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Contents

Abstract

The Sustainable Knowledge Platform, SKEMA, aims to contribute to the establishment of a sustainable transportation system in Europe that will produce less emissions, noise and reduce any damage on societies. To address the *issues* of *sustainable transport*, this report has introduced all external effects of transport services subject to environmental constraints in addition to the budget constraints. Thus the transport costing does not represent exclusively the profit margins but also the environmental and social impact.

The study classifies the external effects into economic, environmental and social, which follows the structure of the SKEMA Policy Index. Then it briefly reviews the existing studies in the UK and Europe that propose ways for calculating externalities. And finally, it develops a case study as practical guidance to illustrate the advantages of the coastal service to the alternative road service.

"Methods for calculating externalities"

Review of Methods and Practical Application

There is a growing consensus among policy-makers around the world that strong cuts in emissions and strong actions are urgently needed. A recent report on climate change examines the economic case for both fiscal stimulus packages and "green" expenditure[1]*. The authors argue that with billions that governments spent on energy, buildings and transport, it is vital that these public investments do not lock us into an unsustainable high-carbon economy for many more decades. Green policies and investments will create new jobs and tackle climate change.*

Introduction

To understand the performance of an entire industry, it is significant to incorporate the *external effects* from industrial activities. Pollution, congestion, noise, accidents, health impacts are such effects from transportation services. These external effects could be classified as economic, environmental and social. A number of methods have been established for calculating them[2]. The economic and environmental impact can be easily quantified using established methodology, but the social external costs are more difficult. The estimation of total external costs (excluding congestion) amounted to €650 billion for 2000, or about 7.3% of the total GDP in EU17. For instance, air pollution and accident costs amounted to 27% and 24% respectively[3]. Noise and life-cycle processes each accounted for 7% of the total costs.

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[1] Bowen A., S. Fankhauser, N. Stern and D. Zenghelis, "An outline of the case for a "green" stimulus", Policy Brief, Grantham Research Institute on Climate Change and the Environment, Centre for Climate Change Economics and Policy, *London School of Economics,* February 2009

[2] DG TREN, Handbook on estimation of external cost in the transport sector

[3] Recent data show some improvement. For more details, see European Environment Agency's home page: http://www.eea.europa.eu/

The theory suggests that the presence of externalities affects the optimal equilibrium and leads to overuse of some activities while others remain underestimated. Thus, incorporating externalities in *sustainability reports* brings a better methodology for evaluating the contribution of an industry to solve environmental problems. In the case of transport, we focus on the following external effects: pollution (carbon emissions); acidification (nitrogen and sulphur oxides); noise pollution; accidents, congestion and health impacts. To reduce these effects, the theory suggests two basic solutions – government-implemented quotas and taxes[4]; and bargaining over externalities.

Objectives and target stakeholders

The present study provides an overview of existing UK and European methods and offers a practical guidance for application. A case study is presented to illustrate the advantages of shipping services based on an analysis, incorporating externalities. This analysis might be of interest to:

- Analysts and consultants providing externality cost estimations;
- Climate Change Committees on a national and EU level;
- Policy makers interested in harmonisation issues
- Promotional organisations in calculating externalities for alternative modes associated with specific routes
- Local authorities, financial institutions involved in infrastructure pricing
- Insurers that offer transport sector insurances
- Shippers interested in selecting / specifying preferred approach and to understand advantages and limitations
- Transport authorities for defining charges

Glossary terms

[4] Pigou, A. "The Economics of Welfare" London: Macmillan, 1932

EXIOPOL (2007) is an Integrated Project aimed to develop a New Environmental Accounting Framework Using Externality Data and Input-Output Tools.
HEATCO (2006) Unit Cost Figures for Externalities - HEATCO's primary objective was the development of harmonised guidelines for project assessment on EU level.

IMPACT (2007) Internalisation Measures and Policies for All External costs of Transport - the main recommendation from IMPACT is an amendment of the Eurovignet Directive on infrastructure charging for heavy goods vehicles.

UNITE (2003) Transport accounts and External cost estimates for most western European countries. This project had three core objectives.

ExternE (2005) External Costs from Energy – the scope of this project was to value the external costs, i.e. the major impacts of economic activities, both referred to production and consumption of energy.

Approach and methods of calculation

In order to address the *sustainability issues* of transportation, we have to introduce the external effects subject to environmental constraints in addition to the budget constraints of a classic model[5]. For this purpose they need to be quantified. Not only this but sustainability also requires *lifecycle analysis,* which considers all quantified impacts over an entire life of an activity or product[6]. In order to simplify the analysis, this study is limited to the models that were already implemented in practice. Thus we start firstly with classifying the effects into economic, environmental and social, which follows the structure of the SKEMA Policy Index[7]:

I. Economic external effects

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[5] Stern, N. "Economics of Climate Change", London 2006

[6] More details in Overlapping generations model (OLG)

[7] See Annex 1

- Congestion
- Accident damages

II. Environmental external effects

- Pollution
- Noise
- Acidification

III. Social external effects

- Health impacts
- Quality of life

Secondly, a brief review of existing studies in the UK and Europe has been provided to propose ways for calculating externalities. All studies use similar methodology which is based on the equilibrium approach. The differences come mainly from the measurement units, which may lead to different types of output. The UK studies tend to use costs per tonne-km measurement while the European Handbook on estimation suggests €ct/vkm (€ cost per vehicle-km). Therefore the next section explores:

1) EU attempts to estimate external effects
2) Best practice approaches
3) UK attempts to evaluate external effects

Review of methods

I. EU attempts to estimate external effects

A few attempts have been made at an European level to estimate the external costs under the 4th, 5th and 6th EU-framework programmes. UNITE project (2003) has developed best practice approaches as a consequence of work done on a few projects. The external costs that are treated in the EU initiatives are explained in Table 1 (see below).

Accident costs, congestion and environmental costs affect different parts of the society directly and indirectly. When not internalise, the external effects are not counted as direct costs of the transport services. They are paid by delay costs; victims of accidents; energy taxes or noise related charges; etc. Therefore they need to be taken into consideration as direct costs of transportation.

Table 1: External costs

Cost component	***Private and social costs***	***External part in general***	***Differences between transport modes***
Costs of scarce infrastructure	All costs for traffic users and society (time, reliability, operation, missed economic activities)	Extra costs imposed on all other users and society exceeding own additional costs	Within non-scheduled transport (road), the external part is the difference between MC and AC based on a congestion cost function
Accident costs	All direct and indirect costs of an accident (material costs, medical costs, production losses, suffer and grief caused by	Part of social costs which is not considered in own and collective risk anticipation and not covered by (third party) insurance	There is a debate on the level of collective risk anticipation in individual transport: Are the cost of a self accident a matter of (proper) individual risk anticipation or a

	fatalities)		collective matter? Besides there are different levels of liability between private insurances (private road transport) and insurances for transport operators.
Environmental costs	All damages of environmental nuisances (health costs, material damages, biosphere damages, long term risks)	Part of social costs which is not considered (paid for)	Depending on legislation, the level of environmental taxation or liability to realise avoidance measures is differing between modes (road, rail, water)

Source: Handbook on estimation of external cost in the transport sector – IMPACT, p.14

II. Best practice approaches

The EU methodology is based on *individual* preferences which reflects the willingness to pay (WTP) for an improvement and the willingness to accept (WTA) a compensation for non-improvement. To measure the willingness to pay, the approaches rely on market prices or real costs after taxes and subsidies. Very often this measurement depends on the level of information and survey design. To measure the willingness to accept a compensation, more differentiated approaches were applied, particularly, for long-term risks and habitat losses.

In the case of long-term environmental damages, another approach has been recommended – the *impact pathway method* (used by ExternE model[8]). The German methodological convention (UBA, 2006) recommended seven steps to carry out this approach as the lack of certain information in the dose-response function (impacts on

[8] The EU developed model for air pollution

human health) requires a combination with a standard price approach. Thus as a second best approach, the avoidance cost method is used.

The complexity of externalities asks for an application of various approaches to obtain the best possible measurements. Naturally, different cost categories are evaluated by differing models. The WTP and WTA approach is applied in the case of accident costs, noise, human health impacts and costs of scarce infrastructure. The impact pathway method is applied in measuring the effects of air pollution and nature. Climate change issues are evaluated by the avoidance cost approach while nature and landscape – by compensation cost approach (for more details, see IMPACT D1).

Another difficulty with all these models is the extraction of marginal costs. In order to get the national averages of marginal costs, an estimation of average variable costs are made on top-down approaches using national data. The existing literature recommends the bottom-up approach following the impact pathway methodology. However, in practice both approaches are combined to obtain better estimations.

Variety of estimations have been suggested, however, the methodology is based on the equilibrium approach. The EU projects suggest the range of Unit cost values per vehicle-km (or train/ship-km) that reflects marginal cost figures. These unit values are the basis for calculating the level of externalities (different traffic situations, modes, countries, etc). For instance, HEATCO project (2006) has recommended unit cost figures for external effects that are used in evaluation of transport related projects. IMPACT project (2007) has made recommendations for methods and values of estimated external costs for pricing policies and schemes. And EXIOPOL project is developing an extended input-output framework with included externalities.

III. UK attempts to evaluate external effects

This section uses the results from existing UK research to establish standards for:

- Congestion
- Accident damages
- Air Pollution (Carbon and Carbon equivalent emissions)
- Noise
- Health impact

The UK research in this field seems to be fragmented. The data and their sources for the calculation of external effects are exclusively government produced by various departments. The methodology is based on the equilibrium approach as the tonne-km values are transferred into monetary terms (£costs).

A. Congestion

The UK Department for Transport data is available for traffic levels on various routes, in each direction (based on 2004/05). For each route it is possible to determine whether the traffic level is very high, high, moderate or light in terms of congestion.

The value of a route is calculated in accordance with a road value – a rate per lorry mile (**69p** for high congested roads; **27p** for medium congested road and **4p** for low congested road). The mileage for each category is then multiplied by the appropriate road value, producing the route valuation. Environmental benefits per annum are then obtained by multiplying the number of lorry trips by the route valuation[9].

B. Transport accidents and casualties

Tables with distribution of road accidents classified by severity and classified by road user type are available from the 'UK on the spot accident data collection study, second phase 2003,' produced for the Department for Transport.

C. Pollution and pricing the CO2 emissions

Carbon emissions are based on the study "CO2 Emissions from Freight Transport in the UK" prepared for the Climate Change Working Group, Logistics Research Centre by Prof. Alan McKinnon. These are also consistent with a report on food miles also produced from DEFRA which compares the emission factors of air and sea transport. The acidification data used are those produced by the Freight Study Group for DEFRA.

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9 Department for Transport – Environmental Benefits Calculator
http://www.dft.gov.uk/eb-calculator/

It is possible to attach a price to emissions using information from the UK and EU Emissions trading schemes. In 2006, the price was in the range of £2 to 4 per tonne CO_2 but this level was much lower than the carbon prices at the European Exchange EEX, which was between 14-24 Euros per tonne. Thus this study uses the 14 Euro lower-band as the market price of carbon.

To demonstrate the importance of quantifying externalities in transportation, we are presenting a case study for a specific route (Felixstowe – Teesport – Felixstowe). This case shows how the internalisation of external effects leads to a more competitive coastal shipping service than the alternative road service.

Practical Application

Case Study

The applied data in this case study has been extracted from existing studies in the UK and EU public domain. The studies were produced by various research organisations and public authorities. Therefore the authors can't accept responsibility for any inconsistency in the available data. The case study has been solely produced as a guiding methodology for calculating externalities.

Case: *two small container ships, of the standard 100m length / 360 teu type, on a daily service between Felixstowe and Teesport. Compare it with the use of road to deliver the same amount of goods applying details of tonnage, kilometres travelled and tonne kilometre calculations.*

At the start we present the calculation of tonne kilometres using the water option and road option. Then the externalities are calculated.

1. Water option

The water option involves two ships simultaneously sailing between Felixstowe and Teesport as a daily service. Goods would then be moved by lorry from Teesport to the final destination. Thus there is a water leg and road leg. Various assumptions have been made in the derivation of tonne kilometres. These are as follows:

- The average laden twenty-foot container weighs 14 tonnes
- The weight of an unladen container is approximately 2 tonnes
- Half of the containers are 40 ft and half are 20 ft. This translates into 166 lorry journeys, 83 carrying 20' containers and 83 carrying 40' containers
- The port is the final destination for half of the containers and the remainder make an average lorry journey from Teesport of 80 km.

Water leg

Felixstowe to Teesport

Distance: 230 nautical miles = 427 kilometres

Tonnage: 250 TEU X 14 tonnes = 3,500 tonnes

Tonne-kilometres 3,500 X 427 = 1,494,500

Teesport to Felixstowe

Distance: 230 nautical miles = 427 kilomteres

Tonnage: 80 TEU X 14 tonnes = 1,120 tonnes

Weight of empty containers 170 x 2 = 340 tonnes

Tonne kilometres (1,120 + 340) x 427 =623,420

Water tonne kilometres 1,494,500 + 623,420 = 2,117,920

Road leg

It is assumed that half of the lorries (83 or 125 TEU) deliver to the port and the remainder travel an average distance of 50 miles (80 kilometres) from the port

Road tonnes 125 x 14 x 80 = 140, 000

Return journey

Assume all empty containers

125 x 2 x 80 = 20,000

Road tonne kilometres 160,000

Total tonne kilometres water option 2,117,920 + 160,000 = 2, 277,920

2. Road option

Distance Felixstowe – Teesport: 546 miles = 880 km round trip

Tonnage: 250 TEU x 14 tonnes= 3,500 tonnes per day

3500 x 440 = 1,540,000

Assume that 80 come back full as with water option

80 x 14 x 440 = 492,800

Others are empty

170 x 2 x 440 = 149,600

Total tonne kilometres: 2,182,400

Calculation of Externalities

I. Economic external effects

1.1 Congestion

Analysis of the congestion effects from 166 lorry journeys per day from Felixstowe – Teesport – Felixstowe, uses the environmental benefits calculator of Department for Transport.

<u>Road Option</u>

The road option uses the following routes which have varying levels of congestion as determined by the Department for Transport:

A14 → A1/A1(M1)

Felixstowe → Cambridge → Peterborough	High Congestion
112 miles = 50 + 62	69p
Peterborough → A19 Junction	Very High Congestion
101 miles	69p
To Teesport – A19/A168	Moderate Congestion
60 miles	27p

Route valuation:

2 * (112 + 101) = 426 * 69p = £293.94

2 * 60 = 120 * 27p = £32.40 Total: £326.34

Total lorry journeys: 166 per day (assuming 50% 20 ft and 50% 40ft containers)

Daily congestion costs from lorry journeys = 166 * 326.34 = **£54,172.44**

Water option

The congestion that arises from the water option relates to the onward delivery from Teesport by lorry. An assumption is made that the average length of journey is 50 miles.

Assume:

25 miles on A1 (M)	High Congested	69p
25 miles on local roads	Moderate/Low congested	27p/4p

Route valuation:

2 * 25 = 50 * 69p = £34.50

2 *12.5 = 25 * 27p = £6.75

2 * 12.5 = 25 * 4p = £1 Total route valuation: £42.25

Total lorry journeys: 83 lorries per day

Daily congestion costs from all lorry journeys = 83 * £42.25 = **£3,507**

1.2 Accident damages

Approximately 3.4% of total annual accidents happen on “goods vehicle” roads (9,958 accidents). From these there are:

1.5% - fatal accidents (150 people)

13.5 % - serious injuries (1,344 people)

85% - slight injuries (8,464 people)

It is complex to put a value on human life or injury but other factors such as police, hospital, vehicle recovery could be easily quantified as direct costs.

The accident statistics are based on number of vehicle-kilometres. Given that the Felixstowe-Teesport return trip accounts for some 39 million vehicle-kilometres per year, **the use of water transport will reduce the likelihood of road accidents significantly per annum.**

II. Environmental external effects

2.1 Pollution - Carbon emissions

Pollution effects from transportation services are assessed using the carbon emissions factors from "CO2 Emissions from Freight Transport in the UK" by Prof. Alan McKinnon, Logistics Research Centre. The figure for the coastal ship of 30g is a mid-range value per tonne-km adopted for the purposes of the study. Additionally, calculations will be made with data provided by VTT Technical Research Centre in Finland for purely comparative reasons[10].

	UK stats		Finnish stats
CO2 emissions factor for a lorry	138g	per tonne-km	58g
CO2 emissions factor for a coastal ship	30g	per tonne-km	42g

Road Option

CO2 emissions from lorry journeys (Felixstowe-Teesport-Felixstowe)

2,182,400 x 138g =

301.2 tonnes of CO2 emissions per day (UK stats)

2,182,400 x 58g =

126.58 tonnes of CO2 emissions per day (Finnish stats)

Water Option

CO2 emissions from a ship journey (Felixstowe-Teesport-Felixstowe)

(2,117,920x 30g)+ (160,000 x 138g) = 63.5 + 22.1 =

85.60 tonnes of CO2 per day (UK stats)

(2,117,920 x 42g)+(160,000 x 58g) = 88.95 + 9.28 =

98.23 tonnes of CO2 per day (Finnish stats)

Pricing CO2 emissions

The price used here is 14euro (EUR 1= GBP 0.78505; 8th, May 2008, ECB).

[10] http://lipasto.vtt.fi/indexe.htm

CO2 emissions in UK monetary terms at price of £4:

UK statistics

From 250 lorry journeys = £4 * 301.2 = £1,204 (£3,310 @ European values)

From a ship journey = £4 * 85.6 = £342.40 (£940.80 @ European values)

Finnish statistics

From 250 lorry journey = £4*126.58 = £506.32 (£1,391@European values)

From a ship journey = £4*98.23 = £392.92 (£1,079.55@European values)

2.2 Acidification

This includes NOx and SO2 based on DEFRA statistics:

Road – 16.7 g per tonne-km   Ship – 9.80 g per tonne-km

Finnish statistics

Road – 1.36g per tonne-km   Ship – 0.5g per tonne-km

<u>Road Option</u>

NOx and SO2 emissions from 166 lorry journeys (Felixstowe-Teesport-Felixstowe):

16.7g * 2,182,400

= 36.40 tonnes of emissions (UK stats)

1.36g * 2,182,400

= **2.97 tonnes of emissions (Finnish stats)**

<u>Water Option</u>

NOx and SO2 emissions from a ship journey (Felixstowe-Teesport-Felixstowe)

9.8 g * 2,117,920 = 20.75 tonnes (UK stats)

0.5g * 2,117,920 = 1.06 tonnes (Finnish stats)

NOx emissions from 84 lorry journeys (Teesport–North Delivery Centres–Tees)

16.7 g * 160,000 = 2.65 tonnes (UK stats)

1.36g * 160,000 = 0. 22 tonnes (Finnish stats)

Total 23.40 tonnes of emissions (UK stats)

Total 1.28 tonnes of emissions (Finnish stats)

We should emphasise here that with the Low Sulphur Diesel Fuel the amount of sulphur is 1/10 the amount found in the commercial diesel fuel. This makes the tonnes of emissions significantly lower. Also the Low Sulphur Diesel Fuel does change the sulphur ratio between Road and Water – it shifts the ratio from 35 to 55. The Water Option produces 35% less acidification but with the Low Sulphur Diesel Fuel it produces 55% less acidification than the Road Option.

2.3 Noise

Lorry journeys add to noise on the highways. Indeed £5 million per year is allocated to Highway Agency to provide noise mitigation at all locations across England. It is clear that the noise from a coastal vessel is minimal except in port.

III. Social external effects

3.1 Health impact and quality of life

Emissions from transport contribute to poor air quality.

The Department of Health estimates that improvements in air quality lead to reduced respiratory illness[11]. Because of the complexity of a life cycle analysis, to quantify such impacts, a combination of methods is required.

<u>Summary of the Case study</u>

It finds that when the external effects are considered, the coastal service:

- saves £50,665 per day in costs of congestion based on DfT standards
- reduces the likelihood of road accidents
- produces less CO2 emissions which, when quantified in monetary EU standards, represents a saving of £2,369 per day (UK stats) or £311 (Finnish statistics)

[11] DH, “The health impact of climate change: promoting sustainable communities”, April 2008

- the low sulphur diesel fuel improves the acidification figures as the water option produces 55% less acidification

- reduces noise pollution

In terms of safety and quality of life, it will also lead to fewer deaths and injury (illness), and related costs of emergency services, hospitals, and vehicle recovery.

Conclusions

Summarising what was discussed in this study, it becomes clear that many approaches have been developed for estimating the externalities. At an EU level, these issues are tackled in a more systematic way while the UK research is more fragmented. Nevertheless, the quantification of external effects has been achieved, which is a major step for further economic developments. It brings new environmental constraints to the classic microeconomic model and expands the understanding of an industry's performance. It provides more detail information about the real impacts of transportation on the society.

References

[1]. Bowen A., S. Fankhauser, N. Stern and D. Zenghelis, "An outline of the case for a "green" stimulus", Policy Brief, Grantham Research Institute on Climate Change and the Environment, Centre for Climate Change Economics and Policy, *London School of Economics* Feb. 2009

[2]. Department for Transport, "The Eddington Transport Study", London 2006

[3]. Department for Transport – Environmental Benefits Calculator http://www.dft.gov.uk/eb-calculator/

[4]. Department for Transport – The UK on the spot accidents, Data Collection Study, Phase II Report

[5]. DH, "The health impact of climate change: promoting sustainable communities", April 2008

[6]. DG TREN, Handbook on estimation of external cost in the transport sector, IMPACT project, December 2007

[7]. "CO2 emissions from Freight Transport in the UK" – Report prepared for the Climate Change Working Group of the Commission for Integrated Transport, Prof Alan McKinnon, Logistics Research Centre, 2006

[8]. DEFRA, Freight Study Group

[9]. OECD, Decoupling the Environmental Impacts of Transport from Economic Growth, Nov. 2006

[10]. Stern N., "Economics of Climate Change", London 2006

Key projects:

UNITE (2003) – Transport accounts and External cost estimates for most western European countries

HEATCO (2006) – Unit Cost Figures for Externalities

IMPACT (2007) – Internalisation Measures and Policies for All External costs of Transport

EXIOPOL (2007) – A New Environmental Accounting Framework Using Externality Data and Input-Output Tools for Policy Analysis

Key journals:

1. Journal of European Environmental Policy
2. Review of Environmental Economics and Policy (Cambridge)
3. Environmental Science and Policy
4. Journal of Environmental Economics and Management
5. Journal of Geophysical Research

Key websites:

I. EU initiatives for sustainable transport:

- The DG ENV programme "Developing a sustainable transport system": http://ec.europa.eu/environment/air/transport/sustainable.htm
- DGTREN actions related to "Greening Transport Package (adopted 8 July 2008)" http://ec.europa.eu/transport/greening/index_en.htm
- Another important issue is also the "Internalisation of transport external costs" http://ec.europa.eu/transport/costs/index_en.htm

II. OECD initiatives for sustainable development:

- Global Forum on Sustainable Development (GFSD.Transport@oecd.org)

III. Canada Ministry of Transport, Infrastructure and Community

- Sustainable Development Strategy

http://www.tc.gc.ca/programs/environment/sd/sds0709/menu.htm

IV. UK Department for Transport

- Towards a Sustainable Transport System

http://www.dft.gov.uk/about/strategy/transportstrategy

V. United Nations Department of Economic and Social Affairs

- Sustainable Development

http://www.un.org/esa/sustdev/sdissues/transport/transp.htm