Towards Better Performing Transport Networks

Edited by
Bart Jourquin, **Piet Rietveld**, and **Kerstin Westin**

ROUTLEDGE

Routledge Studies in Business Organizations and Networks

Towards Better Performing Transport Networks

The performance of current transport systems is inadequate when viewed in terms of economic efficiency, sustainability, and safety. *Towards Better Performing Transport Networks* examines the tools that are necessary to effectively measure these systems and those that are required to improve them.

Utilising advanced tools of network analysis, the contributors challenge various pieces of conventional wisdom and in particular the view that intermodal transport is more environmentally benign than road transport. A broad spectrum of the approaches designed to improve performance are reviewed including regulatory reform with the aim to improve competitive pressure in the aviation and public transport sectors. Another domain covered in this book concerns technological change, in particular the potential contribution of ICT to improve transport systems.

Bart Jourquin is Professor in Computer Science and Transport Economics, Catholic University of Mons (FUCaM), Mons, Belgium. **Piet Rietveld** is Professor in Transport Economics, Free University of Amsterdam, The Netherlands. **Kerstin Westin** is Professor at the Department of Social and Economic Geography, Umeå University, Sweden.

Routledge studies in business organizations and networks

1 **Democracy and Efficiency in the Economic Enterprise**
Edited by Ugo Pagano and Robert Rowthorn

2 **Towards a Competence Theory of the Firm**
Edited by Nicolai J. Foss and Christian Knudsen

3 **Uncertainty and Economic Evolution**
Essays in honour of Armen A. Alchian
Edited by John R. Lott Jr

4 **The End of the Professions?**
The restructuring of professional work
Edited by Jane Broadbent, Michael Dietrich and Jennifer Roberts

5 **Shopfloor Matters**
Labor-management relations in twentieth-century American manufacturing
David Fairris

6 **The Organisation of the Firm**
International business perspectives
Edited by Ram Mudambi and Martin Ricketts

7 **Organizing Industrial Activities Across Firm Boundaries**
Anna Dubois

8 **Economic Organisation, Capabilities and Coordination**
Edited by Nicolai Foss and Brian J. Loasby

9 **The Changing Boundaries of the Firm**
Explaining evolving inter-firm relations
Edited by Massimo G. Colombo

10 **Authority and Control in Modern Industry**
Theoretical and empirical perspectives
Edited by Paul L. Robertson

11 Interfirm Networks
Organization and industrial competitiveness
Edited by Anna Grandori

12 Privatization and Supply Chain Management
Andrew Cox, Lisa Harris and David Parker

13 The Governance of Large Technical Systems
Edited by Olivier Coutard

14 Stability and Change in High-Tech Enterprises
Organisational practices and routines
Neil Costello

15 New Mutualism in Public Policy
Johnston Birchall

16 An Econometric Analysis of the Real Estate Market and Investment
Peijie Wang

17 Managing Buyer-Supplier Relations
The winning edge through specification management
Rajesh Nellore

18 Supply Chains, Markets and Power
Mapping buyer and supplier power regimes
Andrew Cox, Paul Ireland, Chris Lonsdale, Joe Sanderson and Glyn Watson

19 Managing Professional Identities
Knowledge, performativity, and the 'new' professional
Edited by Mike Dent and Stephen Whitehead

20 A Comparison of Small and Medium Enterprises in Europe and in the USA
Solomon Karmel and Justin Bryon

21 Workaholism in Organizations
Antecedents and consequences
Ronald J. Burke

22 The Construction Industry
An international comparison
Edited by Gerhard Bosch and Peter Philips

23 **Economic Geography of Higher Education**
Knowledge, infrastructure and learning regions
Edited by Roel Rutten, Frans Boekema and Elsa Kuijpers

24 **Economies of Network Industries**
Hans-Werner Gottinger

25 **The Corporation**
Investment, mergers and growth
Dennis C. Mueller

26 **Industrial and Labour Market Policy and Performance**
Issues and perspectives
Edited by Dan Coffey and Carole Thornley

27 **Organization and Identity**
Edited by Alison Linstead and Stephen Linstead

28 **Thinking Organization**
Edited by Stephen Linstead and Alison Linstead

29 **Information Warfare in Business**
Strategies of control and resistance in the network society
Iain Munro

30 **Business Clusters**
An international perspective
Martin Perry

31 **Markets in Fashion**
A phenomenological approach
Patrik Aspers

32 **Working in the Service Sector**
A tale from different worlds
Edited by Gerhard Bosch and Steffen Lehndorff

33 **Strategic and Organizational Change**
From production to retailing in UK brewing 1950–1990
Alistair Mutch

34 **Towards Better Performing Transport Networks**
Edited by Bart Jourquin, Piet Rietveld, and Kerstin Westin

Towards Better Performing Transport Networks

Edited by Bart Jourquin, Piet Rietveld, and Kerstin Westin

Routledge
Taylor & Francis Group
LONDON AND NEW YORK

First published 2006
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

Simultaneously published in the USA and Canada
by Routledge
270 Madison Ave, New York, NY 10016

Routledge is an imprint of the Taylor & Francis Group, an informa business

Typeset in Times by Wearset Ltd, Boldon, Tyne and Wear

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data
A catalog record for this book has been requested

ISBN10: 0-415-37971-7

ISBN13: 978-0-415-37971-7

Contents

Figures and illustrations

Figures

Map

Tables

Introduction

Performance of transport networks

Bart Jourquin, Piet Rietveld, and Kerstin Westin

Setting the scene

Transport is often regarded as a prerequisite for economic development – although there is a dispute of the direction of the relationship. Maybe economic growth has necessitated development of transport and infrastructure. Be that as it may – there is a general consensus that in order for our society to develop and for people to manage their daily lives, there has to be a functioning, well-performing transport system.

Transport can be defined as

> The movement of goods and persons from place to place and the various means by which such movement is accomplished. The growth of the ability – and need – to transport large quantities of goods or numbers of people over long distances at high speeds in comfort and safety has been an index of civilization and in particular of technological progress.
>
> (Encyclopaedia Britannica, 2004)

This definition mentions quantity and quality aspects such as volume, distance, speed, comfort, and safety. One might add performance indicators such as ease of access, external safety, sustainability, and economic efficiency.

These attributes are also recognised in the White Paper on the European transport policy (2001), which states that a modern transport system must be sustainable from an economic, social, as well as an environmental viewpoint. The common transport policy is confronted with a certain number of major difficulties. Many expressways and urban transport networks present congestion problems. In addition, transport has harmful effects on the environment and public health. Access to transport modes and transport networks is not equal to all, there are gender inequalities as transport systems were not initially developed to answer the needs of both men and women, the needs of disabled and elderly are often not fulfilled, and we also have differences in access between different social groups.

There are of course reasons for the difficulties we see today in the performance of transport. Transport systems are based on networks that were historically built in a rather ad hoc way to serve the needs of their times: railway networks were essentially developed at the national level without any insight on interoperability with other countries. Roads were created, but a holistic view including land use perspectives is often missing. Nowadays, these networks exist and we have to live with them. From a long term perspective a crucial question is how to anticipate the technological possibilities and needs of tomorrow, both in terms of transport systems and land use. The current trend towards globalisation makes international transport more important than ever. The transport activities are in constant evolution and tend to become more and more complex as the delivery periods shorten. The global economy needs effective transport, and a continuous reflection is needed to best use the present networks and develop them in view of future needs.

Efficiency and sustainability may go together in certain cases. For example, improving load factors in passenger or freight transport has positive impacts on both economic and environmental directions. However, in other cases the two objectives are not easy to reconcile. This has led to extensive research programmes on how to develop our transport system so that a good balance is found between environmental and economic perspectives.

It is clear that the globalisation of the world economy is a process that started long ago (see Table I.1). Exports as a share of the world production increased from a mere 1 per cent around 1800 to 17 per cent almost 200 years later. And noticeable is that the largest leap in growth occurred as late as 1973–1998 – a growth of almost 7 per cent.

An important driving force behind this increasing interdependence of national economies has been the drastic reduction of real transport costs. For example, Table I.2 shows that for ocean shipping the real costs have decreased enormously over the past centuries.

Decreasing transport costs have contributed strongly to globalisation. On the other hand, it is clear that other forces must also have been at work. For example, institutional barriers related to borders and protectionist policies must also have played their roles. Of particular interest may be that the decrease in the real costs of ocean shipping has come to a halt over the last decades. It is probable that this has been compensated by other components of generalised costs of

Table I.1 World merchandise exports as a ratio of world GDP

Year	*Exports/GDP (%)*
1820	1.0
1870	4.6
1913	7.9
1929	9.0
1950	5.5
1973	10.5
1998	17.2

Source: Maddison (2001).

Table I.2 Real costs of ocean shipping (1910 = 100)

Year	*Cost index*
1790	376
1830	287
1870	196
1910	100
1930	107
1960	47
1990	51

Sources: Crafts and Venables (2001), Dollar (2001), Harley (1988), Isserlis (1938).

transport owing to increases in speed, frequency and reliability. Nevertheless it indicates that further decreases of transport costs cannot be taken for granted. It also implies that quality aspects of transport are becoming more and more important. The rapid growth of freight transport that takes place by air – in particular when measured in terms of value rather than tonnes – is an indication that time is more important in the generalised costs of transport than is usually thought (Hummels, 2001).

This very short sketch of long running developments in trade makes clear that as economies become richer there is a strong demand for high quality freight transport which poses a strong challenge on the transport sector. Also, it has been argued by, e.g. Taaffe *et al.* (1963) that there is a parallel evolution of political, economic, and transport systems in developing economies.

A similar story can be told on passenger transport. Domestic transport tends to grow continuously. In countries with high income levels the growth rates are modest, whereas they are very high in developing countries such as China and India. International transport tends to increase at even higher levels (Eurostat, 2004). The gradual shift from manufacturing to services as the main dynamic sectors means that passenger transport will become more important as an input for production processes. This is one of the driving forces behind the observed rapid growth of international passenger transport, in particular via the air. Another important factor explaining the growth in aviation demand is international tourism. For example, in the year 2001 international tourism reached a level of about 700 million arrivals, Europe having a share of almost 60 per cent (Hall and Page, 2002). Given that the demographic profile of the Western world is changing, with a growing number of elderly, well-educated and economically well-situated, it is reasonable to expect international tourism travel to increase.

It is clear at the same time that these strong increases in transport demand, in particular the faster modes, impose considerable threats on the sustainability of the transport sector.

Sustainability

Decoupling of the growth in emissions and economic activities is the main way towards sustainable development. For certain sectors, developments have been favourable. For example, long term trends in the EU indicate that energy consumption, leading to CO_2 emissions is growing much slower than GDP growth. However, transport is a striking exception in this development. Energy use and CO_2 emissions in transport are growing faster than the economy. As a consequence the share of energy consumed in transport compared with total energy consumption has grown considerably during the last three decades.

To understand the mechanisms behind the increase of energy use in transport the following decomposition can be used:

$$\text{Energy use} = (\text{Energy use/transport volume}) \times (\text{transport volume/GDP}) \times (\text{GDP})$$

Given the process of globalisation sketched in Table I.1 it follows that transport volume/GDP has increased. An obvious explanation is that – as indicated above – the real generalised costs of transport are decreasing in the long run. The energy intensity in transport (energy use/transport volume) is remaining about constant. This is a striking result since during the last decades substantial technological progress has been made in improving the efficiency of energy use in transport. This means that countervailing forces must have been at work. For example, the increase in energy efficiency of engines in cars has been accompanied by the gradual increase in the weight of cars. Also there has been a gradual shift from slow to fast transport modes – in particular aviation – which implies higher energy use per kilometre travelled. Further, GDP increased substantially in the EU, although population growth itself has been modest. Thus, the major forces behind the increase of energy use in transport are the relatively high responsiveness of transport to economic growth and the occurrence of rebound effects of energy use within the transport sector that offset the potential efficiency gains that were made possible by technological development.

The above results for the EU lead to concerns on the long term environmental consequences of transport. One should be aware, on the other hand, that for a substantial number of pollutants progress has been made. For example, the phasing out of leaded gasoline in Europe and the US has tremendously reduced lead emissions. Similarly the use of catalytic converters has led a strong reduction of NO_x emissions of road transport. Thus, in other fields, outside the energy domain, large improvements have been made. The main remaining sustainability problems that are difficult to solve in the long run seem to be the local ones related to noise, accidents, etc., and the global ones related to energy use.

At the world level the situation is worse than the European situation suggests. There are two reasons for this. First, although being smaller in population size, the volume of CO_2 emissions in the USA is more than twice as high than in Europe. This means a substantial additional factor in world energy demand.

Second, of particular importance is the position of China and other developing countries with high economic growth. As indicated by WBCSD (2001), the global development of greenhouse emissions will strongly be determined by these countries if they continue to grow as they do now.

Indicators for efficiency and sustainability are needed

> Trying to run a complex society on only a single indicator like the Gross National Product is like trying to fly a Boeing 747 with only one gauge on the instrument panel. Imagine if your Doctor, when giving you a check-up, did no more than check your blood pressure.
>
> (Hazel Henderson, *Paradigms of Progress* (1993))

Indicators are quantified information which help to explain how things are changing over time. It is not only a matter of technical efficiency, but also a question of the way to effectively achieve measurable goals set by private or public actors. Historically, only a limited number of key economic indicators have been used to measure how the economy is performing – for example, output, level of employment, rate of inflation, balance of payments, etc. These figures give a general picture but do not explain the particular trends that are observed. However, they provide reasonable indicators of changes in the economy to the policy-makers and economic policy decision.

Indicators have three basic functions: simplification, quantification, and communication. Indicators generally simplify very complex phenomena in order to make them quantifiable so that information can be communicated and understood. As stated earlier, an effective transport system is an absolute need in our modern world. Industry, commerce, and services depend on it, and even social and recreational aspects of our life are made possible because of the availability of private cars. The key objective for a sustainable development is to tend to a right balance between the ability of transport to serve economic development and the ability to protect the environment and sustain quality of life, both now and in the future.

Policies aiming at enhancing efficiency and sustainability

An important challenge for our society is to reconcile the increasing demand for transport while reducing its environmental impact. About 15 per cent of all consumptive expenditures of households can be assigned to transport. The transport sector represents around 6 per cent of Europe's GDP and 6 per cent of EU employment and, over the past 30 years, goods traffic has increased by more than 75 per cent and passenger movements by more than 110 per cent.

For enhanced efficiency and quality the aim is to improve the overall cost-effectiveness and functioning of transport operations and infrastructure. Particular attention must be paid to how to integrate the respective strengths of all modes of transport in order to provide door-to-door services for both passengers and freight. A significant effort must be devoted to the reduction of congestion into networks in the coming years, but also to increase safety and security.

Table I.3, partly based on Button and Rietveld (1999) suggests a number of policies to improve efficiency and sustainability in transport. The types of measures we distinguish vary from market-based versus command and control measures. We add the distinction between direct and indirect since many measures that are not directly related to efficiency and environmental effects of transport activities have substantial indirect effects. As points of entry we use vehicle, fuel, infrastructure, traffic, and spatial structure, and a group of miscellaneous effects.

Of special importance seems to be the last element of the table, institutional change and regulatory reform. It is clear that these instruments may in the long run have very strong impacts on the performance of transport systems. For example, the liberalisation of the aviation market in the USA and Europe has led to a considerable increase of efficiency in the aviation sector in the form of lower prices and higher frequencies. At the same time, the environmental burden has increased. Another example concerns the regulatory reform of the rail and bus sector in many countries which had mixed effects on the efficiency in transport operations. The outcome is dependent on situational and geographical context, and experiences cannot readily be transferred from one country to another or from one industry to another.

Intermodal transport

It is gradually realised that intermodality may provide a key towards a better performing transport system. Car and truck will undoubtedly continue to dominate passenger and freight transport in Europe during the coming decades, but it is clear that they have their limitations and that they have to be combined with other transport modes. These limitations are obvious for passenger transport in metropolitan areas where congestion and lack of space for the car call for additional transport modes including cycling, walking, and public transport. These transport modes are not only competitors of the car, but may also be complements. For example, the principle that the car provides door-to-door transport has found its limitations in urban centres where pedestrian areas and limited or expensive parking spaces imply that the last part of the trip has to be done with another mode of transport. This calls for careful planning of parking facilities to link the car system with public transport. Also for long distance passenger transport where rail may be more attractive than the car, there is a clear need for a multimodal approach to ensure the local accessibility of railway stations. It makes little sense to carry out large investments in high speed lines when at the same time the quality of the underlying networks providing access to the stations is low. This points to the importance of working with transport planning as an integrated part of planning in general. Transport is intricately connected with all other aspects of daily life, such as housing, shopping, working and recreation, and consequently measures taken or changes made in one of these areas affects all the others.

Table I.3 Typology of policies to address efficiency and sustainability in transport networks

	Market: direct	*Market: indirect*	*Command and control: direct*	*Command and control: indirect*
Vehicle	• Emission fees • Congestion charges	• Tax allowance for new vehicles	• Emission standards	• Mandatory use of low-polluting vehicles
Fuel		• Differential fuel taxation	• Phasing out of high polluting fuels	• Fuel economy standards
Infrastructure		• Compensation for intrusion at time of infrastructure construction	• Noise shields	• Bus lanes • Airport location • Motorway expansion • Railway construction
Traffic	• Kilometre charge for road use, differentiated according to environmental standard of vehicle	• Parking charges • Subsidies for less polluting modes	• High occupancy vehicle lanes	• Speed limits • Restraint on vehicle use
Spatial structure				• Restrictions on settlement densities • Location of new settlements
Others				• Institutional change • Regulatory reform

In freight transport a similar phenomenon can be observed, where rail, inland navigation and short sea shipping are attractive alternatives to the truck. But given the economies of scale in terminal operations, terminal density is limited which implies that the first and last legs of a transport chain usually have to be carried out via road. This again calls for well performing multimodal nodes. Of critical importance are the fixed costs related to the transfer from one mode to the other. These include time costs of loading, scheduling, and waiting since frequencies on rail and water are lower given the large size of the trains and barges. Due to the high costs of modal transfer the threshold for intermodal freight journeys in the European Union is about 500 km. Reducing this for example to 200 km would be a great step forward in the promotion of intermodal transport.

This simple example illustrates that enhancing efficiency can only be achieved if solutions are implemented at several levels. Indeed, better intermodal solutions need:

- technical innovative solutions to fasten transshipment operations at the terminals;
- an in-depth knowledge of demand and supply associated to a reflection on land use considerations in order to create, develop, and operate terminals at sustainable locations;
- a better technical interoperability between the different national railway networks;
- an improved legal framework on transportation considerations;
- a better convergence of the social frameworks for the different transportation modes towards the European countries;
- change of attitudes in order to bring about change of behaviour;
- integrated planning between the different sectors;
- and so on.

Book content

The challenges posed to us are not simple, and much research is still needed. This volume tries to create a small milestone for these aspects.

The contributions to the theme of transport network performance are written by researchers belonging to the Network on European Communications and Transport Activity Research (NECTAR). The first part of this volume mainly addresses the stimulation of better performances by means of regulation and various other policies. It is followed by another series of papers that discuss items related to efficiency and sustainability in transport. The book concludes with some more method-oriented contributions in which efficiency is measured by models and methods.

The first set of papers approaches efficiency and sustainability of some proposed solutions, including intermodal transport.

Political and scientific interest with regard to intermodal transport is due to its sustainable and ecological aspects. By means of a review of the literature

Kreutzberger, Macharis, and Woxenius present an overview tackling the issue of the external effects of intermodal and unimodal transport. The results of the different studies are compared to each other and common conclusions are drawn, giving a clear signal to the market about the lack of cost coverage that should be an incentive for intermodal transport to improve its quality. Moreover, from a more general viewpoint, taking into account internal and external costs, spatial and network policies are crucial.

The paper by Willigers and van Wee draws attention to the fact that literature on environmental impact of underground freight transport is very scarce. Their paper assesses the energy use and the resulting emissions from underground freight transport systems. They use an analysis method based on indirect energy in two case studies: the long distance transport of crude oil in The Netherlands and the underground distribution of packed goods in the city of Utrecht (ULS). The construction of underground infrastructure for freight transport is seen by the Dutch government as a policy measure to achieve a more sustainable transport system. The paper demonstrates that things are not so simple. However, the authors state that a positive direct effect of all the alternatives in the ULS is the shift of emissions from inside the city to its edge and to power plants; this can improve local air quality in the city itself.

An efficient transport system must also be safe. As shown by Westin, Garvill, and Marell reducing the speed is a way to improve the performance of the road system by increasing security on the roads. This paper examines the effects on speed of vehicles equipped with an Intelligent Speed Adaptation (ISA) device and the effects these devices have on the average speed in the Swedish city of Umeå. ISA systems help drivers to avoid exceeding speed limits. The obtained results tend to show that speed was reduced within the test area, and that the observed speed reduction was perceived to be positive by the participating drivers. Thus, ISA is a promising tool to improve network performance from a safety perspective.

Roson makes a link between tangible and intangible networks, starting from the observation that, even if there is competition between agents in a network market, there is also a need for interconnection between them. He shows that concepts and principles can be considered as independent from the specific type of network (Internet, transportation, water distribution, etc.). This interesting paper draws some deep theoretical insight on these concepts, to finally conclude that network economics provide general models for the analysis of imperfect competition in networked markets like transportation, water distribution, and so on. The main insight is that capacity investments have a differentiated impact for on-net and off-net flows. Whereas intra-network flows are directly affected by the increase in capacity, the influence of congestion on inter-network flows depends on both the capacity levels of the source and destination networks. In addition, network firms may compete for quality through capacity improvements.

As mentioned above, indicators are important to address transport network performance. In order to allow decision-makers to imagine various (non-)fiscal policies and measures taking into account environmental aspects, Van Mierlo *et al.* have developed Ecoscore, a rating system able to compare the environmental damages caused by different vehicles. This new approach has been especially developed for urban contexts. The authors warn about the fact that their approach is still modest in comparison with what might be done theoretically but it meets different constraints such as, for example, working with currently available data or having comparable results for different vehicles of a same category. On the basis of the sensitivity analysis, they conclude that the proposed methodology is sufficiently robust for variations of the relative contribution of each specific pollutant.

The second series of papers discuss the impact of rules and policies on the performances of networks in their constrained environment.

Button examines institutional dimensions behind the improved performance of the airline sector during the past decades, in particular with respect to the notion of barriers to entry and exit in markets. He analyses what has happened in air transportation markets since the domestic deregulation in the US. The airline market is rapidly changing and the market share of low cost carriers has increased. He uses the idea of contestable markets to explain the functioning of the current trends. The author also identifies the various forms of market fragmentation initiated by the low cost companies as well as the responses developed by the majors.

Stead and Banister show in their paper that decoupling economic growth from transport growth does not yet take place, which means that sustainable transport is still far away. They discuss the nature of travel and how decoupling can usefully be measured through volumes, distances, and efficiency. They also present possible approaches and strategies for decoupling. For example, they show the impact of land use planning policies on passenger travel distance and the impact this strategy may have on efficiency.

Enoch and Rye discuss travel plans of employers or local governments, which are aimed at reducing car use for commuting and business trips and hence improve their environmental performance. This is an example of institutional change, mentioned in Table I.3, implying a difference in definition of positions of actors, in this case the employer. A travel plan is a package of measures that can be implemented to encourage staff to choose alternatives to single-occupancy car use. This paper establishes a series of scenarios to estimate how travel plans might be more effectively introduced and supported. These models will then serve to develop the future travel plans in the UK.

The appropriate role and function of government in the regulation of the public transport sector is the topic discussed by Mouwen and Rietveld. They assess five regulatory regimes on efficiency and equity objectives of regional and local public transport authorities. They use data from 21 European cities and regions to show that competition is positively related to objectives of efficiency taken by the authorities. This underlines the importance of regulatory regimes adopted to improve the performance of transport systems, in particular public transport.

The last part of the book is more specifically related to methods and models that can help to measure and evaluate efficiency.

Nagurney and Matsypura developed a framework for the modelling, analysis, and computation of solutions to global supply chains. They model the behaviours of three decision-makers – manufacturers, intermediaries, and consumers – and obtain qualitative properties of the equilibrium product shipment and price pattern. This research extends the recent results surrounding the modelling of supply chains in network equilibrium.

The framework allows for the handling of as many countries, as many manufacturers in each country, as many currencies in which the product can be obtained, and as many retailers, as required by the specific application. Moreover, the generality of the framework allows for the demand to have almost any distribution as long as it satisfies certain technical conditions. The dynamic model, which is formulated as a projected dynamic system, provides the evolution of the product transactions between tiers of the global supply chain super network as well as the prices associated with the product at retailer and at distributor levels.

Over the last few years, the European high-speed train network has rapidly developed. Martín, Gutiérrez and Román evaluate the gain of accessibility obtained on the connection between Madrid and Barcelona. The authors use a geographic information system (GIS) to develop some synthetic indices to measure the impact on accessibility of the new line. If the new high speed line Madrid–Barcelona–French border is built, the authors conclude that Madrid, Ciudad Real, Barcelona, Segovia, Guadalajara, Valladolid, Zaragoza, Tarragona, and Lleida would become the most accessible cities in Spain. From a more general viewpoint, the project will increase regional accessibility disparities.

Kreutzberger, Konings, and Aronson point out that Pre- and Post-Haulage (PPH) is an important part of the costs in intermodal freight transport, for which they have developed a simple calculation tool. The impact of PPH costs are known to be an important question for the design of intermodal rail or barge terminals. The authors estimate the relative importance of PPH costs for distances of 5, 25, 50, and 100 km, taking into account the different typical alternative European network operations. As expected, no real general design can be proposed, as the performances depend very much on different aspects such as volumes, length of the main railway chunk, frequencies, etc., showing that the decision to create a terminal, a logistic platform or a shuttle service must be carefully studied and cannot be the simple result of a local political decision.

Bergantino, Bolis, and Canali present a methodological framework to detect the market opportunities for short sea shipping. They noticed that there is lack of empirical data that can be used to determine the operators' choices. They measure the trade-offs among service characteristics that shippers make when they evaluate the Ro-Ro option against alternative surface services. They present preliminary evidence obtained by estimating a model of forwarding agents' behaviour with respect to the maritime alternative, using adaptive conjoint data collecting methods. Reliability and frequency seem to be the key factors in the choice of the transport service alternative. Despite the fact that the outcome of the research is based on a limited sample, it confirms that the use of stated preferences can be a valid option to estimate the attitudes of operators towards the attributes of Ro-Ro freight transport markets.

Raney and Nagel present an improved framework for large multi-agent simulation of travel behaviour. For a long time, multi-agent simulations were considered to be only feasible on small networks. The authors present some new methodological insights and computer implementations of simulations on large networks, opening the way for new model possibilities. This modelling approach is promising since its immediate goal is a replacement of the traditional four-step process for transportation planning; the longer-term goal is to have an agent-based system for all aspects of urban and regional planning.

Macharis, Stevens, De Brucker, and Verbeke present a strategic assessment methodology for advanced driver assistance systems (ADAS). The partners in the research consortium include various public agencies, publicly funded research institutes, transport and insurance companies, and automobile manufacturers from ten different European Union countries. The ultimate purpose of this consortium was to improve road safety in the EU through the introduction of new technologies. Their paper focuses on sensitivity analysis and implementation challenges. The strategy selection matrix and related work intended to develop implementation strategies, provides a new framework to reflect on the complex challenge of ADAS deployment. The methodology, when applied to a number of highly ranked scenarios, was considered helpful by a number of actors involved in strategic thinking on this issue. A certain number of implementation phases were identified, which suggest fruitful avenues for business–government cooperation, especially at the European level.

Conclusion

One of the conclusions that can be drawn from this set of papers is that multimodality, although being promising and promoted, is still difficult to make a success. There are mainly two reasons for this. First, market adoption will remain a problem since generalised costs remain substantial. The second reason is that the environmental performance of multimodality is not as good as one might expect on the basis of the favourable environmental performance of the main mode (for example rail) versus the truck. This is due among other things to the detours made in multimodal transport and to the intensive use of road for pre- and post-haulage, often in already congested areas.

Another conclusion that can be drawn is that – even though substantial progress has been made in some directions – the environmental impact of transport is a matter of continuous concern. Congestion, pollution, traffic safety, and land use conflicts arise more often than ever and decoupling energy use and transport will be a major challenge. A solid assessment and evaluation of these conflicts is needed, in particular since long-term impacts of policies aiming at decoupling are hard to assess.

The challenge of tomorrow is to manage a transport system that is increasingly more global and international, and therefore hard to monitor and manage. This is partly a political issue. National governments have no doubt exerted substantial influence on transport system performance via regulatory measures and taxation, but in small countries there is less scope for intervention. This calls for the formation of geo-political institutions such as the EU to have a public sector that has sufficient power to face the power of transnational corporations and also to address problems with fiscal competition between countries.

A final point we observe is that the performance problems of today are considered to be the most urgent ones. However, demographic trends in the industrialised world, with lower fertility rates and higher life expectancy, lead to an ageing population. This means that our transport system will gradually face new performance standards related to the changing composition of the population. Given the long-term investments involved, it is advisable to start making adjustments to the transport system to meet the needs of the citizens of tomorrow.

References

Button, K.J. and Rietveld, P. (1999) 'Transport and the environment' in J. van den Bergh (ed.) *Handbook of Environmental and Resource Economics*, Edward Elgar, Cheltenham, pp. 581–592.

Crafts, N. and Venables, A.J. (2001) *Globalization in History: a Geographical Perspective*, Paper prepared for the NBER conference on 'Globalization in Historical Perspective'.

Dollar, D. (2001) *Globalization, Inequality and Poverty since 1980*, mimeo, Worldbank.

EC (2002) White Paper 'European transport for 2010: time to decide'.

Eurostat (2004) Passenger air transport 2001–2002.

Hall, C.M. and Page, S.J. (2001) *The Geography of Tourism and Recreation*, Routledge, Glasgow.

Harley, C.K. (1988) 'Ocean Freight Rates and Productivity 1740–1913: the primacy of mechanical invention reaffirmed' *Journal of Economic History*, 60: 819–841.

Henderson, H. (1993) *Paradigms of Progress.*

Hummels, D. (2001) *Time as a Trade Barrier*, mimeo, Purdue University.

Isserlis, L. (1938) 'Tramp shipping cargoes and freights' *Journal of the Royal Statistical Society*, 101: 53–146.

Maddison, A. (2001) *The World Economy: A Millennial Perspective*, OECD.

Taaffe, E.J., Morrill, R.L., and Gould, P.R. (1963) 'Transport expansion in underdeveloped countries: a comparative analysis' *Geographical Review*, 53: 503–529.

WBCSD (2001) World Business Council for Sustainable Development, Mobility 2001, Geneva.

Part I

Efficiency and sustainability in transport

1.1 Intermodal versus unimodal road freight transport

A review of comparisons of the external costs

Ekki Kreutzberger, Cathy Macharis,** and Johan Woxenius****

Abstract

Intermodal transport, the combination and integration of several modes, with the use of loading units, has been said to be more environmentally friendly than unimodal road transport for the carriage of goods. The political and scientific interest in this transport system is largely due to the sustainability and ecological aspect of the intermodal transportation system. In this paper an overview is given of studies and papers that are tackling the issue of the external effects of both intermodal and unimodal transport. An overview is given of the types of external costs that were taken into account (emissions, security, noise, etc.) and the methodologies that were used to estimate the external effects and to value these effects in terms of costs. The results of the different studies are compared and conclusions are drawn.

Keywords: *intermodal freight transport, environmental performance, external costs, internalisation*

1 Introduction

Intermodal freight transport, the combination and integration of several traffic modes with the use of loading units, has often been claimed to produce less emission of harmful substances than unimodal road transport. The political[1] and scientific[2] interest in intermodal transport is largely due to this assumed ecological sustainability together with the potential to fight congestion on the roads.

Despite strong research and policy statements, a study (IFEU and SGKV, 2002) commissioned by the International Road Transport Union (IRU) and Bundesverband Güterkraftverkehr Logistik und Entsorgung (BGL) has brought the assumption of intermodal transport as being ecologically favourable into question. Cases in which intermodal road-rail transport requires more primary energy leads the IRU to recommend a transport policy not supporting intermodal transport. Also Transport en Logistiek Nederland (TLN) refers to an own study (TLN, 2002) advocating longer lorries instead of a modal shift.

Hence, the primary purpose of the article is to investigate whether published studies support the yet dominating opinion that intermodal transport is less environmentally harmful than unimodal road transport and if so, under what circumstances.

A further important point is that a stated goal of national and EU authorities is to internalise the external costs, which are the monetisation of the external effects, of all modes of transport (see, e.g. European Commission, 2001). Estimating the external costs is truly a delicate task and the effects on the competitive situation of the different modes have to be considered. If a policy would be pursued to internalise the external costs, the cost calculations underlying this policy should be reliable. A second purpose is to evaluate how the reviewed studies contribute to the knowledge of external costs.

Assuming that external costs can be accurately calculated, another issue is how they can be used for introducing fair and efficient pricing, which means that all transport assignments carry their internal and external costs. The third purpose is then to investigate what support the studies give to policy-makers and for the competition between traffic modes.

The article reviews different applied research efforts tackling the issues of the external effects of intermodal and unimodal freight transport and evaluates the results structured by the approaches presented in the theoretical framework in Section 2. Much of this kind of research is published as reports and conference papers rather than articles in scientific journals (Bontekoning *et al.*, 2003) indicating that the issue of logistics and the environment is underrepresented in scientific journals (Abukhader and Jönson, 2004). The search for reports and conference papers is a less structured process than reviewing journal publications, and the search and selection process behind this article has been somewhat pragmatic. The fact that many reports are published in national languages also means that there is a correspondence between the selected studies and the nationality of the authors.

2 Considered aspects

The policy field of external transport costs is rather complex and research results and internalisation effects are highly method dependent. Many aspects must then be distinguished and the ones influencing this study the most are listed here.

The focus of the study

The focus describes what the main subject of a study is, namely the size of external effects, possibly also their valuation to costs and benefits and even the cost coverage of social costs by taxes, charges and subsidies or even the relation between real and fair or efficient prices. Another interest could be the comparison of the transport sector with other economic sectors. The focus is of influence for the choice of economic approach.

Average versus marginal costs

Efficient prices according to welfare theory are prices based on so-called short term marginal internal and external costs.[3] Marginal approaches focus on the costs of the last additional unit of transport (vehicle, vehicle-km, ton, tonnekm, loading unit, load unit km; absolute or percentage, etc.). Marginal costs in principle differ from average ones, even though the two can be the same.[4]

The transport system aggregation level

The size of external costs depends on the envisaged transport system level. This can be the whole transport system or sub-categories, like freight and passenger transport. The external costs to 'the society' or non-participants of the evaluated traffic on the one side or transport group on the other side are smaller than if the effects to other system participants are also included (e.g. health effects of freight transport to non-participants only (like residents) and all society (residents, drivers, and passengers)). The most discussed topic in this regard is accident costs. The European research projects UNITE (Sansom *et al.*, 1999) and RECORDIT (Bacelli *et al.*, 2001; D4) consider the own risk of system participants to be internal costs, as these are accepted when deciding to use the system. The long British tradition of comparing infrastructure-related costs with revenues for the road sector by means of 'fully allocated cost' models excludes external costs internal to the transport system (Sansom *et al.*, 2001). Also, ECMT, CE Delft, and INFRAS/IWW define the own risk of system participants as external costs (Dings *et al.*, 2003). Certain costs to others, like accident damages, are not external costs as they are covered by insurance and therefore already internalised.

Another important point here is that even with an aggregate estimation of the external costs, this will not shed light on the individual modal shift decisions of companies and as such will not give an idea on the modal shift pattern on a macro-level. Indeed, at the company-level other costs and criteria are taken into account (Roson, 2003).

The system borders

The external effects can be analysed for the transport system only, or also for upstream or downstream events. Upstream events are external effects of producing something, which is used in the transport system, like petrol or vehicles. Downstream events are external effects of things that have been used in the transport system, like destroying or recycling old vehicles.

A dominating method in this domain is Life Cycle Assessment (LCA), the application of which, however, is not intended for assessing supply chains but for the full life-cycles of physical products (Abukhader and Jönsson, 2004). With some adaptations, LCA can be applied to transportation, e.g. for assessing single transport assignments or networks producing standardised services such as general cargo transport. LCA is rather easy to apply on the level of a vehicle (Van Mierlo *et al.*, 2003). Allocating the external effects to individual consignments, however, requires a number of delicate assumptions regarding, e.g. distribution between different consignments co-using transport resources, which consignment initiated the movement of the vehicle, load factors, and balances (Bäckström, 1999).

The range of external effects

The following list of typical external cost components is not complete, but nevertheless they are often the subject of research projects:

- accidents;
- noise;
- air pollution;
- climate change;
- infrastructure;
- congestion;
- water pollution;
- damage to certain ecological systems;
- land occupation; and
- visual intrusion.

Some of these components are of interest primarily to other system participant groups (like congestion), others primarily to non-participants (like land occupation).

The last three components are, despite their policy relevance in densely populated European regions, not included in the analysis. If it is true that land occupation of unimodal road transport per freight unit is significantly higher than that of intermodal transport (this is doubted by some authors, as we will see below), then this should be expressed in pricing schemes or by other types of political decisions.

The external cost strategy

Internalisation policies can be based on three strategies: the prevention strategy; the damage compensation strategy; and the damage recovery strategy. The first is directed towards (ex-ante) avoiding damage, the second towards compensating for realised damage, the last towards (ex-post) undoing the damage. The size of the costs and of the relation between costs and measures may differ per strategy (Boneschansker and ‘t Hoen, 1993).

Methods to estimate external costs

To substitute the absence of market prices, external costs are estimated in terms of shadow prices. The estimates can be direct or indirect ones, bottom-up or topdown ones, and related to political, scientific or individual targets or norms. They can also include upstream or downstream events. Some examples: CO_2 emissions are direct estimates in the light of – most often – political targets (Kyoto, European, national). The shadow prices reflect the costs to prevent or abate damage due to higher emissions.

Local emissions, noise and accidents are estimated directly or indirectly. A new indirect approach is the ‘Impact Pathway Approach’, which was developed and applied the first time by the ExternE project (Friedrich and Bickel, 2001), later also adopted by UNITE and RECORDIT and by many studies we reviewed here.

The methods of impact valuation

For the direct or indirect valuation of impacts alternative techniques have been developed, among which hedonic pricing, the travel cost method, contingent valuation, and the human capital approach are the most recognised.

The instruments to realise the internalisation

The instruments to realise internalisation are rather independent from the estimation of the size of effects, impacts, and monetary values. But it is useful to have the instruments in mind when thinking about estimation, since the instruments differ per strategy (as defined above). All three strategies can be realised by introducing monetary instruments such as taxes, charges, subsidies or financial compensation, which equalise the distribution of (dis)advantages between generators of traffic effects and persons who suffer or benefit from the impacts. The prevention strategy may also include non-monetary instruments such as the prohibition, the restriction or the enforcement of certain transport or traffic features. These instruments need legal frameworks, for instance a definition of who is the owner of a right or a problem. Only if the non-participant of the transport system (e.g. a resident) is owner of the right of certain residential qualities, can he or she demand financial compensation from the one who causes the quality damages. The legal framework also needs to cover the geographical scale of the problem caused. Hence, noise and local emissions can be dealt with on a community level (e.g. bans on engines running for more than three minutes at stand still), sulphur emissions on a European level, while CO_2 emissions must be negotiated globally.

The analysed modalities

The analysed modalities include unimodal road, rail, and air transport as well as intermodal road-rail and road-barge transport. In literature several comparisons on a unimodal basis were found. Dings *et al.* (2003), Forckenbrock (2001), Beuthe *et al.* (1999, 2002) and De Vlieger *et al.* (2002, 2004) are very interesting from a methodological perspective but are not incorporated in the description of studies as they do not take account of the specific settings of the intermodal transport chain. They are, however, kept in the overview (Section 4) in order to compare the other methodological steps.

All ten aspects serve as check list when reviewing the literature in the following section. The summary of Section 4 contains a table which gives an overview of all reviewed literature in relation to the included aspects.

3 Review of studies

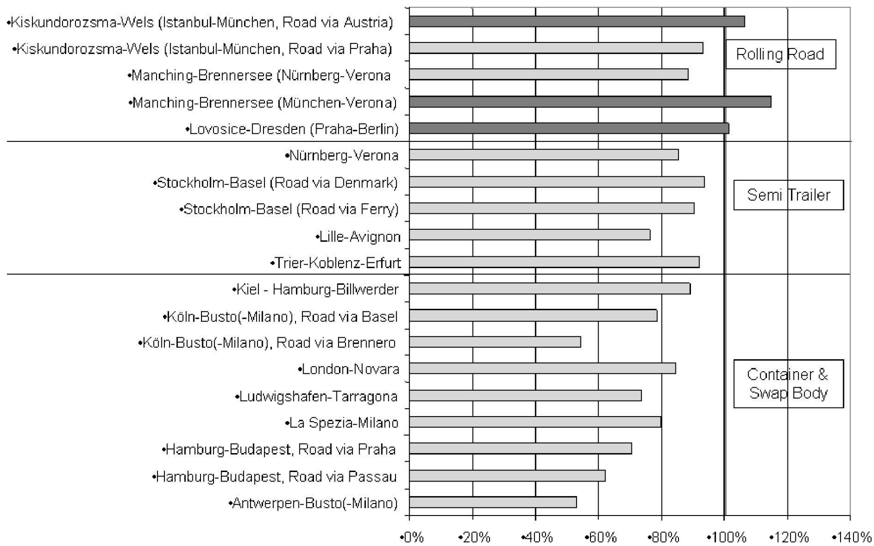
In this section the different studies, projects and articles are reviewed. The utilised methodologies are summarised and the main results given. An overview of the reviewed papers is given at the end of the section. Here the different aspects, as discussed in Section 2, are given for each of the studies. The review covers ten studies (A–J) and starts with some supplementary information on the two critical research reports, which were already presented in Section 1.

IFEU and SGKV, 2002

The IRU/BGL study (IFEU and SGKV, 2002) focuses on the comparison between primary energy needs and CO_2 emissions of unimodal road transport and of an intermodal road-rail transport. The study shows that three of the 19 routes examined require higher primary energy need by intermodal road-rail transport (Figure 1.1.1). Otherwise in eight cases the primary energy need of intermodal transport is up to 20 per cent lower than that of road transport, in six cases it is 20–40 per cent lower and in two cases it is lower by more than 40 per cent. The best results were achieved by swap bodies and containers. If, on the other hand, CO_2 emissions are compared, the same study indicates that in two cases emissions generated by intermodal transport are higher than those generated by unimodal road transport. The rest of the study shows clearly that CO_2 emissions by intermodal transport are lower than those produced by unimodal road transport (for example: in four cases up to 20 per cent lower, in seven cases 20–50 per cent lower).

This study leads the IRU to recommend a transport policy which would not be based on a further promotion of intermodal transport. Such a conclusion represents a biased interpretation of an otherwise solid analysis. The study calculates only direct effects of only two entities, namely energy need and CO_2 emission. The dispersion of CO_2 and the impacts of energy need and CO_2 emission to society, and the valuation of impacts are not subjects of the research. The differences of environmental performance are due to:

- The type of train. Rolling road trains have clear disadvantages regarding energy use compared to trains with semi-trailers and containers.
- The length of train. Trains with ten wagons (*c.*200 m) have a higher specific energy need than road. Trains with 15 wagons (*c.*300 m) already have lower values. Long trains (*c.*700 m) have an energy need of about 60 per cent.



- The amount of pre- and post-haulage (PPH). The study concludes that for PPH 'perpendicular to the main route, the intermodal transport will be energetically disadvantageous when the total distance of PPH is more than half the distance of the direct road transport'. And if the direction of PPH 'is opposite to the main route (backwards) the intermodal transport is less favourable as soon as $\frac{1}{4}$ of the direct road transport distance is required for PPH' (IFEU and SGKV, 2002: 34–35).

The three trains with negative environmental performances have cumulative negative input characteristics: very short main modality distances (two of the three cases), longer PPH-distances than main modality distances (three of three), short train lengths (two of three) and Rolling Road trains (three of three). This allows for drawing the conclusion that average intermodal trains will always have better environmental performances (in terms of energy and CO_2 emissions) than unimodal road transport.

The negative performance of PPH is mainly due to the higher fuel consumption of lorries in local transport (48 instead of 35 litres/100 km), which is very reasonable argumentation. Less reasonable may be the fact that local road performances in unimodal road transport are considered to be short. If local parts had a comparable proportion in the entire road distance as in intermodal chains, the environmental performance of unimodal road would decrease. This reflection in any case indicates the importance of location policies.

Another important observation for conclusions from the IRU/BGL study is that reference lorries are assumed to be loaded in both directions of a round trip. In practice this is often not the case, not only because of freight imbalances (which also bother other modalities), but also because of insufficiently co-ordinated operations.

TLN, 1999

Also the report of TLN (1999) is restricted to direct effects (no dispersion, impacts or valuation). The study focuses on energy need, emissions (local and CO_2) and land occupation of three modalities: unimodal road; intermodal road-rail; and intermodal road-barge transport. The TLN cases refer to the following network and operational features: the main modality route length is 450 km, PPH for rail maritime, rail continental, barge maritime, barge continental are set at 5, 10, 5 and 20 per cent respectively. The trains have 21–28 wagons (maximal length then is approximately 400–550 m). The envisaged barges are the neo-kempenaar (32 TEU) and Europe barge (208 TEU). The report distinguishes maritime and continental flows and concludes that only the first have more favourable environmental performances. The main reason is that PPH distances are relatively short or even zero. The report therefore advocates stopping the myths about the environmental effects of a modal shift.

Even though PPH, also according to other reports, deserves much attention, most results of modality comparisons are presented on a door-to-door level. The effects of PPH are not discussed separately. On this level the global direction of results is indicated in Table 1.1.1.

Some results regarding energy need and CO_2 emissions of the TLN study diverge from those by the IRU/BGL study. The latter is more convincing in terms of methodology. The study assumes a very low fuel consumption of lorries, namely 29 litres/100 km compared to 34 litres/100 km in the IRU/BGL study. Train lengths are not varied and the reference lorry is loaded in both directions of a round trip.

Part of the TLN study is devoted to the coverage of environmental costs. This part of the study appears to be tendentious, cumulating in the conclusions that road covers 28–179 per cent of its costs, intermodal networks, on the other hand, would cover none of their environmental costs.

TLN, 2002

‘Gelijke monniken, gelijke kappen’ (2002) is a new TLN report on external costs rather than an update of the former one. It investigates the external costs of accidents, noise, emissions (climate and local) and infrastructure of road, rail and barge transport, including intermodal transport, and calculates the cost coverage per modality for the Dutch situation in 2002. Congestion costs are not calculated, because such costs can – in TLN’s opinion – not reasonably by assigned to (road) freight transport, which must be considered to be rather a

Table 1.1.1 Environmental performance of intermodal door-to-door transport in comparison with unimodal road transport

	Rail maritime	*Rail continental*	*Barge maritime*	*Barge continental*
Energy need	Favourable	Non favourable	Favourable	Non favourable
CO_2	Favourable	Non favourable	Favourable	Non favourable
NO_x	Favourable	Slightly favourable	Favourable	Non favourable
SO_2 and particles	Non favourable	Non favourable	Non favourable	Non favourable
Land occupation	Non favourable	Non favourable		