest that the area has to be in concordance with the distance over which the new transport infrastructure presents some comparative advantage compared with the rest of transport modes. In this sense, it is necessary to balance the geographical area adequately in order to include the appropriate centres of economic activity.

To sum up, we have seen that these indicators offer a complementary vision and a different conceptualization of accessibility. The first indicator emphasizes the idea of location, separating different zones according to the usual concept of core and periphery. However, this indicator does not deal adequately with the interaction element because it does not take into consideration that geography really matters. For this reason, it is necessary to consider some decay function which embraces the idea that remote cities are less attractive than closer cities. The four indices use GDP or population to measure the interaction element, and estimations of these variables have been used to calculate these indicators for the years 2005 and 2015, but without considering how GDP or population is going to change due to the accessibility changes. This inconsistency is partly due to the fact that the exact relationship between infrastructure, accessibility, economic growth and housing location is usually unknown, and, for this reason, researchers take a conservative naïve approach. However, after large investments or improvements of transport infrastructure, accessibility indicators can be quite different due to the changes in the output or population structure of the cities in the reference set.

10.3 Accessibility Impacts of New High Speed Trains at the European Level: A Partial Approach

High speed trains (HSTs) are considered the best transport alternative for medium distance trips. They substantially shorten travel times between cities and their comparative advantages against other competing modes are based on: quality of service; reduction of access times to the principal economic centres; the possibility of handling large passenger volumes; and a better adjustment to shocks or peaks in demand.

These new infrastructures change the accessibility conditions and the relative location of the cities, thus affecting the attractiveness and the potential development of the regions (Lutter et al., 1992). Moreover, good connections in international networks are critical issues to obtain an adequate distribution of economic activity inside Europe (Bruinsma and Rietveld, 1998).

A good example of this type of infrastructure is the new HST line Madrid-Barcelona-French border. It is being constructed in standard gauge and will be completed by the year 2005. In Spain, this line will be connected with the HST Madrid-Seville that was inaugurated in the year 1992, when the Worldwide Exhibition (EXPO-92) was held in Seville. This new line will produce substantial reductions in travel time between the cities in the Iberian Peninsula and the main
European cities. Table 10.2 shows travel time for the main routes in three scenarios: year 1995 (base period); year 2005 (when the project is going to be finished, together with other projects in Europe); and the year 2015 (when the impacts of TEN-Ts are analysed). Travel-time savings will be even more important when this line is completely connected with the rest of the TEN-Ts. Another good example is the HST PBKAL. This was the first multi-country HST undertaking in Europe, and it connects central European capitals as well as major cities and constitutes a good alternative to passenger air traffic, since journey times are reduced significantly. The entire project is likely to be terminated in 2007, and involves lines passing through the United Kingdom, the Netherlands, Belgium and France.

Table 10.2  Travel time savings produced by TEN-Ts in some international routes

<table>
<thead>
<tr>
<th>Route</th>
<th>Travel time (% reduction)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A min</td>
<td>B min (% red. B – A)</td>
</tr>
<tr>
<td>Barcelona-Marseille</td>
<td>376</td>
<td>211 (–43.88%)</td>
</tr>
<tr>
<td>Barcelona-Milan</td>
<td>729</td>
<td>529 (–27.43%)</td>
</tr>
<tr>
<td>Barcelona-Lyon</td>
<td>425</td>
<td>251 (–40.94%)</td>
</tr>
<tr>
<td>Barcelona-Paris</td>
<td>517</td>
<td>341 (–34.04%)</td>
</tr>
<tr>
<td>Barcelona-London</td>
<td>729</td>
<td>509 (–30.18%)</td>
</tr>
<tr>
<td>Barcelona-Brussels</td>
<td>651</td>
<td>421 (–35.33%)</td>
</tr>
<tr>
<td>Barcelona-Amsterdam</td>
<td>803</td>
<td>526 (–34.50%)</td>
</tr>
<tr>
<td>Barcelona-Frankfurt</td>
<td>861</td>
<td>526 (–38.91%)</td>
</tr>
<tr>
<td>Zaragoza-Marseille</td>
<td>583</td>
<td>286 (–50.94%)</td>
</tr>
<tr>
<td>Zaragoza-Milan</td>
<td>936</td>
<td>604 (–35.47%)</td>
</tr>
<tr>
<td>Zaragoza-Lyon</td>
<td>632</td>
<td>326 (–48.42%)</td>
</tr>
<tr>
<td>Zaragoza-Paris</td>
<td>591</td>
<td>416 (–29.61%)</td>
</tr>
<tr>
<td>Zaragoza-London</td>
<td>799</td>
<td>584 (–26.91%)</td>
</tr>
<tr>
<td>Zaragoza-Brussels</td>
<td>721</td>
<td>496 (–31.21%)</td>
</tr>
<tr>
<td>Zaragoza-Amsterdam</td>
<td>876</td>
<td>601 (–31.39%)</td>
</tr>
<tr>
<td>Zaragoza-Frankfurt</td>
<td>961</td>
<td>601 (–37.46%)</td>
</tr>
<tr>
<td>Madrid-Marseille</td>
<td>766</td>
<td>371 (–51.57%)</td>
</tr>
<tr>
<td>Madrid-Milan</td>
<td>1096</td>
<td>689 (–37.14%)</td>
</tr>
<tr>
<td>Madrid-Lyon</td>
<td>792</td>
<td>411 (–48.11%)</td>
</tr>
<tr>
<td>Madrid-Paris</td>
<td>700</td>
<td>501 (–28.43%)</td>
</tr>
<tr>
<td>Madrid-London</td>
<td>912</td>
<td>669 (–26.64%)</td>
</tr>
<tr>
<td>Madrid-Brussels</td>
<td>834</td>
<td>581 (–30.34%)</td>
</tr>
<tr>
<td>Madrid-Amsterdam</td>
<td>989</td>
<td>627 (–36.60%)</td>
</tr>
<tr>
<td>Madrid-Frankfurt</td>
<td>1074</td>
<td>656 (–38.92%)</td>
</tr>
</tbody>
</table>

Notes: Scenario A: year 1995; Scenario B: year 2005; Scenario C: year 2015.
A GIS (ARC/INFO) is used to calculate the four accessibility indicators presented in the previous section in the scenarios: 1995, 2005 and 2015. A dense intermodal transport network of railways and roads with about 7,000 arcs and 4,000 nodes has been used. The nodes were chosen to provide a uniform coverage across the territory of the EU and to facilitate interpolation and iso-accessibility mapping.

The network includes all the railway lines used by long-distance trains, which are of great interest from the European perspective. The nodes on the network correspond to the stations where long-distance trains stop and the arcs to the sections of line between the stations. The following attributes were associated with the arcs on the train network: country, name of the origin-node, name of the destination-node, type of line, distance in km, and travel time in minutes. The distances and travel times for the year 1995 were obtained from Cook’s European Timetable (1995). For the years 2005 and 2015, we included as much information as we could about the changes foreseen in the upgraded and programmed plans. When we did not have enough information about some link, speeds were adjusted to 275 km/h and 200 km/h on new lines and upgraded lines, respectively.

Some penalty times were also included in turn tables in order to simulate the inconvenience of changes of transport mode (between road and railway) or changes of gauge (between the Iberian gauge and standard European gauge). We considered 60 and 20 minutes of penalty time, respectively. In fact, the 20 minutes time penalty for the change to a different gauge is not estimated. It is the real time consumed for this type of operation.

The section on partial accessibility indicators shows that we also need to establish some economic centres as a set of reference in order to calculate this type of indicators. In our case, we decided to choose 88 urban agglomerations (13 of them in Spain) with more that 300,000 inhabitants. The population data and GDP were obtained from REGIO for the year 1995, and they were estimated for the years 2005 and 2015 on the basis of former growth trends.

For each of the three scenarios, we obtained shortest-time routes between each node and each destination centre included in the set of reference. We also needed to take into account internal relationships in all nodes. Average travel times for these internal relationships were estimated following a standard procedure according to the following formula:

$$t = 15 \log(10p),$$

(10.5)

where $t$ is the average internal travel time and $p$ is the population in million inhabitants. The logarithmic function explains to some extent why the average travel time of internal relationships tends to increase with the size of cities, but that this increase is not linear. The highest value in our study is 26 minutes and it corresponds to the city of Paris.

Once the access times were obtained for all the relationships considered, we proceeded to calculate the partial accessibility indicators of the 4,000 nodes of the network. It can be seen that investments in TEN-Ts will reduce the relative travel
times between the selected urban agglomerations by 26 per cent (comparing 2005 with respect to the situation in 1995) and by 45 per cent (if we compare the situation in 2015 with respect to that in the year 1995). However, the time savings are not distributed uniformly across Europe. It can be seen that cities in the East of Spain will benefit from the construction of the HST between Madrid and Barcelona. Other cities in Germany, like Berlin and Frankfurt, will also experience some dramatic reductions of travel time. Lisbon and Porto, cities in Portugal, will experience the greatest reductions for the year 2015. They will benefit from the construction of the high speed line between Lisbon and Madrid.

If we analyse accessibility patterns with economic potential indicators, we still appreciate a dichotomy between the core and the periphery of Europe. TEN-Ts will increase the relative economic potential of the selected urban agglomerations by, respectively, 54 per cent (2005 vs. 1995) and 124 per cent (2015 vs. 1995). However, the absolute gains in economic potential vary greatly in different locations in Europe. It can now be seen that cities in the industrialized core of Europe, like Cologne, Aachen, Antwerp, and Brussels, experience the greatest absolute gains when we compare 2005 vs. 1995. Similar results were obtained for the comparison between the years 2015 and 2005.

### Table 10.3 Classification of European cities according to accessibility indicators (the reference set)

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lille</td>
<td>Lille</td>
<td>Lille</td>
<td>Lille</td>
<td>Lille</td>
<td>Lille</td>
<td>Lille</td>
<td>Frankfurt</td>
</tr>
<tr>
<td>Brussels</td>
<td>Brussels</td>
<td>Valence</td>
<td>Brussels</td>
<td>Paris</td>
<td>Antwerp</td>
<td>Antwerp</td>
<td>Antwerp</td>
</tr>
<tr>
<td>Aachen</td>
<td>Cologne</td>
<td>Strasbourg</td>
<td>Lyon</td>
<td>Brussels</td>
<td>Cologne</td>
<td>Lyon</td>
<td>Cologne</td>
</tr>
<tr>
<td>Antwerp</td>
<td>Cologne</td>
<td>Aachen</td>
<td>Essen</td>
<td>Brussels</td>
<td>Antwerp</td>
<td>Paris</td>
<td>Paris</td>
</tr>
<tr>
<td>Cologne</td>
<td>Antwerp</td>
<td>Cologne</td>
<td>Strasbourg</td>
<td>Antwerp</td>
<td>Cologne</td>
<td>Strasbourg</td>
<td>Strasbourg</td>
</tr>
<tr>
<td>Sevilla</td>
<td>Malaga</td>
<td>Kobenhavn</td>
<td>Barcelona</td>
<td>Malaga</td>
<td>Murcia</td>
<td>Kobenhavn</td>
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<td>Sevilla</td>
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<td>Granada</td>
<td>Lisbon</td>
<td>Coruña</td>
</tr>
</tbody>
</table>

*Note: Valenc. = Valenciennes.*
Analysing railway accessibility with the partial picture of daily accessibility, we still appreciate the dichotomy between core and periphery, but some cities in Germany and Italy play a different role. Some cities in the Germany-France axis are among the more accessible cities of the EU. It can be seen that the population that can be reached from the selected urban agglomerations within 4 hours will be increased by 58 per cent (2005 vs. 1995) and 156 per cent (2015 vs. 2005), respectively. It can be seen that the centre of gravity of the EU will move to the East in the next ten years. Looking at the daily accessibility indicators, the more accessible cities will change from Brussels, London and Lille (1995) to Frankfurt, Wiesbaden and Cologne (2005).

In summary, Table 10.3 above shows the worst and best performing cities regarding different partial accessibility indicators. In general, we can see that centrally-located European cities show a very good accessibility performance while peripheral cities have the poorest results. In spite of this, the separate interpretation of each individual indicator may produce ambiguous results. For instance, Paris is the city which provides better accessibility results with respect to the location and potential market indicators in the three scenarios analysed, but it is below the fourth place regarding daily accessibility. For this reason, it is necessary to apply a model that helps planners to synthesize these partial accessibility indicators, and thus some overall performance of the cities regarding the complex concept of accessibility may be derived. In the next section, we introduce our synthetic DEA-accessibility indicator.

10.4 A Synthetic DEA Index to Analyse Accessibility

Accessibility involves more than one single criterion. If we study accessibility using partial indicators, like the ones shown in the previous sections, we obtain a different ranking of the cities depending on what partial indicator is used. However, urban and regional planners need a method that allows them to identify the global accessibility of different geographic areas, as well as the accessibility changes produced by the construction of new infrastructures. As the indicators obtained in the previous section do not provide conclusive information about the absolute accessibility gains produced by TEN-Ts at different periods, we use the DEA methodology as a multi-criteria decision-manager approach to synthesize different partial accessibility indicators. This new index is used to obtain a better understanding of the overall picture of accessibility, combining the information provided by the partial indicators.

We have seen that none of the cities of the reference set presents the best performance with respect to all the partial accessibility indicators. For this reason, it is necessary to find a multiple objective problem that encompasses all the information provided by the different accessibility indicators. In this sense, the DEA methodology provides a single unit-less overall index of accessibility. This index will summarize the multifaceted partial accessibility indicators in a single synthetic measure for comparison purposes.
As was previously mentioned a global measure of accessibility needs to embrace a different set of measures of partial accessibility that can be weighted by some metric. It has already been discussed that single dimension measures, such as potential market accessibility indicators, are too narrow to fully capture the global essence of the accessibility concept. We have also shown that these partial indicators have complicated relationships with each other. For this reason, these partial accessibility indicators need to be weighted in some objective and rational way in order to obtain an overall index of accessibility. However, weighting the partial accessibility indicators can be problematical, since it is difficult to know how individuals or transport planners weight these partial indicators from which they obtain utility. Given the nature of multidimensionality, DEA is a proper approach to adopt. In particular, using DEA can circumvent the situation when information on how to weight multiple partial indicators is not clear or even unknown.

10.4.1 The DEA Synthetic Accessibility Index

The DEA methodology applies mathematical programming, which provides a new way of obtaining empirical estimates of extremal relationships, such as the production functions and/or efficiency production possibility surfaces (Charnes et al., 1978). This methodology has numerous applications in different fields: education, health care, banking, armed forces, sports, transportation, agriculture, retail stores, and electricity suppliers. The method was originally designed to evaluate not-for-profit Decision-Making Units (DMUs), which use multiple inputs to produce multiple outputs. The seminal paper was conceived in a context in which prices were suspect at best and missing at worst. Pestieau and Tulkens (1990) defend the DEA methodology that focuses only on technical efficiency in the environment of public vs. private provision of services. Their argument to focus only on technical efficiency is different from other DEA practitioners in a very subtle way. They consider that what is important is not the lack of adequate data to measure the provision of public services, or even the prior weights applied to the different variables, but the recognition that public providers may have different objectives and constraints from those of private counterparts. For this specific reason, they claim that the comparison of their performance has to be done on the basis of their technical efficiency.

However, at present, DEA has evolved substantially and there are many different models and alternative approaches to measure efficiency. Normally in all the DEA applications there are \( n \) DMUs to be evaluated. Each DMU consumes some amounts of \( i \) different inputs to produce \( r \) different outputs. So, following this description of DEA, it seems obvious that each variable has to be classified as either an input or an output. However in our case, we apply DEA to measure the relative railway accessibility of some European cities in a context where there is no clear identification of the relationship between the partial accessibility indicators, and the data cannot be strictly interpreted as inputs or outputs. In such situations, a general guideline for the classification of the variables is that variables for which
lower levels are better are considered inputs, while those variables for which higher amounts are better are considered as outputs. So, a quick examination of the partial accessibility indicators reveals that cities like Paris and Lille clearly dominate other European cities such as Seville and Lisbon (that is, they are more accessible) because they simultaneously have both higher levels of potential market and daily accessibility indicators and lower levels of the location accessibility indicator. In this sense, it is clear that, if some city A presents all these features with respect to another city B at the same time, a higher potential market, that is, more population, may be contacted within an interval of 4 hours, and the average time by rail is lower, then we can conclude that city A is more accessible than city B.

Each of the various models for DEA will classify the cities A and B according to the perception of which city is more or less accessible. A good introduction to DEA notation, formulation and geometric interpretation can be found in Charnes et al. (1994), Ali and Seiford (1993) and Coelli et al. (1998). These references cover all the topics that are going to be used in this section. We can use different envelopment surfaces or orientation in order to develop a DEA model. The nature of our problem has determined the employment of VRS (variable returns to scale) because there is a great heterogeneity among the different cities in Europe; and an output orientation has been chosen because some priority has been given to the location indicator.

The model for the different scenarios is used to seek which of the 88 economic activity centres determine the frontier of the envelopment surface, and are deemed efficient from an accessibility perspective. The cities that do not lie on the frontier are inefficient and the measurement of the grade of accessibility inefficiency is determined by the resolution of the model.

In our analysis, we evaluate the grade of accessibility of n economic activity centres, using location as input, and economic potential and daily accessibility as outputs. Specifically, in production parlance, the ith production unit consumes \( x_{io} \) units of input \( i (i = 1) \) and produces \( y_{ro} \) units of output \( r (r = 1 \text{ to } 2) \). The \( o^{th} \) production unit can now be described more compactly with the vector \((X, Y)\), which denotes, respectively, the vectors of input values (location) and output values (economic potential and daily accessibility) for each city analysed in the study.

Next, we consider the dominant comparisons for this city using the set of all the economic activity centres as a reference. DEA considers the dominance of the linear combinations of the 88 cities, that is, \( \sum_{i=1}^{88} \lambda_i X_i + \sum_{i=1}^{88} \lambda_j Y_j \), with the scalar restricted to be non-negative. City \( o \) is dominated, in terms of location, if at least one linear combination of the rest of the cities shows that the weighted travel times may be diminished without worsening at least one of the other partial accessibility indicators. City \( o \) is dominated in terms of daily accessibility if at least one linear combination of the rest of the cities shows that the population which can be reached within 4 hours may be increased without worsening at least one of the other partial accessibility indicators.
Thus, the method serves to classify a set of economic activity centres into two subsets: the accessibility-efficient cities, and the accessibility-inefficient ones. The method also serves to calculate the level of accessibility-inefficiency $\phi$ of a given city that will be interpreted as the synthetic DEA-accessibility index.

Formally, the DEA-accessibility efficiency index for each city $o$ is calculated by means of the following linear programming problem:

$$\max_{\phi, \lambda, s^+, s^-} z_o = \phi \cdot 1s^+ + \varepsilon \cdot 1s^-,$$

s.t.

$$Y\lambda - s^+ = \phi Y_o,$$
$$X\lambda + s^- = X_o,$$
$$\lambda s^+ s^- \geq 0,$$

where $X$ and $Y$ are, respectively, the input and output partial accessibility matrixes; $X_o$ and $Y_o$ are, respectively, the input and output accessibility vectors of the city $o$; $\phi$ and $\lambda$ are parameters calculated in the model, and represent the maximum proportional output accessibility (economic potential and daily accessibility) that can be attained for the linear convex combination that dominates the $o^{th}$ city; and $\varepsilon$ and $s$ are, respectively, the Archimedian constant and the slack variables. The model compares the city $o$ with all the convex linear combinations of the rest of the cities.

The linear programming problem is solved for every city considered as an economic activity centre in order to obtain the DEA-accessibility index that embraces all the partial accessibility indicators. The DEA-accessibility index obtained can be interpreted as a synthetic indicator, and it is calculated as the inverse of the maximum proportional output accessibility (potential market and daily accessibility) that can be obtained for the indicated accessibility input (location). It is based on the properties of the DEA methodology, but it is more easily understood by describing, how the method evaluates the accessibility efficiency of a given economic centre:

1. A city is said to be accessibility-efficient if it is not dominated by a convex linear combination of other European cities, where domination is taken in the sense:
   a. This convex linear combination has a lower average time (location indicator) than the reference set of the European cities.
   b. It has a higher potential market, and more population can be achieved within 4 hours of travel time.

2. If a city is accessibility-inefficient, its degree of inefficiency is computed as $1/\phi$. By construction, this ratio is less than 1 and greater than 0.
3. If a city is accessibility-efficient, its degree of efficiency is equal to 1.

Table 10.4 shows the DEA-accessibility indicators for the three scenarios considered in the study. We can see that Brussels, Lille, London and Paris are the more accessible cities of the EU in the 1995 scenario. Lille is the major commercial city in the Northern French region of Ascq. Its economic prosperity has been transformed thanks to the Single European Market and, more specifically, to its location as a transport hub at the centre of important commercial routes linking United Kingdom, France and Belgium with the rest of the territory of the EU.

Table 10.4 DEA-accessibility index for the main European cities in scenarios A, B and C

<table>
<thead>
<tr>
<th>City</th>
<th>A</th>
<th>B</th>
<th>C</th>
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<td>Porto</td>
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<td>Alicante</td>
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<td>London</td>
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Table 10.4 (cont.)

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<td>Paris</td>
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<td>Paris</td>
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</tr>
</tbody>
</table>

Notes: Scenario A: year 1995; Scenario B: year 2005; Scenario C: year 2015.

The new Lille-Europe TGV station was opened in 1994, as well as an underground station that integrated the public transport system within the urban area with the HST network. Planners in Lille developed different projects to reap location advantages and make the city attractive at the European level. Lille’s image was profoundly changed due to its connection to the TGV which provides interchanges for HST services in Northern Europe.

New developments increased the amount of existing office premises in the Lille area, and different European corporations were established at the end of the 1990s, representing some tertiary activity sectors, such as banks, insurance and data processing companies. A major criterion for companies to establish themselves in Lille was being at the heart of a high speed transport node, in the centre of a market with over 300 million consumers and only a short journey away from major European capitals (Paris and Brussels).

London and Paris are the two most populated cities (mega-cities) of the EU, and for this reason they have higher partial accessibility indicators. In recent years, we have observed in both cities a general outward trend, both for population and employment. The congestion and the lack of land for new urban developments within the core of the cities has accelerated growth in and around smaller towns in the wider metropolitan area of both cities, especially those adjacent to major national highway and/or railway lines.

A major question for Europe is whether the Single Market and the impacts of the Maastricht treaty will progressively hierarchize even more the different size of the cities, or whether cities with a distinct function within the EU – Brussels, Frankfurt, Rome and Madrid – will progressively assert their role at the expense of London and, to some extent, Paris.

However, the growth of information and communication networks can actually stimulate urbanization, and it is now difficult to imagine that cities like London and Paris will not become important brains of the network society within Europe.
High-order cities are and will be the place where managers and professionals of different sectors do, and will, interchange ideas that produce synergy and a constant flow of information which allow economic growth.

In summary, cities are the places where we find concentrated numbers of systems analysts, designers, accountants, lawyers, bankers, R&D professionals, and so forth, who are in charge of the worldwide activities of the global economy. At the uppermost level, we can not conceive of European cities, such as London and Paris, not being at the heart of constant business, financial, political and cultural information flows.

In the scenarios 2005 and 2015, we see that Paris and Lille will maintain their status of being in the group of the more accessible cities in Europe, but London is displaced from this privileged club. Its chair is occupied by the German cities: Frankfurt and Wiesbaden.

This is the consequence of the HST development programme that was planned in the Northern and Eastern regions of Germany. German Railways (Deutsche Bahn-DB) is now a major player in European HST with its Inter City Express (ICE) programme. The first lines to be upgraded to high speed operation were Hannover-Würzburg and Mannheim-Stuttgart. However, the Frankfurt-Cologne line, which opened in December 2002, is the first German HST line that was especially designed for HSTs, rather than mixed use. It allows the inclusion of very steep gradients (as much as 4 per cent) and makes the line closer in concept to French TGV lines. The powerful ICE3 trains travel at up to 330 km/h, and have brought about a dramatic travel-time reduction for the 226 km trip from 2 hr 15 min to 1 hr via the classic, but tortuous, Rhine Valley route. DB expects passenger numbers to more than double by 2010 to around 20–25 million. Three intermediate stations are provided at Limburg Sud, Montabaur and Siegburg, although most services over the new line make just one stop. Travel between the stations is not possible and the fastest trains run non-stop services.

Table 10.4 also shows that the bulk of the less accessible cities are located in the periphery of the EU. In 1995, Seville was the only city of this group that was connected to the HST network. However, it is only connected through a national link between Madrid and Seville. In the year 2015, the HST will make Seville, one of the most populated cities of Spain located in the South, fully connected to the North of Europe, so it will be possible to travel by HSTs from Seville to Amsterdam. The Mediterranean TGV that connects Marseilles and Paris in 3 hours should be extended to the Spanish AVE Seville-Barcelona with the Perpignan-Barcelona section. While the TEN-T seems to be fulfilling its role in connecting outlying areas to the economic centre of the EU, Table 10.4 also shows that connectivity alone does not guarantee accessibility. The relative position of some cities in the Iberian Peninsula will not considerably change in the 2015 scenario, in spite of being fully connected to the European HST line, for example, Porto, Lisbon, Seville and Cordoba.
10.5 HST Accessibility Disparities in the European Union

A unified European network is essential to achieve a better integration of the Member States. It is necessary to bring the outlying parts of the territory closer to the central core of the EU (Paris-Brussels-Frankfurt). The internal market, the territorial cohesion and the European Constitution of the EU will remain ideas that have failed to succeed if the necessary transport infrastructure is not completed and interlinked to facilitate free movement of goods and people. The TEN-Ts have gradually arisen as one of the driving forces to achieve these objectives. In this section, we would like to try to shed some light on whether TEN-Ts investments will contribute to increasing or decreasing accessibility disparities among the selected cities in the EU.

We did not develop a specific methodology to quantify accessibility disparities in the EU. We just calculated and compared different inequality measures frequently used in the income inequality literature (Cowell, 1995). Thus, we decided to calculate the following inequality indicators: Gini, Atkinson (0.5), Theil (0), and the coefficient of variation of the partial and DEA-accessibility indicators that have been calculated in the previous sections.

Table 10.5 presents the inequality indices of all accessibility indicators. All the indices are well known, so, here, for ease of exposition, we are not going to discuss their basic characteristics and their mathematical representation. These indices may be considered a policy tool to compare the evolution of regional accessibility disparities regarding the different scenarios analysed in the chapter. From this point of view, these indices allow planners to discuss whether the impacts of TEN-Ts serve to reduce or increase the regional accessibility disparities.

The reason to choose different inequality indicators of all the accessibility indicators is twofold. First, it is well known that some inequality indices are quite sensitive to the presence of outliers in the distribution, so the analysis is more robust if we use different indices. Secondly, we study the potential differences associated with the different approaches used, in order to study the complexities of accessibility.

If we analyse the table by columns, we can conclude that regional disparities are more acute if we measure accessibility using the indicator of daily accessibility. This result again highlights the necessity to obtain an overall performance of accessibility. Partial approaches have studied the problem by focusing on some particular aspects, for example, location or economic development. However, the disparities associated with the location and economic potential approaches are quite similar. We can also observe that the disparities associated with the DEA approach are always in-between the partial accessibility approaches, highlighting the synthetic role of this indicator.

However, looking at the table by rows, the evolution of all the inequality measures point to the same conclusion: the TEN-Ts will increase regional accessibility disparities in the first period from 1995 to 2005, but then it will decrease them in the second period from 2005 to 2015. In spite of obtaining robust results without any contradictory conclusion, it is preferable to analyse the results...
Table 10.5 Accessibility inequality indices

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<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
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<td>Location</td>
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<td>0.2205</td>
<td>0.1922</td>
</tr>
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<td>Economic Potential</td>
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<td>0.1936</td>
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<td>Daily Accessibility</td>
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<td>0.3209</td>
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<tr>
<td>DEA-Accessibility</td>
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<td>0.3001</td>
<td>0.2587</td>
</tr>
<tr>
<td>Atkinson (0.5)</td>
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<td>C</td>
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<tr>
<td>Economic Potential</td>
<td>0.0711</td>
<td>0.0828</td>
<td>0.0609</td>
</tr>
<tr>
<td>Daily Accessibility</td>
<td>0.2069</td>
<td>0.261</td>
<td>0.1768</td>
</tr>
<tr>
<td>DEA-Accessibility</td>
<td>0.1066</td>
<td>0.1412</td>
<td>0.1054</td>
</tr>
<tr>
<td>Variation Coefficient</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Location</td>
<td>0.3738</td>
<td>0.4243</td>
<td>0.3638</td>
</tr>
<tr>
<td>Economic Potential</td>
<td>0.3799</td>
<td>0.4053</td>
<td>0.3454</td>
</tr>
<tr>
<td>Daily Accessibility</td>
<td>0.6274</td>
<td>0.6967</td>
<td>0.5579</td>
</tr>
<tr>
<td>DEA-Accessibility</td>
<td>0.4674</td>
<td>0.5326</td>
<td>0.4513</td>
</tr>
</tbody>
</table>

Notes: Scenario A: year 1995; Scenario B: year 2005; Scenario C: year 2015.

The results can be summarized as follows: First, one observes important accessibility disparities among the cities of the EU, favouring the rich and central cities to the detriment of peripheral locations, in all the scenarios. Second, in all the scenarios, it seems that regional accessibility disparities are higher if we use the partial approach based on daily accessibility. Third, the opposite is observed if we use the location or economic potential approaches. Fourth, DEA-accessibility disparities are in between the results obtained in different partial accessibility approaches. Fifth, the evolution of the inequality indices shows that regional disparities will be increased in the first period and they will be reduced in the second period.
10.6 Conclusions

In this chapter, we have studied accessibility changes due to the development of the Trans-European Transport Network (TEN-T). TEN-Ts are an essential instrument to facilitate freedom of movement of goods and passengers. First, we have introduced different measures to study the complex phenomenon of accessibility. In this sense, different indicators have been calculated, such as those of location, economic potential and daily accessibility.

These indicators reflect different conceptualizations of accessibility and offer a complementary vision that needs to be embraced. We have also studied the evolution of investments in TEN-Ts, looking at three different scenarios: 1995, 2005 and 2015. Logically, the accessibility impacts of TEN-T investments are quite different when considering each of the accessibility indices individually. For this reason, it is necessary to obtain a method that allows planners and policy makers to calculate a composite index of accessibility. In this sense, we propose DEA as a valid methodology to evaluate overall accessibility performance. The DEA-accessibility indicator synthesizes in a sensible way all the complementary information provided by different partial accessibility indicators. Inequality measures have been used in order to analyse whether the new TEN-Ts investments reduce or increase accessibility disparities among the selected cities of the set of reference for three different years: 1995, 2005 and 2015.

Investments in TEN-Ts will reduce the relative travel times between the selected urban agglomerations by 26 per cent (2005 vs. 1995) and by 45 per cent (2015 vs. 1995). However, time savings are not distributed uniformly across Europe. It can be seen that cities in the East of Spain will benefit from the construction of the HST between Madrid and Barcelona. Other cities in Germany, like Berlin and Frankfurt, will also experience some dramatic reductions of travel time due to the huge investments carried out in Germany during the 2000s. Lisbon and Porto, cities in Portugal, will also experience important reductions for the year 2015. They will benefit from the construction of the high speed line between Lisbon and Madrid.

If we analyse accessibility patterns with economic potential indicators, we appreciate that the TEN-T will increase the relative economic potential of the selected urban agglomerations by 54 per cent (2005 vs. 1995) and by 124 per cent (2015 vs. 1995). It can now be seen that cities in the industrialized core of Europe, like Cologne, Aachen, Antwerp, and Brussels, have experienced the greatest absolute gains when we compare 2005 vs. 1995. Finally, some cities in the Germany-France axis are the more accessible cities of the EU if we analyse railways accessibility with the partial picture of daily accessibility. It can be seen that the population who can be reached from the selected urban agglomerations within 4 hours will be increased by 58 per cent (2005 vs. 1995) and by 156 per cent (2015 vs. 2005), respectively. We showed that the centre of gravity of the EU will move to the East in the next ten years, and this change will be more acute with the enlargement of the EU. Looking at the daily accessibility indicators, the more

However, the separate interpretation of each individual partial accessibility indicator produced ambiguous conclusions. For instance, Paris is the city which presents better accessibility results with respect to the location and to the potential market indicators in the three scenarios analysed, but it is below the fourth place regarding daily accessibility. For this reason, it is necessary to apply a model that helps planners to synthesize this ambiguous information, and thus make it possible to obtain some overall accessibility performance of the cities. To this end, we propose the DEA methodology as a sensible way to obtain a composite index to measure the overall accessibility of the cities.

The proposed DEA-accessibility index is defined as the synthetic DEA-accessibility indicator and is calculated as the inverse of the maximum proportional accessibility output, measured by economic potential and daily accessibility indices that can be attained with some accessibility inputs used as a reference and measured by location indicators.

We show that Paris and Lille will maintain their status of being in the group of the more accessible cities in Europe for the years 2005 and 2015, but London will be displaced from this privileged club by following German cities: Frankfurt and Wiesbaden. This is the consequence of the HST development programme that was planned in the Northern and Eastern regions of Germany and carried out by the German Railways (Deutsche Bahn-DB) with its ICE programme.

We calculate and compare different inequality measures, which have been frequently used in the income inequality literature, to quantify accessibility disparities in the EU. We obtain important accessibility disparities among the cities of the EU, where the rich and central cities are favoured to the detriment of peripheral locations, in all the scenarios, but regional accessibility disparities are higher if we use the partial approach based on daily accessibility. The evolution of the inequality indices shows that regional disparities will be increased for the first period (1995–2005) but will be reduced for the second period (2005–15). However, the latter reduction will produce similar levels of disparities to those obtained for the year 1995. Therefore, the TEN-T seems to be fulfilling its role in connecting outlying areas to the economic centre of the EU, but one conclusion that can be obtained from the results of our study is clear: connectivity is not a guarantee to reduce accessibility disparities.

In summary, accessibility is a multifaceted concept that is difficult to synthesize. Different conclusions can be drawn depending on what partial accessibility indicator is being used to study the likely changes that are going to occur as a consequence of the construction of the TEN-T. DEA methodology can help planners and policy makers to disentangle this ambiguity, demonstrating that it is an interesting and powerful tool in the search for a composite index to measure the overall accessibility performance. In this way, we have found the cities that can be considered DEA-accessibility efficient. This happens where the vector of partial accessibility indicators is not dominated, that is, it is not possible to improve some partial accessibility indicator without worsening at least one of the others.
However, it is clear that this composite index of partial accessibility indicators has only one purpose in our chapter: to mitigate the contradictory conclusions that planners and policy makers might obtain when looking at distinct partial accessibility indicators. When planners argue that it is necessary to improve some region’s accessibility, they are not trying to make only that characteristic better, but as a means to an end; in their case they are trying to achieve better economic development and diminish economic disparities. So, areas of future promising research can be foreseen in obtaining a framework where these indicators could be used in order to obtain some explanatory or predictive power concerning different economic variables, such as, GDP, added value per capita, location of firms by sector, housing relocation or unemployment.

Notes

1 Forslund and Johansson (1995) showed that improvements of transportation networks reduce interaction costs, increase the overall competitiveness of the system, and allow the use of economies of scale and specialization in order to obtain more benefits. Hence, we can observe that the quality and capacity of a region’s transportation network is a necessary condition to achieve economic efficiency.

2 This corridor is formed by the following national links: Belgium: (F/B border – Brussels – Liège – B/G border; Brussels – B/NL border); United Kingdom: (London – Channel Tunnel Access); Netherlands: (B/NL border – Rotterdam – Amsterdam); and Germany: (Aachen – Cologne – Rhine/Main).

3 However, other studies calibrate a gravity model to estimate the interaction or the demand between each city-pair, and obtain some estimation of the parameter $x$ that is used in the calculation of the accessibility-potential market indicator. If investigators have all the information that is needed, this seems a valid procedure.

4 The relative network efficiency indicator was also calculated, but it was not ultimately included in the final study because we consider that it is not sensible to use this indicator in this study. There were many relationships between some cities in the Iberian Peninsula and Italy in which the straight lines crossed the sea.

5 Revitalizing the railways has always been one of the principal priorities in European Transport Policy. In fact, railways have been one of the key components of the strategy of the European Commission to shift the modal shares in passenger and goods transport services. The Third Railway Package even contains a proposal to make a European Directive on opening up the market for international rail passenger transport services by 1 January 2010.

6 Regio is Eurostat’s harmonised regional statistical database. It covers the main aspects of economic and social life in the European Union.

7 This change will be more acute with the enlargement of the EU, because the TEN-T investment programme was launched in order to provide a comprehensive overview of past and planned future investments necessary in the TEN-T in the enlarged EU. Hence, the scope of work covered the 15 Member States together with the Candidate Countries, Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia. The network was made up of the TEN-T in the Member States, as set out in the 1996 Guidelines and a network in the Candidate Countries, which was based on the TINA network. TINA is the acronym for Transport
Infrastructure Needs Assessment that was made concerning the transport infrastructure networks in the Central and Eastern European Countries.

In a similar context, Delgado (1997) used a method based on principal component analysis (PCA) to obtain a synthetic indicator to measure the transport infrastructure stock of the Spanish regions.

Chen (2004) uses high-end housing price, lower-end monthly housing rental and number of violent crimes as three DEA inputs, and median household income, number of population with bachelors degree and number of doctors, as three DEA outputs in evaluating the living standard performance of 15 US cities.

Different assumptions about the scalars produce distinct envelopment surfaces: VRS, CRS, or extensions of these basic models.

This procedure can be done with the rest of the partial accessibility indicators and it is quite common when we try to build or approximate some frontier of the observed data.

This is the well-known hub-effect that Fujita and Mori (1996) studied in a theoretical framework to show that transport infrastructures play an important role in developing agglomeration economies.

Lufthansa has discontinued its schedules on this important South-North Frankfurt-Cologne communication axis, because ICE travel times and costs are more competitive.

References


Accessibility Impacts of the Trans-European Railway Network


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Chapter 11

The Role of Infrastructure in Location Preferences of Firms: An Overview of Empirical Research for the Netherlands

Frank Bruinsma and Piet Rietveld

11.1 Introduction

In many countries debates are taking place on the economic impacts of infrastructure improvements. Some believe that, as long as environmental problems related to transport infrastructure such as noise nuisance around airports are not properly solved, these infrastructures should not be expanded. Others emphasize the great benefits of infrastructure improvements that can be obtained for firms and households, and the losses that will be incurred when such improvements do not take place. The spatial dimension plays a dominant role here. Peripheral regions hope that improved access to core regions will yield benefits by taking more advantage of dynamics in other regions. And core regions often have to face bottlenecks in their infrastructures and want to get rid of these in order to maintain or improve their competitive position compared with other regions. In many cases, lobby groups seeing an immediate benefit from improved infrastructures try to speed up decision-making processes.

Given the large amount of resources involved in infrastructure investment, it is important that these are based on realistic assessments of their benefits. Several lines of research have been developed to address the theme of infrastructure and economic performance. In the present contribution, we distinguish these approaches according to their aggregation level: aggregated versus disaggregated. At the aggregate level the impact of infrastructure on regional economic growth is studied by, *inter alia*, the production function approach and the interregional trade models. At the disaggregated level the impact of infrastructure is analysed by studying the locational behaviour of individual firms.

In Section 11.2, we will briefly discuss the main results of research on the relation of infrastructure and the productivity of firms at the aggregated – regional – level. For a broader discussion of issues related to transport infrastructure at the regional level, we refer to Bruinsma (1994), Vickerman (1995), Leitham (1996),

In this chapter, however, most attention will be directed towards the impact of transport infrastructure on the location behaviour of individual firms. In general, two approaches are used: revealed preference models, and stated preference models. An example of revealed preference models are regional location models, estimated *ex post* on the basis of actual behaviour of entrepreneurs in the past. These models try to explain the investment level of firms or the development in employment by a number of regional locational factors such as agglomeration effects, labour costs, investment subsidies, sectoral structure, accessibility of markets, and so on. Some examples of this type of research are Mills and Carlino (1989), Bruinsma et al. (1996) and Bråthen and Hervik (1997). The second type of research concerns surveys in which entrepreneurs are asked to give their view on the importance of a number of locational factors on the choice of location or the performance of their company. In Section 11.3, we give a brief discussion of the different types of studies in this field. In Section 11.4, we present a case study for the Netherlands, in which we try to overcome some of the problems that sometimes occur with stated preference studies. Section 5 rounds up with some concluding remarks.

### 11.2 Infrastructure and Productivity

A major contribution to the study of the productivity-increasing role of infrastructure was given by Aschauer (1989). In his empirical studies of production functions for the US, he found rather high values (about 0.40) for the infrastructure elasticity of production. This induced a large number of studies of the same character for other countries, and with slightly different specifications, usually supporting the validity of the approach, but leading to considerably lower estimates of this elasticity (see, for example, Munnell, 1993; OECD, 1995). These studies usually contain one indicator of the total infrastructure stock without distinctions between the various types of infrastructure. Thus, these studies do not even distinguish between transport infrastructure and other infrastructure types, let alone between different types of transport infrastructure.

It should not be forgotten, however, that in Europe already in the 1980s several studies had been carried out on the contribution of infrastructure to productivity, where much attention was paid to various types of infrastructure. For example, Blum (1982) studied the contribution of various types of transport infrastructure to regional productivity in Germany, Andersson et al. (1989) did the same thing for Sweden, and likewise Nijkamp (1986) for the Netherlands, and Biehl (1986) contains the results of a broad EU-wide study on this issue. For example, Blum found clearly significant contributions of the capacity of both long-distance highways and other roads to regional production. Even though these studies give a detailed treatment of various infrastructure types in the production function that does not mean that the ‘early’...
European studies are in all respects superior to the stream of research induced by Aschauer, because most of them have a serious drawback: they are based on incompletely specified production functions, since private capital and/or labour are not always included.

A particular feature of a transport system is that it has a network character. The opportunities to increase productivity depend on where exactly the infrastructure construction takes place. If it concerns, for instance, a missing link or an extension of a link in a congested network, the effect may be large. If it is only an extension in a region with low development potential, the effect on the national economy may be negligible (Nourzad, 2000). This network character has largely been neglected in the literature. The usual approach is that infrastructure is measured as a capital stock, either in terms of the total amount of money invested, or in terms of the length of a network. A better approach would be to focus on the services provided by the infrastructure stock (see Hakfoort and Rietveld, 2003). An example of this can be found in Johansson (1993) and Forslund and Johansson (1995) who specify a production function with accessibility to major export nodes as one of its components. Thus, accessibility is interpreted here as an indicator of the services provided by a transport network.

An attractive consequence of the approach of Forslund and Johansson is that this makes it possible to use the production function model directly for the economic evaluation of, for instance, road expansion schemes. The usual approach of Cost-Benefit Analysis (CBA), which deals with users' value of time, and the valuation of external effects of transport, is thus complemented with an analysis of the contribution of road infrastructure to higher productivity in the economy. Forslund and Johansson show that estimates of the rate of return on investments in roads as measured by standard CBA studies correlate reasonably well with estimates based on the production function technique \( R^2 = 0.50 \). It is important to emphasize here that the two concepts of the rate of return do not measure exactly the same thing. CBA includes both the benefits of consumers and the external costs, elements that are lacking in the production function approach. The two concepts overlap as far as business traffic and freight traffic are concerned. Because of this partial overlap, the outcomes of the two approaches cannot simply be added. Further reflection and research are needed to determine how this method can be used to give estimates of broader economic effects that are not included in traditional CBAs without double-counting the positive effects of infrastructure construction.

We conclude that, in a large number of studies on the contribution of infrastructure to productivity, it is found that infrastructure does play a significant role. However, most of these studies do not lead to elasticities as high as those reported by Aschauer. It should be noted that the number of studies where different types of infrastructure are distinguished is small. As a consequence, while these results support investment efforts in the field of infrastructure, they do not help to determine what type of infrastructure is needed, and neither are they useful to distinguish good from bad projects within a certain type of infrastructure. The work of Forslund and Johansson (1995)
seems to provide an interesting possibility to link the production function approach to the standard practice of CBA.

Economic theory contributes to the issue of infrastructure investments in two ways. First, production functions, as dealt with above are an important building block of the theory of production of firms. According to this theory, an improvement of an external input such as infrastructure implies a modification of the marginal productivity, and thus of the allocation of factors, and then a shift in the production function, with the effect that less private inputs are needed to produce the same volume of production. In the standard case of a Cobb-Douglas production technology, this would (in the longer run) lead to a decrease of both private capital and employment (with other technologies there may be situations where a reallocation takes place between private capital and employment.) This is, however, not the complete story, since in a competitive environment the increase of productivity would lead to lower prices, which would stimulate demand. Thus, in addition to a substitution effect away from labour towards public capital, there will also be a demand effect leading to an increase of production and hence of employment.

An important factor to be mentioned here is the price elasticity of demand: if it is high, a large increase in production volumes and hence in employment may be expected; if it is low, the latter effect will be small. Since different sectors make use of infrastructure with different intensities so that production costs will also change at different rates, shifts will take place between sectors leading to employment growth in sectors with high price elasticities and high intensity of infrastructure use, and the decline of employment in other types of sectors (Baffes and Shah, 1998). Nothing can be said about this a priori, but there does not seem to be reason to expect overall positive employment effects. There is even a reason to expect a negative effect, because the issue of the finance of the infrastructure is not included in this model. If the infrastructure is financed by a general income tax, consumption expenditures would decrease. Or, alternatively, if the infrastructure investment is financed by means of government bonds, it might raise the interest rate and savings leading to a decrease of private investment and of consumption (Agrimón et al., 1997).

Another relevant theoretical perspective concerns interregional or international trade theory (Moomaw et al., 1995). Transport infrastructure improvements lead to a decrease in transport costs, and hence stimulate interregional trade. The intensity of competition increases, with the effect that sectors in certain regions that were formerly sheltered by their isolation are now confronted with cheap imports. The result of such a shift is that consumers buy products at lower prices, but also that employment in these sectors and regions decreases. Of course, in the exporting regions at least a similar increase in employment may be expected. Thus, the theory of interregional trade predicts that in each region employment in some sectors will grow owing to the improvement of infrastructure, and other sectors will decline. The balance of the two depends on, among other things, the sectoral structure of the regions (Demetriades and Mamuenas, 2000). Much depends also on the flexibility of the labour markets. A lack of flexibility would mean, for example, that those workers who lose their job in a
The Role of Infrastructure in Location Preferences of Firms

certain sector will not be able to get a job in other sectors which have the potential to grow and therefore unemployment would increase. For a broader discussion on these issues we refer to Rietveld and Bruinsma (1998).

We have shown that infrastructure improvements may lead to shifts of employment between regions. An important question is whether these shifts lead to a more or a less equitable distribution among regions (Boarnet, 1998). To address this question, we have to take into account economies of scale. Economies of scale in production play an important role in interregional/international trade since they reinforce specialization tendencies (Holtz-Eakin and Lovely, 1996). In the presence of economies of scale, regions with an initial advantage may benefit much more from a reduction of transport costs than other regions (Krugman, 1991), leading to a process of ‘cumulative causation’ (Myrdal, 1957).

A nice example of the trade-offs between transport costs and economies of scale is given by Krugman (see Table 11.1). Production costs in the core (10) are assumed higher than those in the periphery (8) because of differences in factor costs. Because of economies of scale, production in the two locations would be even more expensive (12). Since the core market is larger than the periphery market, the total transport costs are higher when production takes place in the periphery compared with the case where production takes place in the core. Total transport costs are zero when production takes place in both core and periphery. With high transport costs, international trade is not profitable, and production will take place in both core and periphery (note that 12 is smaller than both 10 + 3 and 8 + 8). However, with medium levels of transport costs, total costs of production and transport are lowest when production takes place in the core: 10 + 1.5 is lower than both 8 + 4 and 12 + 0. Here, we observe a process of spatial polarization when infrastructure improves. However, a further improvement of infrastructure would lead to a shift of the production to the periphery, because, with zero transport costs, it would only be production costs that count.

Table 11.1 Hypothetical effects of transport infrastructure improvements on manufacturing

<table>
<thead>
<tr>
<th>Production in:</th>
<th>Production costs</th>
<th>Shipping costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Core</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Periphery</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Both</td>
<td>12</td>
<td>0</td>
</tr>
</tbody>
</table>


This example is obviously simple and partial, but it nevertheless explains important tendencies in the location of manufacturing activity due to infrastructure improvements (see Table 11.2). With high transport costs, production is dispersed; medium
transport costs lead to spatial polarization; and low transport costs lead to a shift
towards the periphery. The general situation in Europe seems to be that transport costs
have already decreased substantially in the course of time, so that a further decrease
will be especially beneficial for the periphery. This holds true in particular when the
decrease in transport costs takes place in the periphery itself. This would make the
periphery more attractive as a potential locational for manufacturing activities.

Table 11.2 Tendencies in the location of the manufacturing sector as a function
of transport costs

<table>
<thead>
<tr>
<th>Transport costs</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal location</td>
<td>Both</td>
<td>Core</td>
<td>Periphery</td>
</tr>
</tbody>
</table>

This does not necessarily imply that the periphery will eventually dominate the
core. The reason is that the process described in Table 11.2 is specific for each sector
or product. It corresponds with the life cycle of products. The eventual shift of
production activities to the periphery partly relates to products in the later phases of
their life cycle. For new products, the core will often be the more attractive location.
Thus we observe a certain division of labour where the core specializes in new
products, high tech, R&D, and the periphery is specialized in the production of goods
in their maturity or saturation phase. In addition, the command and control activities
and distribution activities tend to be attracted by the core.

Another line of research in this area concerns the work of Venables and
Gasiorek (1998) who drew attention, in the context of the report by the Standing
Advisory Committee for Truck Road Assessment of the British Department for
Transport (SACTRA, 1999), to the theme of the indirect effects of transport
investments. The point they make is that when markets are perfect the indirect
effects are entirely covered by the welfare effects on the transport markets. But, in
the case of market imperfections, it may well be that the entire welfare gains are
not well represented on the transport markets, implying that there is a need for a
much more detailed analysis of the reactions in the whole economy to the
infrastructure investment. The appropriate tool for this is the use of spatial general
equilibrium models.

From a theoretical perspective, we may conclude that there is no clear reason why
one would expect infrastructure improvements to lead to employment growth at an
overall level. In the next section, we will concentrate on the results achieved at the
disaggregated level of individual firms.
11.3 Brief Overview of Different Types of Entrepreneurial Surveys in the Netherlands

In this section, we will discuss a number of studies in which the importance of locational factors on the location and/or development (in terms of employment or investments) of firms has been investigated by interviews with entrepreneurs. We distinguish three different ways in which entrepreneurs can be asked to formulate their views on the importance of locational factors:

1. The entrepreneurs express the importance of a whole list of locational factors by either ranking them or by giving them marks.
2. The entrepreneurs give their views on the impact of a major change in one or more locational factors on the location and development of firms.
3. The entrepreneurs give their views on desired types of location.

An example of the first approach is Jansen and Hanemaayer (1991). They surveyed 1,250 Dutch firms located in the Randstad area. Respondents were allowed to give marks for locational factors on a scale from 0 to 10. The results of this study are given in Table 11.3.

Among the six most important locational factors, four relate to transport and communications, the most important one being ‘accessibility by road’. This type of result underlines that transport infrastructure is quite important for locational decisions. Nevertheless, it would be superficial to conclude on the basis of these survey results that infrastructure is a basic determinant of regional or national employment. An important reason is that the perspective used by the respondents is clearly very local. This can already be observed from the high score (rank 2) for parking facilities, which is an infrastructure type that is only useful when it is located very near to the site of the establishment. Another indication of the importance of the spatial scale in the valuation of locational factors is that Schiphol airport and Rotterdam seaport get low scores. These seem to be facilities that are useful for all locations in the Randstad (they are never more than some 80 km removed from any place in the Randstad) which is a satisfactory distance for most firms, so that seaports and airports receive low scores.

A clear gap can be observed between locational factors of above average and below average importance. This gap is between the factors ‘telecommunication services’ and ‘distance to suppliers’. Although studies of this type are interesting because they give a complete listing of the importance of locational factors in general, they have the weakness that it is not known exactly what these ratings stand for.

The second approach which is sometimes used in entrepreneurial surveys consists of interviewing managers about the perceived impacts of a major change in one or more of the locational factors on the location and development (in employment and in investments) of firms. Bruinsma et al. (1996) and Bruinsma et al. (1997) undertook such entrepreneurial surveys after the completion of the Amsterdam orbital motorway and a highway in the Eastern part of the Netherlands, respectively. Some of the results
are given in Table 11.4, where the perceived impacts of the construction of a major highway in the Eastern part of the Netherlands and of Amsterdam’s orbital motorway are presented.

Table 11.3  Reported importance of locational factors by Dutch firms located in the Randstad

<table>
<thead>
<tr>
<th>Score</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0</td>
<td>Accessibility by road</td>
</tr>
<tr>
<td>8.4</td>
<td>Parking lots visitors</td>
</tr>
<tr>
<td>8.1</td>
<td>Education employees</td>
</tr>
<tr>
<td>7.9</td>
<td>Telecommunication facilities</td>
</tr>
<tr>
<td>7.3</td>
<td>Representativity of building</td>
</tr>
<tr>
<td>6.7</td>
<td>Accessibility by public traffic</td>
</tr>
<tr>
<td>6.7</td>
<td>Price/rent building</td>
</tr>
<tr>
<td>6.1</td>
<td>Load/unload facilities</td>
</tr>
<tr>
<td>5.8</td>
<td>Expansion possibilities building</td>
</tr>
<tr>
<td>5.8</td>
<td>Status of immediate environment</td>
</tr>
<tr>
<td>5.3</td>
<td>Telecommunication services</td>
</tr>
<tr>
<td>3.8</td>
<td>Distance to suppliers</td>
</tr>
<tr>
<td>3.4</td>
<td>Access logistic services</td>
</tr>
<tr>
<td>3.2</td>
<td>Quality natural environment</td>
</tr>
<tr>
<td>3.1</td>
<td>Proximity to airport</td>
</tr>
<tr>
<td>3.0</td>
<td>Availability of educational centres</td>
</tr>
<tr>
<td>2.9</td>
<td>Presence of multinational firms</td>
</tr>
<tr>
<td>2.6</td>
<td>Proximity to seaport</td>
</tr>
<tr>
<td>2.4</td>
<td>Proximity to distribution centre</td>
</tr>
<tr>
<td>2.4</td>
<td>Presence of similar companies</td>
</tr>
<tr>
<td>2.2</td>
<td>Proximity to customs warehouse</td>
</tr>
<tr>
<td>2.1</td>
<td>Presence of knowledge centre</td>
</tr>
<tr>
<td>2.0</td>
<td>Opportunities combined transport</td>
</tr>
<tr>
<td>1.6</td>
<td>Proximity inland waterways</td>
</tr>
<tr>
<td>1.1</td>
<td>Opportunities for rail transport</td>
</tr>
</tbody>
</table>


The upper part of Table 11.4 shows the improvements that the entrepreneurs perceived by the use of the highways. The entrepreneurs experienced in particular an improvement in accessibility and travel time. In the lower part of the table the views of the entrepreneurs are given for the counterfactual case that these highways would not be constructed. Ten to thirty (20–30) per cent of the entrepreneurs expected a lower investment level and 6 to 26 per cent expected less employment if the highway was
not constructed. In 1989 – just after the opening of the highway – the percentage of firms that expected that they would have invested less and have less employment if the highway was not constructed was considerably higher than in 1994. Thus, perceptions of the impacts of infrastructure changes on employment or investments are time dependent. A tendency seems to exist that these perceived impacts become smaller as time passes.

Table 11.4 Perceived impacts of new highway infrastructure on the functioning of firms (% of respondents)

<table>
<thead>
<tr>
<th>Perceived improvements by construction of highway:</th>
<th>Highway Eastern part of The Netherlands</th>
<th>Orbital motorway Amsterdam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in accessibility</td>
<td>74</td>
<td>80</td>
</tr>
<tr>
<td>Decrease in travel time</td>
<td>78</td>
<td>76</td>
</tr>
<tr>
<td>Increase in punctuality deliveries</td>
<td>54</td>
<td>43</td>
</tr>
<tr>
<td>Decrease in costs per unit product</td>
<td>37</td>
<td>19</td>
</tr>
<tr>
<td>Increase of turnover</td>
<td>33</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perceived impacts if highway was not constructed</th>
<th>1989</th>
<th>1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company size smaller</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>Less investments</td>
<td>30</td>
<td>19</td>
</tr>
<tr>
<td>Less employment</td>
<td>26</td>
<td>17</td>
</tr>
</tbody>
</table>

Source: Bruinsma et al. (1996, 1997).

Another result of these studies is that over 90 per cent of the firms that relocate are growing firms which report that, because of lack of expansion space at the old location, they are forced to relocate. The main push factor perceived is the lack of expansion space. The pull factors are less clear, however. Amongst them, accessibility is reported to play a role. A common result is that firms in general tend to relocate over short distances.

The third type of research for which entrepreneurial surveys are used, analyses preferences of firms for various location types by means of what are called stated preference techniques. These techniques have been applied extensively in transport studies. For an overview of such applications, we refer to special issues of the Journal of Transport Economics and Policy (1988) and Transportation (1994). An example of this approach in the field of locational analysis is given by Korteweg (1992), who asked office holding companies in the Amsterdam region to choose the most attractive locational for their company on the basis of four location characteristics. These
characteristics were: 1) inside (+) or outside (–) the city centre; 2) inside (+) or outside (–) an office park; 3) close to (+) or at distance from (–) a highway ramp; and 4) close to (+) or at distance from (–) a railway station.

The results for the 16 possible combinations are given in Table 11.5. This study clearly shows that only five location profiles (1, 5, 8, 11 and 14) are preferred. All those profiles have one mutual characteristic: they are close to a highway ramp. In 91 per cent of the preferred profiles, the access to a highway ramp is included. Another interesting result is that in 81 per cent of the preferred profiles, the location is outside the city centre. However, a problem in this study is that it is not known what is the entrepreneur’s willingness to pay to be close to a highway ramp compared with being close to a railway station, inside an office park, and/or outside the city centre, when there are no financial incentives. In other words, how would an entrepreneur react if prices are included?

Table 11.5 Combinations of preferences for situational factors of office holding companies in the Amsterdam region

<table>
<thead>
<tr>
<th>Profile</th>
<th>City centre</th>
<th>Office park</th>
<th>Highway ramp</th>
<th>Railway station</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>9%</td>
</tr>
<tr>
<td>2</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>1%</td>
</tr>
<tr>
<td>3</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>1%</td>
</tr>
<tr>
<td>4</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>4%</td>
</tr>
<tr>
<td>5</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>50%</td>
</tr>
<tr>
<td>6</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>1%</td>
</tr>
<tr>
<td>7</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>1%</td>
</tr>
<tr>
<td>8</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>8%</td>
</tr>
<tr>
<td>9</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>0%</td>
</tr>
<tr>
<td>10</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>+</td>
<td>1%</td>
</tr>
<tr>
<td>11</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>10%</td>
</tr>
<tr>
<td>12</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2%</td>
</tr>
<tr>
<td>13</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>0%</td>
</tr>
<tr>
<td>14</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>8%</td>
</tr>
<tr>
<td>15</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
<td>3%</td>
</tr>
<tr>
<td>16</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1%</td>
</tr>
</tbody>
</table>

Total - - - - 100%


The results obtained by applying the first two and the third types of research may be rather different. For instance, Leitham (1996) used questions of both type 1 and 3 in an analysis of locational preferences of entrepreneurs in the Strathclyde Region of
Scotland. His analysis indicated that, when firms were asked directly (type 1), they generally attached a high degree of importance to road links, but, when asked to select the preferred locational from a set of alternatives (type 3), the weight attached to road links was much lower.

The characteristics of the applications of entrepreneurial surveys discussed above are summarized in Table 11.6 by highlighting the most important pros and cons of each approach.

Table 11.6 Strengths and weaknesses of types of entrepreneurial surveys

<table>
<thead>
<tr>
<th>Type of survey</th>
<th>Strength</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranking or rating of locational factors</td>
<td>Complete listing of locational factors: easy to apply</td>
<td>It is not clear what this ranking exactly stands for: no information on trade-offs between locational factors is given</td>
</tr>
<tr>
<td>Impact of major change in locational factor</td>
<td>Insights in how impacts of improvements are perceived</td>
<td>Difficult to isolate impact from the total context</td>
</tr>
<tr>
<td>Comparison of location types</td>
<td>Useful for spatial planning; information on trade-offs</td>
<td>Less easy to apply especially in the case of a large list of locational factors</td>
</tr>
</tbody>
</table>

Ranking or rating a complete list of locational factors has the advantage of a clear ordering of locational factors. Although this ordering is interesting by itself, it is not completely clear what this ordering actually stands for. The perceived impacts of changes in major locational factors is important because actual locational behaviour might be influenced by these perceptions. However, it is difficult to isolate the impacts of the change in the locational factors from the regional economic context. The information based on a comparison of location types is useful for spatial planning processes. But, when the list of potentially relevant locational factors is large, this method of comparing location types may be difficult to apply.

In Table 11.6 we focused on differences between methods based on entrepreneurial survey data. We must be aware that these methods share a number of problems. For example, the responses may depend to some extent on the information level of the entrepreneurs. Also, some respondents may in their response take into account the possible response of other respondents. In order to reduce the size of these problems, it is essential that respondents are given precise information about the features of the decision problem, including what has to be assumed about the behaviour of other respondents. A general problem is that, since the outcomes relate to stated behaviour, not to actual behaviour, it is not entirely certain whether the entrepreneurs will behave
according to their statements. This is a rather fundamental problem that cannot entirely be overcome, although it can be reduced by a number of research designs to correct for various biases (Hoevenagel, 1994). Further on, we note that the entrepreneurs’ responses may be influenced by their particular circumstances (for example, the importance of a railway station close by can depend upon where the railway line goes to). As will be shown in Section 11.4, by specifying the features of respondents, this type of effect can be accommodated. We conclude that several problems are connected to the use of stated preference methods, and that some of these problems are difficult to resolve entirely. The reason that stated preference approaches are nevertheless used is that they can help to overcome some of the problems with revealed preference approaches. Among these problems are a possible lack of variability among explanatory variables, multicollinearity, and the lack of observations. The ideal approach would be to combine, where possible, stated preference approaches with revealed preference approaches.

In the next section, we will carry out an analysis of the third type (entrepreneurs opinions of various locational factors). Special attention will be paid to estimating trade-offs between locational factors. Costs will be taken into account explicitly.

11.4 A Stated Preference Analysis of Locational Profiles in the Netherlands

In this section, a stated preference analysis will be used to investigate the trade-offs entrepreneurs make between seven locational factors: financial incentives and accessibility/proximity aspects. Labour cost differentials are hardly relevant at the national level, given the collective bargaining agreements. A sample of 510 observations is drawn from firms with more than ten employees in the Eastern part of the Netherlands. This part of the country contains both rural areas and a good number of medium sized cities (50,000–150,000 inhabitants). Given the limited size of the cities, we decided not to address the agglomeration economies and instead to focus on accessibility aspects. Each respondent is requested to answer five questions in which two location types are compared. The location types consist of a profile with seven locational factors. Each pair of location types compared has equal scores for five of the locational factors and different scores of the two remaining factors. Examples of the location types compared are given in Table 11.7. The entrepreneur has to select one of the two locations that each question offers. Each location is represented by two locational factors in which, in location A, the first factor has a relatively positive value and the second factor a relatively negative one. For location B the opposite holds.

Respondents were requested to compare locational profiles for a limited number of pairs. For example, 20 per cent of the respondents compared the five pairs of profiles given in Table 11.7. Other sets of pairs of profiles were generated to be judged by other respondents.
Table 11.7  Examples of choice sets in the stated preference analysis

Imagine you have to relocate your company, whatever the reason may be. Select for each hypothetical combination of locational factors the Location A or B which you prefer most. The other locational factors are assumed to be equal for A and B.

<table>
<thead>
<tr>
<th>Preferred Location</th>
<th>Location A</th>
<th>Location B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>Access to a highway at 2 km distance</td>
<td>Access to a highway at 10 km distance</td>
</tr>
<tr>
<td></td>
<td>Price of the land is €68 per square metre</td>
<td>Price of the land is €27 per square metre</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Investment subsidy of 25%</td>
<td>No investment subsidy</td>
</tr>
<tr>
<td></td>
<td>Most suppliers/customers at 30 km distance</td>
<td>Most suppliers/customers at 10 km distance</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Price of the land is €27 per square metre</td>
<td>Price of the land is €68 per square metre</td>
</tr>
<tr>
<td></td>
<td>A 1-hour bus service</td>
<td>A 15-minutes bus service</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Access to a highway at 2 km distance</td>
<td>Access to a highway at 10 km distance</td>
</tr>
<tr>
<td></td>
<td>Large city (100,000 people) at 30 km distance</td>
<td>Large city (100,000 people) at 10 km distance</td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>Distance to a railway station 500 m</td>
<td>Distance to a railway station 10 km</td>
</tr>
<tr>
<td></td>
<td>A 1-hour bus service</td>
<td>A 15-minutes bus service</td>
</tr>
</tbody>
</table>

The statistical techniques of categorical data analysis – logit and log-linear modelling provide very powerful tools for the analysis of survey data (Leitham, 1996). We use a logit model in which it is assumed that entrepreneurs value the locational factors according to a certain utility function. We assume that this utility function is linear for all entrepreneurs. For entrepreneur \( i \), the utility \( U_{jn} \) of a location \( n \) depends on the locational factors of location \( n \) according to the criteria indicated in Table 11.8:

\[
U_{jn} = a_0 + a_1 z_{i1} + a_2 z_{i2} + a_3 z_{i3} + a_4 z_{i4} + a_5 z_{i5} + a_6 z_{i6} + a_7 z_{i7} + e_{jnr} \] (11.1)
Table 11.8  Values of locational factors as used in the questionnaire

<table>
<thead>
<tr>
<th>Factor</th>
<th>Positive value</th>
<th>Negative value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to a highway access</td>
<td>2 km</td>
<td>10 km</td>
</tr>
<tr>
<td>Price of land</td>
<td>€27</td>
<td>€68</td>
</tr>
<tr>
<td>Investment subsidy</td>
<td>25 per cent</td>
<td>None</td>
</tr>
<tr>
<td>Distance to suppliers/customers</td>
<td>10 km</td>
<td>30 km</td>
</tr>
<tr>
<td>Frequency of bus services</td>
<td>four times an hour</td>
<td>one per hour</td>
</tr>
<tr>
<td>Distance to large city (100,000 inhabitants)</td>
<td>10 km</td>
<td>30 km</td>
</tr>
<tr>
<td>Distance to a railway station</td>
<td>500 m</td>
<td>10 km</td>
</tr>
</tbody>
</table>

In this function, the factors $a_j$ represent the weights (to be estimated) of the locational factors whilst the factors $z_{nj}$ represent the values of alternative $n$ according to criterion $j$. The error term $e_{ij}$ indicates that the preference of an entrepreneur also depends on many other factors, which are not included in the analysis. Therefore, this term presents the uncertainty of the model. Usually, when two alternatives are compared, not all entrepreneurs will have the same preference.

In the survey, questions were asked on several alternative location types. In the utility function discussed above, this implies that the respondents indicate whether $U_{i1} - U_{i2}$ is larger or smaller than 0. When there is a sufficient number of observations, a statistical analysis (in this case a logit model) can be used for estimating the coefficients $a_j$. In this contribution, we will not give a technical description of the model and method used. For the interested reader, we refer to Maddala (1983) and Cramer (1991). The logit model results in estimated coefficients as presented in Table 11.9.¹

Table 11.9  Results of the logit model

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coefficient</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to a highway access</td>
<td>–0.1637</td>
<td>–10.1</td>
</tr>
<tr>
<td>Price of land</td>
<td>–0.0235</td>
<td>–15.7</td>
</tr>
<tr>
<td>Investment subsidy</td>
<td>0.0645</td>
<td>11.7</td>
</tr>
<tr>
<td>Distance to suppliers/customers</td>
<td>–0.0510</td>
<td>–7.6</td>
</tr>
<tr>
<td>Distance to a large city</td>
<td>–0.0468</td>
<td>–7.0</td>
</tr>
<tr>
<td>Distance to a railway station</td>
<td>–0.0219</td>
<td>–1.5</td>
</tr>
</tbody>
</table>

- log likelihood: 1221.9
- log likelihood (all coefficients equal to zero): 1437.6

All coefficients have the expected sign. For most explanatory variables this sign is negative, which is as expected because the variables can be interpreted as ‘costs’
The Role of Infrastructure in Location Preferences of Firms

The only positive coefficient is found for investment subsidies, which is as expected because this variable can be interpreted as a ‘benefit’. It also appears that five of the six locational factors differ significantly from zero. The only exception is the distance to the nearest railway station, which is as expected negative but not in a significant way. Most significant are the price of land and investment subsidies, while access to the highway is the third most significant variable.

In this specification of the model, it appears that 69.7 per cent of the responses are correctly predicted. This is – compared with other analyses with this specification – a fairly good result, although a specification with random answers would already result in 50 per cent correctly predicted answers.

The interpretation of the coefficients $\alpha_j$ in Table 11.9 is ‘utility’ per ‘unit $z_j$’. Because we are not in the first place interested in the value of the coefficients themselves, but in the trade-offs (relative weights) between the factors, the ratios of the coefficients may provide interesting insights. When we take the distance to a highway access as a starting point, the next trade-offs are found. To keep the level of utility constant, a 1 km reduction of the distance to the nearest highway access should be accompanied by one of the following changes:

- a rise of the price of land by about €3.2 per square metre;
- a reduction of an investment subsidy of about 2.5 per cent;
- an increased distance to the most important customers/suppliers by about 3.2 km;
- an increased distance to the nearest large city by about 3.5 km;
- an increased distance to the nearest railway station by about 7.5 km.

For the results discussed until now, we used the most simple specification of the model. In this model, no variables were included that indicated the specific features of a company: all respondents were supposed to use the same weights. In order to broaden the scope of the analysis, we repeated the analysis and added some company-specific features (amongst others: size, economic sector, and current location vis-à-vis a highway). For each of these features, an extra variable has been added, which is defined as the product of the initial value and a dummy. For example, for the variable ‘sector’, a dummy variable has been added which has the value ‘1’ when the company is a manufacturing company and a value ‘0’ in all other cases. The dummy variable for ‘scale’ received the value ‘1’ if the company has more than 50 employees, and the dummy ‘current location’ indicates whether the company is located more than 7.5 km away from a highway access.

In this way it can, for example, be analysed to what extent small companies give different weights than large companies to locational factors.

From the estimation results it appears that these differences are not very large, in general. The coefficients of the dummy variables are in most cases not significant. The largest differences are found in the sector-specific estimation (see Table 11.10). In the upper part of Table 11.10, the coefficients relate to non-manufacturing firms.
these values are rather close to those in Table 11.9. In the lower part of Table 11.10, the coefficients give the shifts in the importance of locational factor when we compare manufacturing with non-manufacturing firms. It appears that manufacturing companies value the distance to customers/suppliers and the nearest city significantly lower (this can be inferred from the positive coefficients found and the high t-values).

Table 11.10 Results of the logit model (dummies for economic sectors included)

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to a highway access</td>
<td>-0.1892</td>
</tr>
<tr>
<td>Price of land</td>
<td>-0.0236</td>
</tr>
<tr>
<td>Investment subsidy</td>
<td>0.0651</td>
</tr>
<tr>
<td>Distance to suppliers/customers</td>
<td>-0.0696</td>
</tr>
<tr>
<td>Distance to a large city</td>
<td>-0.0635</td>
</tr>
<tr>
<td>Distance to a railway station</td>
<td>-0.0288</td>
</tr>
</tbody>
</table>

Dummies for the manufacturing sector:

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to a highway access</td>
<td>0.0507</td>
</tr>
<tr>
<td>Price of land</td>
<td>-0.0010</td>
</tr>
<tr>
<td>Investment subsidy</td>
<td>0.0017</td>
</tr>
<tr>
<td>Distance to suppliers/customers</td>
<td>0.0412</td>
</tr>
<tr>
<td>Distance to a large city</td>
<td>0.0375</td>
</tr>
<tr>
<td>Distance to a railway station</td>
<td>0.0150</td>
</tr>
</tbody>
</table>

- log likelihood: 1207.7
- log likelihood without industry dummies: 1221.9

For the other estimations, we restrict ourselves to a qualitative presentation of the results. The size of a company has no significant impact on the weights given to the distinct locational factors $a_i$. Entrepreneurs who are now located at a distance more than 7.5 km away from a highway access, however, value this criterion significantly lower. This is a nice result since it implies consistency between ‘revealed preference’ information, as indicated by the actual location of firms, and stated preferences, as investigated here. Firms that are at present located further away from highways have apparently managed to adjust to such a location type so that their valuation of this location aspect is relatively low. If they really had attached a high value to highway accessibility, they would never have settled at this location, or they would already have moved earlier. Furthermore, it appears that companies which are located relatively far from a highway access give a relatively low value to the locational factors ‘distance to a large city’ and ‘distance to a railway station’. On the other hand, it appears that these
companies are relatively sensitive to financial variables such as price of land and investment subsidies.

11.5 Concluding Remarks

The conclusion is that the major role of infrastructure concerns its contribution to consumer welfare and productivity. In this chapter we discussed the impact of infrastructure on the economic performance of firms on the aggregated level of regions and the disaggregated level of individual firms. The emphasis is, however, on the level of individual firms.

At the aggregated level, regional production function models and interregional trade models show that there is little basis to expect that infrastructure construction would boost productivity or employment. Infrastructure construction in peripheral regions may lead to a spatial reorientation of employment and this might be beneficial for the peripheral regions, although higher accessibility may be a risk for regions that have little to offer on the market. Research results on the impacts of infrastructure construction usually do not lead to the conclusion that large interregional employment shifts take place.

At the disaggregated level of individual firms, in particular stated preference approaches are applied in research on locational behaviour of firms. Surveys are used for three different purposes: 1) to rank a whole list of locational factors; 2) to investigate the impact of a major change in one or more locational factors on the location and/or the development of companies; and 3) to measure preferences for different combinations of locational factors.

A problem with many of the studies using this approach is that the results cannot be interpreted in terms of trade-offs between locational factors. Therefore we carry out a pairwise comparison approach which does enable trade-offs to be investigated.

It appears that locational factors with direct financial implications (price of land and investment subsidy) are the most important factors. Distance to a highway access, distance to a large city and distance to customers and clients are factors of a second order. The factors concerning public transport (distance to a railway station and the frequency of bus services) are least important. The relatively low willingness to pay for public capital is in line with the findings of Haughwout (2002) for a sample of large US cities. He finds empirical evidence that the marginal productivity of public capital is low, so that it is no surprise to find a low aggregate city willingness to pay for large increases in public capital.

The logit analysis enables trade-offs between the seven locational factors to be investigated. These trade-offs make it possible, for instance, to calculate the cost effectiveness of different regional policy measures, as far as they concern the interest of firms for newly developed industrial sites. By using these trade-offs, national or regional governments can compare the pros and cons of investments in public
transport, and in highways, and then provide more investment subsidies, or offer a lower price of land on industrial sites.

Acknowledgements

The authors wish to thank the two anonymous referees for their comments on an earlier version of this chapter.

Notes

1 In the equation used, it is not possible to estimate the constant term \( a_0 \) of the utility function because the estimations are based on the comparison of alternatives. The constant term disappears in these equations. Therefore, the logit model is estimated without a constant term. Moreover, it appears that, given the chosen values of the scores of the locational factors, there exists an independency in the matrix with the observations of the explanatory variables. The resulting multicollinearity problem is solved by giving the coefficient of the least important locational factor – the frequency of bus services – the value zero.

2 The trade-off interpretation is possible because the independent variables (though dichotomous) were measured as continuous variables (see Table 11.8). In the calculations, the relations between the locational factors \( z_j \) and utility are supposed to be linear. This means that an increase in distance to a highway from 1 to 2 km is supposed to be equal to an increase from 9 to 10 km. Of course, other specifications are possible here.

3 In a technical sense, we introduce interaction effects by using this specification. The introduction of an extra main effect is of no use in this situation, because such an effect will disappear when pairs of alternatives are compared. The reason is that the estimation concerns the differences in utility values of two alternatives as judged by a specific entrepreneur. In such a situation, it is not possible to estimate a constant term.

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The Role of Infrastructure in Location Preferences of Firms


The Spatial Consequences of Air Transport Deregulation: An Overview of the French Case since 1995

Pierre Zembri

12.1 Introduction

In 1984 the European Community chose a progressive liberalization of air transport, to be accomplished in several stages between 1987 and April 1997. This process did not leave the networks unharmed, as demonstrated by the North-American case since 1978, which has been studied by many authors (Button, 1991; Oum et al., 1990, and others). Some companies disappeared completely, some others were strongly restructured, and new operators entered the market on various scales. New strategies of service appeared, with in particular the adoption of hub and spokes structures (O’Kelly, 1998). In addition, new companies, based on a radically different economic model, appeared with the explicit objective to collect a significant share of the market, their favourite weapon being lower prices and ‘no frills’ service, that is, the Low Cost Carriers (LCCs).

Compared with North America, the European market is characterized by a significant compartmentalization on a national basis. The defence of the flag carrier remains a priority at whatever the price, as seen in the recent examples of the former Swissair (which became Swiss) and of the former Sabena (SN Brussels Airlines). Air traffic management itself remains divided. There are no common rules for the allocation of the capacities (slots) among the various carriers in airports. Even if the deregulation process has been enacted on a continental scale, rare are the candidates who have the ambition to operate at this scale while not focusing on a single base in their country of origin.

There has now been a sufficient lapse of time since the beginning of the process to measure the many and profound changes in the domestic networks in Europe, and in particular in France, the largest domestic market of the Union before liberalization thanks to precocious development by a very imaginative company, Air Inter. This chapter accounts for the first results of research in progress on the spatial effects of air deregulation in France and in Europe. We chose to measure the variation of the accessibility of cities which did not host a major gateway in 1997. The development of direct domestic and international links outside of major
Policy Analysis of Transport Networks

hubs, in particular with neighbouring countries, does indeed seem to be a positive (and unplanned) consequence of this deregulation.

Did cities lose in quantity and of quality of service with the deregulation? What has been the change in the panel of destinations directly accessible from a given airport? Have new hubs appeared at the national level? And are windfall gains long-lasting for their catchment area? These questions will initially be addressed to the French cities, and in a later phase to the cities of other neighbouring countries.

We will first focus on the strategies of the main players in the air transport industry (national and regional companies as well as newcomers). Then, we will cover the changes in accessibility of the main French cities in connection with the installation of half a dozen new regional hubs, and the progressive intrusion of low-cost carriers. Lastly, we will attempt to determine whether the current situation is still likely to evolve, by taking into account recent player regroupments and the development of the high speed train network which has widened the field of competition.

12.2 Weaker Competition than Expected on the Busiest Domestic Routes

This first observation was quite unexpected – a current hypothesis is that newcomers in a market focus the competition on the segments which previously had been developed the most by the existing companies. As regards domestic air transport, at the beginning of the 1990s the routes with the highest frequentation were a half a dozen radial connections between Paris and the other main towns being at least 500 km away, the competition of the TGV (the French high speed train) having been felt significantly at distances below this limit. These main routes, representing 60 per cent of French air traffic, were the first opened to competition in 1995 on a national scale (Paris-Marseille, Paris-Toulouse, Paris-Nice, Paris-Bordeaux, Paris-Strasbourg, and Paris-Montpellier).

However, as early as 2000, Air France was the sole operator to remain on the Paris-Strasbourg corridor. A few months later (2001), the failure of the ‘second competition pole’ around Sair Group resulted in the return to an almost total monopoly of Air France on these most important routes. Between January 2003 (end of Air Lib’s operations) and June 2003, the monopoly was complete; as of this date, two new candidates (Aeris, EasyJet) tried to dispute the monopoly but with too few financial margins for the former (in bankruptcy four months after the beginning of operations) and too few slots for the latter. Contrary to this rather disappointing assessment, competition was much more active on direct connections around the two Parisian airports of Orly and Roissy-Charles de Gaulle (CDG).
12.2.1 Only a Few Main Routes Were Concerned by Competition

It is a fact that any air passenger to or from Paris can easily assess: rare are the routes where he will have a real alternative between two companies or more. Air France has continued to benefit from its *de facto* monopoly on the great majority of the radial routes, its fares being undeniably higher than those in 1996 (Table 12.1), if some special offers with restrictions are excluded.

### Table 12.1 Changes in Air France fares on four main radial routes

<table>
<thead>
<tr>
<th>Route</th>
<th>One-way fares, 1997</th>
<th>One-way fares, 2000</th>
<th>One-way fares, 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paris-Strasbourg</td>
<td>€126.00</td>
<td>€171.00 (+35.8%)</td>
<td>€225.36 (+79.65%)</td>
</tr>
<tr>
<td>Paris-Montpellier</td>
<td>€151.00</td>
<td>€198.00 (+31.1%)</td>
<td>€254.36 (+68.45%)</td>
</tr>
<tr>
<td>Paris-Toulouse</td>
<td>€145.00</td>
<td>€189.00 (+30.3%)</td>
<td>€280.36 (+93.35%)</td>
</tr>
<tr>
<td>Paris-Nice</td>
<td>€165.00</td>
<td>n.a.</td>
<td>€304.36 (+84.46%)</td>
</tr>
</tbody>
</table>

*Notes:* All prices in current currency (inflation was very weak during this period). The prices in FRF (1997 and 2000) have been converted into euros, according to the legal parity: €1.00 = FRF 6.55957. All changes given in percentages are calculated from 1997. All taxes included.

The reasons are multiple. The first phase of competition, short but very keen, which took place during the first year, resulted in the withdrawal of a competitor (Euralair), and the near bankruptcy of three others (Air Liberté, TAT and AOM) which were forced to open their capital, the two former to British Airways, the latter to the Crédit Lyonnais bank. If newcomers, AOM excepted, had built their strategy of market conquest on a price war which they could not afford to sustain for very long, Air Inter (then Air France*) reacted by offering more frequent flights. This was possible because the flag carrier had large reserves of slots in the Paris airports, where it was still dominant in 2003. The official saturation of the Parisian airports was a good reason to refuse new slot allocations to newcomers, and there has been no general reallocation since. In addition to these factors should be included the constitution of Roissy-CDG as intercontinental ‘hub’ by Air France, which easily allowed it to be the leader on the pre-routings market by directing more domestic flights towards this platform to which its competitors did not have access.

In 2000, competition on the radial routes was much weaker than in 1997 (Table 12.2). Only the Paris-Nice route included three competitors, four other routes had only two routes and Paris-Strasbourg was again becoming an Air France monopoly. In December 2003, Air France was the only company to operate on three of the six connections and its current competitor begin hardly its operations on the three other routes.
Air France really had no need to worry about its competitors on the main routes. They could not compete with the national company in terms of frequencies, and any price war would have been suicidal because of their frail financial health. Between May 2000 and the end of 2001, it was led to believe that a second French pole was to be created with the announced merger of AOM, Air Liberté and Air Littoral, all new subsidiaries of the Sair Group (head office of Swissair). This competitor would have represented 30 per cent of the domestic market, a hundred aircraft and a total turnover of €1.5 billion. However, the fall of Swissair involved the *de facto* dismemberment of this stillborn pole. In 2002, the merger of AOM and Air Liberté under the commercial name Air Lib, and then the revival by this new entity of a price war on the Paris-Nice, Paris-Toulouse and Paris-Marseille routes, was merely a last-ditch struggle. In January 2003, the French government put an end to this adventure (the fiscal and social debt of Air Lib amounted to more than its capital), causing the immediate and definitive disappearance of the company.

While the competition was turning to the advantage of Air France on the main routes, some new networks of interregional and international connections that bypassed Paris were being set up, creating the conditions for a considerable opening of the French provinces towards other territories.

### Table 12.2 Changes in competition on the six ‘millionaire’ routes in 1996, 2000 and 2005

<table>
<thead>
<tr>
<th>Routes</th>
<th>Competitors, 1996</th>
<th>Competitors, 2000</th>
<th>Competitors, 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paris-Nice</td>
<td>Air Inter, AOM, Air Liberté</td>
<td>Air France, AOM, Air Liberté</td>
<td>Air France, EasyJet</td>
</tr>
<tr>
<td>Paris-</td>
<td>Air Inter, AOM, TAT Air Liberté</td>
<td>Air France, AOM, Air Liberté</td>
<td>Air France, EasyJet</td>
</tr>
<tr>
<td>Marseilles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paris-</td>
<td>Air Inter, Air Liberté, Euralair, TAT</td>
<td>Air France, Air Liberté</td>
<td>Air France, EasyJet</td>
</tr>
<tr>
<td>Toulouse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paris-</td>
<td>Air Inter, Air Liberté</td>
<td>Air France, Air Liberté</td>
<td>Air France</td>
</tr>
<tr>
<td>Bordeaux</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paris-</td>
<td>Air Inter, AOM, Air Liberté</td>
<td>Air France, Air Liberté</td>
<td>Air France</td>
</tr>
<tr>
<td>Montpellier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paris-</td>
<td>Air Inter, Air Liberté</td>
<td>Air France</td>
<td>Air France</td>
</tr>
<tr>
<td>Strasbourg</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Notes:* Only till 31 March Air France is the sole carrier after this date.
12.2.2 New Hub and Spoke Networks Enabled a Real Opening of the Market and Real Competition on Interregional and International Routes Bypassing Paris

Before liberalization, it was nearly impossible to fly from one French city to another and avoid transiting via Paris; the situation was the same for the connections between French towns and other countries. Only a handful of companies, known as ‘third level’ firms, such as TAT, Air Vendée or Air Littoral operated some point-to-point cross-country connections (Tours/Poitiers-Toulouse, Caen-Rennes, Rennes-Brest, Nantes-Toulouse, and so on.). By 1993 Air Inter had gradually founded a ‘rendezvous’ in Lyon, a forerunner of the regional hubs, from which three to four rotations per working day made it possible to reach eight cities without a compulsory transit via the Parisian platforms. Seven other direct low frequency4 routes, and a certain number of seasonal connections on summer weekends (Lille-Montpellier, Nice-Nantes, Toulon-Lille, and so on) were also on offer.

Insofar as most of the competitors before deregulation were third level companies (TAT, Air Littoral, Regional Airlines5), they tended to develop their network starting from the pre-existent core of routes, developing regional hubs6 in airports where they had been able to develop satisfactory relationships with the owners (generally local Chambers of Commerce). Except for TAT, which preferred attempting to develop a network centred on Paris while preserving its regional ‘historical’ routes, they developed coherent strategies in order to avoid Parisian platforms and to open up the rest of the country towards Europe. This explains the flowering of new regional hubs, either in central positions within the territory (Clermont-Ferrand for Regional Airlines, Saint-Etienne for Proteus, or in peripheral positions like Montpellier or Nice (Air Littoral).

In parallel, between 1997 and 1998, Air France empowered its interregional direct services considerably by reactivating the Lyon platform, and once this was accomplished, by transforming various regional airports like Strasbourg, Lille, Bordeaux, Nice and Nantes in as many hubs with five, six and even seven branches. This development strategy constituted a frontal attack against carriers who had chosen to avoid any direct confrontation with the national company on the radial routes. All the players thus seemed to consider that the most significant potential for development was on this emerging market of small cross-country flows, including Air France – the one which was least aware of this fact – taking into account its usual scale of operation.

Up to the emergence of the Air France network’s secondary hubs, we can consider that competition was only partial, and that there was only minor complementarity between networks. Central and peripheral hubs could compete only over a limited portion of the territory. Thus, for example, both Regional Airlines and Air Littoral offered combinations between Bordeaux, Toulouse, Nice, Marseilles and Lyon. However, it was difficult for the latter to compete efficiently with the former on Bordeaux-Lille or Lyon-Rouen. The progressive integration of
the networks into one of the two large national competitive poles radically changed the situation.

12.2.3 This Situation Has Pushed Air France to Multiply Alliances and Takeovers in Order to Remain the Market Leader

In essence Air France has neither the intention nor the technical capability to operate small volume routes. These services require small capacity planes with a seating capacity of less than 100, aircraft that the national company does not own. It has often, like Air Inter in its day, chartered or franchised third level companies like Brit Air or Air Littoral on the less-frequented routes. This phenomenon of regular subcontracting was then extended to some short- and medium-haul international flights in the Air France network, the case today on Paris-Hanover, Paris-Nuremberg or Paris-Southampton.

This movement became systematic within the political development framework of secondary hubs, with a progressive change from simple franchising to vested interests in the capital of the subcontractors. It is also (even especially) for the ‘historical’ carrier a means of preventing the small carriers, who possess the know-how to develop effective hubs and partnerships with foreign companies, from being used as ‘Trojan horses’ by potential competitors. The competition, initially led by British Airways, then more recently by Swissair, gained ground, being ensured of strong partnerships with well-established regional companies. Some of the latter developed complex partnership strategies to avoid being completely dependent on a single major company: Regional Airlines was at the same time (1998) the ‘partner’ of Air Liberté and chartered by Air France, while developing partnerships with KLM, Lufthansa, Alitalia, SAS, Iberia. This ‘multisubjection’, which offered to the passengers of the company the choice of five gateways, could pass at the same time for the demonstration of a willingness towards independence.

In a very different way from British Airways, which had only developed partnership agreements revocable at any moment with regional companies, Air France and Swissair preferred rather to dominate or even acquire other companies in order to boost their market position. The former developed charter contracts and franchising from the very beginning of the liberalization process, before passing to the acquisition of Proteus and the purchase of the majority of the shares (70 per cent) of Regional Airlines. The latter entered into force on the French domestic market by purchasing Air Liberté (which was still operating small routes of the former TAT) and Air Littoral one after another.

The market reconfigurations produced by the above strategies are summarized in Figure 12.1.
The Spatial Consequences of Air Transport Deregulation

Figure 12.1  The reconfigured market – 1998 to 2004
12.3 An Appreciably Increased Accessibility for French Regions

The intensive capital manoeuvres that occurred between 1998 and 2002 completed a process of cross-country route and regional hub development which completely and positively transformed the accessibility to many provincial towns, somewhat in contradiction with the initial forecasts. The extreme lack of use of the Fund for Air Transport Equalization (FPTA	extsuperscript{7}), created in 1995 to allow the survival of the weakest routes compromised by deregulation, constituted an eloquent indicator of this unexpected change. The French cities acquired notably improved accessibility, which we will endeavour to quantify.

12.3.1 The New Hubs: Considerable Windfall Gains for the Cities which Accommodate Them

In 1998 the French Civil Aviation Authority (DGAC) distinguished seven hubs on the national metropolitan territory (Table 12.3).

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Paris-CDG</td>
<td>Air France</td>
<td>38.600</td>
<td>428,537</td>
<td>49.8%</td>
<td>+36.5%</td>
</tr>
<tr>
<td>Nice Côte d’Azur</td>
<td>Air Littoral</td>
<td>8.086</td>
<td>204,085</td>
<td>8%</td>
<td>+31.3%</td>
</tr>
<tr>
<td>Lyon Satolas</td>
<td>Air France</td>
<td>5.211</td>
<td>108,374</td>
<td>40.4%</td>
<td>+17.6%</td>
</tr>
<tr>
<td>Basel-Mulhouse</td>
<td>Crossair</td>
<td>2.960</td>
<td>126,052</td>
<td>31.7%</td>
<td>+25.5%</td>
</tr>
<tr>
<td>Montpellier</td>
<td>Air Littoral</td>
<td>1.533</td>
<td>102,806</td>
<td>12.6%</td>
<td>+24.2%</td>
</tr>
<tr>
<td>Clermont-Ferrand Airlines</td>
<td>Regional Airlines</td>
<td>0.728</td>
<td>62,741</td>
<td>45.6%</td>
<td>+98.7%</td>
</tr>
<tr>
<td>Saint-Étienne</td>
<td>Proteus</td>
<td>0.194</td>
<td>36,877</td>
<td>14.2%</td>
<td>+132.0%</td>
</tr>
</tbody>
</table>


Obviously of varied sizes, it should be noted that, except for Air France at Paris-CDG as in Lyon and Regional Airlines in Clermont-Ferrand, the based carriers were far from being prevalent in the traffic of their airport hub. This was due to the
relative importance of the radial routes ensured by Air France – older and served by medium-sized planes (c. 100 seats). The new candidates’ transverse routes are served almost exclusively by low capacity planes, with frequencies which seldom exceed 3 to 4 rotations per working day.

In terms of change, all the hubs had over three years generated two-digit growth, and even three-digit in the very particular case of Saint-Etienne. It is, however, necessary to relativize the impact of the choice of Nice by Air Littoral on the growth of this platform, taking into account the poorness of its share of the total traffic (8 per cent). The largest part of the growth of the airport traffic is due to the opening of new routes by third parties, sometimes very aggressive commercially, like EasyJet (three routes, 450,000 passengers in 1998) which drains for itself 50 per cent of the Air Littoral passengers over the same period.

The ‘hub and spoke’ structure is intended to homogenize global flight times and the possibilities of connections from any network point to any other (connexity), while avoiding multiplying direct flights for which maximum loading factors would have proved problematic (Varlet, 1997). Even if a stop is compulsory during the trip, the total time remains definitely lower than by train or by car. In the French case, it is necessary to underline that, between regions or between any region and foreign country or countries, a compulsory stopover has always been the rule, though with some rare exceptions taking into account the radial structure of the then Air Inter (today Air France) network. One can note that the connections at the two Parisian platforms definitely require more transit time than at smaller airports. The ‘hub and spoke’ structure could be a solid sales point for provincial customers irritated by time wastage in Paris; a company like Regional Airlines did not fail to use this argument, thus popularizing a technical term up to that point only known by those rare initiates.

De facto, this also developed the city in which the hub is located, creating a considerable windfall effect. If we focus on the case of Clermont-Ferrand, 19 French destinations and six European ones with service two to three times daily were gradually offered, whereas before only one route to Paris was in operation. In the previous case of better served platforms like Nice, the windfall gain is less important insofar as the tourist attractivity of the French Riviera justified the creation of several point to point domestic or European routes.

The progressive change in these platforms’ network scale created the conditions for real competition for medium- and long-haul links. The passenger living away from the Paris area discovered real alternatives to the former mandatory transit via the major Air France (Roissy-CDG) hub. Certain competitors maintained this strategy, without forcibly depending on a large foreign carrier. Thus Regional Airlines, before its purchase by Air France, had concluded agreements with five large European airline companies, offering up to five choices on intercontinental connections like Clermont-Ferrand-New York or La Rochelle-Rio. The fact that these same large European companies come to pick up passengers on certain large platforms, either by themselves or via a ‘partner’ regional carrier, could have caused the national company some concern: for example, Nice dispatches one
Policy Analysis of Transport Networks

million passengers annually towards London and only 670,000 towards Paris-

CDG.

Table 12.4  Traffic change at airports currently or having been regional hubs

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyon</td>
<td>Air France</td>
<td>Yes</td>
<td>5.211</td>
<td>5.509</td>
<td>6.026</td>
<td>6.115</td>
<td>5.787</td>
<td>5.953</td>
</tr>
<tr>
<td>Clermont-Ferrand</td>
<td>Regional Airlines</td>
<td>Yes</td>
<td>0.728</td>
<td>0.873</td>
<td>0.940</td>
<td>0.863</td>
<td>1.090</td>
<td>0.955</td>
</tr>
<tr>
<td>Bâle-Mulhouse</td>
<td>Crossair (Swiss)</td>
<td>Yes</td>
<td>2.960</td>
<td>3.581</td>
<td>3.765</td>
<td>3.536</td>
<td>3.057</td>
<td>2.486</td>
</tr>
<tr>
<td>Montpellier</td>
<td>Air Littoral</td>
<td>No</td>
<td>1.533</td>
<td>1.636</td>
<td>1.750</td>
<td>1.546</td>
<td>1.565</td>
<td>1.568††</td>
</tr>
<tr>
<td>Saint-Étienne</td>
<td>Proteus</td>
<td>No</td>
<td>0.194</td>
<td>0.167††</td>
<td>0.130</td>
<td>0.127</td>
<td>0.112</td>
<td>0.115</td>
</tr>
<tr>
<td>Bordeaux</td>
<td>Air France</td>
<td>Yes</td>
<td>-</td>
<td>2.918††</td>
<td>3.066</td>
<td>3.077</td>
<td>2.932</td>
<td>2.823</td>
</tr>
<tr>
<td>Le Havre</td>
<td>Regional Airlines</td>
<td>Yes</td>
<td>-</td>
<td>0.139</td>
<td>0.118</td>
<td>0.060</td>
<td>0.050</td>
<td>0.065</td>
</tr>
</tbody>
</table>

Notes:
† Last year of operation as a hub.
†† First year of operation as a hub.


A more recent point shows that only four of these hubs still survive (Paris, Lyon, Clermont-Ferrand and Mulhouse). The reasons for this high mortality rate will be explained below (Section 12.4.1). Among these airports, Clermont-Ferrand is the one which benefited the most from its promotion: reaching more than one million passengers in 2002 (+27.9 per cent compared with 2001, +45.6 per cent compared with 1998), it became the 12th national airport. In the meantime, two other regional hubs were created: Le Havre (Regional Airlines) and Bordeaux (the new Air France ‘Iberian gate’). Table 12.4 above shows the traffic change from 1998 to 2003.

12.3.2  A Generalized Widening of Destination Range Offered Initially by the Vast Majority of the French Airports

If the development of regional hubs outside of Paris opened possibilities for the airports concerned, it also modified the overall accessibility of many cities affected by several networks which had been either partial competitors or complementary if
they belonged to the same group. The possibilities of relationships between provincial towns were multiplied overall in time less significantly than those of the services of the French Railways (SNCF), as the two examples show below (Figure 12.2). In both cases, it can be seen that Air France considerably increased its deterrent force by taking over Regional Airlines.

Figure 12.2 Two examples of the multiplication of air transport possibilities between provincial towns (official timetables, working days, summer 2003)

Though remaining within the Air France nebula, many regional capitals saw the number of direct connections with other cities increase considerably, particularly in the case of Rennes from which 24 direct flights (working days) to 11 different destinations were possible, offered by two companies (Figure 12.3).
Also could be quoted is the case of Bordeaux, the promoted gateway to the Iberian peninsula from the French regions: 19 destinations were accessible directly, including nine foreign ones. These mini-hubs were developed by Air France, which used the planes of its subsidiaries like Regional, Proteus or Brit Air to ‘explore’ the new routes.

12.3.3 The Recent Surge in LCCs Has Widened the Range of Destinations and Opened Small Platforms to International Traffic

This phenomenon is far from being marginal, insofar as it concerns an increasing number of airports, and as the generated traffic has been on the increase in very significant proportions. A recent synthesis of the DGAC (DGAC, 2003) reports a progression of 85 per cent between 2001 and 2002! From 1.285 million passengers
in 1999, the traffic jumped to 5.130 million passengers in 2002, that is, to say fourfold.

So far, this phenomenon is the exclusive domain of foreign companies if the unachieved and suicidal incursion of Air Lib in 2002 is excluded. In fact, Britain generates the majority of the traffic (58.9 per cent), but this proportion has been dropping regularly, whereas other countries’ (Germany, Sweden, Belgium) share has been progressing.

Taking into account the above-mentioned shortage of slots in the two major Parisian airports (Roissy-CDG and Orly), LCCs have mainly invested in regional and sometimes very small-sized airports. This is illustrated by the case of Buzz in 2002 (Figure 12.4). They have primarily set up routes between French regions and foreign countries, taking part only very marginally in competition on domestic flights: in 2002, they transported only 283,000 passengers compared with 5.129 million passengers on international connections (DGAC, 2003).

Figure 12.4 French airports served by Buzz just before its purchase by Ryanair (2002)

In 2002, the LCCs were serving 28 French airports. They have recorded variable traffic according to the size of the airport and the number of companies stopping at it. We propose the following typology based on each airport’s market share:

a) **Very weak market share at airports with high levels of traffic**: Paris CDG (1.6 per cent), Paris Orly (0.9 per cent), Lyon (1.2 per cent), Toulouse (1.1 per cent), Strasbourg (1.5 per cent), and so on.
b) **Average market share at regional airports:** Biarritz (14.8 per cent), Caen (19.3 per cent), Limoges (24.6 per cent), Grenoble (27.6 per cent), Rouen (28.2 per cent), and so on.

c) **Prevailing market share at small airports:** Beauvais (90.5 per cent), Carcassonne (99.7 per cent), Dinard (76.3 per cent), Bergerac (77.9 per cent), Tours (90.5 per cent), and so on.

d) **Average market share at airports with high levels of traffic:** It is the particular case of Nice, the second-largest French airport after Paris, where the share of LCCs borders on 20 per cent. Nice handles eight different LCCs, which can be explained by the tourist attraction of the French Riviera and by the absence of alternate airports in the vicinity. Do carriers really have the choice?

The chart of the services parallels that of British citizens’ holiday homes in France, with the western half of the country clearly prevalent: Brittany, Normandy, the Tours region and Loire river valley, the Poitiers region, Périgord and Aquitaine are all directly connected to London.

With rare exceptions, they are not very frequent services. For a French regional airport, a daily flight four to six times weekly seems to be the standard level. Concerning schedules, they are those which the company sets. Most outbound flights are scheduled after 22.00 hours (10.00 pm). From France, it is generally impossible to spend a whole day or even half a day at the destination.

We can temporarily consider that, in the current situation, the LCCs first of all target foreign customers in search of direct low-cost flights. Competition with the ‘classical’ companies will be frontal only if LCCs develop more high-frequency domestic flights or services between major European cities.

### 12.3.4 More Contrasted Changes in Services Between Paris and Other French Cities

Two periods must be distinguished between 1993 and 2003, with a hinge around 2000. At first, Air France, confronted with the rise in competition on its best routes, developed the maximum amount of its frequencies on them. Concurrently, the rise in prevalence of the intercontinental hub at Roissy-CDG imposed an increase in frequencies of flights towards it. The destinations concerned there thus gained doubly. After 2000, competition became less intense (except from the TGV) and a series of crises struck the air transport industry in general (the 11 September 2001 attacks, the Iraq war, and so on). Air France reduced its network and redefined its frequencies selectively.

Focusing only on the change in the Air France-Air Inter network between 1993 and 2000, it is obvious (Figure 12.5) that all the destinations in continental France did not undergo the same changes quantitatively. While the ‘millionaire’ routes were particularly favoured with the introduction of hourly services under the commercial name *La Navette* (The Shuttle) and the intensification of connections Roissy-CDG, the number of flights for other destinations changed only very
slightly. Three destinations (Grenoble, Tarbes and Saint-Etienne) kept exactly the same number of services as in 1993. In addition, nine cities are still not directly connected to Roissy-CDG: Quimper, Béziers, Nimes, Tarbes, Avignon, Grenoble, and the three Corsican airports.

Source: Official schedules.

Figure 12.5 Change in radial routes of the Air France group between 1993 and 2000
No reduction in service is to be noted except for the wave of cuts in 1996 which affected Toulon, Perpignan and Nantes, the first two largely compensated by the arrival of AOM and Air Liberté.

On routes where competition remains, the total number of services increased considerably by cumulating concurrent offers. Thus, on Paris (CDG and Orly)-Nice, not less than 48 daily flights (working days) were offered in each direction, compared with the 21 flights offered in 1993 by Air France and Air Inter. On Paris-Toulouse, the cumulated offer of Air France and Air Liberté under the same conditions reached 51 flights in each direction in 2000 compared to 19 flights in 1993.13

The second period, which began in 2000, progressively witnessed significant falls in the radial offer, also because of the Air France policy upon the withdrawal of its competitors. Thus, the disappearance of Air Lib at the beginning of 2003 brought back the total number of movements between Paris and Nice to 31 flights, which created a shortage considered to be unacceptable by the local economic players; the possibilities of travelling at reduced fares were reduced considerably.

The situation developed comparably between Paris and Toulouse, from 51 flights in 2000 down to 32 flights in 2003. Air France, on the other hand, has replaced Air Lib on the Toulon and Perpignan routes.

The crises which air transport in general went through contributed to reductions in the Air France service. A certain number of airports are no longer served by the national company: Saint-Etienne, Nimes, Béziers, Tarbes/Lourdes, Chambéry. In the majority of these cases, service has been recovered by small companies like Air Jet, Air Atlantique or Airlinair, but at lower frequencies – two rotations per day in general. It is easy to understand the interest which these airports have had in the arrival of LCCs.

The opening of a new high speed railway line between Valence and Marseilles (TGV Méditerranée) in June 2001 was also the occasion to reduce frequencies selectively. Marseilles is thus the airport which has lost the most services to this fact, with the simultaneous withdrawal of Air Lib and the reduction of the Air France service, which passed from 33 to 24 daily flights. It is within this framework that the already-mentioned closures of the routes from Paris to Nimes and Béziers have occurred.

Finally, the overall service remains higher than what it was in 1993, but definitely lower than that it was between 1996 and 2000. The radial routes went through a golden age of competition. The return to a monopolistic situation will most certainly penalize them.

12.4 A Situation Yet to be Stabilized

We can now give an account of the main trends in terms of accessibility changes. It is, however, not certain that such a developed offer really corresponds to needs, and the ongoing concentration of operators will inevitably result in the short and
medium terms in network reorganizations aiming at avoiding redundancies as much as possible, sources of costs unacceptable a priori in a competitive context.

12.4.1 The First Regional Hub Closures: Saint-Etienne, Nice and Montpellier

The fate of Saint-Étienne is revealing of the difficulty in making competing hubs cohabit within the same group of airlines. The hub was created in the second half of 1997 by the regional company Proteus, under conditions and with goals comparable to those of Regional Airlines in Clermont-Ferrand. Upon opening, 11 routes were operated from Saint-Étienne Bouthéon, with two daily frequencies in each direction.14 Even if transported volumes were modest compared with other hubs, this opening made it possible for the young company to multiply its customers by four between 1996 and 1997. The airport for its part gained 25 per cent more passengers and 33 per cent additional movements in the same lapse of time.

This success story did not fail to interest large foreign companies and, as of the end of 1997, Proteus saw 34 per cent of its shares purchased by Delta Airlines. Delta handed over to Proteus the slots it gave up in Orly at the time of its transfer to Roissy-CDG. Simultaneously, Proteus increased its dependence in comparison with Air France by multiplying franchised routes, which caused its chairman Franklin Devaux, interviewed by *La Vie du Rail* in May 1998, to remark that seven of the 18 planes of the fleet fly on behalf of Air France. In 1998, the hub of Saint-Étienne was directly connected to 12 destinations and 14 were scheduled for Q1 1999. It also opened internationally with the arrival of the LCC Ryanair. The engineering departments and the maintenance of Proteus were transferred the same year from Lyon Satolas to Saint-Étienne, while the manager of the airport undertook FRF 26.5 million (€4.04 million) extension and modernization work.

The rapprochement of Delta and Air France, which created their Alliance (Skyteam) in 1999, as well as the faster development of the Lyon hub by the national company created ripe conditions for the abandonment of the Saint-Étienne hub. In compensation, Proteus was franchised on new cross-country routes from Lyon, Marseille and Toulouse. This was all accomplished on 31 October 1999. Only maintenance activity remained at the Saint-Étienne airport. It was a hard blow for the airport, which lost roughly 12 connections and 25,000 annual passengers, that is, approximately 13 per cent of its traffic in 1998, without any alternative solution. On the other hand, it was not at all an obstacle to the development of the Proteus company, whose 1999 revenues exceeded FRF 1 billion (about €150 million), and whose fleet grew from 42 to 65 planes. The two-year set-up at the Saint-Étienne airport thus constituted an appreciable springboard for the development of the operator, without the creation of indissociable links.

In 2003, the former hub of Saint-Étienne was served only by three daily flights. Two rotations towards Paris were offered by Air Jet, a small company with uncertain financial health. The third rotation served London Stansted (Ryanair).

The cases of Nice and Montpellier have been linked to the evolution of Air Littoral. These peripheral hubs were operating on the western part of the
Mediterranean Basin, with links to Spain, Italy and Corsica. During the last year of operation (2003), Montpellier was directly connected to nine destinations, while Nice was linked with 14 other cities. The disappearance of Air Littoral caused more of a predicament for Montpellier than for Nice. The latter can rely on the demographic weight (about 1 million inhabitants) and the dynamism of the whole French Riviera. Air Littoral was rapidly replaced by other carriers.

12.4.2 Could Other Hubs Disappear?

It seems obvious that the recombination of various operators’ nebulae has created new situations of redundancy. One is quite naturally tempted to question the future of the hub of Clermont-Ferrand, following the purchase by Air France of Regional Airlines in January 2000. The last independent carrier which had barely tried, as seen before, to avoid dependence on a large player on the market, thus entered the national carrier group. Can its central hub, a direct rival of Lyon, be maintained in the long run?

For the moment, Clermont-Ferrand does not seem to be in danger. On the Air France web site,15 it can be seen that transit through this hub still appears in the list of proposals for routing between provincial towns as well as Lyon, and that all the Regional flights have received an AF flight number. We can put forward the assumption of a better effectiveness of the Clermont-Ferrand airport, recently reorganized around the exchange between Regional Airlines flights, which has made it possible to consider transit times ranging between 25 and 45 minutes, while the Lyon Satolas airport imposes connection times ranging between 45 minutes and 1 hour 10 minutes, according to whether or not there is a change of terminal. If that is the case, any change of the Lyon hub towards more effectiveness could put the current balance at risk.

For Air France, Regional Airlines can even seem to constitute an agent in developing new secondary hubs in some regional capitals, such as Bordeaux, which, since October 2000, has been reinforced by the addition of new destinations. All the interregional or international routes, new or pre-existing, are operated under the Air France label by its new subsidiary company. On the other hand, Regional has ceased operations at its secondary hub in Le Havre, which was especially used to feed, from the greater French north-west, the network of KLM via Amsterdam. This small hub has been taken up by Air Jet which ensures two daily rotations per working day towards four destinations (Toulouse, Amsterdam, Brussels and Nantes), Air France in parallel offers two daily flights towards Lyon. The current difficulties of Air Jet, which filed for bankruptcy in May 2003, again bring up the question of the longevity of the small Le Havre hub.

12.4.3 A Player that Had Remained Discrete up to That Point: French Railways (SNCF)

Against its will, SNCF was projected into the battle for the maintenance of the profit of market shares waged by the competitors in the French skies. The
‘millionaire’ routes initially concerned were routes where rail services did not make significant time savings in comparison to those offered by air travel. Thus, only the fares and the frequency could make the difference. With the exception of the Paris-Toulouse route and this for a short period (1995–96), SNCF fares were always lower than those of air competitors. On the other hand, the significant increase in air frequencies determined the travellers’ modal transfers, primarily for business purposes. The increase in the quality of service in air transport could also have been significant for this same category. This meant that the SNCF lost market shares, in particular on its services from Paris to Nice, Marseilles, Strasbourg and Toulouse.

Nevertheless, SNCF had not said its last word on connections served by TGV. It cannot be beaten on destinations like Lyon or Nantes, which in addition profited from hourly or half-hourly service clocking. The prolongation of the high speed line to Marseilles in June 2001 logically brought profits of market share for the railroad on this destination as well as to Avignon, Nimes and Montpellier, to the detriment of the air industry. Air Lib had given up its flights to Marseilles as the TGV accelerated, and Air France substantially reduced the frequency of its Orly-Marseilles ‘shuttle’. The train remains very competitive on interregional high-speed connections like Lille-Lyon where prices and frequency are combined. Competition is thus wild on a certain number of routes, and it has not inevitably turned to the advantage of the airlines.

An area of agreement between rail and air can be also found for the feeding of the hubs having a high speed rail station (Lyon Saint-Exupéry, Paris-CDG) by train. After limited attempts like the pre-routing under an AF flight number of air travellers from Lille to CDG since 1995, SNCF and Air France shifted to a higher speed in September 1999, offering under the commercial name TGV’Air attractive rate and time combinations from a half-dozen of relatively close towns, even from abroad (Lyon Part-Dieu, Poitiers, Tours, Mans, Angers and Brussels). In this case, the railway company has played a role of feeder as well as an airline chartered or franchised by a major carrier. There are, however, no mutually-exclusive bonds: SNCF has also made a deal with United Airlines. This carrier offers preferential fares to the holders of the SNCF card for 12–25 year-olds. For the moment, the national company has refused to engage in a total alliance which would profit from the exclusiveness in feeding efforts.

Up to that point, the agreement was easy to obtain because it concerned connections on which SNCF does not compete directly with domestic air transport. The saturation of the Parisian airports, the main cause of the slow development of competition on radial routes, could lead one of the candidates to develop a closer relationship with the owner of the TGV. This would enable it to widen its range, and particularly to serve CDG.
12.5 Conclusions

As of today, we can break up the events which have occurred since 1995 into four phases:

a) A fare and/or service war on a limited number of main radial routes, which finished in the long-term set-up of two new relatively weak competitors (AOM, Air Liberté) and the maintenance of Air France, supported by the possession of a vast majority of the slots at the saturated Parisian platforms. The situation stabilized from 1997 on this basis.

b) A flowering of central (Clermont-Ferrand, Saint-Etienne, Lyon) or peripheral (Nice, Montpellier, Le Havre, and so on) regional hubs multiplying the possibilities of cross-country connections and enabling the emergence of real competition on these connections. This movement began from the first half of the 1990s and the last development of hub announced in 1999 related to Bordeaux (Air France).

c) A recombining among competitors which led to a duopoly and which should logically have led to network simplification and a reduction in the number of hubs. But the premature bankruptcy of Swissair in 2001 stopped this movement. Air Lib (Air Liberté + AOM) struggled for life but was locked into choices that could only lead to bankruptcy, which came about at the beginning of 2003. Air Littoral has recovered its independence but suffers from a permanent lack of its own capital stocks. The carrier was put up for sale in autumn 2003, and finally disappeared in December 2003.

d) Since January 2003, the radial routes have been flown only by planes of the group Air France, and subjected to only very symbolic competition by some LCCs. Such low-level competition on the main routes was relaunched with Aeris and Easyjet, but these two companies have not recovered half of the slots of the late Air Lib at Paris-Orly. The disappearance of Aeris in October 2003 left EasyJet singularly alone to face the flag carrier. One can thus consider that Air France will control its domestic market over the long term, the place left to its competitors hardly giving them room for manoeuvre.

However, we can consider that never has the opening of the various French regions towards the outside been as large, because of the unquestioned multiplication of point-to-point interregional connections. In that, the deregulation of air transport will have done more for regional planning than all the policies put forward and enacted previously, especially those aimed at connecting a few businessmen to the central Parisian decision-making centre.

Notes

1 In the French case, that means that Paris has been excluded from the study; in the German case, Frankfurt should be excluded as well.
The two companies merged in 1997. Air Inter was a purely domestic company and Air France was almost exclusively an international operator.

Lille-Strasbourg (three rotations per working day), Marseilles-Bordeaux (two rotations), Lille-Bordeaux, Lille-Nice, Lille-Marseilles, Bordeaux-Toulouse, Toulouse-Nice (one rotation). The lines between Corsica and the mainland have not been taken into consideration, due to their special status (they are heavily subsidized).

Formerly Air Vendée.

By ‘regional hubs’ we mean airports concentrating several lines and have not adopted a wave-system structure in their airline flight schedule (Bootsma, 1997).

In French: Fonds de péréquation du transport aérien. This Fund is financed through a tax on all plane tickets sold in France (FRF 4.00 – €0.61 initially).

Between 1995 and 1997 included, the boxed receipts were FRF 330.4 million (€50.37 million), while the expenses reached FRF 190.9 million (€29.10 million). This strong surplus led the government to reduce the level of taxation by three quarters in two phases (1996 and 1997). In 1999, the annual expenditure for the support of eligible lines was FRF 51 million (€7.77 million).

Varlet, 1997. Forty per cent of the passengers of the Clermont-Ferrand hub were inhabitants of the Auvergne region.

We could quote the very short attempt (only a few months in 2002) by Buzz to create two cross-country domestic lines between Quimper and Marseilles and Bordeaux and Grenoble. Only EasyJet has tried to compete with Air France on Paris-Nice and Paris-Marseilles, but with a limited number of flights (four rotations for each).

At 80 km far from Paris, Beauvais is the preferred Parisian airport for low cost carriers.

Thus, the single daily flight departing from Clermont-Ferrand to London Stansted (Ryanair) takes off at 22.15. The two daily departures of Ryanair from Montpellier leave at 21.55 (Frankfurt Hahn) and 22.20 (London Stansted). Schedules available in May 2003.

Source: http://www.adp.fr. Request on the flights of Thursday, 14 September 2000 in both cases.

Lille, Nantes, Bordeaux, Toulouse, Perpignan, Avignon, Nice, Chambery, Annecy, Strasbourg and Reims. Proteus also operated six franchised lines for Air France from Paris, Lyon and Marseilles, and some interregional lines for its own account (Lorient-Lyon, Nantes-Pau, and so on).


Except for the CDG – Lyon Satolas route.

It would repeat what Lufthansa had carried out with Deutsche Bahn at the beginning of the 1980s: freighting complete trainsets between two airport train stations (Frankfurt-Cologne) in order to recover useful slots for long- and middle-range links.

The brittleness of the TAT/Air Liberté and AOM unit situations at that point enabled large foreign carriers to gain minority participation in their capital.

Aeris could be considered as the first real French LCC.

In March 2003, the two challengers obtained 14,912 of the 44,528 slots left vacant by the disappearance of Air Lib (33.49 per cent): 7,612 slots for Aéris, 7,300 for Easyjet. A third candidate, Virgin Express, obtained 5,840 slots, which enabled it to ensure three daily rotations to Bordeaux, and two to Toulon. This attribution did not create serious competition for Air France.

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Chapter 13

ICTs and High-Order Integration of Remote Regions. Distance as a Remaining Barrier?

Marina van Geenhuizen

13.1 Introduction

The use of information and communication technologies (ICTs) has attracted attention from many researchers and policy makers dealing with urban and regional economic development. ICTs in business transactions enable a quicker and denser communication and a tighter coordination within and between companies, and between companies and customers. Through their ‘distance shrinking’ nature, ICTs enable interaction over much greater distances than before, allowing companies to become footloose and locate more freely. In addition, based on the latest optical network technology, opportunities are created to facilitate the flow of huge amounts of data. In connecting computer technology, modern communication and science, e-science is created, allowing research institutes and companies to participate in basic and applied research and in development and design over great distances in an interactive manner. In recent studies, it is recognized that communications infrastructures disproportionately agglomerate in metropolitan areas and that high-order activities increasingly concentrate there, with low-order activities being exported to peripheral regions (for example, Malecki and Gorman, 2001; Richardson and Gillespie, 1996; Pollard and Storper, 1996). According to evolutionary theory, this seems an inevitable development based on selection and self-reinforcing mechanisms and cumulative processes. However, in various evolutionary approaches it is also recognized that chance and taking advantage of unique circumstances and creativity may lead to opportunities in peripheral regions to catch up and narrow the divide by attracting innovative economic activities (for example, Arthur, 1994; Boschma and van der Knaap, 1997).

The impact of ICTs on research and development and production is based on various unique and far-reaching characteristics of the Internet (Kenney and Curry, 2001). Probably the most powerful feature is intelligence, that is the ability to collect information across the network, to store and process the information, and utilize the results. This also includes the more sophisticated activities of:
monitoring as a decision support tool and as an advanced business service; grid cluster computing to efficiently connect computer power and data inventory capacity across a network; and interactive experimentation, development and design. An example of the latter kind of interaction is the distributed participation of thousands of scientists in research at the accelerator facility of CERN (Geneva) using a highly sophisticated optic network (Gigaport, 2004).

At the same time, it is said that the use of ICTs is still modest due to various technical limitations in practice (for example, Bolisani and Scarso, 2000) and various behavioural and institutional barriers. Substitution of physical meetings by telecommunication is only possible if the communication is standardized, and if there is sufficient trust between the parties concerned. In the case of non-routine communication, such as in learning about context, creation of trust and comfort, negotiation including risk-taking, all of which contain high levels of tacit communication, telecommunication is facing basic shortcomings (for example, Howells, 2002). However, barriers may increasingly be removed by technical solutions, such as intelligent agents and multimedia which enable communication through codification of some tacit knowledge, facilitated by high-capacity hybrid networks. Barriers in organizations may be removed through an increased learning, including cultural adjustment (Andriessen, 2002).

In the light of the above ideas, the aim of this chapter is to explore opportunities for remote regions to 'escape' the digital divide. To this purpose we address the following questions: 1) What is the nature of the organizational and institutional barriers to the adoption of ICTs in remote areas? 2) What are the barriers in the quality of the ICT networks? 3) What type (order) of economic activity is likely to move to remote areas? Are companies that traditionally enjoy agglomeration economies now becoming more footloose?

We answer the above questions through a mix of study of the literature and original empirical work. We use a case study to explore the ICT connectivity of a relatively remote region in the Netherlands, that is, the three Northern provinces, and compare this region with the economic core, the Randstad. Furthermore, we use an original empirical research on footlooseness of innovative companies and we use a sectoral case study of call-centre development in the Netherlands and the United Kingdom mainly based on existing literature. But first, we revisit the concept of distance.

13.2 Distance Revisited

The concept of distance (proximity) in space has received a renewed attention in the geography of production since the late 1980s. With the recognition of the influence of positive externalities of proximity, many authors have focused on localized human resources and knowledge spillovers, and so on (see, for example, Audretch, 1998; Porter, 1998). Distance as an attribute of space has different meanings. We may distinguish between geographical (physical) distance, organizational distance, and
institutional distance (Table 13.1). Geographical (physical) distance means a separation in space and in time-space; it is also associated with missing physical connections in transport and telecommunication infrastructures. Note that physical distance may be appreciated differently in countries of a different size. Thus, the same physical distance may be seen as a barrier for interaction in small countries but not as a barrier in a much larger country.

<table>
<thead>
<tr>
<th>Type of distance</th>
<th>Separation</th>
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<tbody>
<tr>
<td>Geographical (physical)</td>
<td>In space and time-space</td>
</tr>
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<td></td>
<td>In physical transport and communication connections</td>
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<tr>
<td>Organizational</td>
<td>In interaction and coordination</td>
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<tr>
<td></td>
<td>In accessibility of transport and communication connections and socio-economic networks</td>
</tr>
<tr>
<td>Institutional</td>
<td>In traditions, expectations, thoughts, and rules and laws that influence behaviour</td>
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Organizational distance refers to separation in interaction and coordination. It is based on the logic of similarity and means that actors do not belong to the same ‘space’ of relations (firms, networks) and do not share common knowledge and capacities (Torre and Gilly, 2000). In other words, an emphasis is put on accessibility of socio-economic networks and lack of (perceived) opportunities for interaction (Andersson and Karlsson, 2002). Organizational distance may include geographical distance, but this is not necessary. The third type of distance distinguished here, institutional distance, is also based on the logic of similarity. There is institutional distance if the actors do not belong to a common ‘space’ of representation, sets of norms and rules, thoughts and action, or if certain laws prevent interaction. The conclusion may be drawn that, even if physical distance is overcome by telecommunication, interaction may still be hampered by organizational and institutional distance. The latter types of distance are quite basic and cannot be changed overnight, but it seems that boundary-spanning agents (individuals, organizations) are able to act as relational bridges (Gertler, 2003).
13.3 Diverse Views

13.3.1 Euphoria

Initially, there has been a strong optimism in regional economic policy, expecting that the use of ICTs will overcome traditional barriers of physical space and improve the competitiveness of economies in remote areas. The rationale behind this optimism was mainly based on an assumed positive relationship between ICT investment and economic growth (for example, Kotvall, 1999; World Bank, 1994). There are various ways in which investment in ICTs may structurally contribute to economic growth. First, economic growth is enhanced by an increase in productivity and a reduction of transaction costs of existing companies due to ICT-based innovations, such as new internal and external logistics: for example, inventory control in supply chain management. A second regional impact is the establishment of new companies based upon ICT products and services, as well as the attraction of footloose companies or departments from economic core areas. Particular companies were thought to become more footloose, causing a larger freedom in their location while remaining connected with the main information sources. Along functional lines, these included order booking, direct marketing and sales promotion (for example, Amirahmadi and Wallace, 1995). Accordingly, specific shortcomings in remote areas could be overcome and regional comparative advantage could be improved by the ‘shrinking’ of physical distance between remote areas and the economic core (Gillespie and Williams, 1988). The type of economic activity concerned was, nevertheless, mainly relatively low-order activity.

13.3.2 An Organizational and Institutional Perspective

In the course of the 1990s, the role of ICTs in the economic development of remote regions became increasingly questioned on the basis of various institutional factors. The most important limiting factor was the quality of the seedbed conditions in the recipient economy and society. There was a growing awareness that ICTs cannot simply be transplanted into a remote economy with information directly affecting this economy like a bullet hitting the target. There is no simple linear cause-effect model of the introduction of ICTs in the regional economy. Rather, the outcome is the result of a complex interplay between the technologies and the socio-economic field of forces in the recipient economy (Graham and Marvin, 1997). The impact of ICTs on regional economic growth, for example, varies according to the regional production structure, in terms of the size of local companies and their embeddedness in larger supplier/customer networks. Regions with many large companies linked with metropolitan areas and the global economy seem to benefit more from ICTs than regions with a dominance of independent, small and medium-sized companies (SMEs) (Capello, 1998; Cornford and Gillespie, 1993). Thus, a
certain amount of networking between companies must exist before it can be mediated through ICTs. Policy cannot create networks where none existed before simply by providing an ICT infrastructure (Melody, 1991). The point made here is that the competitive position of regions cannot be changed merely through the introduction of ICTs in a supply-side approach. Much depends on the organizational quality and learning attitude in the recipient economy (Grimes, 2003).

In addition, local policy making on ICT-based development has often appeared passive or poorly coordinated. A first limiting circumstance is the lack of awareness in policy making about the potential of ICT use, such as the emergence of new corporate strategies and the supply of new services by private and public actors. A second factor is the way in which policy initiatives come into being. In the absence of a clear vision, initiatives often emerge as a result of brainstorming sessions without a structure for continuation of action. Follow-up elaboration is then often based upon optional action, with high risks of lack of commitment. A further reason for lack of success is that ICT initiatives are derived from other existing policy fields, leading to a fragmented approach and sometimes overlap. What is often missing but needs to be there, can be summarized as follows (Cohen et al., 2002, 2005; Gibbs and Tanner, 1997; Sleurink et al., 2001):

- awareness of the potentials of ICTs and of the required network connections;
- explicit policy attention for the development of up-to-date ICT networks as a field on its own, instead of a derived issue;
- sufficient horizontal coordination between policy areas affected by ICTs, like education, transport, and economics, and a coherent policy vision that underpins initiatives and guarantees a systematic follow-up;
- joint learning by municipalities, provinces, firms, and so on, based on a common sense of urgency for ICT use, trust and reciprocity.

We may conclude that the circumstances described above seriously hamper the attraction of economic activity based on ICTs. This does not exclude the possibility that particular private or public initiatives can close mental gaps or span boundaries between important organizations, through which conditions may improve, in some cases even drastically. The recognition of the possibility to ‘escape’ from an almost predetermined development path stems from evolutionary thinking. In most cases, once started, development paths are reinforced by path-dependency and lock-in phenomena, but chance and a creative policy making may enable ways to be found to escape from such paths (for example, Arthur, 1994; Grabher, 1993).
13.4 Quality of Telecommunication Networks

Research on the quality of networks in transportation has received a great deal of attention in recent years (for example, van Geenhuizen, 2000; Rietveld, 1997). However, this is not true for telecommunications networks, inter alia, due to a lack of standard statistics. 1 In this section, we attempt to transform the most important transport quality concepts from a user perspective to cover ICT networks:

- **Networks**: spatial lay-out of nodes and links in physical and services networks, including capacity of nodes and links (bandwidth);
- **Time**: duration time of transfer and processing, including duration time of delay (queuing);
- **Connection (failure of)**: frequency and duration of failure (disruption), including reconnection time;
- **Compatibility**: degree of match of systems, languages, software programs, and so on, and amount of loss of information in a situation of a poor match.
- **Specific services**: supply of user-friendly interfaces, store capacity, supply of additional information and links, maintenance and update;
- **Safety and protection**: safety in business relations through authorization, protection of private (secret) information, and protection of privacy.

Cost is not considered here as a quality aspect in itself. It is seen as a set of quality aspects together with costs that determines the willingness to pay for particular hardware, software, subscription to network services and costs of operational use. The six quality aspects, which partly overlap, will be discussed in more detail below.

The first quality aspect is the spatial lay-out of ICT networks and their capacity (bandwidth). As bandwidth is commonly used to designate transmission speed, we include the second quality aspect, time, in our discussion. Only selected networks can accommodate the high-speed Internet that matters today in information transfer and knowledge interaction. Advanced broadband connections and high-speed Internet (a minimum transmission speed of 10 Mbit/s) enable for highly complex activities like data-mining and multimedia applications (CBS, 2003). A new development in research networks is to facilitate extremely large data flow between fixed points without bothering the Internet traffic, by using a hybrid network as a combination of a state-of-the-art Internet network and revolutionary optical technology using light paths (optical end-to-end connections). An example of such a new network in the Netherlands will be the future SURFnet6, with Netherlight as the optical Internet exchange in Amsterdam, aimed at providing ground for services through connections with cities abroad on a 2 x 10 Gbit/s wavelength.

Many empirical studies indicate that it is mostly the largest cities that are connected with advanced glass fibre grids allowing high-speed communication of huge amounts of information (Graham, 1999; Malecki and Gorman, 2001). But
extending these networks to remote places in times of liberalized telecommunications markets and a global downturn in the telecommunications sector is problematic. There are signs, however, that a few new ‘network cities’ could also benefit from ICT networks (for example, Malecki, 2002). Wireless technology affordable by companies could be a solution but seems to lag behind in capacity compared with the gigabits of the advanced optical networks, although, in some cases, it might help to bridge the ‘last mile’, from backbone to customer.

A shortage of bandwidth causes delay in transmission but also loss of information. In synchronous modes of communication, delay is more problematic than in other modes. As in video-conferencing and virtual interactive design, it is particular annoying, whereas e-mail through its asynchronous nature allows for a time-lag between receipt and response (Mitchell, 1999). Delay is also related to our third quality issue, that is, connection and its failure (disruption). Failure of connections refers to the frequency and duration of disruption, and waiting time to the restoration of connections. Failure is not only a technical matter (a highly intensive use of the network in particular areas). It can also be caused on purpose, such as by inserting viruses that spoil software, connections and databases.

Compatibility refers to hardware and software, and to entire information systems, and to date it is still problematic in advanced applications. Compatibility problems prevent interaction and cause information loss. It is not only a technical issue, but also a matter of the willingness of the actors involved. Sometimes, non-compatibility is used on purpose to prevent the disclosure of sensitive information to, for example, competitors. Our next quality aspect, services, seems to be the most comprehensive with many parties and user functions involved. It embraces hardware and software suppliers, and all kind of service providers, and refers to user interfaces and supporting services (portals, searching machines), storage facilities of messages and data, connections with additional links, and maintenance and upgrading to newest versions such as of software. The last quality aspect to be discussed here, safety and protection, is considered as a separate class of services. Safety and protection are important in business relations for the authorization of electronic transactions – to be sure that these are acknowledged and safe – and in situations of sensitive information concerning, for example, privacy and bank accounts, and latest innovations.

It is not possible to cover all aforementioned quality aspects of telecommunications networks in the next section. The focus will be on the spatial lay-out of networks and the broadband capacity involved.

13.5 Broadband Networks in the North of the Netherlands

In the following study of broadband infrastructure in the Northern provinces of the Netherlands, we will focus on two components, that is, what are called ‘last-mile’ connections’ in the commercially-established broadband infrastructure, and the
spatial pattern of the network for research and education purposes, SURFnet, as it has evolved in the past few years (Gigaport, 2000, 2002, 2004).

According to the Northern Development Agency (NOM) (2001), the three provinces are well covered by digital infrastructure to transmit fairly large amounts of data, that is, the ‘backbones’. There is also a direct international link with abroad (Tycom) and an Internet node in the city of Groningen, which links networks of providers. However, there are heavy shortcomings in connections on the level of the ‘last mile’, that is, with potential users on the spot. A quick scan of broadband connections of business parks shows a low level of connection, that is, ranging from about 40 per cent of all business parks (Province of Friesland) to 10 per cent of all business parks (Province of Drenthe). This situation reflects the problem that, given free market conditions, prices to provide access to the backbone using a local ring in more remote areas are higher than in the economic core-area, whereas performance may be lower (Sleurink et al., 2001).

We now focus on SURFnet. In the analysis of network connectivity of cities in the remainder of this section, we use Points of Presence (PoPs) where network operators can hand information onto the network of another operator (Grubesic and O’Kelly, 2002) as an indicator.

We may draw the following conclusions on the situation in the Northern provinces (Table 13.2):

- In SURFnet4, there was one Point of Presence: namely, in the largest city (Groningen).
- In SURFnet4, there was no Cluster Leader, meaning that connections at highest speed level (up to 622 Mbit/s at that time) were missing.
- Following the shift to SURFnet5, there has been a small improvement in terms of refinement of the grid, with one Remote Point of Presence (Leeuwarden).
- In 2003, the grid was strongly refined in the province Drenthe by six Remote Points of Presence, thanks to a subsidy from the province.

Initially, the picture of SURFnet4 and SURFnet5 partly complied with commercial grids, with the basic data transport infrastructure present and local access only for the largest town (Groningen), but without access for some smaller medium-sized towns in the region, even those with higher educational institutes and research facilities. Thus, it can be concluded that, initially, distance played a role in terms of lack of connections. However, since 2003 there is an ‘anomaly’ in this pattern due to a strong support of the province of Drenthe (and the lobby of astrophysics) to make the grid better accessible through additional access points, particularly the radio telescope space observatory in Westerbork (ASTRON, 2003).
The improved accessibility of SURFnet5 in the province of Drenthe illustrates that regional policy initiatives (subsidies) may sometimes change situations in remote areas drastically by utilizing particular research facilities (which by their very nature are located in empty and remote areas, such as radio telescope stations for astronomy research, nuclear research facilities, earth observatories, air-traffic observatories) as an anchor point (node) and connecting various small towns in the area. Accordingly, relatively empty regions may ‘escape’ the digital divide.

We may conclude that the previous analysis indicates a general lagging behind of remote regions but also the potential of a sudden jump ahead, causing a differentiated pattern of potential for integration through high-order activities. In addition, the analysis illustrates that any study in the field of telecommunications infrastructure tends to be just a snapshot of one moment in time, thereby facing the danger of overlooking ongoing developments like stagnation or quick growth.

Table 13.2 SURFnet4 and SURFnet5 networks in the Netherlands

<table>
<thead>
<tr>
<th>Stage</th>
<th>Cluster Leaders</th>
<th>Points of Presence (PoPs)</th>
<th>Comments on the Northern Provinces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes in</td>
<td>No change</td>
<td>10 additional (remote) PoPs: Alkmaar, Arnhem, Den Bosch, Deventer, Zwolle, Leeuwarden, Haarlem, Heerlen, Dordrecht, Nieuwegein</td>
<td>One additional remote PoP (Leeuwarden)</td>
</tr>
<tr>
<td>SURFnet5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latest change</td>
<td>No change</td>
<td>6 additional (remote) PoPs: Emmen, Meppel, Assen, Hoogeveen, Dwingeloo and Westerbork</td>
<td>Six additional remote PoPs in the province of Drenthe</td>
</tr>
<tr>
<td>in SURFnet5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2003)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13.6 A Behavioural Perspective on Companies: an Increased Footlooseness?

A concept that is at the heart of the discourse on ICT advantages for remote regions, is footlooseness. Despite its frequent use, it is poorly conceptualized with regard to companies (van Geenhuizen, 2005). An early conceptualization can be found in the work of Klaassen (1967) as a situation in which the long-run profitability of an industry is the same for any location in an economy. Although we agree with the core idea, we prefer to include the notion of different degrees of footlooseness and add spatial entities other than national economies, such as larger regions within countries.

We now discuss whether higher-order economic activities – traditionally in large cities as qualified incubation milieus – are becoming increasingly footloose today. There are a few sector-based studies in the US that address the question of footlooseness (or, conversely, location-boundness) in terms of changing location patterns (Gorman, 2002; Sohn, 2004), and these studies point to either an increased agglomeration or modest dispersion; the latter, however, in an uneven pattern on a local scale, connected with a higher level of IT infrastructure. Additionally, in an exploratory study in the Netherlands, a micro-approach was used based on the valuation of agglomeration advantages by entrepreneurs of young, innovative companies (van Geenhuizen, 2005). The following trends were found in that study:

1. The pattern of location-boundness and footlooseness is rather differentiated, even within economic (sub)sectors like biotechnology and ICT services.

2. Network characteristics of the company seem the most determining factor of the degree of footlooseness and these are connected to corporate status (origin), the role of networks in the business model, and the stage of maturing of innovative activity. For example, companies that are corporate spin-offs employing the mother company’s global networks; the ones that subcontract most activities to other companies; and the ones that are highly innovative and employ global alliances are all footloose to some extent.

3. Over time, location-boundness tends to be reinforced, whereas footlooseness tends to be reinforced for some company types but tends to be reduced for others.

In more detail, among location-bound companies local linkages tend to increase in importance, based on the presence of local knowledge workers, customers, knowledge institutes, and the personal network of the entrepreneur. This specific trend is exemplified by young research companies and service-companies in biotechnology, and by customer- and labour-market-oriented ICT service companies. These patterns suggest a remaining influence of agglomeration economies for a substantial part of highly innovative companies. Despite advanced telecommunication, including wireless technologies, there is no general trend among highly innovative companies to
ICTs and High-Order Integration of Remote Regions

become more footloose. In terms of spatial connotation, footlooseness tends to refer to the South-East of the Netherlands and the highly urbanized West, and a large centrally located region. However, it does not refer to the entire country and to relatively remote regions, except for the largest town there (Groningen).

So far, our preliminary conclusion on the results on footlooseness does not provide support for the idea of increased opportunities for remote regions to attract innovative economic activity from highly urbanized areas, except for some specific company types. This would mean an important role for endogenous initiatives.

In the remaining section, we focus on call centre growth as an opportunity for ICT-based regional development. ‘Call centres’ is a broad descriptive term for organizations that answer and distribute telephone calls, using advanced telecommunications hardware and software and computer assistance. Their main goal is to support their own or customers’ organizations in terms of public relations, customer services, account handling, technical support, telemarketing, and so on. Not all of these tasks apply to all call centres. There are very simple centres, providing basic advice by telephone. There are also more advanced centres that are fully functionally-integrated in the business processes and also serve the learning activity of the company involved, by using feedback from marketing and customer management information. Note that in terms of sophistication, there is an upward move from answering simple questions to a full integration in the business processes.

Call centres are either back-office units within existing organizations or newly established entities working for a variety of related organizations. In both cases, it is possible that the call centre is a separate physical unit (an office) or largely a virtual organization with most employees working from home. Note that commercial call centres are the creation of two distinct but related processes, both based on the pursuit of low-cost competitive advantage. First, there is the process of decentralizing back-office or routine corporate functions in-house to sites away from the corporate core, a process which is still common in the financial and business service sector. The second process is that of the outsourcing or subcontracting of non-corporate functions to a third party outside the company. Call centres have already been operating for quite a number of years; therefore a classification can be established using various important dimensions (Table 13.3).

To date there is little systematic research on the location pattern and strategy of call centres in the Netherlands, a study by Beekman et al. (2002) being an exception. Therefore we make use of a research study in the UK, and compare it broadly with results from this study on the Netherlands. The UK study reveals a high level of concentration of call-centre activity and employment, with large shares in South-East (24 per cent, of which 7 per cent are in Greater London) and in Scotland (19 per cent, of which 11 per cent are in the Strathclyde region, with Glasgow as its centre) (Bristow et al., 2000). A low call-centre concentration tends to be found in rural, more sparsely populated, areas. The broad picture of call-centre location in the Netherlands matches that in the UK, that is, a relatively large number in the
Policy Analysis of Transport Networks

metropolitan regions of the Randstad (51 per cent of all call centres). About one third is in a zone adjacent to the Randstad (34 per cent) and there is a small number in remote regions (15 per cent). The relevant location factors are also broadly similar to those in the UK: labour market supply, including accessibility of the location for employees; and – for in-house call centres – proximity to the parent company (in UK mainly financial and business services and communication).

Table 13.3 Classification scheme of call centres (simplified with two extremes)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Extreme at one end</th>
<th>Extreme at the other end</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sophistication</td>
<td>Answering simple telephone calls</td>
<td>Integrated in learning loops of the organization (firm)</td>
</tr>
<tr>
<td>Character of initiating</td>
<td>Public (non-commercial)</td>
<td>Private (firm)</td>
</tr>
<tr>
<td>organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relation with initiating</td>
<td>Internal</td>
<td>External (out-sourced activity)</td>
</tr>
<tr>
<td>organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical mode</td>
<td>Physical entity</td>
<td>Virtual (employees work at home)</td>
</tr>
</tbody>
</table>

In particular, the location factors in Amsterdam – as illustrated by a case study of advanced call centres – indicate that the most important factors cannot be found in remote regions, like the specific local labour supply (young, well-educated and multilingual), the presence of a cluster of clients, and proximity to an international airport (Table 13.4). On the basis of these findings, we may assume that high-order call centres are an option for the North of the Netherlands but only for a limited range of activities, excluding activity with strong financial and business services links (customers), and with the need for frequent personal contacts and meetings abroad. Labour market needs for high-order call centre activity also tend to be difficult to satisfy in remote areas. Although particular remote areas (border regions) may benefit from a multilingual situation (see, for example, van Geenhuizen and Rietveld, 2003), they do not offer large numbers of young, flexible and relatively well-educated employees.
Table 13.4 Location factors in call centre development in Amsterdam

<table>
<thead>
<tr>
<th>Important factors at the time of establishment and today&lt;sup&gt;(a,b)&lt;/sup&gt;</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local labour&lt;sup&gt;(3)(5)&lt;/sup&gt;</td>
<td>Young and qualified people that like to live in Amsterdam for some years</td>
</tr>
<tr>
<td>Proximity to clients&lt;sup&gt;(5)(3)&lt;/sup&gt;</td>
<td>Clients in Amsterdam</td>
</tr>
<tr>
<td>Room for office expansion&lt;sup&gt;(5)(5)&lt;/sup&gt;</td>
<td>Previous location in inner-city; present location at the edge of the town</td>
</tr>
<tr>
<td>Proximity to intern. Airport&lt;sup&gt;(4)(4)&lt;/sup&gt;</td>
<td>Serves interaction with offices abroad</td>
</tr>
<tr>
<td>Public transport access&lt;sup&gt;(4)(4)&lt;/sup&gt;</td>
<td>Serves the needs of employees</td>
</tr>
<tr>
<td>Local knowledge institutes&lt;sup&gt;(4)&lt;/sup&gt;</td>
<td>Higher educational institute and university</td>
</tr>
<tr>
<td>Local suppliers&lt;sup&gt;(4)&lt;/sup&gt;</td>
<td>Cable providers</td>
</tr>
<tr>
<td>Local personal network&lt;sup&gt;(4)&lt;/sup&gt;</td>
<td>–</td>
</tr>
</tbody>
</table>

Notes:

<sup>(a)</sup> Based on an in-depth case-study; the numbers in brackets refer to the valuation in terms of a scale from 1 to 5, with (1) indicating a low importance, and (5) indicating a high importance.

<sup>(b)</sup> Valuation today is in italics.

Thus, at this stage of our knowledge, advanced call centres are not likely to contribute to an integration of relatively remote regions through high-order activities. Physical distance to large concentrations of (potential) business customers and to an international airport tends to remain the major bottlenecks.

13.7 Policy Implications

If remote areas are not able to catch up in terms of seedbed conditions for ICT use and terrestrial connections with advanced high-speed infrastructure, activities like e-science, virtual development and design, and sophisticated e-services, based on advanced application of large amounts of data, are likely to remain absent. These regions accordingly miss some of the highly innovative activities and particular services that contribute to innovation. Wireless technologies at affordable prices do not seem to be a solution in the near future for missing terrestrial connections in highly advanced networks, but these technologies may replace terrestrial connections at less advanced levels in solving the ‘last-mile’ problem.

In this chapter, using results mainly from the Netherlands, we have addressed the issue of whether remote regions can integrate with the global economy at a higher level than before. The findings about company behaviour, that is, weak signs of a comprehensive and increasing footlooseness of innovative companies, provide no evidence for the likeliness of integration of remote regions at a higher level than
in the past. Similarly, the results on organizational and institutional barriers do not support the idea of a high-order integration. However, particular remote regions are able to ‘escape’ the situation of poor connectivity by utilizing their remoteness or emptiness as a positive asset in developing information-intensive research facilities for which emptiness is prerequisite. Such research facilities can justify a connection with the highest bandwidth in the national telecommunications infrastructure and can help to develop local research companies linked with them on a similarity (scientific disciplines) or a supplying basis following an endogenous growth path.

There are various rules of thumb in policies to improve connections, such as to concentrate higher quality broadband provision in business-park locations, rather than attempt to provide it more diffusely to all company locations (Grimes, 2003). Furthermore, isolated initiatives need to be prevented in getting ‘last-mile’ connections off the ground. Initiatives preferably combine with other initiatives or ongoing projects. However, no matter which strategy for local broadband access is chosen, all initiatives need to be underpinned by an institutional approach to learning and changing the mind-set to benefit from ICT. In this context, the initiative to establish a comprehensive monitoring system of ICT-related policy impacts in the Northern provinces of the Netherlands (Sleurink et al., 2001) is an interesting example of a major step forward. Particularly if results from monitoring serve a regular adaptation of policies, policy making on ICT becomes a learning activity itself and may contribute to bringing high-order integration nearer.

Notes

1 Despite the basic nature of the digital infrastructure, there are no standard statistics. Data are only available from private network owners, service providers, users, and private research institutions. This hampers the creation of a comprehensive view.

2 To indicate the capacity at the end of 2003: two-thirds of the connected institutes (117 over the country) had a connection with SURFnet5 of 1 Gbit/s.

3 The size of the call-centres sector in the Netherlands is in dispute, because of the use of different definitions, that is, 200 call centres (excluding in-house call centres) offering employment to approximately 23,500 persons, most of them part-time (75 per cent) (Braaksma, 1998), versus 910 call centres with 48,000 job positions (Kinder, 2001).

References


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Chapter 14

Interaction in the Baltic Sea Area.
Patterns from an Aviation Perspective

Jan Henrik Nilsson

14.1 Introduction

The process of integrating ten new Member States into the European Union has finally succeeded. The new members are a highly diverse group of states, with different sizes, historical backgrounds and political cultures. They are also set in different geographical contexts, bordering different countries of the contemporary Union. Looked upon this way, the process of integration could be seen as consisting of a number of sub-processes in different parts of Europe, it can not just be seen as one process. One of these sub-processes concerns integration in the Baltic Sea Area. The idea of integration in the Baltic Sea Area has been on political agendas since the fall of the Soviet Union in 1991.

14.2 Baltic Integration

To be able to discuss these matters, we first have to make clear what we mean by ‘integration in the Baltic Sea Area’. To start with the latter, the Baltic Sea Area is here defined in a rather narrow way as the regions on, or close to, the Baltic Sea. According to this definition the area includes Denmark, Sweden, Finland, Estonia, Latvia and Lithuania, but only parts of Germany, Poland, Belarus and Russia (see Figure 14.1).

The fact that only parts of the most important countries in the area are included in it is causing some problems when dealing with the issue of integration. It is obvious that we cannot talk about integration between the territorial states, certainly not when Germany and Russia are involved. Moreover, the central regions of these countries are situated relatively far from the Baltic Sea. An alternative option is to regard Baltic integration as a process connecting the regions around the Sea. In the area, the larger city regions are the main economic actors, in the sense that they have the highest standard of living and the most advanced economies, are the most important targets for investments, and so on. Another factor which emphasizes the role of major city regions, in this context, is that most of the areas between these regions are very sparsely populated.
Figure 14.1 Baltic Sea area
Only Denmark and North-Western Germany have population densities that are anywhere near Western European ones. The city regions can, in other words, be seen as the main nodes in an emerging transborder network. It would, on the other hand, be improper to regard it as a system of cities. This concept normally means a system where the relationships between cities are very close, where cities are mutually dependent on one another. This is normally the case within territorial states.

Integration, on the other hand, could be defined as: ‘the creation and maintenance of intense and diverse patterns of interaction and control within and between social groups, political units, economic activities, economies and modes of production’. It is thus clear that integration could be understood more as a process than a state of affairs and that interaction must be seen as a necessary prerequisite for integration (to occur). Thus, the focus should be on interaction, in any attempt to study integration from a geographical perspective. Whereas political scientists focus on the formal sides of integration, geographers ought to have the informal material aspects in mind. Interaction is here defined as flows of goods, people, money and communications. It could also be regarded as the materialities of integration. On this basis, Baltic integration is here viewed as a process connecting the major city regions in the Baltic Sea Area, by means of interaction.

When discussing interaction between city regions in a transborder environment such as the Baltic Sea Area, two major concepts come naturally in focus: systems of cities, and barriers.

### 14.3 Systems of Cities

The relative economic importance of cities has increased significantly over the past centuries, with the introduction of industry and later with the transition to a service economy. Although major cities have always been important nodes connecting their respective hinterlands with the outside world, cities have in this process become more dependent on developments in other cities, through trade, travel, flows of information and so on. Different systems of cities have become more visible, on different geographical levels.

Cities within a territorial state tend to form hierarchies with a few cities on top and many small towns at the bottom. There seems to be a certain regularity on how such hierarchies are formed. Accordingly, national systems of cities attracted much scientific interest during the main part of the 20th century (Kant, 1935; Pred, 1977). This was a natural point of departure at a time when the territorial state was the dominant arena in political and economic life. In some cases, however, the possibility of a European system of cities was discussed (Christaller, 1950; Pred, 1977). More recently, with increasing internationalization, the transborder relations between major cities have come more and more into focus. Individual cities have been analysed as arenas of globalization, with the main focus on the activities of transnational corporations and organizations (Sassen, 1991, 1994). Much work has been done on the consequences of globalization on the local and regional levels.
Globalization in general and European integration in particular have also drawn attention to international systems of cities: how they develop and the position of individual cities in these emerging networks (Taylor and Hoyler, 2000; Taylor and Walker, 2001).

Today, in the early 21st century, we seem to be in a position where the national hierarchies remain very influential at the same time as international interaction is rapidly increasing. Transborder interaction tends, however, at least in the Baltic Sea Area, to go through the leading city regions (though not necessarily the capitals) of the respective states. Two different but interrelated systems thus seem to be concerned simultaneously.

14.4 Barriers

Spatial interaction is, apart from generating factors, influenced by distance and barriers. The effect of distance on travel and trade, the friction of distance, is taken into consideration in most interregional trade models, for example, the gravity model. Barriers have traditionally been discussed in connection with transborder interaction, since borders have been significant barriers to trade and travel. Barriers should be viewed as obstacles to interaction, other than simple friction of distance. These are often associated with borders, but other barriers to international interaction do exist as well, although seldom as significant as at borders.

A number of phenomena can function as barriers, from physical barriers like mountains and coasts to differences in terms of culture and language. Because it is a broad concept, several attempts have been made to construct typologies of different sub-categories of barriers. The different categories are most often based on the types of barrier (physical, cultural, and so on), but the division may also be based on the effects of barriers, if the obstacles cost money or time. Rietveld (2000) makes a rough distinction between obstacles directly related to barriers, ‘discontinuities in flows’, and obstacles that are effects of differences between the two sides of the border, ‘non-homogenities among places at different sides’ (Rietveld, 2000, p. 82). When analysing the first aspect, he identifies four types of obstacles, which concern: supply of transport and communication services; preferences of consumers and producers; regulations or interventions of national governments; and lack of information on foreign destinations (Rietveld, 2000). When Gunnar Törnqvist (1996) discusses barriers, he broadens the perspective and uses the following categories: physical and technical barriers; fiscal and institutional barriers; and cultural and ethnic barriers (Törnqvist, 1996). The two latter categories have more to do with differences between territories than with border-related obstacles.

In the work related to the Baltic Sea Area a slightly different typology has been used, based on: physical and infrastructural barriers; institutional barriers; and cultural and discursive barriers. With the use of the term ‘discursive barriers’, the effects on interaction of how neighbouring people and countries are described (often negatively) are taken into consideration (Nilsson, 2003). These examples
show that it is possible to construct different sets of categories of barriers depending on what degree of complexity one wants to display. It is possible to go very far in discussing aspects of borders and barriers (Komornicki, 2001). There are of course similarities between different categorizations, some obstacles exist in almost any case of transborder interaction. But typelogizations are also influenced by the study area in question. Categories differ in relative importance between Western and East-Central Europe.

Although barriers that affect interaction between countries are still of substantial importance in Western Europe (in the EU) (Rietveld, 2000), barriers are undoubtedly more important in the East. It is also the case that, as some borders are becoming more open, others are becoming less so. For example, Polish borders to the West have become more open during the 1990s. In recent years, however, traffic across its Eastern borders has been reduced as a result of more strict regulations on travel. In accordance with EU rules, visas are now compulsory for Belarussian and Ukrainians who wish to enter Poland.

14.5 Operationalization and Method

Interaction is a diverse matter, the amount of flows ‘out there’ is uncountable. In order to study integration the first step must be to focus on some specific form(s) of interaction. To regard the Baltic Sea Area as a network of city regions makes some data difficult to use. Trade, for instance, would be an obvious object of study. It has a big economic impact because the flows of goods normally also involve flows of money and communications. The problem is that data are generally based on the territorial states. Traffic flows could be a good alternative. The total amount of traffic is, however, also almost impossible to grasp, and tighter delimitations have to be made. Here, passenger flows by air is chosen as primary empirical material. They connect airports and cities, not primarily territories. These flows can also be seen as an indicator of general economic interaction and, to some extent, flows of information. Economic activities create a need for travel and the most important people involved in these activities tend to travel by air. Businessmen and politicians travel by air more often than holidaymakers and petty tradesmen. Nevertheless, these petty traders, individuals doing small scale business by taking advantage of price differences between neighbouring countries, do in many cases have a large effect on figures describing cross-border traffic (cf. Komornicki, 1996).

Another important reason for studying air traffic is simply that it is possible to do. It is very difficult to get an equally useful overview using any other material. There are, however, some methodological difficulties involved when counting traffic, converging on specific destinations that have to do with lack of available information and different measuring methods used by different parties involved. Perhaps the most important difficulty is that there is a lack of proper passenger statistics, due to matters of business secrecy (cf. ICAO, 2000). In this chapter, the traffic is instead described in terms of potential flows: the highest possible number
of passengers to fly during a week (when/if the planes are fully booked). This can also be described as the number of seats flown per week. These figures are taken from the international aviation timetables (OAG World Airways Guide), from which it is possible to draw information about flight frequency and types of aircraft used. The timetables cover all scheduled flights. Using the timetable material is, to my knowledge, the only way of obtaining equivalent data for all flows involved.

This analysis is thus based on a calculation of the potential flows of passengers between the 21 most important city regions of the Baltic Sea Area (those with international air connections), for one week in 1988, 1993, 1996, 1999 and 2001, respectively. The relatively long period of time has been chosen in order to get an overview of the fundamental trends of change. In the research process, the material was divided into three different categories (domestic, intra-Baltic, international traffic within Europe, and so on), and grouped according to the origins and destinations of the different flows.

14.6 Main Findings

The process of integration that is undoubtably taking place in the Baltic Sea Area can not be viewed as one coherent process. Instead, it should be discussed in terms of several different processes, not all of which point in the same direction. All studied city regions have been influenced by the major geopolitical changes. The changing patterns of air traffic are clear signs of this. All cities have gone through, more or less radical, restructuring of their international air connections. The Western cities have improved their connections to the Eastern parts of the area. The most thorough changes have, however, taken place in the East where most cities have drastically improved their Western connections, especially towards the Nordic countries and Western Europe.

It is, at this point, important to note that all change recorded has taken place against the background of a situation where aviation in general is very unequally spread within the area. The Western parts have traffic that amounts to levels that many times exceed the Eastern ones. The connection between the Øresund region and Stockholm, for instance, exceeds the entire international traffic of Belarus 20 times. Even so, there have been improvements after all, the Eastern share of the total traffic has increased from 9.5 per cent in 1988 to 14.6 per cent in 2001. But, still 85 per cent is all Western. The inequality of traffic flows is very clear when mapped.

The Nordic city regions are part of strong national and intra-Nordic networks. Their international traffic has a very clear orientation towards Western Europe. But, despite this Western orientation, all three Nordic capital’s regions have strong positions within the Baltic Sea aviation network. The three Nordic capitals are especially important as nodes for the traffic from the Baltic States’ capitals, above all from Tallinn and Riga. The three Baltic capitals have increased their international traffic considerably. The traffic shows a strong Western orientation, where connections to the East have declined, including in absolute numbers. As
shown in Table 14.1, the increase recorded for Tallinn’s Eastern connections between 1996 and 2001 comes from increased traffic to Riga and Vilnius. The most important difference between the cities lies in the exact geographical orientation of their international traffic. Estonia and Latvia have developed strong links to Finland and Sweden while Lithuania has a more Southern orientation.

Table 14.1  Air traffic from Warsaw and the Baltic states’ capitals to three categories of destinations, * 1988–2001, in seats per week

<table>
<thead>
<tr>
<th></th>
<th>1988</th>
<th>% of total</th>
<th>1996</th>
<th>% of total</th>
<th>2001</th>
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</tr>
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<tbody>
<tr>
<td>From Warsaw to:</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>2,812</td>
<td>9.1</td>
<td>4,013</td>
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<td>25,762</td>
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</tr>
<tr>
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<td>1,716</td>
<td>15.0</td>
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<tr>
<td>From Vilnius to:</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>2,560</td>
<td>100</td>
<td>1,698</td>
<td>18.5</td>
<td>1,616</td>
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</tr>
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<td>Nordic countries</td>
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<td>1,918</td>
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<td>4,275</td>
<td>46.6</td>
<td>4,125</td>
<td>38.0</td>
</tr>
</tbody>
</table>

Note: * Other categories are omitted.


Aviation from St. Petersburg and Minsk could at best be described as stagnating. The positions of these cities within the Baltic networks have thus been considerably weakened – from an already low level. Minsk has had the worst development of all the studied regions when it comes to aviation. Total traffic from Minsk amounted to 5,500 seats/week in 2001, a very low level, considering it is the only international airport in a country of almost ten million people. Destinations in the Baltic Sea Area are only of minor importance for these two cities, their primary connections go towards Russia, on the one hand, and directly to Western Europe, on the other. During the period, Kaliningrad was just about capable of holding on
Warsaw has had the fastest-growing traffic of all major city regions. The city has thus strengthened its relative position more than any other region. Traffic to Western Europe and to the Nordic countries has increased more than to other destinations, whereas its Eastern traffic has been slightly reduced relatively. Despite increased traffic to the Nordic countries, the connections to the Baltic Sea Area are of minor importance for the Polish capital. The connections from Warsaw to the Berlin region are very weak. Instead of going to Berlin, the most important Polish flows ‘leap-frog’ the immediate surroundings and go directly to Western Europe: to West Germany, Great Britain, France, Italy and the Benelux countries.

East Germany is the most important of the areas that are jumped over in this process. In view of the problems this part of Germany has gone through, this may not be surprising. On the other hand, the weak contacts between Berlin and the rest of the Baltic Sea Area are highly remarkable. Despite its function as the German capital, Berlin is clearly in a secondary position within the Baltic Sea context. Berlin has weakened its relative position in the area more than any other Western city, above all in terms of the intra-Baltic traffic. Despite its geographical position and its increased political importance, its connections to the East and North have remained underdeveloped. The city has a position as an Eastern outpost of a national and Western system. Hamburg’s connections to the Baltic Sea Area have developed almost as poorly as Berlin’s. Both cities are thus increasingly turning their backs to the North.

On a generalized level, the changing patterns of interaction in the Baltic Sea Area should primarily be viewed as a process of internationalization. In the Western parts of the area, this is a continuation of previous trends. The process of internationalization is however most clearly visible in the Baltic States and Poland, since there it commenced from a very low level and has developed rapidly during the 1990s. The Russian and Belarussian regions differ from this pattern. But, even there, it was possible to see signs of growing internationalization during the first parts of the decade. Since then, however, developments have stagnated.

It is possible to see clear signs of cross border-integration in some parts of the area. The established pattern of interaction between the Nordic countries is clearly visible in the statistics. Apart from that, an increasingly close pattern of connections between the Nordic and the Baltic countries is visible, most strongly between Estonia, on the one hand, and Finland and Sweden, on the other. Another clear pattern is the declining interaction between the Baltic countries and Russia, which strongly implies growing disintegration in this part of the area. The Western parts of the former Soviet Union are pulled in different directions, the Baltic States towards the West, and Western Russia still towards the East. The development of traffic flows, as shown in Figure 14.2, confirms this. Belarus lacks clear orientation and is hardly part of any visible system at all.

It can be argued that an Eastern zone of weakness is being formed, from Narva by the Gulf of Finland to Lviv on the Carpathian foothills, along the Eastern border of the European Union. The prevalence of similar, although not as pronounced,
zones along the German-Polish border and along the Northern coasts of Poland and Eastern Germany, could also be a matter for discussion. Northern Poland is peripheral within the national context, and it is fair to say that Poland is turning its back to the sea. Krätke has analysed the process of integration in the German-Polish border region and found strong barriers to it, which have to do with the national processes of transition as well as strong institutional and cultural barriers (Krätke, 1998, 1999).

Figure 14.2 Traffic to Moscow, in seats per week

Changes in the patterns of interaction, as revealed in this chapter, may point to important changes in the effects of barriers in the different parts of the studied area. It is, however, difficult to pin-point exactly what kinds of barriers are the most influential. To be able to do that more detailed studies are needed. But on the basis of the regional literature it is safe to conclude that institutional and cultural barriers generally are more important than physical ones (Böhme et al., 1998; Komornicki, 2001; Krätke, 1998, 1999). This is not to say that physical barriers are not important. The Baltic Sea itself is, of course, an important barrier, and so is the fact that this part of Europe is rather sparsely populated. The regional geography of the area thus gives fundamentally different preconditions for interaction than in Western Europe.

14.7 Concluding Remarks: the Baltic Sea Area as a System of Cities?

The changing structure of barriers is an important aspect for understanding the situation in the Baltic Sea Area. Equally important are influences of national and transnational systems and hierarchies of cities. On the basis of this study of aviation in the Baltic Sea Area, it is possible to interpret the process of integration in the area as taking place within four different, but connected, subsystems: in other words, four tendencies of development linked to four systems of cities, each
with a different character. These are linked to different parts of the Baltic Sea Area:

- The Nordic and Baltic countries;
- Russia/the former Soviet Union;
- Germany;
- Poland.

The leading city regions in the four sub-systems have an important position within these systems. The interaction between these regions are revealed as being the primary pattern of interaction. International in- and out-going interaction is to a large extent channelled through these city regions. This can be very clearly seen in Russia and Poland, where Moscow and Warsaw are natural nodes in their respective national systems, and at the same time the leading city regions when it comes to transborder interaction. The fact that Moscow is situated relatively far from the Baltic Sea Area thus has negative consequences for integration in the area as a whole. A similar pattern is visible in the German context. The main difference is that the decentralized German system lacks a dominant city region. On the other hand, it is clear that Germany’s central region is not situated in the North and East, but in the network of cities stretched along the Rhine valley from Stuttgart to Düsseldorf, with Frankfurt as its most important traffic node. The Nordic and Baltic countries have one leading city region each. However, the Nordic countries as a whole lack an obvious centre, although the Øresund region is, in many respects, the leading region, followed by Stockholm and Helsinki. The Baltic capitals are national centres but at the same time so small that they do not play an independent role in the international networks. The internationalization processes of these city regions take place through some larger, most often Nordic, region.

This short description of different patterns of interaction in the Baltic Sea Area may have given the reader the impression that developments have been very fragmented. This may very well be true, but this depends very much on the time span in view. The area has never ever been so fragmented as it was during the Cold War. The developments since 1991 do go in right direction. It is, however, another question if this progress could be termed ‘Baltic integration’. Much of the results presented here suggest that the primary path of development in the area is the process of internationalization, and that this should be seen as a part of a larger process of European integration.

Finally, the emerging patterns of interaction within the Baltic Sea Area can not be fully understood as a regionalization process and neither as a system of cities, but rather as an archipelago where major city regions are the main centres but without being systematically interdependent. The Baltic Sea Area is, however, not an archipelago in the normal sense. The city regions are far too bound up into their own national contexts, especially those on lower hierarchical levels. Instead, we are dealing with a mixed structure: a network of city regions, where the national hierarchies, originally founded in the respective territorial states, have a very large
influence. Cross-border interaction, the process of internationalization, is thus taking place through an archipelago built up by the leading city regions in the respective subsystems.

Notes
2 There is normally a correlation between different forms of interaction: if there are large amounts of goods being transported, there will normally be large transfers of people, money and communications too, and vice versa. There are, of course, lots of exceptions to this ‘rule’, especially when exports of raw materials are involved.

References
Kant, E. (1915), Bevölkerung und Lebensraum Estlands, Postimehe Truck, Tartu.
Luftfartsverket (2001), Luftfart 2000, Norrköping.


15.1 Introduction

Traditional economic theory is rather clear on how economies specialize when they become more integrated. Trade theory suggests that economies specialize according to their comparative advantages due to technology (Ricardo) or factor endowments (Hecksher-Ohlin). However, these basic theories do not provide an explanation for the concentration of activities nor the increasing intra-industry trade, at the expense of inter-industry trade, that takes place between very similar economies, such as those of the European Union Member States. As an alternative to traditional theory, Marshall (1890) and Perroux (1950) introduced the logic of agglomeration. They consider that concentration of activity in one place increases the incentive for other firms to locate there, so that they benefit from the external economies (mainly technological externalities) associated with agglomeration.

New economic geography theories propose that the location of production depends on the relative strength of centrifugal forces (congestion costs, factor price differences, among others) and centripetal/agglomeration forces: as transaction costs increase with distance, firms concentrate in a region with a larger market and close to the supply of production factors and intermediate goods. Hence, concentrated firms benefit from greater pecuniary externalities, technological externalities and increasing returns to a greater extent than isolated firms (Krugman, 1991; Krugman and Venables, 1995; Venables, 1996; Fujita et al., 1999). As soon as an agglomeration (such as a metropolitan-centred region) becomes important, centripetal forces are self-sustained above a certain threshold. According to this approach, increasing returns and decreasing transportation costs are the key elements in generating the uneven spatial distribution of activity and development.

In the European case, greater integration has reduced transaction costs and intensified trade relationships. Therefore, a shock that would hit a certain region or country will be passed on to all other regions and countries much more quickly than before because of increasing backward and forward trade linkages. This could
Policy Analysis of Transport Networks

Contribute to a synchronization of regional business cycles within the EMU (Krieger-Boden, 2002; Frankel and Rose, 1998).

In addition, the production structure of the EU Member States is becoming more similar, reflected in the growing dominance of intra-industry trade (indicating diversification) as opposed to inter-industry trade (specialization). Jones and Kierzkowski (1990, 2001) would argue that this phenomenon results from the fragmentation of production, whereby the value chain of production is broken down into a larger set of tasks, many of which are sequentially performed in different locations. A general framework for analysing fragmentation was presented for the first time by Jones and Kierzkowski (1990), in which they state that production blocks can be connected by service links. Arndt and Kierzkowski (2000) further noted that fragmented production need not be performed in close spatial proximity, while Jones and Kierzkowski (2001) suggest that the process of fragmentation is emerging as one of the dominant new patterns of production process in the world economy. Hummels and Levinsohn (1993) and Hummels et al. (1998) formalized these processes into the notion of vertical specialization of production, whereby different stages in the commodity chain of production would be performed in different locations, in many cases different countries. Hence, interregional trade is increasingly based on intra-industry trade with vertical differentiation (by quality) at the expense of horizontal differentiation (by variety) of products (Maurel et al., 1999). Differences in the quality of goods result from differences in factor composition and from comparative advantages due to previous investments in human capital and R&D, to regional size, and the limited technological externalities over space. These comparative advantages are dynamic. The rich countries/regions tend to specialize in high quality goods, because their higher development and income make them more attractive for human capital and R&D and also more able to benefit from technological externalities, whereas peripheral and poor countries/regions tend to specialize in lower quality goods.

However, only limited attempts have been made to explore the manifestation of these processes in the economic structures of regions and countries within the EU and the degree to which these structural changes may condition the processes of development. In this chapter, the focus will be on the development of a framework to explore the role of national structural changes in the promotion of convergence tendencies within the EU, by focusing on structural interdependencies in a way that previous analysis has not done. The goal is to explore ways in which changes in structure in one sector or country penetrate the rest of the EU. The analysis may be considered as a prelude to a more formal evaluation of the role of structural change and structural integration in the processes of convergence in welfare. The next Section 15.2 is devoted to exploring changes in the production structure of the European economies. Then the model we use to evaluate the structural convergence process is described in Section 15.3. Thereafter, the empirical evidence will be presented in Section 15.4, and some interpretation of the results is given in Section 15.5. Finally, Section 15.6 provides some concluding remarks.
15.2 Exploratory Analysis of Structural Change in the EU Economies

This section aims at providing some insights into the evolution of the productive structure of the European economies. We focus on five countries (Germany, France, Italy, the Netherlands, and Belgium), since the input-output tables that will be used in the rest of the analysis concern these countries only. In this section, we use data from the Cambridge Econometrics database; the data cover the 1975–2002 period and five sectors (Agriculture; Energy and Manufacturing; Construction; Non-market services; Market services) which are slightly different from the ones used in the following sections. Indeed, in Section 15.4, energy and manufacturing are separated.

To examine the extent to which the production structure has become more similar across countries, we introduce an index of inequality in productive structure based on the one developed by Cuadrado-Roura et al. (1999) as follows:

\[
I = \sum_{i=1}^{5} \left[ \frac{(WA_{it} - WA_{it})^2 + (WEM_{it} - WEM_{it})^2 + (WC_{it} - WC_{it})^2}{(WNMS_{it} - WNMS_{it})^2 + (WMS_{it} - WMS_{it})^2} \right],
\]

(15.1)

where \(WA_{it}, WEM_{it}, WC_{it}, WNMS_{it}\) and \(WMS_{it}\) denote, respectively, the weight of agriculture, energy and manufacturing, construction, non-market services, and market services in total Gross Value Added in country \(i\) at time \(t\); and \(WA_t, WEM_t, WC_t, WNMS_t\) and \(WMS_t\) are the corresponding sectoral weights at the European level (EU-5). The value of this index would be zero if the productive structures were the same across all the countries.

This index is represented in Figure 15.1 and shows that, in terms of GVA, the productive structure of the studied countries has become more uniform over time. This index can be divided into the sum of inequalities in productive structure by sector as follows:

\[
IDA = \sum_{i=1}^{5} (WA_{it} - WA_{it})^2, \quad \text{(15.2)}
\]
\[
IDEM = \sum_{i=1}^{5} (WEM_{it} - WEM_{it})^2, \quad \text{(15.3)}
\]
\[
IDC = \sum_{i=1}^{5} (WC_{it} - WC_{it})^2, \quad \text{(15.4)}
\]
\[
IDNMS = \sum_{i=1}^{5} (WNMS_{it} - WNMS_{it})^2, \quad \text{(15.5)}
\]
\[
IDMS = \sum_{i=1}^{5} (WMS_{it} - WMS_{it})^2, \quad \text{(15.6)}
\]

where \(IDA, IDEM, IDC, IDNMS\) and \(IDMS\) denote, respectively, the index for agriculture, energy and manufacturing, construction, non-market services, and market services; and the variables on the right hand side are the weights described above.
Figure 15.1 Total index of inequality in productive structure

Notes: IDA = index for agriculture; IDEM = index for energy and manufacturing; IDC = index for construction; IDNMS = index for non-market services; IDMS = index for market services.

Figure 15.2 Index of inequality in productive structure by sector
These indices are represented in Figure 15.2 above. It shows that the reason for the greater homogeneity in productive structures can be traced to the harmonization of market services and energy and manufacturing structures among countries. However, the homogenization process acts in opposite directions in both sectors. Countries that had a high weight of the energy and manufacturing sector in total GVA at the initial period (Germany, France, the Netherlands) have experienced a decrease of this sector’s weight (respectively, by 24 per cent, 21 per cent and 20 per cent). Indeed, there has been a transfer of resources from this sector towards more productive sectors that has been more marked in these countries than in others. The more productive sector that has increased its weight in total GVA is the market services sector. Its weight has increased in all the studied countries (France: 21.2 per cent, Belgium: 3.3 per cent, Holland: 18.9 per cent, Italy: 16.7 per cent), with the greatest increase recorded in Germany (40 per cent). However, Germany and France were the two countries with the smallest initial weight of this sector in their economy (respectively, 38 and 44 per cent). Changes in the productive structure do not seem to come from the non-market services, agricultural or construction sector, for which the index of inequality is small and rather flat over the whole period.

15.3 Analysing Structural Change Through Key Sectors Identification

In the present chapter, the analysis of structural change will make reference to the well-known static Leontief input-output model defined as:

$$ x = Ax + f $$

(15.7)

where $x$ is the output vector, $A$ the matrix of input coefficients representing technology, and $f$ the exogenous final demand vector. The expression in Equation (15.7) can be rewritten as:

$$ x = (I-A)^{-1}f = Bf $$

(15.8)

where $B$ is the Leontief inverse matrix. Since we are interested in using the EC inter-country input-output tables; it should be noted that the matrix $A$ in the case of $n$ countries is (with the subscripts indicating the origin-destination relationships):

$$ A = 
\begin{bmatrix}
A_{11} & A_{12} & \cdots & A_{1n} \\
A_{21} & A_{22} & \cdots & \vdots \\
\vdots & \vdots & \ddots & \vdots \\
A_{n1} & A_{n2} & \cdots & A_{nn}
\end{bmatrix} $$
and the corresponding Leontief inverse matrix is:

$$B = \begin{bmatrix}
B_{11} & B_{12} & \cdots & B_{1n} \\
B_{21} & B_{22} & & B_{2n} \\
\vdots & \vdots & & \vdots \\
B_{n1} & B_{n2} & \cdots & B_{nn}
\end{bmatrix}$$

One of the main tasks in recent years has been the attempt to capture the influence of changes in technology through the methodology of field of influence, developed in order to guide the updating procedure of input-output tables (Sonis and Hewings, 1989) and to identify the key sectors of the economy (Cuello et al., 1992; Sonis and Hewings, 1992; Sonis et al., 1995). The field of influence can be considered as a mapping of a specific technological change into its system-wide impact, where the system can be a single economy or, in the case of the EU, a set of interdependent economies.

In particular, if a change $e$ occurs in the element $a_{ij}$ of the matrix $A$, then the components of the new Leontief-inverse matrix $B(e) = [b_{ij}(e)]$ can be calculated through the Sherman-Morrison (1959) formula:

$$b_{ij}(e) = b_{ij} + \frac{b_{im}b_{jm}e}{1-b_{lj}e}.$$  \hspace{2cm} (15.9)

Following Sonis and Hewings (1989), the direct field of influence $F[i, j]$ of $e_{ij}$ can be calculated as:

$$F[i, j] = \begin{bmatrix}
b_{11} \\
b_{21} \\
\vdots \\
b_{m1}
\end{bmatrix} \begin{bmatrix}
b_{1j} & b_{2j} & \cdots & b_{mj}
\end{bmatrix}.$$  \hspace{2cm} (15.10)

If the Leontief inverse may be thought to reflect the economic landscapes of linkages between industries and countries, then Equation (15.10) provides a landscape generated by change in one or more elements of the original matrix $A$. Equation (15.9) can be rewritten as:

$$B(e) = B + \frac{e}{1-b_{lj}e} F[i, j].$$

The matrix $F[i, j]$ should be interpreted as the sensitivity of the Leontief inverse to a change in in individual coefficient.
Drawing on the use of Monte Carlo simulation in exploring uncertainty in input-output systems, we use an alternative procedure to run a sensitivity analysis, as proposed in Percoco et al. (2004). Let us write Equation (15.7) as:

\[ \mathbf{x} = f(b_{1i}, \ldots, b_{ij}, \ldots, b_{nn}), \]

where the constituent elements \( b_{ij} \) are affected by uncertainty. If we fix \( b_{ij} = \bar{b}_{ij} \), then the variance of sector \( x_i \) is:

\[
V(x_i | b_{ij} = \bar{b}_{ij}) = \int \left[ \int [f(b_{1i}, \ldots, \bar{b}_{ij}, \ldots, b_{nn}) - E(x_i | b_{ij} = \bar{b}_{ij})] \prod p_i(b_i) \, db_i \right] \\
= \int \left[ \int [f(b_{1i}, \ldots, b_{nn}) \prod p_i(b_i) \, db_i - E(x_i | b_{ij} = \bar{b}_{ij})] \prod \right] \\
(15.11)
\]

In order to carry out sensitivity analysis, we are interested in integrating \( V \) over the probability density function of \( b_{ij} \):

\[
E[V(x | b_{ij})] = \int \left[ \int [f(b_{1i}, \ldots, b_{ij}, \ldots, b_{nn})] \prod p_i(b_i) \, db_i - \int [E(x_i | b_{ij} = \bar{b}_{ij})] \prod p_j(b_j) \, db_j \right] \\
(15.12)
\]

Let us define the variance of \( x_i \) as:

\[
V(x_i) = \int \left[ \int [f(b_{1i}, \ldots, b_{ij}, \ldots, b_{nn})] \prod p_i(b_i) \, db_i - [E(x_i)]^2 \right]. \\
(15.13)
\]

By subtracting Equation (15.12) from Equation (15.13) we have:

\[
V(x_i) - E[V(x | b_{ij})] = \int [E(x_i | b_{ij} = \bar{b}_{ij})] \prod p_j(b_j) \, db_j - E[E(x_i)]. \\
(15.14)
\]

By adopting the classical ANOVA decomposition for this expression, we have \( V(x_i) - E[V(x | b_{ij})] = V[E(x_i | b_{ij})] \), and, dividing it by the unconditional variance, we have what may be termed the Sensitivity Index of the \( ij^{th} \) element of the Leontief inverse:

\[
S_{ij} = \frac{V[E(x_i | b_{ij})]}{V(x_i)}, \\
(15.15)
\]

with \( S_{ij} \in [0,1] \).
Following Percoco et al. (2004), the ordered set of the sensitivity indices are defined as the Importance Matrix $S_{nxn}$. This matrix measures the importance of technical coefficients in order to explain the variance of the output of the economy. In particular, the reacting sectors (that is, the ones affected by a change in the technical coefficient $b_{ij}$) are in the columns, whilst the activating sectors (that is, the ones whose technological change is meant to generate volatility of the reacting sectors) are in the rows. The generic element $S_{ij} = [s]_{ij} \in S$ measures the effect on the output of the economy of the sector $i$ of a change in the technology of sector $j$. The methodology will now be applied to the EU countries to explore a new perspective on structural convergence.

15.4 Structural Convergence in EU Countries

The aim of this section is to use the model described in the previous section to demonstrate that, even if we do not have convincing empirical evidence of convergence in welfare terms among EU members, another kind of convergence has arisen in the last few decades. We refer to it as structural convergence, implying that the economies become more similar in terms of response to unpredictable technological shocks. In particular, we will focus on both the impact of a generalized productivity change in a country and the effect of a change occurring in one sector of the European economies. Our measure of convergence differs from the standard definition, in the sense that we do not consider the temporal path of GDP, but rather a measure of structural homogeneity. This concept is captured by the increasing similarity in the ability of production structures in responding to changes occurring in technical coefficients.

The data we use to analyse the importance matrices in the context of the European Union are inter-country input-output tables for the period 1965–85. In particular, we consider the same five countries as Section 15.2 (Germany, France, Italy, the Netherlands, and Belgium), and, following van der Linden et al. (2000), an aggregation of six sectors (private services, energy, building, market services, agriculture, and manufacturing). The Importance Matrices $S_t$ (where the subscript denotes the time period so that $t = 1965, 1970, 1975, 1980, 1985$) are computed by running a Monte Carlo simulation, under the assumption that all the coefficients of the Leontief inverse $B$ are distributed as a log-normal probability function with a 99.7 per cent confidence interval (Bullard and Sebald, 1977, 1988) with the expected value equal to the observed coefficient.

In Tables 15.1–15.3, we present the result of an experiment numbering 2000 runs for the year 1985. In order to interpret the results, two marginal indices have been constructed: the index of absolute importance, $S_j = \sum_i S_{ij}$, which measures the absolute importance of sector/country $j$ for the economy, and the index of
absolute sensitivity \( S_j = \sum S_{ij} \), which provides a quantitative measure of the reactivity of the economy.

Table 15.1 Geographical Importance Matrix (1985)

<table>
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<tr>
<th></th>
<th>DE</th>
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<th>IT</th>
<th>NL</th>
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<tr>
<td>DE</td>
<td>0.252</td>
<td>0.412</td>
<td>0.506</td>
<td>0.388</td>
<td>0.720</td>
<td>2.278</td>
</tr>
<tr>
<td>FR</td>
<td>0.448</td>
<td>0.874</td>
<td>0.546</td>
<td>0.644</td>
<td>0.760</td>
<td>3.272</td>
</tr>
<tr>
<td>IT</td>
<td>0.780</td>
<td>0.900</td>
<td>0.876</td>
<td>0.310</td>
<td>0.550</td>
<td>3.416</td>
</tr>
<tr>
<td>NL</td>
<td>0.592</td>
<td>0.322</td>
<td>0.740</td>
<td>0.588</td>
<td>0.780</td>
<td>3.022</td>
</tr>
<tr>
<td>BE</td>
<td>0.170</td>
<td>0.108</td>
<td>0.314</td>
<td>0.228</td>
<td>0.890</td>
<td>1.710</td>
</tr>
<tr>
<td>( S_j )</td>
<td>2.242</td>
<td>2.616</td>
<td>2.982</td>
<td>2.158</td>
<td>3.700</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes:
DE: Germany; FR: France; IT: Italy; NL: the Netherlands; BE: Belgium.

Table 15.2 Sector Importance Matrix (1985)

<table>
<thead>
<tr>
<th></th>
<th>Public Services</th>
<th>Energy Services</th>
<th>Building Services</th>
<th>Market Services</th>
<th>Agriculture Services</th>
<th>Manuf. Services</th>
<th>( S_j )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Services</td>
<td>0.013</td>
<td>0.111</td>
<td>0.012</td>
<td>0.048</td>
<td>0.133</td>
<td>0.096</td>
<td>0.41</td>
</tr>
<tr>
<td>Energy</td>
<td>0.300</td>
<td>0.164</td>
<td>0.268</td>
<td>0.329</td>
<td>0.252</td>
<td>0.369</td>
<td>1.68</td>
</tr>
<tr>
<td>Building</td>
<td>0.373</td>
<td>0.291</td>
<td>0.568</td>
<td>0.355</td>
<td>0.419</td>
<td>0.435</td>
<td>2.44</td>
</tr>
<tr>
<td>Market Services</td>
<td>0.533</td>
<td>0.507</td>
<td>0.585</td>
<td>0.569</td>
<td>0.657</td>
<td>0.611</td>
<td>3.46</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.359</td>
<td>0.385</td>
<td>0.209</td>
<td>0.481</td>
<td>0.382</td>
<td>0.354</td>
<td>2.17</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.556</td>
<td>0.538</td>
<td>0.523</td>
<td>0.533</td>
<td>0.307</td>
<td>0.503</td>
<td>2.96</td>
</tr>
<tr>
<td>( S_j )</td>
<td>2.135</td>
<td>1.996</td>
<td>2.165</td>
<td>2.315</td>
<td>2.149</td>
<td>2.369</td>
<td></td>
</tr>
</tbody>
</table>

Table 15.1 shows the geographical dimension of the linkages within the European economy and the results indicate that Italy and France are the countries with the highest potential for initiating structural changes. It is also interesting to notice that Italy has one of the highest values of \( S_j \) (2.982). Table 15.2 examines which sector production multipliers are the most affected by a structural change in any other sector. The results confirm our conclusion from Section 15.2, since they reveal that market services and manufacturing are the most important sectors, as well as the most sensitive ones, while public services are unlikely to be driving structural change. Table 15.3 provides information not only on which sectors’ technological changes would have the strongest impact upon the Leontief inverse matrix, but also on information about which EU Member States would exert the
greatest influence. Somewhat surprisingly, Italy is the most likely to embrace changes in the EU economy, while market services and agriculture are the most affected by those changes.

Table 15.3 Country-by-Sector Importance Matrix (1985)

<table>
<thead>
<tr>
<th></th>
<th>Public Services</th>
<th>Energy</th>
<th>Building</th>
<th>Market Services</th>
<th>Agriculture</th>
<th>Manuf.</th>
<th>$S_j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE</td>
<td>0.231</td>
<td>0.126</td>
<td>0.206</td>
<td>0.253</td>
<td>0.194</td>
<td>0.284</td>
<td>1.294</td>
</tr>
<tr>
<td>FR</td>
<td>0.287</td>
<td>0.224</td>
<td>0.437</td>
<td>0.273</td>
<td>0.322</td>
<td>0.335</td>
<td>1.878</td>
</tr>
<tr>
<td>IT</td>
<td>0.410</td>
<td>0.390</td>
<td>0.450</td>
<td>0.438</td>
<td>0.505</td>
<td>0.470</td>
<td>2.663</td>
</tr>
<tr>
<td>NL</td>
<td>0.276</td>
<td>0.296</td>
<td>0.161</td>
<td>0.370</td>
<td>0.294</td>
<td>0.272</td>
<td>1.669</td>
</tr>
<tr>
<td>BE</td>
<td>0.165</td>
<td>0.085</td>
<td>0.054</td>
<td>0.157</td>
<td>0.114</td>
<td>0.045</td>
<td>0.620</td>
</tr>
<tr>
<td>$S_j$</td>
<td>1.369</td>
<td>1.121</td>
<td>1.308</td>
<td>1.491</td>
<td>1.429</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: DE: Germany; FR: France; IT: Italy; NL: the Netherlands; BE: Belgium.

Using the orders of the importance and sensitivity indices for countries and sectors, it is possible to design Figures 15.3a–c as probabilistic economic landscapes. Note that, in Figure 15.3a, a clear hierarchy among countries does not seem to be confirmed, meaning a great similarity of the economies and thus a clear path towards greater equality in the structure of countries.
Figure 15.3b  Probabilistic economic landscapes of the EU economy (sector-by-sector)

Figure 15.3c  Probabilistic economic landscapes of the EU economy (country-by-sector)
The simulation described for 1985 has been carried out over the whole period 1965–85, and the results are presented in Figures 15.4a–d. There has been a constant decline in the importance of Belgium and Germany and a rise in the importance of France and Italy. Focusing on the sectors, it can be seen that the increase in the importance of the manufacturing sector coincides with the decline of agriculture. Market services became both important and sensitive starting from the 1970s.

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes:
Numbers in the time columns indicate sectors as follows: 1: Public Services; 2: Energy; 3: Building; 4: Market Services; 5: Agriculture, 6: Manufacturing.

Figure 15.4a  Absolute importance hierarchy by sector 1965–85

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Notes:
Numbers in the time columns indicate sectors as follows: 1: Public Services; 2: Energy; 3: Building; 4: Market Services; 5: Agriculture, 6: Manufacturing.

Figure 15.4b  Absolute sensitivity hierarchy by sector 1965–85
By analysing the path of the trace function of the importance matrices, it is possible to show the pattern of hollowing out among the sectors and the economies (the latter implying increasing international (inter-country) interdependence). The higher the trace value, the higher is the intra-sectoral or national trade, and, in this case, the less is the specialization of the country. Figure 15.5 shows a constant decline in the trace function over the period 1965–85, but it is interesting to note that the value fell by 33 per cent for sectors, but only by 12 per cent for countries. This means that there is a growing path of inter-sectoral linkages, implying growing complementarities among sectors (this is also a proof of the rising importance of the market services as ancillary to industrial and agricultural production). On the other hand, even though the hollowing out process is present for the national economies, it should be stated that it is slower than in the case of the integration between sectors. This can be explained by at least two factors. First, our data set covers just the period 1965–85, thus it ignores the impact of the European Monetary Union and the integration effects of the single currency. Secondly, we consider just five countries, so that we do not have any evidence of the increasing or decreasing interdependence between, for instance, France and Spain or between Italy and Austria.
Thus, Figure 15.5 should be interpreted in the sense that the increasing complexity of production is much more rapid than the internationalization of the member economies. Continuing the exploration of the structural convergence, let us consider the intensity of the total Importance Matrix defined as:

\[ I = \sum_i \sum_j I_{ij}, \]  

(15.16)

and the relative variance. Figure 15.6 traces the temporal pattern of this indicator. It is interesting to observe that the intensities at both national and sectoral levels are decreasing, implying a decreasing sensitivity of the European economy as a whole to sector and international shocks. However, what is more interesting is the fact that the rate of change of the intensities over the period 1965–85 equals the rate of change of the trace function over the same time period, that is, the intensity of the importance matrix by sector declines by about 33 per cent and that of the spatial matrix by about 12 per cent. This finding implies, first, that even though the EU economies are more sensitive to international shocks (in 1985, the intensity of the spatial matrix is still higher than the one of the importance matrix by sectors), they will be decreasingly affected by technological shocks. Secondly, the increasing complexity in the production process is likely to be driving a
diversification path among the economies (and this could also explain the decreasing sensitivity to international structural changes).

Note: S = Sensitivity.

**Figure 15.6** Importance Matrix intensities over time

Note: S = Sensitivity.

**Figure 15.7** Importance Matrix variances over time

Notes: S = Sensitivity.
Finally, by analysing Figure 15.7 above, it is possible to verify the path of structural convergence among the European economies and sectors in terms of sensitivity. The graph depicts the temporal pattern of the variance for the spatial and sectoral matrices, and it shows a constant decline of both functions. This means that both sectors and economies are becoming more similar in responding to technological shocks. In addition, it should be noticed that this figure seems to confirm that sectors at the European level are becoming more similar than the national economies as a whole. This result means that, in terms of technology, sectors are converging faster than countries.

15.5 Interpretation

The process of integration among European economies has not led to a strong specialization of European economies, but rather to a possible specialization of regional economies within countries, depending on the geographic position of the region at the European scale, and their level of investment in technology and human capital. Fatas (1997) demonstrates that specialization in technology and quality is more obvious between EU regions than between EU countries. In addition, it seems that agglomeration forces are limited to the country where they take place: lower transaction costs and higher factor mobility within countries than between countries (due to cultural, linguistic differences) can maintain regional dynamics in the form of increasing polarization/specialization. As regions within a country become less similar over time, we may expect that region-specific fluctuations increase within countries, whereas the reduced specialization of the national economies makes them less sensitive to specific shock. In other words, better opportunities for the exploitation of scale economies (via localized knowledge spillovers) tend to foster the spatial concentration of industries and increase the likelihood that a given shock will have asymmetric effects on different regions because of the growing differences in regional production structures. In essence, the degree of regional specialization influences the degree of shock susceptibility: the more specialized the region, the more sensitive to shock, and vice versa. The problem accounts for the lack of adjustment mechanisms when a region is hit by adverse region-specific shocks. In the absence of labour mobility or wage flexibility within a country, two alternatives remain: increased subsidies through regional development policies or an increase in unemployment in the region hit by adverse shocks.

Further, the aggregated nature of the sectoral analysis may hide important differences in the production structure; while sectoral allocations may appear similar at an aggregated level, it is likely that the fragmentation process alluded to in the introduction may be manifested in differences in the commodity composition of output by sector. In addition, the fragmentation process is likely to accelerate integration across sectors; for example, as the value chain is broken
down into more discrete processes conducted in different locations, coordination with logistics requirements will become more critical.

15.6 Concluding Remarks

The proposal to explore structural convergence was advanced as a prelude to its integration with the more familiar analyses of welfare-based convergence. However, it is clear that two modifications are essential; first, the analysis needs to be conducted with a far more disaggregated set of input-output accounts and, secondly, there needs to be a further spatial disaggregation to explore the ways in which the structural properties are manifested in the constituent regional economies. While the welfare-based convergence process in Europe has resulted in a reduction of income disparities between nations over time (see Dall’erba and Hewings, 2003, for a review), the results are less optimistic at the regional level (see Esteban, 1994; Neven and Gouyette, 1995; Quah, 1996; Martin, 1998). LeGallo and Ertur, (2003), and Dall’erba and LeGallo (2003) note that numerous poor regions, with a per capita GDP below 75 per cent of the European average, (Objective 1 regions) and mostly located in the periphery, did not succeed in catching up with the core and rich regions. However, the increase in regional inequalities is not a phenomenon specific to the poorer countries. Regional disparities have increased in almost all the European countries, but at different rates; regional disparities have decreased only in Germany, the Netherlands and Belgium.

In the literature on convergence, attention has been focused on the progress of measures such as per capita income or other measures of welfare. The analysis explored in this chapter examines a complementary part of the process – the structure of the economy. The challenge now is to find ways in which the contribution made by economic structure in promoting or retarding convergence properties, defined in welfare terms, can be incorporated into some of the standard models that have explored convergence processes. The results indicate that the greater harmonization of the EU Member States’ productive structures comes mainly from the market services and energy and manufacturing sectors that are becoming more similar over time. While the weight of the first one is increasing, the weight of the second one is decreasing, mostly because it is not as productive as the market services sector in France and Germany. Using the measures of sensitivity and associated Importance Matrix, we highlight next that convergence of economic structure seems to be dominated by convergence of technological similarities at the sector level rather than at the country level. However, the analysis needs to be extended over a long period to chart the degree to which the country convergence eventually begins to mirror the developments at the sector level.

The evidence, in terms of structural convergence, that countries are converging slower than sectors may contribute to an understanding of the basis for differences
in growth rates of EU economies. However, with greater integration comes greater dependence on transportation infrastructure; Button (1998), for one, has explored the important role that infrastructure investment may play in stimulating economic convergence by reducing frictions due to transport costs. Parr et al. (2002) and Glaeser and Kohlhase (2004) have both noted the significant reduction in real transport costs generated by a combination of technological innovations and, more recently, deregulation of the transportation industries. These are likely to be driving changes in the spatial structure of production by reducing the friction of distance and broadening the spatial extent of the market for inputs and the market for outputs. Thus, European infrastructure policies, by enhancing the linkages between regions in a more efficient way, may be affecting the economic structure and thus the welfare levels.

In the framework we have developed in the present chapter, technical coefficients are functions of transport costs and consequently determine interactions among economies in terms of interregional trade (Sonis and Hewings, 1998). A change in transport costs can be thought of as a variation in the coefficients of the Leontief inverse matrix, and thus generating a change in the level of production. Investing in infrastructure networks results in an increasing complexity in the set of interactions among countries and, as convincingly shown by Canaleta et al. (2002), in fostering structural change and homogenization of production technologies.

However, as argued by Vickerman (1996), infrastructures themselves should be considered only as a necessary, rather than a sufficient, condition to encourage development in less-developed regions. Other economic-environmental factors should be objects of simultaneous ad hoc policies in order to avoid the risk of economic implosion of backward systems. In fact, a number of economists have shown that, in a dualistic economic system with developed and less-developed regions, a decrease in transport cost will result in a change in the economic structure and in a widening of regional disparities. In the absence of constant coordination among all sector policies, European cohesion actions might result in strengthening already strong regions by broadening the spatial extent of their markets. It is clear from the analysis that focusing attention on economic structure provides an important, complementary perspective that will deepen the full understanding of the manifestations of spatial development policy.

**Acknowledgements**

Marco Percoco gratefully acknowledges financial support from Bocconi University (Ricerca di Base).
Notes

1 In Sonis and Hewings (1995) an extension to the technological change in one sector is presented in the column ‘field of influence’ as well. In addition, van der Linden et al. (2000) provide an application of the methodology to the EU inter-country input-output tables.
2 For a review of the arguments of the different types of uncertainty in I-O models, see Bullard and Sebald (1977), Jackson (1986), and Jackson and West (1989).
3 Further details on the tables are in van der Linden and Oosterhaven (1995), and Oosterhaven (1995).
4 The aggregation procedure was carried out by using the PyIO Module (Nazara et al., 2003).

References


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Index

9/11
New York City transit projects 77–8
transportation disruption 79

accessibility 5–7, 190, 208–10
daily accessibility indicator 193–4
Data Envelopment Analysis (DEA) 199–205
Decision-Making Units (DMUs) 200
disparities 206–7
economic indicator 193
impacts of High Speed Trains (HST) 195–9
indicators 191–5
inequality indices 206–7
Lille 203–4
location indicator 191–2
London 204–5
Paris 204–5
partial accessibility indicators 197–9
potential market indicator 193
relative network efficiency indicator 192–3
Seville 205
synthetic accessibility index 200–205
Trans-European Transport Network (TEN-T) 200–10
accidents 3–4
nuclear 61–75
agglomeration 287
AGV see automated guided vehicles
Air France 235–41
air transport see aviation
aircraft see also airports; aviation
operating costs 42–4
substitution of High Speed Trains (HST) 119–40
airports see also aircraft; aviation
closures 44–5, 54–6
compensatory measures 56
travelling costs 58
cost-benefit analysis (CBA)
input data 48–50
planning approach 57
political debate 53–4
results 50–52
selection 45–8
sensitivity analysis 52
travelling costs 58
viewpoints articulated 54–7
network effects 45
supplied capacity 44–5
Atkinson's welfare function 30–31
accessibility 206–7
automated guided vehicles (AGV) 107–15
drivers' tasks 107–8
technology dimensions 107–8
uncertainty 109–14
adaptive policy 113
coping with 112–14
external inputs 110
flexible policy 113
fragmented knowledge 111
identification 112–13
real options approach 113–14
reduction 113
smart policies 113
system boundaries 110
system performance and responses 110–11
valuation of policy outputs 111–12
average cost pricing 41
aviation see also aircraft; airports
Baltic Sea Area integration 279–85
cost-benefit analysis (CBA) 39–45
aircraft operating costs 42–4
airport closures 44–5, 54–6, 58
network effects 45
supplied capacity 44–5
deregulation
competition 236–40, 248–50
France 235–54
Baltic Sea Area
- cross-border integration 282
- disintegration 282–3
- integration 275–7
  - aviation 279–85
  - barriers 278–9, 283
  - operationalization and method 279–80
- internationalization 282
- as a system of cities 283–5
- barriers to spatial interaction 278–9, 283
- Benthamite social welfare function 27–8
- Bothnia, Gulf of, evacuation flows 68

- call centres 267–9
- CBA see cost-benefit analysis
- cities, systems of 277–8, 283–5
- Civic Alliance 91–2
- climate change 132–5
- coefficient of variation
  - accessibility 206–7
  - incomes 31–2
- compensating variations 24, 28
- compensatory measures 56
- consumer surplus 28, 41–2, 57
- cost-benefit analysis (CBA) 23, 33, 135
  - aviation 39–45
    - aircraft operating costs 42–4
    - airport closure 44–5
    - network effects 45
    - supplied capacity 44–5
    - consumer surplus 41–2
  - Norway, regional airports 45–52
  - regional airports 41–5
- weaknesses 58
- criminal acts 4
- cross-border integration, Baltic Sea Area 282

- daily accessibility indicator 193–4
- Dalton's principle of transfers 30–31
- Data Envelopment Analysis (DEA) 199–205
- dead weight loss 41
- Decision-Making Units (DMUs) 200
- decision support tools 8–11
- Denmark

- fixed links 165–7
- freight transport 169–70
- deregulation, air transport see aviation, deregulation
distance 258–9

- economic indicator 193
- economies of scale
  - in production 219
- transport costs 219–20
- Empire State Transportation Alliance (ESTA) 91
- entrepreneurial surveys
  - locational factors 221–3
  - Netherlands 221–32
  - stated preference (SP) studies 226–32
- strengths and weaknesses 225–6
- environmental costs 123–4
- equity 3, 19–34
  - units of measurement 34
- equivalence scales, interpersonal comparisons 24–7
- ESTA (Empire State Transportation Alliance) 91
- European Union (EU)
  - cohesion 20, 22–3
  - enlargement 210
  - inequality 20–23
  - poverty 21–3
  - productive structures 289–91
  - social exclusion 21
  - structural convergence 294–304
    - analysis 291–4
  - structural funds 20–21
  - evacuation 72–3
  - efficiency 74–5
  - flows 63–4, 68
  - societal aspects 74–5
  - evaluation in policy making 7–11

- Finland, nuclear accidents 61–2 see also
  - modelling of transport flows
- fixed links 165–7, 185–6
- Denmark 165–7
- economic development 171
- flow networks 168
- freight transport 169–70
Index

policy implications 182–4
research design and methodology 171–3
spatial compression 168
Sweden 165–7
time compression 168
traffic infrastructures 167–71
transport and logistics chains 167–9
logistical structures 174–5
product flow 176–80
transport resources 180–82
transport logistics 167–9
flow networks 168
fragmentation of production 288
France, air transport
accessibility for Regions 242–50
bypassing Paris 239–40
competition 236–40, 248–50
deregulation 235–54
destinations from Regional airports 244–6
hub and spoke structure 243
low cost carriers (LCCs) 246–8
partnerships 240–41
regional hubs 239–40, 242–4, 251–2, 255
Saint-Etienne hub 251–2
SNCF (French Railways) 252–3
subcontracting 240–41
freight transport
Denmark 169–70
value of travel time savings (VTTS) 146–7, 151–3
generalized optimization 71–2
geographical distance 259
Germany, High Speed Trains (HST) 205
Gini-coefficient 31
accessibility 206–7
globalization 277–8
Great Belt fixed link (Denmark) 165–7
see also fixed links
group welfare, ordinal measures 24
High Speed Trains (HST)
accessibility impacts 195–9

Germany 205
PBCAL (Paris-Brussels-Cologne-Amsterdam-London) corridor 190, 196, 210
substitution for aircraft 119–20, 138–40
evaluation of benefits 120–22, 135–7
to airlines 122–5
climate change 132–5
en-route activities 126–8
environmental benefits 131–5
environmental costs 123–4
Local Air Pollution (LAP) 131–5
noise pollution 132
operating costs 122–5
overall 135–7
to passengers 125–31
to society 131–5
value of time (VOT) 128–31
policy implications 138–40
travel times 195–8
ICTs see information and communication technologies
incident management 3–4
income inequality see inequality
increasing returns to scale (IRS) 40–41
individual utilities, sum of 27–8
inequality 20–23
decomposition 32
index 32
measures 22–3, 30–32
information and communication technologies (ICTs) 257–8
broadband networks 263–5
call centres 267–9
economic growth 260–61
footlooseness of companies 266–7
Netherlands 263–5
policy for 261
policy implications 269–70
telecommunication networks 262–3
infrastructures see traffic infrastructures;
transport infrastructures
institutional distance 259
integration 7
intelligent transport systems (ITS) 107–15
internationalization, Baltic Sea Area 282
interregional trade 218–19
IRS (increasing returns to scale) 40–41
ITS (intelligent transport systems) 107–15

Kola Nuclear Power Plant (KNPP) 61–2
see also modelling of transport flows

LAP (Local Air Pollution) 131–5
LCCs (low cost carriers) 246–8
Leontief input-output model 291–2
Lille, accessibility 203–4
LMDC (Lower Manhattan Development Corporation) 83–4
Local Air Pollution (LAP) 131–5
location indicator 191–2
location of firms, Netherlands 221–3
test scenario results 67–70
money-metric utilities 26, 27–8, 29, 33–4

societal aspects 74–5
methodology 63–4
model extensions 71–4
population points 64–5
road networks 65–7

NAFTA (North American Free Trade Association) 20
Netherlands
broadband networks 263–5
entrepreneurial surveys 221–6
location of firms 221–6
locational factors 221–3, 226–32
stated preference analysis 226–32

New York City
Civic Alliance 91–2
capital costs 88
capital costs 88
construction time 89

economic growth 81
Empire State Transportation Alliance (ESTA) 91
global prestige 98
investment in transportation infrastructure 89–90

Lower Manhattan Development Corporation (LMDC) 83–4
Metro Region 98
Partnership for the City of New York (NYCP) 91
planning issues 79–81

Regional Plan Association (RPA) 91
regional transportation decision makers 85–6
test scenario results 67–70

transit projects 77–99
9/11 77–8
ancillary projects 89
candidate projects post-9/11 86–90
capital costs 88
capital costs 88
construction time 89
evaluation 92–7
funding 95–6
implementation 96–7
passenger benefits 89
revenue sources 88–9
stakeholders 90–92
transportation benefits 89
transportation agencies 84
transportation decision makers 85–6
transportation issues 78–82
transportation policy 82–5
noise pollution 132
North American Free Trade Association (NAFTA) 20
Norway, regional airports 37–9
cost-benefit analysis (CBA) 45–52
airport selection 45–8
input data 48–50
planning approach 57
political debate 53–4
results 50–52
sensitivity analysis 52
travelling costs 58
viewpoints articulated 54–7
nuclear accidents 61–75
NYCP (Partnership for the City of New York) 91

Øresund fixed link (Denmark/Sweden) 165–7
see also fixed links
organizational distance 259

parameter uncertainty 105
Paris, accessibility 204–5
partial accessibility indicators 197–9
Partnership for the City of New York (NYCP) 91
passenger transport, value of travel time savings (VTTS) 147–9, 154–8
PBCAL (Paris-Brussels-Cologne-Amsterdam-London) corridor 190, 196, 210
physical distance 259
Polyarnye Zori, evacuation flows 68
potential market indicator 193
poverty 21–3
measures 29
poverty line 21, 29

price elasticity of demand 218
production, fragmentation 288
production functions 217–18
productive structures, European Union (EU) 289–91
productivity
economies of scale 219
transport infrastructures 216–20

regional airports see also airports
cost-benefit analysis (CBA) 41–5
aircraft operating costs 42–4
airport closure 44–5
network effects 45
supplied capacity 44–5
Norway, cost-benefit analysis (CBA) 45–52
regional development 5–7
regional network integration 11–14
Regional Plan Association (RPA) 91
relative network efficiency indicator 192–3
revealed preference (RP) studies, value of travel time savings (VTTS) 149
risk 102
road networks 65–7
modelling of transport flows 65–7
RP (revealed preference) studies 149
RPA (Regional Plan Association) 149
Russia, nuclear accidents 61–2 see also
modelling of transport flows

Saint-Etienne hub 251–2
Seville, accessibility 205
SNCF (French Railways) 252–3
social exclusion 21
social surplus 28, 31
social welfare functions 24
aggregation levels 32
Atkinson's 30–31
Benthamite 27–8
coefficient of variation of incomes 31–2
homogeneous 29–31
linear approximation 34
measures of poverty 29
properties 27
sum of individual utilities 27–8
Thiel's entropy measure 31–2
SP studies see stated preference (SP) studies
spatial compression 168
spatial convergence 6–7
stated preference (SP) studies
location of firms 223–5
Netherlands 226–32
value of travel time savings (VTTS) 150
structural convergence, European Union (EU) 294–304
structural uncertainty 105
subjective value of travel time (SVTT) see value of travel time savings (VTTS)
sum of individual utilities 27–8
Sweden
nuclear accidents 61–2 see also modelling of transport flows
Øresund fixed link 165–7
synthetic accessibility index 200–205
systems of cities 277–8, 283–5
TCA (total cost analysis) 142
telecommunication networks 262–3
TEN-T see Trans-European Transport Network
terrorism 4
Thiel's entropy measure 31–2
accessibility 206–7
time compression 168
TINA (Transport Infrastructure Needs Assessment) 210–11
total cost analysis (TCA) 142
traffic infrastructures see also transport infrastructures
economic development 171, 189–90
fixed links 167–71
research design and methodology 171–3
trains see High Speed Trains (HST)
Trans-European Transport Network (TEN-T) 189–91
accessibility 206–10
EU enlargement 210
transit projects, New York City 77–99
translation uncertainty 105
transport and logistics chains 167–9, 169–71
decision making 173
fixed links 167–9
product flow 176–80
research design and methodology 171–3
trading links 175–6
transport resources 180–82
transport costs, economies of scale 219–20
transport flows, modelling see modelling of transport flows
Transport Infrastructure Needs Assessment (TINA) 210–11
transport infrastructures see also traffic infrastructures
economic development 215
economies of scale in production 219
financing 218
indirect effects 220
interregional trade 218–19
location of firms 215–16
price elasticity of demand 218
productivity 216–20
transport logistics 167–9
tyranny of the majority 56
uncertainty 4–5, 101–3
automated guided vehicles (AGV) 109–14
classes of 104–5
conceptual framework 103–6
external inputs 104, 106
future external inputs 104
metrical 105
model 105
parameter 105
strategies for dealing with 106–7
structural 105
system boundaries 104
translational 105
valuation of policy outputs 105
utility functions 33–4
utility scales, interpersonal comparisons 24–7
value of time (VOT) 128–31 see also value of travel time savings (VTTS)
value of travel time savings (VTTS) 145, 158–9 see also value of time (VOT)
aggregate modal-split models 149
aggregate studies 149
analytical framework 146–9
behavioural models 149
benchmark model
freight transport 146–7
passenger transport 147–9
data collection 149–50
disaggregate studies 149
freight transport 146–7, 151–3
inventory models 149
neoclassical aggregate models 149
passenger transport 147–9, 154–8
revealed preference (RP) studies 149
stated preference (SP) studies 150
welfare functions see social welfare functions