EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT

ASSESSING THE BENEFITS OF TRANSPORT

OECD

EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT (ECMT)

The European Conference of Ministers of Transport (ECMT) is an inter-governmental organisation established by a Protocol signed in Brussels on 17 October 1953. It is a forum in which Ministers responsible for transport, and more specifically the inland transport sector, can co-operate on policy. Within this forum, Ministers can openly discuss current problems and agree upon joint approaches aimed at improving the utilisation and at ensuring the rational development of European transport systems of international importance.

At present, the ECMT's role primarily consists of:

- helping to create an integrated transport system throughout the enlarged Europe that is economically and technically efficient, meets the highest possible safety and environmental standards and takes full account of the social dimension;
- helping also to build a bridge between the European Union and the rest of the continent at a political level.

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A Committee of Deputies, composed of senior civil servants representing Ministers, prepares proposals for consideration by the Council of Ministers. The Committee is assisted by working groups, each of which has a specific mandate.

The issues currently being studied – on which policy decisions by Ministers will be required – include the development and implementation of a pan-European transport policy; the integration of Central and Eastern European Countries into the European transport market; specific issues relating to transport by rail, road and waterway; combined transport; transport and the environment; the social costs of transport; trends in international transport and infrastructure needs; transport for people with mobility handicaps; road safety; traffic management; road traffic information and new communications technologies.

Statistical analyses of trends in traffic and investment are published regularly by the ECMT and provide a clear indication of the situation, on a trimestrial or annual basis, in the transport sector in different European countries.

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The ECMT's Documentation Service has extensive information available concerning the transport sector. This information is accessible on the ECMT Internet site.

For administrative purposes the ECMT's Secretariat is attached to the Organisation for Economic Co-operation and Development (OECD).

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The report was finalised for presentation to Ministers by the ECMT Group on Transport and the Environment.

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EXECUTIVE SUMMARY

Much attention has been given in recent years to the external costs of transport, such as congestion and pollution. It is known that when transport prices do not reflect such costs, potential economic and welfare benefits may be foregone. In principle, the same argument should apply to any external transport benefits, if they also are not reflected in the costs. This raises the issue of the wider effects on economic activity, arising from a transport investment, which are often important considerations in policy and investment decisions. Theory, and historical experience, suggests that these wider economic impacts can arise if transport costs are changed (for example by shortening journey times): they include effects on employment, prices, and economic growth at the local, regional, national or international level.

Not all countries use, or rely on, cost-benefit analysis (CBA), but when well-specified cost-benefit analyses are carried out, they have the great advantage that changes in transport production costs are usually identified and measured, including both the money cost of movement and the time costs. The question is whether the inclusion of these costs fully represents their direct and indirect value to the economy.

In some circumstances, where the overall economy is relatively undistorted and the general price level reasonably closely reflects the costs of production, the costs and benefits measured in CBA are a reasonable measure of the overall economic effect. But in other circumstances, the value of these wider effects is greater than the effects measured in CBA, and in that case some extra allowance should be given. However, the wider economic effects are not all benefits – in some circumstances they can have negative impacts on the economy, not positive. Therefore there can be no justification for any simple rule-of-thumb to add a uniform ‘economic factor’ to CBA results.

Transport investments are sometimes intended to produce specific economic benefits in particular locations, such as regeneration of a depressed area or growth in a peripheral region. These intentions are not always realised, as the benefits may actually accrue to a different, competing region.

Thus transport infrastructure or policy may act as an instrument for economic development, but it is first necessary to identify the specific mechanisms by which a transport change could have an impact on the competition between firms and areas under consideration. This is likely to depend on careful analysis of the current prices charged for transport services, and prices charged for goods by companies using those transport services, in relation to the costs. Without this analysis, well-intended initiatives may have unintended effects, even the opposite of what is desired.

Depending on the circumstances, there can be a net extra benefit from the wider economic effects, which therefore will strengthen the case for an infrastructure investment (road, rail or other, according to local conditions), provided it actually delivers its promised improvements in costs, speeds etc. In other conditions, however, wider economic benefits may be more effectively achieved by transport initiatives other than infrastructure investment (for example traffic management, infrastructure pricing, etc.). In general, where there are distortions in pricing, it is better to correct the prices than to develop investment projects based on the existing prices.

There are various suggestions for methods of carrying out project and policy assessment of the wider economic effects of transport, some of the proposals involving very elaborate computer models and very extensive data collection. None are yet proven. However, more practical outline assessments can be made now by identifying:

– the specific economic weaknesses which a transport initiative is intended to solve (for example external costs imposed by traffic, monopoly prices in local industry, competition for scarce labour, etc);

– the mechanisms by which changes in transport costs are expected to address these weaknesses;

– the relative competitive strength of the different areas or regions concerned.

It will then be possible broadly to distinguish between those cases where changes in transport costs have the intended, or unintended, effects.

This approach leads to the conclusion that a well-carried out Cost Benefit Analysis is crucial to the assessment of the economic costs and benefits of projects and policies, whether in conditions of perfect competition or not.

It should be noted that the failure to realise potential benefits does not arise only – or even mainly – because of imperfections in the measurement of some benefits. It also arises from the gap between best practice project assessment, and the reality of the process of decision-making in which such assessments may be omitted, or may be of poor quality, or may be ignored. Therefore there is a broader question of understanding the sources and nature of this gap, and developing procedures which could help to align investment decisions more closely with the results of project assessment.

Even transport projects and initiatives that have passed a thorough CBA test are not always implemented. In some cases, this is because they are believed to 'crowd out' private investments which are thought to be more worthwhile. The problem is that financial assessment tests differ between private and public sectors, making direct comparison of value for money difficult. The appropriate test is to see whether the calculated return on the public investment exceeds its cost by more than an allowance for the opportunity cost of public funds. This opportunity cost might be measured by the long term bond rate, including a weighting if higher public expenditure would affect this rate. A project that passes this test – and satisfies environmental, legal and other related conditions – would then be justified. Such a decision rule has been employed in practice, for example in France where an opportunity cost rate of 8% was used for most of the 1990s.

Employing such an objective rule in investment decisions has important implications for the development of efficient pricing in transport. It demonstrates that the revenues from marginal social cost pricing arise as part of a consistent set of economic instruments, not as a result of under-investment.

1. INTRODUCTION

1.1 Background

Transport systems of regions and countries always have been considered as important for development, and investments for different transport modes have been made to facilitate mobility for the public and for different enterprises. The increased awareness of environmental issues and the knowledge of the negative environmental impact of transport have gradually led to a more critical attitude towards transport. The transport field is crucial regarding the efforts in making society environmentally, socially and economically sustainable.

These two factors - the intended positive development aspects and the feared negative impacts due to transport - are the main reasons why it is important to measure benefits and costs of transport. In order to achieve an efficient transport system relatively thorough assessments have to be provided for decision-makers.

Assessing the benefits of transport and other public investments is difficult because:

- Effects of different measures have to be studied empirically, and generalisations from one case to another leads to uncertainties.
- There are many different approaches to benefit calculation. The proposed methods can differ depending on the analysts' research fields and the purpose of the assessment.
- Unlike products sold on the private market, the benefits of transport often do not have a monetary value on an actual market.
- The development of regions and countries is influenced by a wide range of factors, of which transport is one. It is always difficult to judge which single factor is most important, and sometimes meaningless.
- Valuing different effects, positive and negative, in monetary terms cannot be made in a general way, but is dependent on current national policy and other economic circumstances. There may also be factors that cannot or should not be valued in economic terms.

Opinions on how to resolve these difficulties are divided but some of the best attempts of measuring the benefits of transport are summarised in this report. Key assumptions in different studies are highlighted and discussed.

1.2 Aims and delimitation

This report covers benefits from transport at the infrastructure project level and at the general national policy level. For each level it attempts the following:

- To compile the most relevant information from studies of the economic benefits of transport.
- To present and compare the different approaches and methodologies employed in different countries for analysing the economic benefits of transport. The focus is on transport infrastructure investments.
- To highlight parts of different countries' approaches to measuring benefits as examples of good practice that could be used as sources of inspiration for other countries.
- To conclude how costs and benefits should be compared.

It is not possible completely to divorce the question of the assessment of benefits from the wider questions of the overall practice of decision-making, and in particular imperfections which arise because best practice in theory is not always carried out in the real world. Therefore while the main focus of this report is on the issue of economic benefits, there is inevitably some treatment of various costs and other implications. The Annexes also include papers which set the discussion in a broader context: in this respect, see the suggestions and procedures discussed by Roy in Annex 1: *Means and Ends: Cost-Benefit Assessment and Welfare Maximising Investment*, and by Grant-Muller *et al*. in Annex 2: *Economic Appraisal of European Transport projects – the State of the Art Revisited.*

2. THE MAIN BENEFITS OF TRANSPORT

2.1 Accessibility

Society is dependent on accessibility, and accessibility through transport networks is crucial for many activities. Historically the objective of building a transport link was often to open possibilities to reach new geographical areas. There is no doubt that these initial investments in transport links, which improved accessibility considerably, contributed significantly to economic growth and regional development.

For developed countries or regions, projects to construct virgin infrastructure links between settlements or enterprises are now rare. New links in most cases serve more or less the same purposes as existing ones, but in a more efficient way, i.e. a newly constructed road does not dramatically change the possibilities to reach new destinations. It is possible to upgrade interurban railway connections more radically than interurban roads. New high speed railways can open possibilities to reach destinations by decreasing the travel time considerably. An example is the proposed "Interrapid" railway between Berlin and Hamburg, where the decrease in travel time from 2 hours and 20 minutes to 1 hour, would have made it more convenient to undertake day trips between the two cities, to the intended benefit of either or both.

The benefits of transport investments in developed countries relevant to this report are in most cases the effects of marginal improvements.

The accessibility situation is especially difficult for roads in areas suffering from congestion problems. These problems are most common in urban areas. Traditional infrastructure investments (bypasses, urban arterial roads etc.) can improve accessibility in congested areas, but it is often more cost-efficient to improve utilisation of existing links e.g. by traffic control measures or by affecting transport demand in different ways.

Conclusions:

- In developed countries with an extended infrastructure network, the focus is mostly on effects of marginal improvements.
- It is not possible to extrapolate directly from the historical experience of opening virgin undeveloped territories by new transport systems.

2.2 Benefits due to increased accessibility

Most traffic and transport do not have an intrinsic value, and the value has to be searched for in the activities which the travel is enabling[1]. The most important function of infrastructure networks is to work as an integrator or connector. New possibilities of transferring goods and services between regions may improve living conditions in regions that otherwise only would have been dependent on products produced from local resources. This is applicable to both freight and passenger transport - both producers and consumers will use the transport system in order to reach customers/suppliers. Provided that the competition situation is unconstrained, this will continue to the point where the price difference on each single product between the regions reflects the difference in marginal transport costs, and therefore transport investment which reduces costs will also reduce prices, or increase consumption or the participation in activities, or some combination of these. Long term benefits may be produced from increased productivity for regions.

Thus the indirect benefits of transport are derived from time and other cost changes for goods transport, business travel and private travel.

When considering project investments it is important to analyse the opportunity costs, i.e. costs which arise when a particular project restricts alternative uses of a scarce resource. The size of an opportunity cost is the value of a resource in its most productive alternative use. To get a complete picture of the effect of transport investments, one must in principle therefore consider what other investment may not have been undertaken as a result. In practice this is rarely done, though it is hoped that selection of some form of 'pass-mark' in the economic appraisal does this implicitly: however, there are problems if different appraisal rules are being used in different sectors of the economy. In addition the economic effects of transport must also include the economic consequences of any negative effects on the environment, health and traffic safety – some, but not all, of which may not be included in the analysis.

In the UK, the Department of the Environment, Transport and the Regions initiated a study on Transport investment, transport intensity and economic growth. The study was being carried out by the Standing Committee on Trunk Road Assessment, SACTRA. In an interim report from SACTRA (1998)[2] some mechanisms were listed by which roads and transport investment are claimed to promote economic growth/regeneration, and this interim report was circulated for discussion within the UK and internationally, and was therefore able to inform and influence some of the earlier documents studied for this report. (SACTRA's final report took the argument further, and is discussed in Chapter 7). The initial list of mechanisms was as follows:

Jobs and labour markets	Transport investment may broaden the access of employers to a pool of qualified labour.
Product markets	Transport investments may facilitate the expansion of market areas for goods and services.
Inward investment	Transport investment may be a requirement, or an element in a package, to attract foot-loose inward investment.
Image and confidence	Transport investment may be a lever to bolster the image of a region which requires regeneration, e.g. by reducing travel times below a critical threshold.

Unlocking land — Where land for development is constrained, new infrastructure may be required in order to unlock suitable development sites.

Spending effects — This differs from the others since it is a relatively short term effect. In conditions of widespread unemployment, there may be an initial stimulus to employment and income as a result of a transport investment. This may then be augmented by further induced economic activity (as a result of increased consumption by the previously unemployed).

The effects above are results of increased access for both people and goods. Personal travel can be separated into business and private travel (where private travel is commuting and leisure travel). Not only freight transport and business travel, but also private travel, will have an impact on the productivity of enterprises in a region. This is since enterprises are dependent on qualified employees, and one determining factor when taking a job is private travel preferences like commuting time.

There are counter arguments to the benefits above, and one which is often mentioned is that the effects might be the opposite of what was intended for a region: people or business activity leave and economic polarisation takes place at the expense of a less competitive region. Therefore the impact on different regions has to be studied before decisions on major investment schemes.

Conclusions:

- Most traffic and transport do not have an intrinsic value, the value deriving from the activities or consumption facilitated. Economic development benefits derive mainly from decreased time and money costs of movement.
- There is a linkage between transport investments and economic development, though the direction of the connection is not always clear.
- The key question is whether the benefits are considered so great that it is worth spending money on a certain investment.

2.3 Benefits in terms of cost savings

In socio-economic assessments for transport projects it is often argued that a project is worth implementing because of the environmental and traffic safety benefits expected. When infrastructure investments do result in positive effects in the fields of traffic safety and environmental protection, these effects are often considered just as important as the traditional accessibility objective. Although these effects are highly important for society they are not usually included as economic growth or productivity benefits of transport, partly for reasons of the conventions of national income accounting which do not accord them an economic value.

Achieving improved accessibility is usually an objective of transport improvements, though it should be recognised that the word ‘accessibility’ is also used in a number of specialist ways, notably (a) in relation to specific disadvantaged groups of travellers; (b) by deliberate contrast with ‘mobility’, to reflect easier access to destinations by other than transport methods, for example by better location of facilities. For these specialist meanings, accessibility is not well measured by changes in speed, but in more general discussion the magnitude among the socio-economic assessment (CBA) parameters which corresponds most to improved accessibility is travel time, and it is this, together with money cost changes, which link most directly to expectations of economic growth. The money cost, and the monetary value of the time saved, due to infrastructure investments, (conveniently combined in a generalised cost) can be used in CBA as an indicator of the trigger from which economic growth could, potentially, arise.

Conclusions:

- In socio-economic cost-benefit assessments the time saving effect, together with direct money cost changes, can correspond most to improved accessibility, though in some circumstances accessibility may not be well measured by speed changes.
- Socio-economic cost savings in the traffic safety- and environmental fields are very important effects which can influence investments in transport infrastructure.

3. DIFFERENT APPROACHES TO MEASURING ECONOMIC BENEFITS OF TRANSPORT

3.1 Economic or other types of analyses

Governments and National Administrations usually have some sort of economic assessment base in their transport strategies. However, it is well known that socio-economic terms are not the only way of expressing the feasibility of different actions in the public sector. The policy discussions before decisions cover a wide range of fields, and several different perspectives in assessing public benefits can be identified in current research.

The following list is an attempt at identifying different approaches to assessing infrastructure policies[3]. The list could also be seen as different approaches of measuring the benefits of transport, emanating from different research disciplines. The approaches emphasised in each country differ for historical and political reasons.

1. *The engineering perspective* focuses on the technical capacity standard of the transport network. As a method for studying the need for infrastructure investments the engineering perspective could be a help but it will not be sufficient since it will not contribute in finding a balanced level between costs and benefits. It would be wrong to develop the transportation system to a technical standard without considering e.g. transport demand factors and the fact that public investments outside the transport sector could be more cost-efficient.

2. *Political measures based on voting outcomes* is a common and inevitable perspective in every democratic country. A political discussion about which objectives are important for national/regional governments is necessary, but the discussions will not be relevant unless the arguments are based on economic and technical assessments. Political decisions often seem to be too short term oriented, and long term development benefits are often not enough emphasised.

3. *Geographical localisation/regional development* concern the effects of investments in terms of localisation. It is not obvious where the main benefits of a new transport investment will occur - the benefits of one region may be at an other's expense. This could be avoided if analyses of the effects on labour regions and product market are undertaken before infrastructure investments.

4. *Economic estimates of productivity impact* is a macroeconomic perspective for measuring benefits due to investments. Economic input-output analyses are used to measure the growth of productivity in a region or country. And the results can be used to appreciate the benefits of transport and other activities.

5. The *Civic planning* perspective focuses on the structure of towns and cities. The importance of the transport system should not be underestimated in this sense. New infrastructure links leads to a spread of the population in cities[4] which certainly means some positive effects for individuals and enterprises like better possibilities to reach outdoor leisure areas and unlocking land for production. However, such spread also tends to increase journey distances and the total volume of traffic, and may have complex side effects on land use including housing, and environmental impacts. So densely populated cities with an efficient public transport system may result in lower external costs in terms of pollution and congestion, and in some circumstances improved accessibility to destinations.

6. *Economic measure of rates of return* Cost-Benefit Analysis (CBA) comprises a range of microeconomic tools, which in transport applications are usually taken to include both the direct and some indirect costs of travel, whose changes may be compared with the cost of an investment. Cost-benefit analyses based on technical and economical characteristics of different transport modes are the key approach if society is to achieve cost-effective solutions to problems due to deficiencies in the transport system. This microeconomic approach requires estimates of future changes in demand of transport and transport infrastructure, using complementary e.g. traffic forecasts derived from macroeconomic data. Because of the difficulties in valuing some factors, other types of analyses (no 1-5 above) always have to be added to cost-benefit assessment in order to get an acceptable base for decisions.

It cannot be stated that only one perspective is the best and should be used alone in developing an efficient policy on transportation. It is rather obvious that the design and standard of the transport system must be adapted to many different factors in society. However in order to be able to chose investments which are efficient, economic assessments have a vital role. Economic evaluation methods make it possible to aggregate benefits of different kinds, to compare these benefits to investment costs, and, with caution, to compare the efficiency of investments in different public sectors.

Conclusions:

- An economic benefit perspective has to be taken in order to assess which project investments or which overall investment level is socio-economically efficient and is in accordance with the current traffic policy.
- Microeconomic and macroeconomic evaluations have to be complemented with perspectives from other research disciplines.

3.2 The Macroeconomic approach

Some measure of *productivity* is often used as an indicator of the economic performance for regions and countries. Macroeconomic analyses can be used to measure the part of the productivity growth enhanced by transport infrastructure investment. In this report the "macroeconomic approach" refers to assessments based on linkages between productivity growth and investments in new transport.

Factors which can be used as indicators of productivity are e.g. employment, expenditures, income, production of goods and services and competitiveness[5]. These factors are of interest at both national and regional levels. The easiest way of expressing productivity is to compare economic input and output over time. Results of these kinds of analyses are derived from macroeconomic data such as changes in GDP, which then can be compared to changes in the stock of transport infrastructure capital. The challenge when interpreting the material is to find causal linkages between infrastructure investments and productivity.

Macroeconomic analyses are ex-post calculations (i.e. they are based on historical data). But such analysis can be taken into consideration before decisions on infrastructure plans and major investment projects are taken.

A major deficiency of the macroeconomic approach is the difficulty in identifying causal linkages between transport and productivity. Moreover, productivity is also a narrow indicator of economic benefits, and far from all socio-economic benefits are captured in macroeconomic assessments.

3.2.1 Empirical macroeconomic linkages between infrastructure investments and productivity

Many attempts have been carried out in order to measure "output elasticities" of infrastructure investments at GDP-level. This elasticity indicates the expected percentage change in production (according to the model used) with a 1 percent change (increase) of an infrastructure variable. Two main categories of studies can be identified:

- *Time-series analyses* where information from one country or region gathered over a certain time period.
- *Cross*-section *analyses* where information of productivity and economic growth are compared from a number of countries or regions at one point in time.

A combined approach is to use "pooled" data sets, i.e. a combination of observations for several time periods and several cross-sectional areas.

Very high elasticities have been shown in some time series analyses. In a compilation by Johansson *et al.*[6] of results from different countries several elasticities reach over 0.50, see table 3.1. Results from time series analyses, in this area as many others, are notoriously affected by spurious correlation, since many factors will grow fairly smoothly over time, and selecting any two of them always shows a strong statistical link. Time gaps between investments in infrastructure and economic growth also affect the reliability of the results.

Table 3.1. **Output elasticities derived from aggregated production functions**
Data sets based on time-series

Country	Output elasticity
United States	0.29-0.64
Netherlands	0.48
Japan	0.15-0.39
Germany	0.53-0.68
Canada	0.63-0.77
Belgium	0.54-0.57
Australia	0.34-0.70
France, UK, Finland, Norway, Sweden	Wide range between highest and lowest value

Source: Johansson *et al.* (1996), *Infrastruktur, produktivitet och tillväxt - En kunskapsöversikt*, KTH, Stockholm.

Some more detailed studies have been carried out in particular countries.

A study by Baum, Schultz et al in Germany asked the question – how large would the German economy be in 1990 if there was only the same amount of movement of goods and people as there had been in 1950? The conclusion was that the economy would be roundly 50% smaller, and this effect was counted as an estimate of the 'total' contribution of transport to the economy. In some incautious discussion of these results, some commentators have inferred that half the growth in the economy of the Federal Republic of Germany between 1950 and 1990 was due to investment in transport infrastructure, which would be of profound importance if this inference is valid. However, critics of this approach point out that (by the same argument) the same growth could be attributed to very many other factors which had grown in the same period, but which were not included in the analysis, e.g. education, telecommunications, energy use, computers, health or welfare expenditure etc. In addition, even if the analysis of the 'total effect' were valid, it does not follow that any particular individual new investment would have the same proportional effect on causing added new economic growth. Logically, this criticism must be true, or it would be possible to achieve any desired rate of growth, no matter how unrealistically high, simply by spending more and more on transport, which is untenable. Further information about this analysis is given in Annex 5 by Schultz.

A study by Prud'homme and Lee, of Paris and other French cities, suggested that transport infrastructure improvements (road and/or public transport) which successfully increased travel speed over the network as a whole would widen the labour market and in turn increase productivity. However, if the 'sprawl' of the city increased, this would reduce the effective labour market, and therefore reduce productivity. The question then is how to increase speed without increasing sprawl: as argued by Mogridge and others, increasing travel speed has been one of the main influences in making cities more spread out over time. In connection with an urban road scheme, this argument would then lead to a need to balance the economic effect of any added effect on sprawl (negative) and on labour markets (positive): it might be concluded that other policies, such as building regulations or planning control, were as important as transport initiatives. Further details of this analysis are also given in Annex 4 by Prud'homme and Lee.

In a review from US Department of Transportation[7] (US DoT) a compilation of a number of papers dealing with empirical economic growth effects is presented, see table 3.2. The most well known of these is probably Ashauer's work from 1989[8]. In most of the papers "pooled" data sets were used, i.e. a combination of observations for several time periods and several cross-sectional areas. Overall, these studies indicate a small positive relationship between public capital and productivity. The output-input coefficients vary between 0.03 and 0.39 in the selected studies (the highest value according to one of Aschauer's studies 1989). This is a much weaker relationship than was shown in most time series analyses, and the spread of the results reflects the difficulties in this research field.

Aschauer tried to compare the rate of economic growth in different US states, with the transport infrastructure investment in those states. A strong connection was found: where growth was higher, so was transport investment. The author concluded that the investment was a major cause of the growth. This conclusion was widely quoted for a period, in the USA and elsewhere, in support of expanded road-building programmes. However, when other analysts inspected the methods in detail, as reported in SACTRA (1999), they argued that the same data could be interpreted in the opposite way – the transport investment was the result of growth, not the cause of it. (Because richer states naturally had more money, they tended to spend more on transport, and indeed on many other things as well). For these, and other more technical arguments, most, though not all, specialists now consider that the work probably exaggerates the size of the effect.

Table 3.2. **Output elasticities derived from aggregated production functions Pooled data sets used**

	Coefficient	Level of Analysis	Infrastructure Variable	Productivity Variable
Aschauer (1989)	0.39	National	Public capital	National output
Munnell (1990)	0.33	National	Public capital	National output
Aschauer (1989)	0.24	National	Core public capital	National output
Lynde and Richmond (1991)	0.20	National	Public capital	National output
Hulten and Schwab (1991)	0.03	National	Public capital	National output
Moomaw and Williams (1991)	0.25	State	Highway density	Total factor productivity
Costa, Ellson, Martin (1987)	0.20	State	Public capital	Output
Munnell (1990)	0.15	State	Public capital	Gross State Product
Munnell (1990)	0.06	State	Highway capital	Gross State Product
Garcia-Milà and McGuire (forthcoming)	0.04	State	Highway capital	Gross State Product
Deno (1998)	0.31	Metro Area	Highway capital	Manufacturing output
Duffy-Deno and Eberts (1989)	0.08	Metro Area	Public capital	Personal income
Eberts (1986)	0.03	Metro Area	Core public capital	Manufacturing value added

This table shows the variation in the researchers' estimates. The coefficients, which in most cases are also elasticities (if the question estimated used log variables), show the strength of the estimated effect, that is, for a 1 percent change in the infrastructure variable the elasticity indicates the percentage change that can be expected in the productivity variable. The productivity variable is typically some measure of output that serves as a proxy for productivity.

Source: US Department of Transportation, Federal Highway Administration (1992), *Assessing the Relationship Between Transportation Infrastructure and Productivity*, Searching for Solutions, A Policy discussion Series, Number 4.

3.2.2 Problems with aggregated analyses

Macroeconomic analyses is often too aggregated for measuring the linkage between transportation investment and economic development in a useful way. This was shown in a study carried out within the National Co-operative Highway Research Program in the US[9].To improve understanding of the linkage between transportation investment and private economic activity, a disaggregate set of data was developed and different analytical approaches were used to analyse the linkage between transport investment and economic activity. The following three points summarise the results from analyses based on different models.

1. *Assessments of industry production functions with highway capital as an input*[10]. Traditional production function analyses do not include highway capital as an input. Garcia-Mila and McGuire found that highway capital has a significant impact on the performance of some industries, namely retail, trade and services.

2. *Transportation investment and economic activity: evidence from public sector demand analysis*[11]. Preliminary analyses of the data by Man and Bell indicates that: 1) demand for transport investments is much more sensitive to personal income than previously thought, 2) demographic trends have an impact on the demand for investment in individual modes in different but important ways, 3) industry mix is an important element in determining the demand for transportation investment and it has different implications for each mode, and 4) the level and quality of service provided, not just the level of investment, are important.

3. *Transportation and other public infrastructure in a neo-classical growth model*[12]. Using a neo-classical growth model, Crihfield and Panggabean investigated the productivity of infrastructure capital and concluded that the public infrastructure impact on metropolitan economies appears to be weak, at least at the margin. These models estimate growth in per capita income in a region by the endowment of various factors including private capital, labour, technology and public capital.

All the three analytical approaches above consider many different dimensions of the relationship between infrastructure investment and economic performance, and it can be concluded that the effect on economic performance varies by transport mode, by industry and by region. Thus a lot of important information is hidden in more aggregated macroeconomic analyses.

Conclusions:

- It is difficult to measure the relationship between infrastructure investments and growth in GDP and studies tend to be marred by several sources of error.
- Empirical studies carried out generally show a positive relationship, though the results vary over a wide range.
- The strongest positive relationship has been shown by using analyses of time series data. Some studies where combinations of time series and cross sectional data sets are used, i.e. “pooled data sets”, indicate a weaker relationship.
- Approaches seeking to identify transport benefits from macro-economic correlations do not lead to unambiguous or widely-supported conclusions.
- A risk when using macroeconomic aggregated data is to draw non significant conclusions about the relationship between certain types of infrastructure investments and productivity in different sectors. It has been shown consistently that the economic performance due to infrastructure investments varies by transport mode, by industry and by region. These variations are hidden when using highly aggregated data.

3.3 The microeconomic approach - Cost-benefit assessments

When taking the microeconomic approach to measuring the effects of transport provision, data is measured directly in the transport system and is used as input for cost-benefit assessments (CBA). The CBA methodology is based on welfare theory, i.e. the objective for every measure should be to maximise total welfare for society. In order to make different types of effects comparable, effects of different actions are valued in monetary terms and expressed as opportunity costs for users and others who benefit or suffer from impact of the traffic system.

The effects measured in CBAs are mixtures of factors which are directly linked to productivity (e.g. transport costs for companies and business travel time) and factors which are due to each transport user's willingness to pay (e.g. value of time for leisure trips).

CBA is mostly used for single project assessments. The result gives guidance on which investment and which alternative is most feasible according to criteria of cost-effectiveness. It could also be used to make ex-post assessments of larger investments, so that decision-makers are able to learn from earlier successes and mistakes. This is not done on a routine basis in many countries.

One disadvantage of the microeconomic cost-benefit approach is the difficulty in assessing and valuing some effects. Because of these difficulties it is normally not advisable to compare benefit-cost ratios for measures in the transport sector with investments in other public sectors. In a report to the Norwegian Ministry of Finance[13], which takes a cross sector approach to CBA, it is concluded that assessments worked out for different ministries are often not comparable.

There are two further reasons for interpreting CBA cost savings in a critical way. The first is that in many CBA methodologies for roads, no attention has been paid to the effects of new generated traffic. This traffic will of course cause additional environmental and traffic safety impacts. If new high-class roads are being built the estimated net benefits of travel time and cost may be overestimated, and benefits of traffic safety and some environmental factors are almost always overestimated, if no attention is paid to induced traffic. However, this is not an inherent failing in CBA, whose principles work perfectly easily to cope with induced traffic when it is included: rather it is an example of poorly defined CBA in which the bias arising from convenience of calculation has not been adequately considered.

The second reason for interpreting CBAs critically is the positive net effect due to improvements that easily could have been made on the current link. One example of this is decreased noise level which can sometimes be achieved by improvements to the current link, hence the construction of a new link should in this case not be justified by cost savings if the problem could be solved by less expensive measures along the current road. Thus it is crucial to compare alternative solutions before taking decisions on investments.

Conclusions:

- CBA: should not only be carried out in order to assess future investments: ex-post calculations in order to follow up the effects is an important activity, overlooked by most countries.
- Assessments undertaken for different sectors (e.g. transport versus health care) are often not comparable.
- In assessing cost-effectiveness, new investments should always be compared with alternative ways of making improvements.

3.4 The macroeconomic or the microeconomic approach?

A highly relevant question is which approach is most feasible for measuring economic benefits at different levels in society. Before answering that question the following will shed light on the structural difference between the macroeconomic and microeconomic perspectives.

Lindberg (1992)[14] has shown in one example that almost 50% of the CBA net present value of effects would not be covered in a macroeconomic method based on GDP-data. The basis for Lindberg's example was the aggregated result of project CBAs carried out for the Swedish long term national road scheme 1991-2000. The total net present value of the scheme was divided into effects which would have been reflected if a GDP approach had been taken and those which would not. It is important to state that the GDP approach in this case is not a real macroeconomic approach (in that it is not an approach employed by the government), this example is rather a discussion of which factors would have been reflected in some way in an approach based on macro-econometric magnitudes.

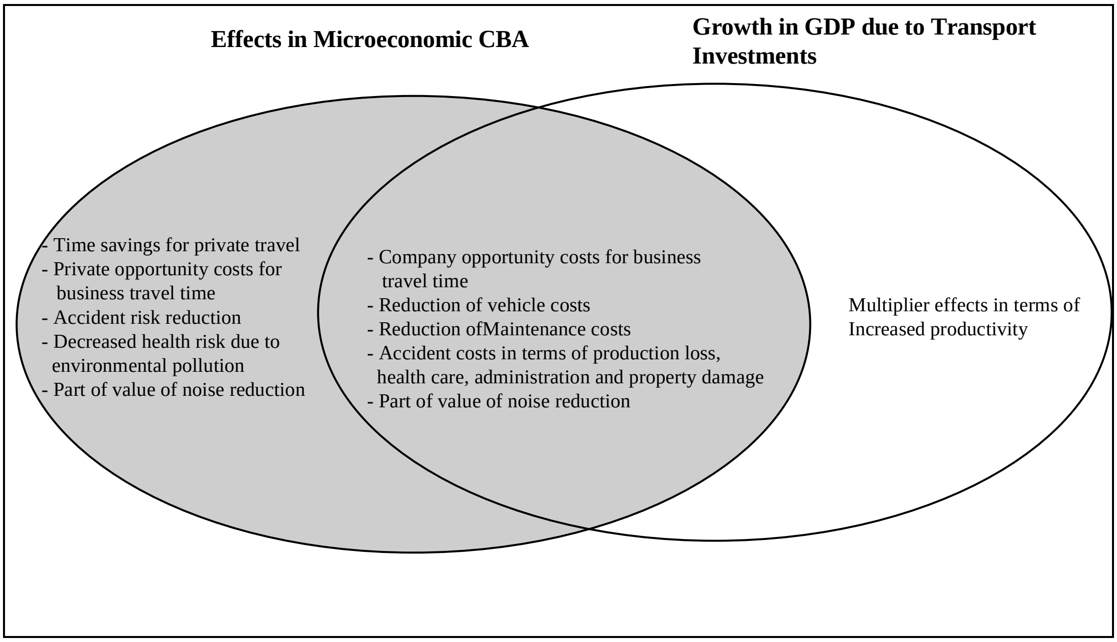
Travel time: The value of travel time for lorries and the greatest part of business travel for other modes would be reflected by the GDP approach. The part of business travel value with private opportunity costs and the value of savings for leisure trips as a whole would not be reflected. There are few transport investments which can be justified if these non-GDP benefits are excluded.

Accidents: The costs of lost production, health care, administration and property damage would be reflected by the GDP approach. The value of risk reduction would not be reflected.

Other cost reductions: Vehicle costs, maintenance, parts of noise and pollution and some other costs would be reflected. For pollution the same theory as for accidents is applicable, i.e. the costs for risk reduction would not be reflected. In practice, even some important environmental effects which manifestly have economic impacts (e.g. flood damage due to global warming) would not be included, because of uncertainty of information. Severance (barrier effects) would also not be reflected.

In this example about 50% of cost reductions in the fields of travel time and accidents and about 30% of other cost reductions would not be reflected in a GDP analysis. Overall this means that a little less than 50% of the total value of cost savings would not have been reflected if a strict GDP approach had been taken. An illustration of the this example is shown in figure 3.1.

Figure 3.1. **Effects in CBAs which would in some way have been reflected in a macroeconomic GDP-based analysis**
(The figure is schematic, no conclusions about the magnitudes of the effects)



Source: Lindberg G. (1992).

A conclusion of this example is of course that macro- and microeconomic assessments to large extent measure different types of economic effects, whilst there is a core of common elements. According to welfare theory many important effects are included in macroeconomic analyses. On the other hand positive network effects — additional benefits and costs — are covered in macroeconomic assessments and not in microeconomic assessments. The basic idea behind these additional effects is that a direct effect on business expansion can lead to an indirect effect by increasing the business activity of suppliers, as well as an induced effect from spending of more personal income and from increased public spending due to greater tax incomes for the government.

To conclude, the different approaches are complementary. Microeconomic CBAs are the best approach for project assessments and should be used both to achieve an optimal capacity standard of a new investment and to compare the cost efficiency of different investment projects. Macroeconomic assessments should be used for complementary information on possible long term network effects which are not covered in CBAs.

A further important dimension of the question is the extent to which microeconomic effects might be *converted into* macroeconomic effects. This is significantly different from Lindberg's approach, since it would allow, for example, for immediate changes in time spent on leisure journeys to have consequent effects on housing location, hence labour catchment areas, hence productivity and employment: the question could not be seen as a static division of effects into one class or the other, but as a dynamic process in the economy. This is considered further in chapter 7.

Conclusions:

- The major deficiencies of CBAs are that network effects (additional effects) are difficult to include and that it is difficult to value some important factors in monetary terms.
- The major deficiencies of macroeconomic assessments based on growth in GDP are that large parts of the effects (positive and negative) according to welfare theory are not covered and that finding a casual linkage between infrastructure investment and economic growth is marred with large uncertainties.
- CBAs contain important information for project assessments, concerning users' willingness to pay even for goods or services which are not exchanged in a market.
- Macroeconomic analyses of productivity growth due to infrastructure investments are useful as background information before long term government policy decisions on infrastructure schemes. They will contribute to knowledge about long term network effects. However, the information is not always reliable.
- Effects marred with great uncertainties, and effects for which it is not clear how or whether to value them in economic terms, can be covered by multi-criteria assessments, and should be seen as complementary information to CBAs.

3.5 How can the different approaches be improved / widened?

3.5.1 Macroeconomic / GDP

There are two major routes to improving the macroeconomic approach to assessment of benefits.

Growth in GDP is a rather narrow indicator of development, and the first attempt is to add environmental factors to the GDP-measure and achieve a "green GDP" indicator. Implementing this would need a substantial change of practice in many countries.

The second attempt would be to focus on the knowledge of the linkage between infrastructure and economic performance. Most of the studies carried out so far have been based on very aggregated data, so it would be necessary to start more detailed research work on how great a share of productivity growth in different sectors is due to infrastructure investments in different transport modes.

Both might improve the accuracy of analyses to some extent, but the analyses will always be uncertain.

Conclusions:

Two different ways of improving calculations based on growth in GDP are:

- Extension of the conception of GDP by including environmental and other factors
- Further research on causal linkages between transport and productivity in different sectors

Even if these improvements were made, the analyses would still be uncertain.

3.5.2 Microeconomic / CBA

Two factors have to be added to make CBAs more comprehensive, additional effects and effects which are difficult to value in economic terms. This implies that the CBA should be extended to a multi-criteria assessment (MCA).

Additional benefits and costs, which are often long term effects, are difficult to assess. Knowledge of these effects (although uncertain) is to some extent available in results of macroeconomic analyses. Thus to add long term economic additional effects to CBAs, information can be taken from GDP-based analyses. As discussed in chapter 7, it cannot be assumed that additional effects are always such as to increase the CBA value: in some circumstances they will decrease it.

Effects which are difficult to express or cannot be expressed in monetary terms are sometimes very important and should not be excluded in decision making. If the uncertainties are too big the effects should not be monetised. Many attempts have been made in the field of MCA to create yardsticks for these factors.

The most important consideration when adding effects to CBAs is to keep the calculations transparent. If factors of great uncertainty are added this should be presented very clearly. It must be stressed that difficulty of measurement does not in any way imply that the omitted effect is negligible.

Conclusions

- Network effects derived from macroeconomic analyses can be added to CBAs, but the uncertainties when including these are considerable.
- Effects which are hard to express in monetary terms should not be included in CBAs, but be presented separately according to existing MCA yardsticks.
- It is important that the assessments are kept transparent.

4. SOCIO-ECONOMIC COST-BENEFIT ASSESSMENT

In order to estimate the balance between benefits and costs of transport before decisions on investments, the CBA-methodology appears to provide the best approach. This chapter will discuss what should be included in CBAs and how different factors should be weighted. The focus is on overall methodology and on the selected key area of how to treat the value of time.

4.1 Which benefits and costs should be accounted for in CBA?

Theoretically all benefits and all costs should be accounted for in socio-economic cost-benefit analyses. That is not the general practice though, mainly because of the difficulty in expressing all criteria involved in monetary value. Some evaluation techniques like stated preference analyses and revealed preference analyses are difficult to apply in some areas. Examples of these kinds of effects are environmental qualities such as site amenities, and the loss of unique natural or heritage assets. The most common way of treating such effects is to report impacts separately, outside the quantified appraisal. However, it should be stressed that the exclusion of categories of cost or benefit from the CBA for reasons of difficulty of measurement is not equivalent to their exclusion because the figures are trivially small – to assume ‘unmeasured’ means ‘zero’ would introduce a serious bias into the appraisal. Multi-criteria analyses are efficient methods of presenting data which includes quantitative and qualitative information, but they do not enable the problem of trade-off between them to be ignored.

Effects of investments on different links in a transport network are sometimes not possible to treat in an additive way. Therefore some effects that occur when networks are built cannot be treated within the CBA framework. Network effects could be added to the other benefits in a CBA, but the result must be presented in a way that makes it possible to recognise them and easily subtract them to make assessments comparable. This is particularly important when comparing different sequences for a schedule of investments where the full network effect is only obtained after completion of the final link.

In a European Commission EURET report[15] an appraisal spectrum is suggested. At the extremes of the spectrum lie the purely multi-criteria analysis (MCA) and purely cost-benefit analysis (CBA). The MCA approach employs weights to results derived from a variety of techniques, with a large degree of subjective assessment and expert judgement likely to be involved. At the other extreme of the spectrum, CBA appraisal employs exclusively monetary valuations and claims more objective and explicitly defined criteria but over a narrow range of factors.

Table 4.1 shows proposed evaluation methodologies for different kinds of effects of inter-urban road infrastructure projects based on the two mentioned main evaluation approaches MCA and CBA.

Table 4.1 **Evaluation methodology for inter-urban road infrastructure projects**

Impacts	**Size of Road Infrastructure Project**		
	Large	**Medium-sized**	**Small**
Core Impacts			
1. Investment costs	CBA	CBA	CBA
2. System operating and maintenance costs	CBA	CBA	CBA
3. Vehicle operation costs	CBA	CBA	CBA
4. Travel time savings	CBA	CBA	CBA
5. Safety	CBA	CBA	CBA
6. Local environment (air pollution, noise, severance)	CBA	CBA	CBA
Non-core, non-strategic impacts			
7. Driver convenience (comfort, stress)	MCA	MCA	MCA
8. Landscape and urban quality	MCA	MCA	MCA
Non-core, strategic, impacts			
9. Strategic mobility (accessibility and networks)	MCA	(MCA)	
10. Strategic environment (greenhouse gases, ecological damage)	MCA	(MCA)	
11. Strategic economic development (regional effects)	MCA	(MCA)	
12. Other strategic policy and planning impacts	MCA	(MCA)	

Source: European Commission, Directorate-General Transport (1996), *Cost-benefit and multi-criteria analysis for new road construction*, Transport Research EURET Concerted Action 1.1.

4.2 General evaluation method

In comparisons between results of different cost-benefit assessments it is necessary to know the conditions behind and assumptions made for each assessment. Major factors which may lead to wrong interpretation in comparisons are:

- measure used: benefit/cost ratios of different kinds or a rate of return measure
- evaluation period
- discount rate
- traffic forecast
- economic value of different parameters (weights)

4.2.1 Expressing cost-efficiency: Different measures

Costs of infrastructure investment could be divided into construction costs and operation and maintenance costs. The natural way of comparing costs and benefits for each investment is to summarise all achieved socio-economic cost savings and to compare these with investment- and operation costs. Since benefits as well as maintenance costs will occur during the whole economic lifetime of the link, values for each year are normally discounted and summarised to a total *net-present value*. A formula recommended for socio-economic benefit/cost ratios in a European Commission document[16] is shown below. The numerator is the net present value of the project to society and the denominator is the present value of the constrained resource, which is taken to be present and future government finance. There is no need here of suggesting any other definitions of benefit-cost ratios than this. Most countries use this kind of ratio when describing cost-efficiency of infrastructure projects.

$$\frac{\left(PV_b - PV_c\right)}{PV_a}$$

where PV_b is the present value of the benefits
PV_c is the present value of the costs
PV_a is the present value of the public finance required for the public finance required for the capital and net future maintenance outlays.

An alternative measure, also based on the net present value, is to use the term *rate of return*, which describes the average return on investment. It represents the discount rate which, if applied, would produce a net present value of zero for a given evaluation period (Thus higher discount rate represents shorter pay off time). Since both methods are based on the net present value of investments, it does not matter which method is used. It is convenient though if all countries used the same measure in their assessments.

A different approach to describing cost-efficiency is to use the first year rate of return. This is implemented in e.g. the Danish Highway Investment Evaluation Model[17], in which future operation and maintenance costs but not future benefits are discounted to the base year. This is to account for uncertainties in traffic forecasts and the delivery of future benefits.

In France both types of approaches are recommended but for different purposes. The net present value method is the base, but first year rate of return or a short time rate of return is used to appreciate the optimal year of entry into service. Also whenever it is necessary with a short "running in" period the short time rate of return should be determined in the year the project is brought into full service[18].

It will be shown in the following sections that there are many factors of uncertainty when calculating a long term discounted value of net benefits. However since this is the most realistic methodology in describing benefits it should be applied - infrastructure investments are carried out to serve future transport demands and it would be wrong to use only current figures of traffic. One can argue that when prioritising projects within a single country the forecasts for every project should be the same, but even in different regions of a country traffic growth and other factors will differ significantly. The recommendation here is therefore to always use discounted net present values when assessing project benefits. The first year of return rate can be used as complementary information according to the French practice.

Conclusions:

- Results of CBAs should be presented by a net present value as a base. A ratio between the net present value and the public, or total, finance required for the investment can be used for describing the cost-efficiency of each project.
- First year rate of return can be used as a complement to help determine the optimal year of entry into service.

4.2.2 Evaluation period and rate of discount

For calculations based on net present values the evaluation period used will affect the result considerably. Economic lifetime stands for the time which a constructed link is assumed to be used in its intended function, after this it will be cost-efficient to make reinvestments. Especially for projects in or close to urban environments, economic lifetime is difficult to judge. This is due to the uncertainty of future development and expansion of cities. New settlements or industries could cause great changes in traffic demand, and the capacity or the stretch of constructed infrastructure links may be inappropriate earlier than expected. The expected economic lifetime is here recommended as the evaluation period, but in case of considerable future uncertainties shorter periods could be chosen. In the latter case a residual value of the project could be assessed and added as a positive effect.

An adjusted rate of discount is sometimes used as means to counter ‘promoter’s optimism’ which can lead to overestimation of positive effects in cost-efficiency calculations. The chosen rate of discount shows the expected return for investments - choosing a high discount rate means that we are on the "safe side" when stating that a project is cost-efficient, in the case of an investment where costs are mostly up-front and benefits flow later, though the opposite may be true if there are large delayed costs e.g. maintenance or renewal. A similar effect is sometimes produced when choosing a higher rate of discount is used as a rationing device, to bring the list of ‘justified’ projects down to the budget available. Generally, both mechanisms are effective in reducing the size of the overall list of justified projects, but problematic because they distort the relative merits of different schemes within the justified list. This is because the main role of a discount rate is to weight present and future flows against each other, and a higher discount rate will tend to favour schemes which have more immediate benefits and/or more distant costs. Therefore it is better, if possible, to use a discount rate which accurately reflects the balance of present and future resources, and use other mechanisms to counter over-optimism or meet a budget constraint.

A further difficulty in choosing discount rates in the context of transport derives from current understanding that some effects, especially environmental effects, may be quite slow, and result in problems of intergenerational equity. Discount rates usually chosen in effect imply that no effect is worth considering beyond about 30 years or so. This runs counter to current international views on environmental impacts, especially relating to global climate change.

The impact on project net present value due to different evaluation periods is higher if the discount rate used in the assessment is low. Evaluation periods for road assessments and rates of discount used in different countries are shown in table 4.2.

Table 4.2. **Evaluation periods for road investments and rates of discount**

Country	Evaluation Period	Rate of Discount
Belgium	Infinite[1]	4%
Germany	Project lifetime	3%
France	Infinite	8%
Sweden	Trunk roads 60 years Other roads 40 years	4%
United Kingdom	30 years	6%

[1] In the Belgian framework effects are estimated over a thirty year period and assumed to remain constant thereafter. The cost and benefit flows are then discounted over an infinite lifetime.

Source: European Commission EURET and complementary information from national CBA handbooks.

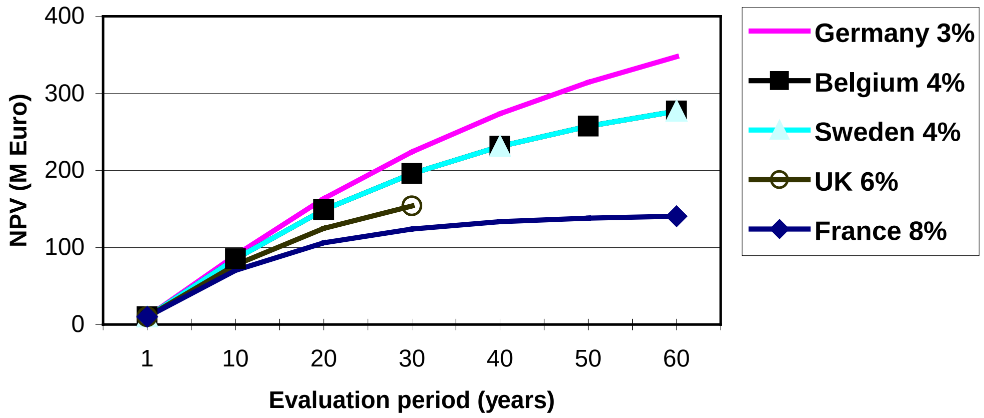
A simple example will show the effects on the net present value if using different rates of discount and evaluation periods. Assume benefits of Euro10 M for the first year of operation. By using the rates of discount and evaluation periods recommended for road investments in each of Germany, Sweden and United Kingdom the growth of the net present value for each country is calculated. The evaluation period used in Germany depends on each project's economic lifetime, and in this case an assumption of 30 years is made. The equation used is:

$$PV_b = (B_o / (r\text{-}a)) * (1\text{-}(1 + r\text{-}a)^{-n})$$

where PV_b is the net present value of the benefits
B_o is the benefits of the first year in service (assumed Euro 10 M)
r is the rate of discount (3-8%)
a is the annual growth of benefits (assumed 1%)
n is the evaluation period (30-40 years)

The result of this brief example is shown in figure 4.1. The impact of different practice is obvious. Similar projects show net present values varying from 140 to 350 million Euros depending on the national methodology applied. Assuming a similar level of benefits in year 1, the total calculated net present value is smallest in France, 9% larger in the United Kingdom, 65 or 98% higher in Sweden depending on the category of road, 98% larger in Belgium and 148% greater in Germany than in France. The discount rate employed has a slightly stronger influence on NPV than the period chosen for evaluation, in this sample.

Figure 4.1. **Relationship of net present value (accumulated) to discount rate and evaluation period**



Source: European Commission EURET and complementary information from national CBA handbooks.

One conclusion of the 1992 ECMT round table on the evaluation of investment in transport infrastructure[19] was that many difficulties are experienced in evaluating long-term effects and one should beware of the uncertainties when estimating benefits over a long time. The recommendation here is to use realistic evaluation periods based on forecast economic lifetime, otherwise the strategic point of the assessments will get completely lost.

The evaluation period could be shortened or the rate of discount increased if traffic and other forecasts are marred with great uncertainty. (Alternatively, different policy solutions can be considered that are not so sensitive to future uncertainty - flexible management solutions rather than inflexible fixed infrastructure solutions, for example). In order to achieve consistent assessments similar economic evaluation periods should be used for technically similar projects within a country unless very credible information is available to justify differences for a specific region. For good consistency the rate of discount should always be equal within a country. This should also be considered to an increasing extent internationally, e.g. in developing Trans-European Networks.

Conclusions:

- When comparing CBAs from different countries, care is needed because of different assumptions, particularly the rate of discount and evaluation period used.
- Realistic evaluation periods based on forecast economic should be used. High rate of discount, or short evaluation period, endangers the strategic view.
- Consistent economic evaluation periods should be used for technically similar projects in similar environments within a country (and to an increasing extent internationally).
- Discount rates should not be so high as to conceal longer term, especially environmental, impacts.

4.2.3 *Traffic forecasts*

Traffic forecasts are a very important input to CBA. Expected high traffic growth is often one argument when capacity improvements are argued for, and the forecast rate of traffic growth used in calculations will of course affect the net present value in assessments (The impact will be especially high if using a low rate of discount).

Highly technical traffic demand models exist, and more sophisticated methods are under development. They require detailed demographic, socio-economic and industrial information, as well travel surveys and analyses. The amount of money spent on development of traffic models is a cost-efficiency matter of itself, and it always has to be considered if additional development steps are worth their cost: a poor quality demand forecast will certainly undermine the robustness of any economic appraisal.

One way of at least showing the uncertainties of traffic growth estimations is to work out several scenarios. These should reflect e.g. a range of technical and general economic assumptions.

Scenarios can also be used in order to reflect future strategies, and shed light on conflict areas between different policy objectives. The impact of different policy measures can be studied by changing parameters in traffic demand models. In the preparation work for a new 1998 transport policy in Sweden different policy directions were analysed. The mobility scenarios were defined along two different dimensions. One dimension reflected the general development of society and the other different future transport policies[20]. In this way it was possible to analyse how the traffic demand would be affected by measures like infrastructure investments, taxation, charges, regulations etc.

The significant issue for economic evaluation of transport benefits in all such tests is the crucial assumed balance between (a) the amount of traffic growth calculated as a result of external effects such as income and demographic trends, and (b) the amount of traffic growth calculated as a result of internal (i.e. transport policy-related) factors such as cost, speed etc. This is because if the balance between these two types of effect is wrongly estimated, the calculation of benefits and also the calculation of traffic growth will both be biased. One example of this is where traffic is assumed to be dependent only on income, with no induced traffic from infrastructure investment itself: in this case the relief from congestion will be overestimated.

Conclusions

- Traffic forecasts have a considerable effect on calculated cost-effectiveness for infrastructure investments.
- Scenarios are a very useful tool for analysing effects of different measures and developments.
- Particular care should be taken not to attribute travel cost-related traffic changes to external factors (e.g. income), or vice versa, as this will bias the estimation of benefits.

4.3 Time Saving

4.3.1 Time saving benefits and willingness to pay

Benefits of time saving form normally, together with decreased costs for traffic safety, the major part of the net present value in CBAs, and time saving effects is the standard CBA parameter closest linked to increased accessibility and economic growth.

The basic assumption in socio-economic cost-benefit assessments is that users of the transport system, whether it is a private person or a company, have a willingness to pay for the possibility to reach a certain destination. Hence if the travel time is shortened to a destination, one can also appreciate a value of saved time, and this willingness to pay for all users will form a positive effect in cost-benefit assessments. The willingness to pay for undertaking trips is of course due to a lot of factors but the most important could be summarised under the headlines:

- purpose of the trip
- distance of the trip
- the mode used
- urban or inter-urban conditions
- travel time or waiting time
- personal income and other economic incentives or restrictions

The two main survey methodologies for measuring value of time (VoT) are Stated Preference (SP) and Revealed Preference (RP) analyses. SP analyses are carried out by interviewing people or using questionnaires and in RP analyses the actual behaviour due to different improvements or impairments of the transport system. Although the RP methodology will give results that are more in accordance to the current real situation the advantage of adapting the questions to the specific purpose of the study has made SP methodologies more widely spread. In a review of 105 studies in the UK between 1980 and 1996 (Wardman, 1998)[21] it was concluded that there is a good level of correspondence between SP and RP methods. This finding is, however, somewhat problematic when considering the difference between the explicitly equilibrium assumptions of most revealed preference analysis, and the implicitly dynamic assumptions of most stated preference analysis: in principle, it may be argued that the two methods ought to give different answers, not the same answers. In recent years it has been common to test SP results against some form of 'known' RP base quantities, and it may be that this has resulted in more convergence of results than would be justified.

Countries that have published national value of time studies recently are Norway (1997)[22], Sweden (1996)[23], Finland (1996)[24], Great Britain (1996)[25] and the Netherlands (1996)[26] (References derived from Wardman, 1998). Even though these studies were commissioned by governments, they have only affected practice in CBAs to some extent. For example in Sweden the last national decision on VoT for all modes was to take the values from the new VoT study regarding trips longer than 100 km, but to keep the recommendations used earlier for trips shorter than that.

A table of average VoT for different European countries and Canada is presented in table 4.3. The range of the values in different countries is very wide - from 3.8 Euro per vehicle and hour in Greece to 27.3 Euro per vehicle and hour in Switzerland. Although national figures should not be compared without considering other economic factors like price level and income level, this compilation gives an indication of the spread in values, the difference between the highest and the lowest value (of a factor 7) is surprisingly high.

Table 4.3. **Value of travel time in some European countries and Canada**

Country	**Euro per hour and passenger car**	**Euro per hour and goods vehicle**
Belgium	7.8	29.7
Canada	4.5 [1)]	n.a.
Denmark	7.2	20.9
Finland	4.6 [2)]	16.9
France	9.5	25.2
Germany	4.6	28.3
Greece	3.8	5.9
Ireland	11.3	14.1 [3)]
Luxembourg	13.5	16.5
Netherlands	7.8	9.5
Norway	7.8 [1)]	n.a.
Portugal	4.3	5.2
Spain	10.0	16.5
Sweden	5.4	21.5
Switzerland	27.3	61.7
Turkey	4.8 [4)]	n.a.
United Kingdom	9.9	12.2

1) Leisure time travel.
2) Average value business trips and leisure time trips.
3) Average value heavy and light goods vehicles.
4) Value of time for driver.

Source: INFRAS (1998), ECMT *Survey on internalisation policies, Interministerial instructions*, Data source given: DIW (1998).

One reason for valuing time savings higher than the actual willingness to pay is to undertake sensitivity analyses. As a preparatory work for the Swedish national decision on transport policy 1998, the different infrastructure administrations analysed a number of different directions for future infrastructure policy. The analysis involved different macro-economic scenarios and different investment directions for the infrastructure network. For example in the context for the calculations in the "environmental direction" the values on environmental parameters were raised, and in the "economic growth" direction the VoT was set higher for freight transport.

The most important approaches of valuing time will be covered in the following sections. As a start of this discussion, table 4.4 shows that there is a considerable difference in time values and how they are expressed in different countries. The costs in the table only cover in-vehicle time and no vehicle costs per driven km are included (hence for lorries the cost is for the driver in this case and not for the carried goods).

Table 4.4. **Value of travel time in France, Germany and Sweden (Price level 1997)**

France[27]		**Germany**[28]		**Sweden**[29]	
	Euro/h/person		Euro/h/p		Euro/h/p
Road	6.37***	**Workdays**		**Spare time trips**	
Railway		private cars*	5.60	local commuter trips	4.04
2nd class	9.94	lorries*	21.36	local leisure trips	3.00
1st class	25.32	road trains**	30.52	interregional trips (commuting and leisure)	8.09
Air	44.90	buses**	63.58	**Business trips**	
		Sundays		cars	21.95
		private cars*	2.80	air	17.33
				inter-city trains	16.17
				high speed trains	16.17
				regional trains	12.71
				inter-city buses	12.71
				regional buses	12.71
				lorries	23.45

* Average occupancy factor for cars is 1.1-1.7 depending on the trip purpose. Here an average assumption of 1.4 is made. The occupancy factor of lorries is assumed to be 1.1.

** The values are per vehicle and hour.

*** In fact the value of time for private car use is linked to comfort as a result of the model used to estimate values of time in France. Inseparable pairs of time/comfort values are used.

Source: National CBA handbooks.

The French model is about to be reworked and the time values disaggregated, but the structure of values used now in France is shown as an example of an approach where not many assumptions of different purposes of trips are made for each project. The VoT for road transport is an average value for all purposes and the railway VoT has been divided roughly into 1st and 2nd class passengers, probably based on the assumption that a higher amount of business travellers among 1st class passengers will lead to a higher average willingness to pay.

The German values of time for car trips are divided into weekday and Sunday trips, where the workday trips contains an average rate of business trips of 31,2%, which explains the higher time values of workdays.

The values of time in Sweden is the most disaggregated of the countries compared above, since it also covers different trip distances. The detailed information on time values for different modes and trip purposes gives the analyst a possibility of adapting the assessment to the current traffic condition. If no traffic surveys have been carried out on the site for the project, assumptions of average trip purposes and distances have to be made. The Swedish National Road Administration use mostly weighted values of time in CBA: e.g. a share of 14.3% interregional and 85.7% local commuter trips is assumed on national trunk roads.

Trip surveys could be carried out for large projects or where the traffic conditions are believed to be special, but in other cases the share of different types of trips have to be estimated and standard values used. Although aggregated values are used in practice it is important that the methodology used is transparent so that the assumptions of different purposes and trip distances could be derived.

Conclusions

- There is evidence of a level of correspondence between SP and RP methodologies.
- Even though value of time cannot be compared without considering different income level, infrastructure network, macroeconomic factors etc. it can be stated that the VoT in different countries varies to a considerable degree.
- Socio-economic valuation as an instrument for enhancing a certain transport policy could be a fruitful approach (e.g. higher VoT for freight transport to emphasise their contribution to economic growth), but the methodology used has to be transparent.
- Time values which are aggregations of different journey purposes and distances could be used in project assessments, but it is important that the assumptions made are clearly explained. Therefore detailed values of time should be presented parallel with the aggregated ones in national documents on CBAs.

4.3.2 Private Travel

In the Norwegian value of time study (1997)[30], which is based on SP methodology, a significant difference between VoT for inter-urban and urban travel were found. The differences are presented in Table 4.5.

Table 4.5. **Difference in in-vehicle VoT between urban and inter-urban travel according to the Norwegian VoT study 1997**

	Urban travel, per cent of average industrial rate *)	Inter-urban travel, per cent of average industrial rate *)
Car	35%	80%
Public Transport on roads	27%	45%
Rail	45%	50%

*) 108 NOK in 1995.

For the value attached to headway time (the time needed to reach public transport) the Norwegian study showed that the situation is the reverse of that in relation to the value of time spent in vehicles, i.e. the time spent heading to the bus/train is valued higher in an urban context than in inter-urban travel. The same trend was shown for travel delays, for urban public transport on roads waiting time was almost four times higher than in-vehicle time.

The Swedish value of time study[31] found that the value of time is considerably higher for long trips (>50 km) than for short ones and that the largest difference concerns car travel. It is claimed that a possible explanation for this may be that the convenience of the car mode is counteracted by fatigue effects when driving long distances.

Commuter trips are normally considered as non-business trips. Although the employer could achieve some benefits of shortened commuter time most of the time saved due to transport improvements will be used for leisure activities. In the recent UK value-of-time study (1996), commuter trips were estimated to have 26% higher value than leisure trips. Another interesting finding derived from UK data is that London commuters are estimated to have values of time 35% higher than leisure travellers, while commuters elsewhere and peak travellers had values 14% higher[32].

The differences of commuter VoT in large cities compared to other urban areas could be due to the difference of income level, but also simply because the travel conditions are worse because of the congestion situation in large cities.

4.3.3 Business Travel

The valuation of business travel time savings was initially based on the neo-classical economic theory that at the margin, wage rate is a measure of production lost or gained by the work force (e.g. quicker business travel). Hensher (1977) suggested a new methodology which is used in e.g. Norway and Sweden as a base of estimations of VoT for business travel.

According to Hensher the VoT for business trips are due to one business component and one private component, where the private component is estimated by SP trials with private money. For a further description see Hensher 1977 [33]. The Norwegian VoT study suggests a slightly revised form of Hensher's equation, but the basic idea of treating VoT for both the employer and employee is still suggested.

It is important to make it clear for the respondents of the SP trials which view they should bear in mind when they answer the questions. If survey results are going to be used in the Hensher model, the private valuation should be separated from the company travel policy etc. Wardman (1998) found examples of surveys were business travellers were asked to bear the company travel policy in mind, which means that the study would reflect the employer's value.

4.4 Safety Improvements

As already noted, although benefits from transport investments in terms of traffic safety and environmental protection are highly important for society they are not usually included as economic growth or productivity benefits, partly for reasons of the conventions of national income accounting which do not accord them an economic value. However, safety is normally included in multi-criteria analyses undertaken in support of project assessments and in some countries incorporated directly in CBA. Safety is often determinant for the results of the overall assessment. In France, for example, safety typically represents 10 to 15% of the benefits of road projects.

The value assigned to safety improvements depends greatly on the statistical value of life employed. For example a value of Euro 570 000 is employed in France whilst a value of Euro 1 M is employed in the United Kingdom34. This results in major differences in the outcomes of project assessments between the two countries: road projects resulting in safety improvements are given comparatively greater priority in the UK and projects resulting in time savings in inter-regional transport greater priority in France.

5. ADDING EFFECTS TO CBA - MULTI-CRITERIA ANALYSES

5.1 Differences between CBA and MCA - Can they be combined?

CBA and MCA can be seen as two extremes on a scale where CBA focus on effects which are possible to quantify and MCA emphasise subjective criteria provided by analysts and decision-makers. One definition of the two is provided from the United Nations Seminar on International Transport Investment 1987[35]:

"The primary difference between the two methods is that in cost-benefit analysis, the analyst attributes the weights to the various objectives and is responsible for the aggregation of the project's effects, whereas in multi-criteria analyses the decision-maker gives the weights to the objectives and is involved in the final evaluation phase."

All effects are monetised in CBA but other yardsticks are often used in MCA. If monetary terms are used in MCA the critical difference between CBA and MCA is that the values are primarily based on the preferences of the users and those affected in CBA but supplied by the analyst or the decision maker in a MCA. A main argument for using MCA is the difficulty in monetising different effects for projects in different environments, thus other yardsticks than money are used and weighted by decision-makers according to the current policy.

Methodologies in CBA are highly developed concerning the appraisal of some effects and although values differ among countries there is a broad consensus that the methodology should be the base for project assessment. Some countries have started work on extending the assessments by adding MCA data. This is clearly the most progressive approach in order to cover all necessary facets when taking decisions. To provide reliability it is highly important to make a clear disposition of the analyses - transparency is required.

The idea of combining CBA and other data is not really new and many countries have developed manuals for project feasibility studies. The new approach is to use a merge of the two methodologies on a strategic level, when considering how projects should be prioritised. Belgium and Netherlands are the two countries closest to MCA with only a limited contribution of CBA. Countries with broad frameworks of both CBA and MCA are France, Germany, Italy and United Kingdom[36].

CBAs should definitely be the base of assessments but attempts to expand the framework should be encouraged since this is a step towards more comprehensive analyses. In the following section the new UK attempt in this area will be discussed, the "New Deal for Trunk Roads in England"[37].

Conclusions

- CBA should be the base when undertaking strategic assessments on investment projects.
- The most progressive approach in order to cover all necessary facets in decision-making is to add quantitative and qualitative aspects to the CBA core analysis.
- Assessments should be transparent.

5.2 A new deal for trunk roads in England - Assessment principles

The new approach to appraisal in England is an example of a methodology with a CBA core, but extended to cover other factors. The different parts are simple to separate which makes the whole approach transparent. The methodology was developed for a general Roads Review and the appraisal methodology is presented in two documents[38 39]. Work is in hand to develop the new approach for all forms of transport and in multi-modal studies, and to consider changes recommended by SACTRA (1999).

The new approach takes account of five criteria:

- Environmental impact (noise, local air quality, greenhouse gas emissions, landscape, biodiversity, heritage, water).
- Safety.
- Economy (investment & maintenance costs, journey time & vehicle operation costs, journey time reliability, regeneration).
- Accessibility (pedestrians and others, public transport, community severance).
- Integration (considering different transport modes and land use planning).

The results are presented on a single sheet (appendix 3 of the New Deal report) and three different scales are used in the appraisal:

1. Monetary value
2. Other quantitative units (for effects which should not be monetised)
3. Assessment scale, usually seven points (for effects that cannot be expressed in any relevant quantitative units)

The category "economy" only includes the factors most closely linked to economic growth, all monetised except urban/regional regeneration, for which there are two yes/no questions:

- Serves regeneration priority area?
- Development depends on scheme?

Even safety and local environment (air pollution, noise) which normally are relevant to include in CBA are separated from the economic core of the assessment. Safety effects are monetised but not local environmental effects.

This type of assessment is “multi-criterial” in the way that decision-makers are served with comprehensive information that has not been weighted too much by the analyst. It is said in the guidance “*Because each seven point scale measures a very different criterion they cannot be compared with each other*”. Since there are few “built-in” weights, the presentation is flexible and can be directly applicable in countries other than England.

Conclusions:

- The new approach to appraisal in for trunk road projects in England is an example of assessment methodology with CBA core but extended to cover other important effects.
- Local environmental effects are not monetised in the approach, which is in some ways a deficiency.

6. HOW LARGE A PART OF THE EXTERNAL BENEFITS IS CAPTURED BY CBA?

6.1. External and internal benefits

All effects discussed so far in this report have been characterised as socio-economic effects without any separation between internal and external effects.

When defining externalities one has to be clear which subsystem is taken as the boundary between internal and external effects[40]. Subsystems which are relevant to distinguish are (1) the individual transport user, (2) a group of transport users, e.g. car users, public transport passengers, etc and (3) the entire transport sector. It should be stressed that the appropriate boundary depends on the use to be made. For example, when judging equity and distribution effects it is rarely possible to consider a particular individual, so analysis usually relates to broad groups. When considering pricing, on the other hand, the useful boundary is that between 'the decision-maker' (who may be an individual, a family group or a company) and the rest, since this is the level at which prices can have an effect on behaviour. In the limit, in the world as a whole, there is no such thing as external effects – all costs are borne by somebody, somewhere[41]. Two types of external effects can be distinguished:

1. *Technological external effects* are not actively or voluntarily processed through markets.
2. *Pecuniary external effects* are actively or voluntary processed through markets.

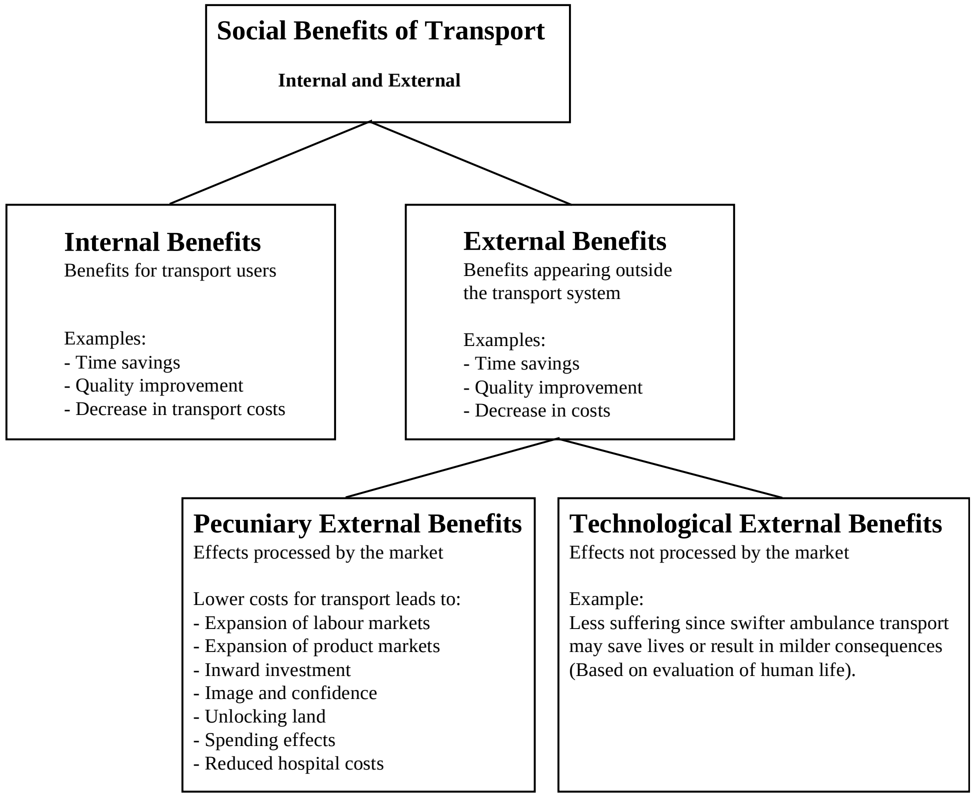
Private benefits for transport users are internal and reflected by e.g. the willingness to pay for time savings. Also time and other cost savings for hauliers and business travellers are internal to the transport system.

The increased productivity due to transport improvements for enterprises are one example of pecuniary external benefits - thus time and other cost savings do here appear outside the transport system but are still processed by the market (benefits for transport users here contribute to benefits for a third-party). The effects captured by macroeconomic input-output assessments are purely pecuniary and do not bias the individual decision with regard to transport services[42].

The technological external benefit of greatest importance is less suffering for the victims of accidents since swifter ambulance transport may save lives or result in milder consequences. The valuation of this benefit emanates from what is sometimes called the statistical value of human life, estimated by the willingness to pay for a given risk reduction[43]. There are also some small and unimportant technological external benefits such as the enjoyment some people find in watching traffic or vehicles.

Figure 6.1 shows possible linkages between transport user benefits and the two different types of external benefits.

Figure 6.1. **Internal and External Benefits of transport.**



Source: ECOPLAN[44] and SACTRA[45]

It is obvious in figure 6.1 that the external benefits are derived from the same criteria used to estimate internal benefits (time savings, quality improvements, decrease in transport costs). This has been used to suggest that it would be possible to estimate external benefits as a constant proportion of internal benefits, although SACTRA specifically argued that this would be invalid, since the size (and sign) of the multiplier would be different in different circumstances.

Conclusions:

- Almost all types of benefits of transport are internalised to the market.
- The key technological external benefits are found in increased efficiency for emergency services.

6.2 Technological External Benefits and CBA

The key technological external benefit is due to decreased suffering due to more efficient emergency service. Is this included in CBAs? Since suffering could be characterised as a part of the human value, the answer is depending on how human life is valued in different countries.

An interesting observation is that human life is not valued at all in CBAs in some countries, including Germany, Spain, the Netherlands, Portugal and Greece[46]. Cost estimates in these countries are based on elements such as costs of hospitalisation, loss of production, etc.

Sweden is one example of countries where human life value contributes considerably (65%) to the cost savings attributed to traffic safety improvements. It is difficult to say how large a part is valued as reduced suffering.

To understand this difficulty it is necessary to know how the value of human life is calculated. The value emanates from individuals' average willingness to pay for risk reduction. The following example is taken from the latest Swedish revision of guidelines for socio-economic values[47].

Assume that 100 000 people benefit from a traffic safety improvement which will reduce the casualty risk by 1/100 000. The forecast number of casualties in this group will then be reduced by exactly 1. If each individual is willing to pay e.g. 8 Euro for a casualty risk decrease of 1/100 000, the total willingness to pay for this safety improvement will be 800 000 Euro. This is equal to the average individual willingness to pay divided by the risk reduction. The average value of this ratio is the definition of the value of a statistical life.

It is realistic to assume that suffering is to some extent included in the average willingness to pay, but it is very difficult to estimate its magnitude.

The Swiss framework suggests a figure, although marked by high uncertainty[48]. For Switzerland the estimation of benefits due to swift emergency service is between 30 and SFr 50 M per year. This is only 2-3% compared to the overall external costs for casualties in the road sector of SFr 1 500 M.

Conclusions

- It is realistic to think that the valuation of swift emergency service is included in the willingness to pay for risk reduction - hence also in the value of human life. The share is difficult to estimate though.
- A Swiss calculation suggests a value between SFr 30 and 50 M. This is only 2-3% of the overall value for external cost of casualties in the road sector.

6.3 Pecuniary external benefits and CBA

There is a significant risk of double counting if additional effects are added to CBAs. In the Swiss framework for CBA it is claimed that the transport user benefits reflect all market effects[49]. This means that time savings and other cost advantages for infrastructure users are assumed to cover all the external pecuniary effects and no additional effects should be added to CBAs.

Current practice in some other countries, e.g. the UK and France, suggests that external benefits should be covered in a non-quantitative way in order to avoid the high uncertainties of quantitative assessments. For example the new approach to appraisal of road investments in England involves regeneration issues by general yes/no questions (e.g. Serves regeneration priority area? Development depends on scheme?).

The German Evaluation Guidelines stands out as a framework where pecuniary external benefits actually are added[50]. For CBA the guidelines advise that "Spatial Benefits" should be added. These are the following and can be characterised as pecuniary external benefits:

- Regional economic benefits due to employment effects during construction.
- Regional economic benefits due to employment effects during operation.
- Regional structure benefits.
- Promotion of international benefits.

A quantitative example of economic assessment for a road investment is given in the German guidelines. It is not claimed to be a typical example but can however give an indication of the magnitude of external pecuniary effects. Table 6.1 shows data from the assessment.

Table 6.1. **Benefits of a road investment, Germany (bypass in the state of North Rhine-Westfalia)**

	Benefit (Million DM)	Benefit Share (%)
Savings in Transport Costs	0.464	17.4
Road Maintenance Costs	- 0.067	- 2.5
Safety Contributions	0.189	7.1
Improvement of Accessibility	0.405	15.2
Regional Effects	0.089	3.3
Environmental Benefits	1.581	59.5
Total Benefits	2.661	100

An interesting observation is that 60% of the total benefits are attributed to environmental improvement. The project is a bypass which is thought to improve the environmental conditions considerably in the community. The largest part, 84%, of the environmental savings are due to reduction of separation effects (measured by annual time losses of the population affected in the crossing of the road).

In this example time savings for freight transport is a part of "Savings in Transport Costs" and the term "Improvement of Accessibility" covers time savings for cars and buses. The term "Regional Effects" is a part of the "Spatial Effects" mentioned earlier in this section and represent the pecuniary external benefits of the road investment[51].

The benefits "Savings in Transport Costs", "Improvement Accessibility" and "Regional Effects" represent 35.9% of the total benefits, and 9% of this sum are benefits of "Regional Effects". The corresponding figure for a railway project example presented in the same publication is 11.5%.

Hence in the German assessment framework, which includes an adjustment for expected "additional effects", the benefits from these seem to be rather small — about 10% of the total internal benefits of time savings and transport cost reductions in the examples presented in the German guidelines.

This still leads to a quite important conclusion. If there exist pecuniary external benefits not reflected in initial benefits to transport system users, these are quite small, only about 10% in the road and railway examples given.

Conclusions:

- There are different opinions of how large share of the pecuniary external benefits that are reflected by internal cost savings in terms of time and other transport cost savings.
- The Swiss evaluation framework suggests that all pecuniary external benefits are included in time and other cost savings included in CBA.
- The German evaluation guidelines suggest that effects should be added to CBA in order to cover all pecuniary externalities. Practical assessment examples indicate that these effects are quite small - about 10% of the total internal benefits of time savings and other transport cost savings.

7. THEORETICAL TREATMENT OF THE RELATIONSHIP BETWEEN TRANSPORT AND THE ECONOMY

7.1 Introduction

In the review of evidence so far in this report, we have found support for the proposition that macroeconomic effects are not adequately dealt with in standard transport cost-benefit appraisal, and note that research which has tried to measure these wider effects directly has had limited success. Thus there is insufficient basis, at present, to add quantified monetary estimates of additional effects.

These conclusions are broadly consistent with those work recently reported of an international review of evidence and new theoretical development[52] reported by the UK Standing Advisory Committee on Trunk Road Assessment, SACTRA, which extended the theoretical analysis by using a framework, previously applied to the potential benefits and costs of removal of trade barriers, developed by Venables and Gasiorek. This report has been widely treated as a major contribution to this topic, and we now summarise, and comment on, its main findings. Further more technical commentary is provided in the supporting Annex by Vickerman following this report.

The work depends on distinguishing between two main cases, perfect competition and imperfect competition. These will be considered in turn.

7.2 Perfect competition

7.2.1 Context and assumptions

In this theoretical world, it is assumed that all prices for all goods and services (including wages) are correctly aligned with costs, as a result of active competition among many firms. There are no distorting effects on economic activity due to taxes, subsidies, and no uncharged indirect costs such as pollution or congestion.

It had long been concluded that - if such idealised conditions apply - the conventions of social cost benefit analysis would provide a full and unbiased estimate of the economic value of a transport improvement.

Consider the case of the dominant item in many evaluations of this sort, time savings. Estimates can be made of how much the various travellers would be prepared to pay for such savings in time, bearing in mind their various constraints, alternatives uses for the time that are open to them, etc. Now it may well be these time savings go on to have all sorts of wider economic ramifications - for example, widening the catchment area of labour, hence changing wage costs; altering local property prices, hence encouraging a different pattern of development; giving access to more distant markets; etc.

Each of these wider affects will clearly have a pattern of economic costs and benefits. However, the theoretical analysis of perfect competition implies that the value of these wider impacts is not *additional* to the values captured in the initial time savings, but only a change in their incidence or form. Thus it may be of interest to know how the mechanisms work (and especially where they work), but the overall economic basis for a decision to go ahead or not is not changed.

This proposition is very powerful, as it makes it possible to come to reasonably firm advice on the economic merits of an investment without needing to know all the indirect, longer term, ramifications.

Because of its importance in underpinning cost benefit analysis, the actual theoretical argument itself has been revisited from time to time, just to check that it holds. SACTRA also did this, and concluded:

“The identity of initial and final benefits is a theoretical proposition arising logically from the assumption of ‘perfect competition’ in the economy as a whole...If these conditions hold, we concur that the value of the estimated costs and benefits to transport users (notably time savings, operating costs and accident reduction), and to non-users (notably environmental impacts - provided they have all been identified and a money value attributed to them) would give a full and unbiased estimate of the value of the overall economic impact. This is equivalent to the statement that no ‘additional’ economic impact exists.”

This is broadly the same conclusion that previous investigations had supported, and which has for nearly half a century justified the practice of cost benefit assessment of transport projects.

7.2.2 Conditions and Implications

The work did, however, reveal that - even in the case of perfect competition - there were a number of quite important conditions for this conclusion to be valid, some of which have quite awkward policy implications.

First, the time savings (and other benefits to transport users) must actually be achieved. It is not good enough that they should be intended. If the modelled calculations of these potential benefits is faulty (as in the case, for example, of overoptimistic estimates of a 'relief from congestion' which in the event fails to occur), then hopes for downstream wider economic benefits will also be disappointed. So full and realistic allowance for induced traffic must be made, for example. Indeed in some - but not all - cases, the induced traffic that undermines congestion benefits may itself be the form of 'wider economic benefit' that had been hoped for. But it is now established that the value enjoyed by the induced traffic is, in conditions of congestion, less than the losses imposed on other traffic. This argument applies also for subsequent economic impacts.

Secondly, in the quotation above there is the passing comment about environmental impacts, in brackets, 'provided they have all been identified and a money value attributed to them'. This is an important condition, especially since there is no immediate prospect that all environmental impacts will be fully and correctly incorporated in cost benefit studies. The implication of this is that even in conditions of perfect competition, the “conventionally calculated transport net present value...can only provide an unbiased measure of the value of the final economic impact...in the case where there are no environmental benefits, either negative or positive.”

This conclusion applies however difficult it may be in practice to quantify the environmental costs. If they exist, then they are having an effect on the economy, whether they are included in a model or evaluation framework or not. SACTRA argued that

“Accepting that the full money valuation of all external environmental costs is not in prospect, it is still unavoidably necessary to make a case-by-case judgement about whether those environmental costs are likely to be large enough to make the marginal social cost greater than the price, since this is critical to the whole analytical framework.”

Thirdly, there is an odd, obvious, but previously unremarked implication which follows from the case where perfect competition does exist, therefore the initial estimated transport benefits are identical in total value to the final economic benefits. In casual professional discourse, such an effect is usually expressed in words like ‘the time savings work their way through to the wider economic impacts’ or ‘at first, travellers save time, and later there will be increased employment’, etc. Although the calculations then must be based on the identity of benefits, the language somehow softly implies that these later affects are additional.

This must be misleading, since as soon as we accept, under assumptions of perfect competition, the identity of initial user benefits and final economic benefits, then the logical necessity is that in order for the later, wider economic impacts to come through, the initial value of the user benefits must be eroded. Therefore the incidence of benefit must evolve over time, and groups who received the initial benefits - say, motorists receiving time savings which they value - must have some or all of the value of those benefits taken away from them, by the operation of the market, if the wider benefits are to appear.

This is never said. Travellers may be told ‘you will receive time savings and these will then improve economic efficiency’, but they are not told ‘the value of the time savings you will receive will be taken away from you, and received by someone else, in order to provide for wider benefits of economic efficiency’. While strictly this is a matter of equity and distribution rather than net benefit, it raises important issues of policy consensus, as it implies that the ‘natural constituency’ of users supporting a transport improvement because it will benefit them (and who may, in political argument, be quite happy to buttress their case with wider arguments of economic efficiency) may, over time, have their expectations disappointed.

In summary, the approach implies:

In conditions of perfect competition, if wider economic benefits are hoped for from transport improvements, it is necessary to ensure: (a) that the initial transport user benefits are genuinely delivered, (b) that environmental costs are fully included (or, may confidently be discounted), and (c) that there will be political acceptance of the erosion of initial user benefits in order to deliver the final economic benefits.

This is important for the interpretation of those studies cited above where transport investment is seen as a source of economic growth. Accepting the various uncertainties of analysis, there is nevertheless a pattern of association which suggests that at least some effect can be achieved.

However, most of those analyses do not make any attempt at all to include environmental costs as among the genuine economic costs to be included. Further, they do not really demonstrate *additionality* of benefit, because they do not allow for the 'taking away' of user benefit and its conversion to other benefits, for other people. The range of empirical results includes values that - even if they were completely reliable - are consistent with simply demonstrating the practical working out of this theoretical argument.

7.3 Imperfect competition

Real economies are not, in general, very similar to the textbook case of 'perfect competition'. It is this that gives rise to the real possibility that wider economic impacts are not just a change of the *form* of the initial user impacts, but may actually be *additional* to them. Since there are two sources of imperfection (the transport-using and transport-providing sectors), and each of them may take three values (prices higher, lower or equal to the perfect competition case), there are logically nine different situations, of which eight represent different cases and combinations of imperfections where this additional impact could apply.

It is convenient to start with the case which gives most comfort to the hope that transport investment may be significantly more productive, overall, than is conventionally assumed.

Consider a region which is very poorly connected with the outside world, and therefore within its own local economy there is a degree of monopoly power of local producers and traders, cushioned from their distant competitors. In this case, the usual expectation is that the general level of prices will be higher than they need to be: the local monopolies will be extracting a higher than normal rate of profit. Consumption and production will be depressed, and so, therefore, will employment. Overall, the economy is marked by some degree of inefficiency, and consequently loss of potential economic welfare.

If an improved transport link is now provided with neighbouring economies, reducing the cost of movement between them, these inefficiencies now come under pressure of competition. Prices will be driven down to the prevailing market levels, demand and therefore production and employment will increase. Economic welfare has therefore increased.

In these circumstances, there is a genuine additional impact which has not already been fully counted in the transport user benefits.

It would be convenient if this case was reliably the typical effect of taking account of imperfect competition. However, here we must consider other cases as well. The nature of different forms of imperfections which can exist in the real world is shown in simplified form of a three-by-three matrix, as shown in simplified form in table 7.1. (A more elaborate version is given by Vickerman in Annex 3). Each box considers how the actual price levels in force in the economy compare with the marginal social costs which, in principle, would lead to the optimal allocation of resources.

Table 7.1. **Simplified presentation of effects on CBA of economic impacts**

	Transport using sectors of the economy		
	Prices greater than marginal costs	Prices equal marginal costs	Prices less than marginal Costs
Transport prices *less than* marginal social costs	Transport prices and general prices pull in opposite directions: indeterminate effect on CBA	Ignore general price effects, but reduce traffic levels by increasing user charges.	General subsidies and uncharged external costs: CBA will overestimate economic benefits of transport improvements. Better to reduce traffic levels.
Transport prices *equal to* marginal social costs	External costs can be ignored, but benefits are underestimated	Perfect competition: CBA results unbiased	Ignore external costs, but benefits overestimated
Transport prices *greater than* marginal social costs	Goods overpriced because of monopoly, transport also overpriced: CBA will underestimate benefits of transport improvements. Should reduce transport prices.	Ignore general price effects, but should increase transport usage, reduce user charges.	Transport prices and general prices pull in opposite directions: indeterminate effect on CBA

Thus we distinguish the transport-using sector of the economy, and the transport-providing sector. In each sector prices may be less than, equal to or greater than marginal social costs - depending on whether there are distorting subsidies or taxes, monopoly power, uncharged external costs, etc.

The central box - where prices equal social marginal costs in both sectors - is the same as perfect competition: there are no imperfections, and no additional wider economic benefits. Each other box represents some combination of imperfections, and some additional wider economic impacts can apply, whose value is over and above the net transport user benefits included in a cost benefit study.

The useful and important result of this presentation is that it changes the nature of the concept of 'additionality' - because the underlying analysis demonstrates that the *additional impact may be either positive or negative*.

Thus in the case above, where there is local monopoly, external costs are ignored, and transport improvements lead to greater competition, the additional impact is positive, and the overall benefits are greater than the simple cost-benefit analysis.

However, if the local economic condition had not been one of monopoly prices, but of for example prices which had been subsidised to lower than their social marginal costs, the opposite could apply, and the final benefit of the transport improvement would then be less than had been calculated in the CBA, not more. Another case where this would apply would be where transport itself was imposing significant environmental costs, not reflected in prices, and was therefore undercharged in economic terms. Again, a transport system expansion could then lead to additional wider economic costs rather than wider economic benefits.

This logic certainly justifies taking very seriously the need for careful economic analysis of wider impacts should be carried out, in addition to usual forms of cost benefit analysis. But the reason for doing so was not - as has often been debated - because 'important benefits are being omitted'. Rather it was because of the danger that 'important benefits *and costs* are being omitted'. In some cases, consideration of the wider impacts would strengthen the case for an investment, but in other cases it would weaken it - and there was no way of telling which situation would apply without systematically considering whether the pattern of prices was higher, or lower, than the relevant marginal social costs.

There is a further, politically important, aspect of this analysis. Even in the strongest case given, where unambiguous additional benefits are provided, it is manifest that these will not necessarily accrue to the target area. In the example, it may well be that the benefits of increased output and employment will actually be enjoyed not by firms in the area concerned, but by their more distant competitors who are now able to capture a market previously too costly to compete in. SACTRA called this the 'two-way road' argument which 'reminds us that improved accessibility between two countries (and, similarly, between cities, areas or regions) may sometimes benefit one of them to the disbenefit of the other'.

In this situation, which area really ends as the main beneficiary is nothing to do with either the *intention* of the investment, nor even its precise *location*: it is an outcome of market processes. There is some suspicion that - as often happens - it may most frequently be that the stronger economies benefit more, at the expense of the weaker economies. While this does not seem to be absolutely inevitable, it is an ever-present danger. A weak economy which proposes to improve its efficiency by exposing itself to competition with its more efficient neighbours over a bigger geographical area is taking a gamble which, at the least, is likely to need active supporting measures outside the transport sector entirely.

Finally, we note a further profound implication of the analysis that wider economic impacts might go either way - to strengthen, or weaken, the cost-benefit case.

This analysis was developed in application to a classical transport investment designed to reduce the price of travel, in time or money, and, in general, provide for an increase in the volume of traffic.

It follows that the same may be true, in reverse, for transport policies which are designed to increase some prices of travel and provide for a reduction in the volume of traffic. It is widely accepted that in some circumstances to do so may have environmental benefits, but now we ask the important question: under what circumstances might such policies lead to greater economic efficiency, growth, competitiveness or output - again, in addition to that calculated in conventional social cost benefit analysis?

The answer, in general, is the reverse of the conditions above. There is a symmetry in the analysis, and where current prices are less than the full marginal costs, there are additional wider economic benefits to be gained from - for example - road pricing, or targeted demand management measures aimed at broadly the same effects. (The theory is very much clearer in the former case, which also has the additional advantage that the generation of revenue streams make possible either direct compensation, or use as a lever to ensure that the incidence of the extra benefits stayed in the originally intended target area. But the greater practical experience and sometimes detailed advantages of the better established methods of transport management, notably pedestrianisation of town centres, are also to be taken into account).

7.4 Implications of the theoretical approach

This analysis marks three important turning points in the use of economic analysis for transport project and policy appraisal.

First, it brings together theoretical and empirical analysis to affirm that there are, indeed, economic impacts whose value is additional to the net values measured in conventional cost-benefit analysis. The argument that - in principle - if a CBA is well carried out it will then be valid to ignore the wider economic impacts, is substantially weakened, except under special (and rather unrealistic) assumptions.

Second, it changes the nature of the policy implications that follow from taking these additional impacts into account. In the past, the argument that there were additional impacts was usually expressed only in the form that these impacts were all benefits, which accrued from infrastructure investment as well as the intended time savings or similar transport effects. As a result, the argument of 'wider effects' tended to lead to the conclusion that CBAs have systematically underestimated the value of transport investment, and that this has contributed to a long term tendency to underinvestment.

The new analysis suggests that this does not follow. In accepting that wider, additional, economic impacts of transport investments exist, it is now necessary to accept that these may be negative, not only positive - either for a particular area (because another area gets the benefit) or indeed overall (because more movement is provided for than is optimal for the economy).

The argument therefore effectively calls for an end to the sort of optimistic marketing claims sometimes used by development consultants to justify any major project in terms of the boost it will give to the local, regional, national or indeed European economy. If such claims are to be made, they have to be proved by very careful analysis of the specific forms of economic imperfection they will credibly resolve. While the process of making such a case will undeniably be complex, there is also the basis for rejecting claims which have not been well supported, which may simplify decisions in at least some circumstances.

Thirdly, it extends the policy arena so that it is possible to consider not only major infrastructure projects, but also the wide range of important new policy initiatives in pricing, demand management, traffic restraint and environmentally beneficial transport interventions. These also have wider economic impacts and - in some circumstances - they will be favourable. Identifying these circumstances becomes a key policy task, since they represent possibly the most important of current preoccupations - the need for transport initiatives which are environmentally sustainable as well as economically beneficial.

7.5 Practical application and research

SACTRA recommended that the appraisal process for assessing economic impacts should be structured around four questions, namely

What is the rational for the intervention?

This involves making a formal and explicit argument to demonstrate a need to correct a market failure, or achieve a public good, and identify the mechanisms why it is believed that the transport project will actually deliver this outcome. It is expected that this should be applied at an early stage of work on a project, and therefore the assessment is likely to be in rather broad terms. No specific prescribed format or methodology is recommended – partly because there is not yet sufficient experience in practice to do so – but there is a strong implication that it is necessary to distinguish between the aspirations of the policy and its outcome.

What are the benefits and disbenefits – initial assessment?

This stage is based on carrying out a 'best-practice' CBA, in which it is assumed that the economy operates under perfect competition, but with modelling procedures that are sufficiently complex, both for freight and passenger transport, to allow for induced or suppressed traffic, short and long run shifts in demand conditions, and well-specified values of time. It is accepted that in some circumstances not all these estimates will be worth making – but without them, it is not realistic to make estimates of any additional wider economic impacts. The first stage in the assessment, therefore, will need to be a conventional appraisal that is, as far as possible, fully specified in its demand effects.

What are the wider economic impacts?

The crucial questions here are to assess whether there are material features of the areas/regions and economic sectors which would be affected by the transport cost changes, which depart from the assumptions above – i.e., in broad terms, which cell of the matrix in table 7.1 above applies. Here there are certain to be problems of data and methodology, since this is a new exercise for which there is no tradition in transport assessments. Countries in which there is a tradition of use of input-output analysis for economic planning, however, may find that this analysis provides useful insights at least into the non-transport sector cost/price conditions. It is also certain that there will be weaknesses in the assessment of uncharged external costs, since methodology for their estimation is still developing. However, it may often be possible to make a broad assessment of which cell is appropriate even when exact measurement is not available. In the case where the judgement is made that the central cell is appropriate, then the result of the standard cost-benefit analysis may itself be taken as the best available estimate of the wider economic impacts. Where other cells are indicated, then this – at least – gives an indication of whether the CBA result is likely to overestimate or underestimate the wider economic effects, and guidance about which type of other policies (in transport or other fields) may perhaps be more useful than the project under consideration.

In due course, it may be that studies seeking to carry out these calculations produce more exact estimates of the appropriate multipliers to increase or reduce the CBA results quantitatively. That is not at present feasible.

What is the pattern of gains and losses?

Both in the case where the CBA result is taken as the direct estimate of wider economic effects, and in the cases where these are greater or smaller than the CBA result, it will be necessary to tackle the issue of who gains and who loses. In the longer run, methods for doing this will have to be based on better quality retrospective empirical assessments than are at the moment available: it would be very desirable if the actual economic changes following major transport projects could be monitored in some large-scale, long term research projects. These would need to focus both on the target area and on neighbouring (or perhaps more distant) competing areas. Some modelling tools are available which can help, especially land-use/transport interaction models, though they are data-hungry and not always adequately validated. At the least, it will be necessary to consider the specific nature of the competition between locations and sectors in order to identify the stronger and weaker parties, which will help to answer the question of which are most likely to benefit from the project. A useful reminder is that any claim for added economic activity in one area must be accompanied by an assessment of whether that is at the expense of another area, since this is at the heart of the problem.

It will be seen that these assessments are not conveniently provided with ready-made, off-the-shelf modelling packages which will swiftly and cheaply answer the question. If it were that simple, then it would not have been necessary to spend so much time and argument trying to assess the nature of economic benefits from transport. We must accept that economies are complex, and our understanding of the transport impacts is not going to be stronger than our still imperfect understanding of the effects even of the core economic instruments such as interest rates, money supply, Government economic policy, European integration, or liberalisation of trade - all of which are the subject of continuing debate.

8. SUMMARY AND CONCLUSIONS

8.1 Introduction

In recent years it has been the practise to assess whether or not to make a transport investment by using social cost benefit analysis (CBA), which estimates a cash value to some costs and benefits such as changes in the level of congestion, time savings, accidents, and – sometimes – environmental effects. These costs and benefits may then be compared with the capital cost of the investment. Other policy factors are also taken into account, of course, but the CBA is often the core of the information given to policy-makers.

However, the objectives of a road or rail scheme will usually include wider economic aims, such as local regeneration, employment, competitiveness, and productivity. The question that has been asked is – *does the CBA (implicitly) take these wider effects fully into account, or are the wider economic impacts being underestimated?*

Three positions have recently been the subject of debate among specialists:

Argument 1: There are wider economic effects, but they are triggered by the direct changes in travel costs and speeds, which are included in the CBA. It would be 'double-counting' to make extra allowance for them. Therefore the results of good CBA studies will give an accurate estimate of the overall economic impact.

Argument 2: CBA pays too much attention to the 'costs' of transport (i.e. congestion, pollution etc). But the wider economic effects are mainly benefits, and they are additional to the direct transport impacts. Therefore if they are not counted there will be a bias resulting in insufficient investment.

Argument 3: Discussion on 'wider effects' pays too much attention to infrastructure investment, and not enough to other policy instruments such as demand management. Economic welfare will be improved more by 'decoupling' economic growth from transport growth, in order to get the benefits of the former without the costs of the latter.

This note assesses the balance among these three arguments. ECMT has reviewed the evidence, by in-house technical reviews, and consideration of research carried out by national governments and others. An international workshop was convened of leading specialists working for government, consultants, academics, and interested parties in industry. Consensus was reached on many, but not all, points.

8.2 Evidence

The theory of the relation between transport and economic activity is a long-standing part of economic history, and has been an important influence on how we understand the development of new territories (e.g., opening up the West in America; development of Siberia, etc). There is now a strong body of theory which explains how reductions in transport costs can have wider economic effects, including productivity of transport-using industries, wider labour markets, more intense competition between neighbouring areas, and location of industry and services. This general approach is not under real challenge from any of the specialists working in this area. It is fair to say that there is a broad measure of agreement, in principle, that such effects can, and do, happen.

However, there are three strong theoretical conditions that must be taken into account.

First, traditional economic theory suggests that that the wider economic benefits are mostly not additional to the time and cost savings that generated them, but only a change in the form and incidence of these benefits. Their value should not then be counted again.

Secondly, newer economic theories dispute this, suggesting that sometimes these wider economic effects do have additional value beyond that counted in a CBA – but these wider effects should not all be counted as benefits. Some of them make economic performance worse, not better.

Thirdly, even if there is an overall benefit to the economy as a whole, and even if this benefit is additional to CBA results, local effects can be perverse. An area singled out as a target for special action may not be the winner from more intense competition with its more efficient neighbours.

There is not yet full agreement among specialists about exactly how to identify the circumstances which drive these three effects. The main theory, expounded in recent independent work carried out to advise the UK Government, is that the crucial condition is how far the real economy departs from the economists' model of 'perfect competition'. This relies on a series of conditions (contestable markets, perfect information, etc) whose main practical effect is that under perfect competition companies have to accept prices which are set 'by the market' and which closely correspond with costs, whereas under imperfect competition companies have a degree of power to set their prices, and tend to do so at a level where prices are higher than costs, and production lower than under perfect competition. These typical signs of imperfection are not the only possibility, however: other distortions can include subsidies, or predatory pricing at lower than cost. The same arguments can apply to labour markets, which might be influenced through transport policies or investment projects which change the conditions of competition for jobs or for workers. Economies of scale can also give rise to a similar effect.

Under perfect competition the first condition above would apply, i.e. no 'additionality'. Under imperfect competition the second would apply, i.e. the possibility of additional impacts over and above those measured in CBA. Under both conditions, however, the third condition can apply, i.e. benefits may not necessarily accrue to the intended target area or sector.

Thus in summary: theory suggests that transport investments will often have wider economic effects. The value of those effects will not always be additional to the values already taken into account in CBAs. Sometimes there will be additional effects, which strengthen the case for making the investment. Great care is necessary when using this argument, since in some conditions the wider economic effects will, unexpectedly, weaken the case for the investment. Moreover, the danger that benefits will flow to other than the intended targeted should always be considered.

Concerning the statistical and empirical evidence intended to test and measure these theories, we cannot report a professional or technical consensus. There have been a number of studies to try to measure these impacts, at national or local level. It must be said that there is much more controversy over the results of these statistical studies than there is about the basic theory. No single study has yet commanded a real professional or scientific consensus, and some have been seriously criticised with suggestions of misleading conclusions or questionable methods.

In summary, there is much dispute about the interpretation of statistical evidence which tries to back up or measure the theoretical expectations. Some studies have claimed to find very high effects indeed, such that transport investment has a bigger effect on economic growth than almost any other factor. These results do not command very widespread specialist support. Other studies have found it difficult to measure any real detectable effect at all. It has to be said that the quality of the empirical evidence is not, yet, sufficient to convince specialists in the field. Therefore policy-makers have to be cautious in accepting the proofs which are sometimes claimed.

8.3 Implications for Policy and Practice

Although there are minor disagreements on the theory, and major disagreements on interpretation of the evidence, the ECMT workshop of specialists did find important areas of agreement about the policy implications, and especially considerations in appraisal of investment schemes and transport policies. In summary, we can say that a well-carried out conventional CBA does measure the full benefits of transport projects and policies, except where:

- Imperfect competition (monopolies, economies and diseconomies of scale) exist in transport-using markets, including labour markets, and the change in transport costs caused by the investment or policy successfully influences the volume and price of production in these markets;
- Imperfect competition exists in transport markets, such that transport prices do not equal the marginal costs in this sector.

Irrespective of whether competition is perfect or not, there exists considerable policy concern about the distributional effects of projects and policies, which are likely to be complex and may not be those that were initially expected, or intended.

Thus we conclude:

1. Wider economic effects do follow from transport initiatives – whether investments in infrastructure or other policies on pricing, traffic restraint, etc. These effects are complex, and not entirely understood. For this reason, great care is needed if it is intended to use transport policies or investment to produce specific economic outcomes. But wider effects should be taken seriously: there was no support for the idea that they can be ignored.

2. In some circumstances, the actual value of these wider effects does not add anything extra on top of the values calculated in a well-carried out conventional cost-benefit analysis. Even so, it will still be necessary to carry out analysis of these wider effects. This is because the wider economic effects will accrue to different people or places than the initial transport effects – benefits are likely to reduce for one group of transport users over time, as they are replaced by wider repercussions. An example would be if increased speed of travel resulted in higher rents and property prices, transferring some of

the advantage from travellers to land-owners. Another example would be if increased speeds led to a wider labour market, enabling distant workers to compete for jobs which currently are filled only by local employees. In each case, somebody certainly benefits but those who originally expected to benefit - and indeed do so at first - might find that after the initial impact, they then become relatively worse off over time, not better. A practical example might be the case of improvements to a road which serves a peripheral region, intended to increase employment in that region. These improvements might then make it possible for firms selling products in the region to close down a local manufacturing facility and serve the region more efficiently from a central base. The effect will then be an overall improvement, but a reduction in employment in the region which was originally intended to benefit from the investment. It is therefore important for policy-makers to test that the likely wider outcomes are consistent with their initial intentions.

3. In other circumstances, the value of the wider effects will indeed be additional to the values calculated in the CBA. In this case there will be two reasons why it is necessary to carry out analysis of these effects. The first reason is the same as above: it will be necessary to test that the geographical or sectoral pattern of effects is actually what is intended, not counter to it. The second reason is that it will be right to modify the results of the CBA to take into account the additional extra impacts. However, this will not always be to increase the calculated rate of return: sometimes it will be to reduce it[53].

4. These implications do not only refer to transport investments, but also to other transport policies. Sometimes, wider economic benefits may be most efficiently pursued by investment in road, or rail, or other transport infrastructure: this will depend on the circumstances, the general transport strategy, etc. In other cases, wider economic benefits may be achieved more efficiently by introducing prices which correspond more closely to costs, or by reallocating existing infrastructure more efficiently as between users, or by adopting other transport policies. In all these cases, the same basic principle applies: be aware that impacts may be negative as well as positive, in particular locations and overall. Outcomes may not be the same as intentions.

5. A consistent approach to wider economic benefits, in conditions of imperfect competition, can lead to a different pattern of prices in the transport-using markets prices than is currently observed – some prices would need to go up, and others come down. Within the transport sector, prices will also change if they are brought closer to the full marginal social costs of transport activities. In turn, this could imply a pattern of making greater net revenues in some sectors, and introducing subsidies in other sectors. These policy implications are not all entirely consistent with current preferred policy directions at national or European level. Particular care is necessary about the wider economic effects of investments or policies which are carried out when (for whatever reason) prices in one or more sectors do not closely reflect costs, since this is where perverse economic effects are most likely. Generally it is better to correct transport prices than to make investments to compensate for inefficient transport prices.

6. Where there are wider economic net benefits from a transport investment or policy, this also implies that there will exist groups or sectors which stand to benefit, indirectly, from these investments. Capturing a proportion of these indirect benefits (by charging) should be considered as a means of widening the potential sources of finance which would allow the initiative to be funded. This should be consistent with a policy of charging indirect costs caused (e.g. under ‘polluter pays’ or road pricing initiatives), and may provide political support and funding to help deliver worthwhile investments that might otherwise not be undertaken. There may also be advantages for equity and consensus if those who fund the project are those who ultimately will most benefit from it.

7. The ‘wider effects on the economy’ argument does not lead to a single, simple policy conclusion: rather, it enriches the argument and debate about all important transport policy decisions. Thus some of the specialists argue that the wider effects justify a larger road programme, others that they justify more rail investment, and others that they justify user pricing to manage traffic growth. The varying conclusions appear to reflect implied judgements about the specific nature of barriers to economic efficiency in current conditions, and the effectiveness of different transport instruments to reduce them. This will clearly depend on the particular circumstances of different countries, regions and sectors, but there is no simple short-cut to define ideal transport packages directly from the declared economic objectives of a country.

8. We note that it is unlikely that a transport investment or policy will be very successful in generating wider economic benefits unless it first successfully produces direct benefits in relief of congestion, more efficient use of resources, lower external costs of accidents or environment, more attractive street conditions for shoppers, or other visible improvements. Thus achieving the direct transport effects is likely to be the necessary condition for producing the indirect wider benefits.

9. In the same way, achieving improved estimation of indirect benefits is unlikely to be successful unless it is grounded on implementation of best practice procedures in project assessment. There is a need for wider application of CBA, ensuring that its assumptions and forecasts are the most reliable that can be made, and with substantially improved communication of its results.

10. More fundamentally, as argued by Roy in Annex 1, even transport projects and initiatives that have passed a thorough CBA test are not always implemented. In some cases, this is because they are believed to ‘crowd out’ private investments which are thought to be more worthwhile. The problem is that financial assessment tests differ between private and public sectors, making direct comparison of value for money difficult. In this case, the appropriate test is to see whether the calculated return on the public investment exceeds its cost by more than an allowance for the opportunity cost of public funds, as might be measured by the long term bond rate (including a weighting if higher public expenditure would affect this rate, and adjusting for the inflation-free assumptions in most CBAs, compared with inflationary expectations internalised in any market rate). A project that passes this test – and satisfies environmental, legal and other related conditions – would then be justified. Such a decision rule has been employed in France, using an opportunity cost rate of 8% for most of the 1990s. The rule would have implications for marginal social cost pricing in transport, demonstrating that its revenues do not arise simply as a result of ‘under-investment’, but are part of a consistent set of economic instruments.

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34. See Efficient Transport for Europe, ECMT, 1998 for a full report on statistical values of life.

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41. This distinction explains the difference between those economists who count congestion as an external cost, imposed by road users on each other, and those who say it is not ‘external’ because it is contained within the group of road users as a whole. In either case, however, there can be benefits from explicitly including congestion costs in prices.

42. *Ibid.*

43. The value of a statistical life is given by the ratio: (average willingness to pay)/(reduction of risk for casualty). The human value is this ratio minus the average own value of lost consumption.

44. ECOPLAN (1993), *Externe Nutzen des Verkehrs, Wissenschaftliche Grundlagen*, No 39 Schweizerischer Nationalfonds zur Förderung der Wissenschaftlichen Forschung.

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51. In this case the project is located in a region which is not characterised by a below average living standard which means that the "Regional Structure" benefits = 0. No international traffic links are affected which means that the post "Promotion of International relationships" = 0. Although, in cases where these terms are added they normally contribute to far less than the effects of employment during the construction and operation period.

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APPENDIX

Response to ECMT Request for Material on the "Benefits of Transport":
Reports Received from Transport Ministries and some other National Sources

Austria

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Annex 1

MEANS AND ENDS: COST BENEFIT ASSESSMENT AND WELFARE MAXIMISING INVESTMENT

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SUMMARY

This paper argues that the main problem with cost-benefit assessment (CBA) is not its incomplete identification of benefits but rather its inability to elicit consistently the investment decisions required to realise the benefits it identifies. The paper analyses two limits inherent to CBA – sectoral and national – which help to explain this inability, and proposes solutions in each case. It recommends the use of macro-economic analysis to test the crowding-out counter-argument sometimes used by Finance Ministries whenever that counter-argument threatens to veto the CBA-passed projects of Transport Ministries. And it recommends the use of supra-national analysis to correct the problem of evaluation that arises whenever cross-border projects are funded as separate national sections.

1. INTRODUCTION

Distinguishing means and ends

Cost-benefit assessment (CBA) is not an end in itself but a means to an end. It is conducted not for the intrinsic value of the information it provides but for the use to which that information is put. This general observation may seem a mere truism. In fact, it has highly specific implications for the current inquiry on "Assessing the Benefits of Transport".

Judged as a means to an end, the current limitations or incompleteness of CBA in measuring all potential benefits is a distinctly second-order problem. The far more serious, and quantitatively significant, problem arises from the inability of CBA to elicit consistently the investment decisions required to realise perfectly conventional, well-defined benefits.

The premise of the argument developed here is that the purpose of CBA is to provide decision-makers with the information required to make the "right" decisions on public investment proposals. Now the underlying economic rationale for such investment decisions to be made in and by government is that, in certain identifiable sectors of the economy, the market, unaided, would deliver a highly sub-optimal outcome in terms of the welfare of society as a whole. In the light of this, the "right" investment decisions required of government are decisions that maximise social welfare. Thus, the end to which CBA must serve as a means is welfare-maximising investment.

This paper holds that the underlying rationale is indeed well-founded. The point here is not the mere fact of market failure – all real world markets will, to some degree, fail, if only because the full attainment of the welfare optimum in any one market requires that it be attained simultaneously in *all* markets. In this sense, market failure is pervasive. The question rather is the manner and degree of it. And the answer is that market failure is both systematic and large in certain identifiable sectors, of which transport is certainly one.

Two important implications follow from this. First, in order to fulfil its purpose, it is not necessary for CBA to measure precisely every potential benefit. The pervasive nature of market failure is such that, in every sector, pricing, consumption and investment deviate somewhat from their welfare-maximising levels. But the monitoring apparatus of government keeps us informed that, in most sectors, the consequent welfare losses are not of a scale to require the intervention of a regulatory apparatus or to justify the costs of that intervention. Hence, so far as the measurement of transport benefits is concerned, the main reason for seeking accuracy and completeness is not to measure up to a hypothetical perfection but rather to ensure that the imperfection does not distort the *relative* merits of alternative investments and hence the ranking thereof.

Secondly, and vitally, the most perfect instance of CBA is useless unless it elicits the actual decisions that realise the identified benefits. To be sure, occasional or random or insignificant deviations of investment decisions from CBA results can be set aside. But if such deviations are persistent and systematic and significant – and if moreover they can be traced to certain inherent limits in the practice of CBA – then that is a problem that does need to be addressed and corrected.

This paper identifies two such limits – sectoral and national – and the solutions required to correct the problems arising therefrom.[1]

The inherent limits of CBA: sectoral and national

The inherent limits of CBA are those limits that belong to its nature, given the more or less permanent features of its institutional context. Hence, to identify such limits does not imply a call for changes to the practice of CBA. Rather, it suggests a need to complement the CBA test with others.

First, the scope of CBA is limited to its own sector.

In the transport sector, the last half-decade has witnessed a significant research effort aimed at arriving at a common framework for the evaluation of projects across all modes of transport – embodied especially in the European Commission's EURET Concerted Action. But little progress has been made or attempted in arriving at a generally applicable CBA framework across the various sectors in which public ownership/regulation/investment predominates. And even if we were to witness such progress, CBA would necessarily be limited to the public sector of our mixed economy.

Purely private-sector investment projects are, and will continue to be, selected on the basis of an entirely different criterion: the criterion of financial profitability, based on the calculation of private costs and benefits. The social returns from such projects, based on a calculation of their social costs and benefits, may be above or below or equal to the financial returns – but since that calculation is not undertaken the result is not known. CBA-passed investment proposals in the public sector are thus not directly comparable to the range of potential investments in the private sector.

This makes projects that have passed the CBA test of Transport Ministries vulnerable to the well-rehearsed counter-argument of Finance Ministries that, however beneficial in welfare terms, such projects would "crowd out" private investments capable of making a greater contribution to macroeconomic variables held to be of over-riding importance: productivity, growth, employment. And this crowding-out counter-argument has indeed been employed to veto CBA-passed transport projects and thereby to thwart the purpose of the original CBA. It is this – rather than any incompleteness in the calculation of benefits – that has been the decisive factor in producing the under-investment that can be identified in regard to certain places and periods. It is in order to test this counter-argument and thereby to ensure that the benefits identified in CBA are indeed realised that this paper proposes the use of macro-economic analysis.

Secondly, so long as we are condemned to live in a world of separate nation-states, and even where such states are also member-states of a larger trading union, public investment is, by and large, undertaken on behalf of the national taxpayer. It follows that the CBA required to evaluate such investment is also – and correctly so – undertaken from the viewpoint of the national taxpayer.
This generates a particular problem in the case of cross-border projects, first identified in the course of work on the Trans-European transport networks.[2]

In any cross-border project where each jurisdiction is principally responsible for the funding of its national section – and that is the conventional practice – the evaluation of the project will be fragmented into separate national evaluations of the respective sections. And in order to determine the degree to which their section merits public subsidy from the national taxpayer, most governments will quite naturally seek to limit their recognition of benefits to the share accruing to their own residents. In short, they will calculate their own national benefit.

This is not an error: the national taxpayer should not be made responsible for securing, and to that end evaluating, the benefits accruing to foreigners travelling on his national section. But there is an a-symmetry here: the same national taxpayer is unable to evaluate, let alone to secure, the benefits accruing to his own fellow-residents in the foreign sections of the same cross-border project. (And the same applies in the case of each national evaluation.)

For example, in a hypothetical Anglo-French project, a British CBA of the British section conducted on behalf of the British taxpayer will count the benefits accruing to British travellers, and a French CBA of the French section conducted on behalf of the French taxpayer will count the benefits accruing to French travellers. But the benefits to British travellers on the French section, and to French travellers on the British section, will not be counted at all!

The result – the unintended exclusion from view of no less than half the international consumer surplus – is articulated in Section 3 of this paper. So too is the requisite solution: the methodology to calculate and re-integrate these "supra-national" benefits. What is relevant here is the more general point: CBA, being national, will fail to capture the supra-national dimension of cross-border projects and hence fail to elicit the right level and mix of public investment therein – unless complemented by a further, supra-national analysis.

Moreover, if CBA succeeds in ranking projects accurately in very other respect, the national limit will also serve to distort the relative merits of cross-border and domestic projects and thereby fail to elicit the welfare-maximising result.

These two limits – sectoral and national – both indicate the need to complement CBA rather than to "improve" it by amendment. But the scope of the two issues is different. The sectoral limit applies to *all* projects; but macro-economic analysis is required *only* if the crowding–out counter-argument threatens to veto a CBA-passed proposal. The national limit emerges as a problem *only* in the case of conventionally-funded cross-border projects; but supra-national analysis is required in the case of *all* such projects.

2. THE RELEVANCE OF MACRO-ECONOMIC ANALYSIS

The limited relevance of additional impacts

This paper advocates the use of macro-economic analysis as a test of the crowding-out counter-argument used against CBA-passed projects. But this is quite distinct from the advocacy of macro-economic analysis as a searchlight for "additional" benefits resulting from the impact of transport projects on the wider economy – benefits additional to those captured in CBA. From the perspective of this paper, such additional impacts are likely to be of limited relevance to the task at hand: strengthening the means to elicit welfare-maximising investment.

This scepticism on the relevance of additional impacts is based on empirical considerations rather than theoretical or procedural ones.

Theoretically, the possibility of additional impacts is incontestable.[3] That possibility is admitted once we assume that the real world on which transport projects impact is one of imperfect competition – an assumption that is well-founded. Thence, there is no reason to suppose that the sum of primary benefits captured in a CBA calculation (such as time-savings and other cost reductions) should be exactly equal to the sum of downstream benefits captured in macro-economic analysis (such as productivity growth and price reductions). Exact equality – with all imperfections netting out precisely – would be a fluke.

Procedurally, it may be difficult to isolate genuinely additional benefits, as distinct from the downstream counterpart to the primary benefits identified in CBA. But it would be dogmatic to suppose that robust techniques could not be developed.

Empirically, however, there are grounds for scepticism.

Insofar as research has sought to isolate benefits genuinely additional to the primary benefits captured in CBA, the results have been quantitatively modest.[4] And transport research is not the only relevant information source here. Additional benefits are a derivative of imperfect competition. From economic research in other sectors and the monitoring efforts of competition authorities, we can gain an indication of the degree of imperfection in other markets. We know that imperfect competition is the norm. We also know that, with some important exceptions, the imperfections are not large. Therefore, there is reason to suppose that additional benefits are also – and correspondingly – modest.

It is true that macro-economic research has often revealed very high returns from infrastructure investment, especially US research in the late 1980s/early 1990s and UK research then and now.[5] But this should not occasion surprise. These results mirror the fact of very high average benefit : cost ratios for marginal projects – in short, evidence of under-investment – in just the same places and periods: the US in the 1980s and the UK then and now.[6]

Indeed, this last point, so far from pointing to the importance of additional benefits, points rather to the limited relevance thereof. Where highly beneficial projects that have passed their CBA test with flying colours have nonetheless failed to win the investment they merit, it is difficult to see why they should have succeeded had they been shown to have some benefits additional to the many identified in the CBA test. Clearly, the source of the problem lies elsewhere.

Finally – and this is the key message of the SACTRA report from the UK – it needs to be said that, whilst additional impacts are indeed likely to obtain under conditions of imperfect competition, not all the additional impacts are likely to be additional *benefits*. Whether such impacts turn out to be beneficial in net terms will depend on the direction and degree of the deviation of prices from marginal social cost in the transport sector relative to the direction and degree of that deviation in the sectors on which transport impacts.[7]

On the other hand, whilst this is an important conclusion of the SACTRA analysis, the implications of that analysis for the future assessment of transport benefits are also of limited relevance – or at least they *should* be of limited relevance. For the answer to the problem of welfare-reducing prices in the transport sector is to correct those prices! And the European Union has now embarked on doing just that.[8]

Once transport prices are corrected, CBA can proceed without needing to factor in price distortions in this sector. And since the overwhelming evidence on imperfect competition in the transport-using sectors points to prices being generally but modestly above marginal social cost, we are in fact led back to where we started. Impacts additional to the primary benefits captured in CBA are likely to be positive in sign and modest in size.[9]

Testing the crowding-out counter-argument

What is far from modest is the loss of benefits resulting from the inability of CBA to elicit consistently actual investment in projects that have passed its test. Projects that have been shown to yield social returns of 30%, 40%, 50% or more, on the basis of the most conventional evaluation, have yet failed to get off the ground for want of the requisite level of public funding.[10]

Whilst the incidence and extent of such failures and the resulting welfare losses have varied greatly from place to place and period to period, a common factor has been present for more than a decade in most of the industrialised world: the crowding-out counter-argument. "In the current context", runs the line, "we cannot afford" the funding required – because "we cannot afford" to crowd out private investment, and the productivity, growth and employment that it brings.

The proposition that a given public investment *would* crowd out an equivalent volume of private investment rests of course on two important assumptions deserving of further analysis. The assumption that productive resources are fully employed – and hence that there is no scope to call on unused capacity – is the one that is usually challenged. Operationally, however, that is, as a guide to decision-making, it is arguably well-founded. Whilst the fact of cyclical unemployment can hardly be denied, it would be reckless to base long-term investment decisions on the opposite assumption of long-term spare capacity.

Crowding-out also presupposes that fiscal resources are fully employed – and that government is therefore obliged either to raise taxes immediately or else to borrow and repay that borrowing by means of higher taxes at a later date, thereby reducing the pool of savings available for private investment. Hence, the result that the public investment in question is at the expense of *private* investment rather than other items of *public* expenditure. In turn, this suggests either that existing government expenditure has been optimised – which seems improbable – or else that deserving infrastructure investments are, as a matter of fact, given a lower priority than sub-optimal expenditure in other sectors. If so, the fact of crowding-out might also indicate a need to revisit the fiscal priorities.

More fundamentally, it may be objected that the fear of the *consequences* of crowding out reflects an economic error on the part of finance ministries. These macro-economic variables are themselves no more than means to an end, the end being the maximisation of welfare. In this light, the only test applicable to a public investment proposal is whether its anticipated social return passes a hurdle rate reflecting the opportunity cost of public funds. The latter is given by the long-term bond rate *plus* an appropriate weighting, if necessary, to incorporate the anticipated effect, if any, of higher borrowing on that bond rate. *Ceteris paribus*, any project that passes this test enhances welfare – and all projects that do pass this test should be implemented.

Such a decision-rule is by no means utopian. For example: French planning has long incorporated it and French practice has been more or less consistent with it, with a hurdle rate of 8% applied to both road and rail projects through much of the 1990s.[11] (Interestingly, the UK also operated a hurdle rate of 8% for public-sector projects through this period but the hurdle was somewhat a-symmetrical: it was used to rule *out* projects with a social return of <8% but not necessarily to rule *in* those with return of >8%.)

Moreover, the case for such a decision-rule will become more compelling in the context of implementing marginal social cost pricing. For a pricing regime based on short run marginal cost needs to be complemented – in the long run – precisely by such an investment regime. Without it, the revenues from congestion pricing will increasingly be perceived not as a derivative of the act of correcting prices but rather as the targeted outcome of a deliberate under-provision of infrastructure. Without it, therefore, the consensus supporting the pricing regime and hence the pricing regime itself would face the threat of collapse.

Nonetheless, it would be unrealistic to suppose that we are close to arriving at such a non-discretionary rule. The immediate agenda is likely to be dominated by a protracted, politically-sensitive effort to move from the highly sub-optimal prices of today toward an efficient pricing regime. Investment is likely to be viewed as a lower priority, and perhaps even as a ready-to-hand discretionary tool to be used as a *quid pro quo* in response to immediate needs and demands. In the foreseeable future, therefore, and especially in regard to large-scale, long-term investments, the crowding-out counter-argument will need to be met.

The point however is that the counter-argument's conclusion is not obviously true. It should be tested. It should not simply be *presumed* that the macro-economic benefits of the private investments crowded out are *greater than those of the project in question*. And although the usual lines of macro-economic research do not lend themselves to supplying such a test – much macro-economic work on infrastructure has been concerned with aggregate relationships whilst many project-specific impact studies have been inconsistent with the corresponding CBA – recent research has occasioned the development of a methodology more adequate to the task: one which has been successfully applied by the European Commission in the context of the transport TENs.[12]

The key to this application is to base the macro-economic modelling input values precisely on the output values of the project's CBA.[13] For example: the CBA value for business time-savings enters as a potential increase in productivity, the CBA value for leisure and commuting time-savings enters as a potential reduction in wage inflation, and so on.[14] The impacts that are then tracked by means of simulating the model in order to arrive at the final result are thus the macroeconomic counterparts of the primary impacts.

Now this approach has two important advantages. It dissolves the question of the consistency between the micro-economic (CBA) and macro-economic impacts. And it allows for the macro-economic assumptions of the decision-maker to be the crucial determinant of the final result. All that is required for the test to work is that the decision-maker states his assumptions in advance.

In this particular case, these assumptions made for a very tough test. The assumptions of the European Commission's QUEST II model on the negative effects of public borrowing in the light of the Maastricht criteria – with all new public borrowing rapidly repaid by means of higher taxes so as to maintain the 60% rule on public debt – are such that simulations runs on QUEST II have converted a 1% increase in government expenditure into an absolute reduction in GDP and employment.[15] Any public investment which shows a net positive effect on GDP and employment against QUEST II can confidently be regarded as superior in its impact to the spectrum of investment it crowds out. And against this test, the project in question was shown to have not only a net positive impact on GDP and employment but a significantly positive one.[16]

This experience suggests the basis for a dialogue with, and a challenge to, Finance Ministries: if crowding-out is a genuine concern with a given project, let us test the project against the spectrum of investment it crowds out. In the first place, however, it is a challenge to Transport Ministries. For if the realisation of transport benefits is the ultimate aim informing the effort of calculation, then a correctly-specified, well-conducted CBA is not enough. The investment decision, hence the concerns of Finance Ministries, hence the potential role of macro-economic analysis in meeting those concerns – all this does matter.

3. THE RELEVANCE OF SUPRA-NATIONAL ANALYSIS

The problem of evaluation in cross-border projects

The transport TENs – specifically, the Paris-London-Brussels-Cologne-Amsterdam high-speed rail project, PBKAL – also occasioned the identification and solution of the problem of evaluation in cross-border projects: namely, the exclusion from view of an entire stream of perfectly conventional benefits.[17] Without it, many of these much-heralded projects made little sense – which perhaps helps to explain why they had made such little progress.

In any cross-border project where each jurisdiction is principally responsible for the funding of its national section, the evaluation of the project will be fragmented into separate national evaluations of the respective sections. And in order to determine the degree to which their section merits public subsidy from the national taxpayer, most governments will calculate their own national benefit.

In the UK and France, for example, explicit investment rules serve to define the boundary of national benefit. Thus, three streams of benefits are counted:

– the financial return;
– domestic economic benefits: user benefits to passengers making domestic trips on the new international lines – for example, London-Ashford on CTRL, Paris-Lille on LGV Nord – as well as the standard non-user benefits;
– the national share of international economic benefits. This includes, principally, the estimated share of the international consumer surplus which falls to own-residents within the total cross-border traffic – an estimate based on a passenger split derived from data sources such as the International Passenger Survey.

In both countries, the rules governing the determination of national subsidy explicitly discount a fourth stream of benefits:

– the supra-national share of international economic benefits: the share of benefits which falls to non-residents. For example: in the case of CTRL, the estimated consumer surplus for French and other international passengers on the British line; in the case of LGV Nord, the estimated consumer surplus for British and other international passengers on the French line.

Quite properly, each national evaluation calculates its national benefit. The unintended consequence, however, is that the full set of national evaluations excludes from view no less than half the international consumer surplus.

The point is best made with the aid of a simple two-country example. Suppose that two geographically contiguous countries, A and B, invest in a new cross-border high-speed line which generates a time-saving gain of 1 hour in each of the two national sections: a total of 2 hours. The benefits are expressed in terms of time-savings only: *ceteris paribus* applies to all the other elements. The required investment cost is 1 billion euros in the case of each national section: a total of 2 billion euros. The estimated traffic is two million passengers. And in each national section the estimated passenger split between residents and non-residents is exactly 50/50.

In this example, Country A's evaluation of its national section will show *inter alia* a benefit equal to the value of 1 million hours of time-saving gains measured against an investment cost of 1 billion euros: a ratio of 1:1. Country B's evaluation will show just the same. The implicit sum will thus show a benefit equal to the value of 2 million hours of time-saving gains measured against an investment cost of 2 billion euros: a ratio of 1:1. The truth, however, is that the investment in the project as a whole will enable each of the 2 million passengers to gain 2 hours of time-savings - thus generating a benefit equal to the value of 4 million hours of time-saving gains measured against an investment cost of 2 billion euros: a ratio of 2:1.

This is of course a highly stylised picture. Realistically, the passenger split is likely to vary. Countries with a greater than average share of resident passengers on their own sections will capture in their evaluations more than half the international consumer surplus on these sections. But this will be off-set by at least one other country with a less than average share of resident passengers. The sum of "resident passengers" in this sense cannot exceed half the number of total passengers. Hence, *ceteris paribus*, the set of national evaluations will fail to capture half the international consumer surplus.

Leaving all else aside, the result is that *correctly* specified national evaluations of the respective national sections will generate an *incorrect* estimate of the total benefits from the project as a whole as well as on each national section.

Re-integrating the supra-national benefits

The solution to the problem of evaluation in cross-border projects is *not* be found in amending the CBA undertaken by each country so as to capture the full value of the international consumer surplus generated on its territory – at least, not as a general rule. For countries with a higher-than-average share of non-resident traffic, amending their national evaluations thus would mean making a gift to all the others. And whilst it is their prerogative to make such a gift, it is not necessarily their duty to do so. It is not Belgium's sole responsibility to solve the problem of the PBKAL traffic – any more than the problem of the trans-Alpine traffic is the sole responsibility of Switzerland and Austria.

The general form of the solution is rather to recognise the distinction between the streams of benefits identified above and then to re-integrate the excluded fourth stream – by complementing the set of national evaluations with a supra-national analysis. The exact form of the analysis will depend on the identity of the decision-maker with an interest in, and responsibility for, recognising and securing this stream of supra-national benefits.

Thereafter, the exact steps required to provide a corrected measure of the return on each section and on the project as a whole are not especially complex. The data for calculating the fourth stream of benefits in each section are the same as those for calculating the third stream. It is thus a matter of first establishing the full social return on each section, distinguishing between its national and supra-national components, and, secondly, by averaging the national inputs on a weighted basis, establishing the full social return for the project as a whole.[18]

In the case of the PBKAL, this analysis sufficed to show that the supra-national component accounted for fully a quarter of the full social return on the project as a whole – and that it contributed to raising the return from the borderline of viability to a level comfortably above the standard hurdle rate for public-sector projects applying in the relevant Member States.[19]

In turn, this analysis became the basis for the European Commission's proposal for EU public subsidy as the solution to the financing problem of the project[20] – and the basis for the Transport Commissioner's successful application for a step-by-step, multi-billion euro "top-up" to the 2 billion euro TENs budget line.

To be sure, it remains to be seen whether these two lines of analysis, having been successfully tested and applied by the European Commission in collaboration with the relevant Member States, proceed to become fully incorporated into EU practice. But the future of the TENs programme is not the concern of the present discussion. What is relevant here is the bearing of that experience on the current inquiry on "Assessing the Benefits of Transport".

Clearly, the size of the benefits at stake in these two cases – cross-border projects, and projects that collide with the crowding-out counter-argument – is large. On the evidence to hand, it is larger by far than the size of the additional benefits that conventional CBA apparently fails to capture.

In both cases, the source of the problem lies not in any incompleteness in the methodology of CBA but rather in the inherent limits (sectoral, national) that apply to CBA, given the institutional context in which it is situated (the multi-sector mixed economy, a world of nation-states).

In both cases, the solution is not to be found in attempts to improve CBA by amending it in one way or another. Rather, it lies in complementing CBA with other tests: macro-economic analysis, supra-national analysis.

In both cases, therefore, implementing the solution requires practitioners of CBA to cross all manner of barriers and boundaries – disciplinary, sectoral-hence-Departmental, national – and step into somewhat unfamiliar territory.

This may help to explain why the issues treated here have been somewhat marginal to the mainstream discussion on benefits. But the size of the benefits at stake suggests that these issues should be of more than marginal interest.

NOTES

1. The core of the argument presented here is based on research carried out from 1994 to 1996 for the European Commission and member-state governments, the results of which have been partially incorporated into EU practice. The key documents are: Rana Roy, Investment in Transport Infrastructure: The recovery in Europe, ECIS Report, November 1994; Roy, Lost and Found: the Community Component of the Economic Return on the Investment in PBKAL, ECIS Report, Rotterdam, November 1995 – originally published by the European Commission/PBKAL Working Group in PBKAL: Final Report on the High-Speed Rail Project Paris/London-Brussels-Cologne(-Frankfurt)/Amsterdam, Brussels, October 1995; CEBR, Methodology for an Assessment of Macroeconomic and Employment Effects of Trans-European Transport Networks, London, August 1996; Roy (ed.), The Macroeconomic Effects of the PBKAL, ECIS Report: in collaboration with the CEBR, Rotterdam, November 1996; and European Commission/Commission Staff Working Paper for the European Parliament, The Likely Macroeconomic and Employment Effects of Investments in the Trans-European Transport Networks, Brussels, January 1997.

2. See Roy, *Lost and Found, op. cit.*

3. The nature of the problem is clearly spelt out in chapters 1 to 8 in this volume. The comments here build on that discussion.

4. See chapters 1 to 8.

5. For summaries and commentaries on the evidence, see Alicia Munnell, "An Assessment of Trends in and Economic Impacts of Infrastructure Investment", in OECD, *Infrastructure Policies for the 1990s*, Paris, 1993, and Roy, *Investment in Transport Infrastructure, op. cit.*

6. *Ibid.*

7. See the SACTRA Summary Report (drawn from the SACTRA report on "Transport and the Economy") elsewhere in this volume, and also the commentary thereon in the paper by Goodwin, *op. cit*. especially the three-by-three matrix of possible effects.

8. We refer to the European Commission's White Paper, *Fair Payment for Infrastructure Use: A phased approach to a common transport infrastructure charging framework for the EU*, Brussels, July 1998, and its subsequent adoption by the EU Transport Council with the expressed support of 13 of the 15 Member States.

9. In terms of Goodwin's matrix (see above, n. 7), we would then expect, as a general rule, to be situated in the box in the middle row of the third column.

10. For detailed evidence, see *inter alia* the sources cited in n. 5. But to enter into discussion of that evidence would be to detract from the line of argument in this short paper.

11. See Roy, *Investment in Transport Infrastructure*, *op. cit.*

12. We refer here to the methodology initially developed by CEBR in partnership with London Transport and further developed and applied in partnership with ECIS and the European Commission (DGII) in the context of work on the transport TENs. See CEBR, *Methodology, op. cit.*

13. See *ibid*., Chapter 3.

14. The qualifying adjective "potential" is important here: "the actual addition to productivity will depend on the solution to the model and the impact on economic activity generally." *Ibid.*

15. *Ibid*. – and also the Commission Staff Working Paper for the European Parliament, *The Likely Macroeconomic and Employment Effects of Investments in the Trans-European Transport Networks*, Brussels, January 1997.

16. See Roy (ed.), *The Macroeconomic Effects of the PBKAL, op. cit.*

17. What follows draws on Roy, *Lost and Found*, *op. cit*., and the larger report of which it is a part, European Commission/PBKAL Working Group, *Final Report*, *op. cit*.

18. See *Lost and Found, op. cit.*, in particular, Figure 4, and Attachments 1 and 2.

19. *Ibid.*, Attachments 1-9, for the full set of results.

20. See European Commission/PBKAL Working Group, *Final Report*, *op. cit*., in particular, Chapter VIII.5, "Justification for Common Funding Options", p. 19, and Conclusions, p. 20.

Annex 2

ECONOMIC APPRAISAL OF EUROPEAN TRANSPORT PROJECTS THE STATE OF THE ART REVISITED

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Substantial investment has been made at national and European level in transport infrastructure over the last fifty years and is likely to continue in the future. The need to appraise transport projects in economic and social terms has developed alongside this in both scope and complexity. Here we review the state of the art of the economic appraisal of transport projects, assess progress and identify future challenges. The review addresses the general framework, treatment of major impacts, presentation of outputs and issues such as uncertainty. It draws upon national practice in Western European countries, which varies substantially reflecting a range of cultural and economic differences. Some points of commonality exist and the principle of monetising direct transport impacts is generally accepted. Progress has been made towards the measurement of environmental impacts, but the assessment of the wider impacts remains under-developed. Increased sophistication and complexity has brought increasing data and presentation requirements, where computerised decision support methods have potential. Many challenges exist for the future of appraisal and we conclude with a discussion of some key issues. At the heart of these is the continuing debate between the relative roles of national and European government in decision making and resource allocation.

1. INTRODUCTION

During the last half century, the European transport infrastructure has been revolutionised. Motorway networks, high speed rail services, the airport and air transport network and the development of city region transit systems are all products of this time. Huge resources have been devoted to this infrastructure investment programme. Nonetheless, it is clear that substantial further investment has a high place on the European policy agenda, especially with regard to links to the former East European states that are now seeking EU membership. The purpose of this paper is to review the progress that has been made in the economic and social appraisal of transport infrastructure and to identify perceived future challenges.

The development of transport appraisal has been a response to an identified need. Many of the early and important projects, such as the M1 London to Birmingham Motorway in the UK were committed prior to any economic consideration of the case for the road (Coburn, Beesley and Reynolds, 1960). The major spurt in the development of appraisal techniques for transport projects came in the late 1960s and early 1970s. During this period, the principles of cost-benefit analysis of transport projects were given practical detailed effect through programmes of theoretical and empirical work on for example, the relevant monetary values for time and safety benefits. This work found its application in the appraisal of individual mega-projects, in the development of standard appraisal methods for smaller projects such as new sections of road, and in the assessment of city and regional transport plans.

In those far off days when the EU consisted of just six Member States one of the most important meeting places for the discussion and development of ideas relating to appraisal was the series of ECMT Round Tables held in Paris under the famous organisation of Arthur de Waele. A series of Round Table reports, among them Harrison and Quarmby, 1969, Beesley and Evans, 1970, and Frost, 1977, chart the practical development of cost-benefit analysis at that time. The work of this vintage has provided the foundation for current appraisal practice, and it is against this base that progress should be measured.

If the role of appraisal had remained the same, then progress could be measured purely in terms of the development and refinement of the methods and values used. In a number of respects, however, things have changed so that appraisal is aiming at a moving target. First, the focus has broadened. Appraisal based on time, cost and safety impacts is seen to be too narrow, and has been extended to cover environmental impacts and wider policy impacts such as economic development. Incorporating environmental impacts poses formidable measurement and valuation problems. Dealing with the economic development and other secondary impacts creates issues of both principle and practice.

Secondly, the appraisal context has changed in a number of ways. Although there are obvious exceptions it is probably not an unfair generalisation to say that the paradigm of appraisal in 1970 was at the project level for a single mode and funded by Government. Now, the emphasis is much more on plans at the area or corridor level, on the interactions between and integration of modes within those plans, and on a variety of funding sources. The latter may involve mixes of central, local and European Government together with private sector operators and sources of private finance in partnership.

Thirdly, the balance of power between Governments and the public has shifted. Whereas forty years ago it was possible for Government to push through a large motorway programme with relatively little public consultation and with relative immunity from technical challenge, that is not the picture today. Now, Governments need to demonstrate their case to an often sceptical public with access to professional expertise.

All these developments have placed increasing demands on the appraisal system. Appraisal needs to incorporate environmental and wider policy impacts as well as the direct transport impacts. It needs to be multi-modal and multi-agency in structure. The results have to be accessible and comprehensible in arenas such as public inquiries. It is therefore timely to revisit the state of the art to see how appraisal of transport projects and plans is responding to these challenges. We do this by considering implications for the appraisal framework, for the appraisal content and for the presentation and use of appraisal results.

2. THE APPRAISAL FRAMEWORK

Before considering the nature of changing appraisal needs, it is useful firstly to review the historical context of developments in this field and summarise some of the features of current appraisal practice. At the national level, considerable differences currently exist within Europe in the definition and scope of the appraisal framework. In table 1, our understanding of the scope of appraisal frameworks currently used in a selection of European states is indicated. These represent official, standard or representative examples (where no standard framework exists).

One of the common bases for an appraisal framework is Cost-Benefit Analysis (CBA) and the main characteristics of this approach can be summarised as follows. Both the potential costs and potential benefits of a particular project are estimated across a set of impacts and converted into monetary terms by multiplying impact units by prices per unit. The overall or net benefit of the project can then be found by calculating the difference between the sum of the monetised benefits and the sum of the monetised costs. Often this is reported in terms of present day prices as a Net Present Value, but other summary values may also be produced. There are many issues that arise as part of this process, however, including:

- Identifying the broad group of impacts which should be included in a CBA and can be monetised in this way.
- Specifying how each of the impacts included should be formally defined and measured.
- Modelling or otherwise estimating the size of the impact in terms of the measured units.
- Arriving at a set of prices per measured unit for each impact based on social market valuation or willingness to pay principles.
- Defining appropriate time horizons over which costs and benefits are measured and a suitable discount rate.

Issues concerning the evolution and state of the art for some of these points are discussed within section 3, but for general background on Cost Benefit Analysis see Pearce and Nash, (1981) or Sugden and Williams (1978). The basic principle underlying the CBA, however, is that the decision objective is to maximise the net socio-economic benefit of the project. In other words, there is an underlying assumption that social decisions can and should be founded on the aggregation of individuals' willingness to pay.

An alternative approach to appraisal may be objectives led, with the goal of maximising with respect to a set of socially-based objectives rather than market values. Multi-Criteria Analysis (MCA) typifies this approach and a number of different techniques fall within this category. A simple and characteristic MCA methodology is as follows.

Based on the objectives of the responsible decision makers, a group of impacts is defined which between them capture the performance level of each alternative project in achieving the set objectives. Unlike CBA, achievement of objectives can be assessed in a number of ways, such as a measured quantity, qualitative assessment or rating. These assessments are then transformed onto a numerical scale (typically 0-100) giving a score for each impact for each project. The overall performance of the project can then be estimated by producing an overall project score, calculated by multiplying each impact score by a relative weight for that impact (reflecting its importance with respect to the other impacts) and then summing over all impacts. As with the CBA, there are many potential complexities and issues involved including:

- Identifying and defining the impacts to be included
- Specifying the measurement method and how each impact will subsequently be assigned a score
- Issues surrounding the use of weights and how these might be obtained in practice
- Variations in how the scores and weights are combined to give an overall project score.

Over and above these technical questions a number of additional factors surround the use of MCA appraisal frameworks (see for example, Beuthe *et al*, 1997 for a discussion). In particular MCA is often seen as competing with CBA, although there is no reason why the two approaches may not be used in an entirely complementary manner within the overall framework. Whilst monetising impacts (as in a CBA) gives considerable clarity within the appraisal process, the intrinsic difficulty of measuring and even defining some impacts typically included in an MCA gives potential for some ambiguity. The choice and use of weights within the process may be seen as somewhat arbitrary and the interpretation and role of the overall project score can also be misunderstood in the appraisal context. In particular there may be a sense that the MCA is *making the decision* rather than *supporting the decision maker* where projects are ranked by overall score, although it is interesting to note that broadly similar concerns exist about the role of CBA assessments. Further detail and discussion of MCA techniques may be found, for example, in Olson (1995).

Our review of European practice reveals that in spite of these issues, many countries have a strong historical tradition of MCA analysis in a transport appraisal context and others include some form of MCA procedure in an overall appraisal framework. Within table 1, the black cells indicate a descriptive treatment of impacts and the blue or red cells indicate a quantitative measure. Whilst the dark grey cells indicate a quantitative measure with no monetary value, the light grey cells indicate impacts that have a quantitative measure, are monetised and included in the CBA.

From table 1, across a selection of European countries for which detailed information on the appraisal framework is publicly available, three points are apparent. Firstly, all appraisal frameworks contain a mixture of impacts that are monetised, impacts that are measured in physical terms and impacts that are assessed in qualitative terms. Secondly, practice in different countries is not uniform. Although the direct transport impacts tend to have monetary values, and the environmental and socio-economic impacts tend not to be monetised, there is variation between countries. Thirdly, the details of the framework within which the impacts are brought together also vary across the CBA/MCA spectrum.

Within the broad framework spectrum ranging from the CBA dominated through to the largely MCA or qualitative, it is clear that most national frameworks have a CBA at the core. In some cases (for example Denmark and Sweden) there are few or no impacts measured or qualitatively assessed in addition. For other countries (including the UK, Netherlands and Finland) it appears that the CBA is a part of a more holistic approach, encompassing further impacts which are either measured, formally included in an MCA or on which a qualitative report is required. In these cases there are a number of ways in which the framework and overall assessment procedures link the different impact groups and impact treatments together in the decision making process.

The numbers of impacts included in the national appraisal framework ranges from a relatively small number (ten in the case of Denmark) to a comprehensive list (over thirty for Greece). In both these cases this represents road appraisal only and a general point to make is that several countries currently have entirely separate frameworks for different modes. Regardless of the total number of impacts considered, their scope is seen to stretch from direct impacts such as capital and maintenance costs through environmental impacts to a group of socio-economic impacts such as land use and peripherality. The treatment of different impacts and their place in the evaluation framework is discussed in some detail in section 3.

Table 1: **Evaluation framework and impacts by country**

		AUS	BEL	DEN	FIN	FRA	GER	GRE	IRL	ITA	NRL	POR	SPA	SWE	UK
			Road	Road				Road						Road	Road
DIRECT IMPACTS															
Capital	Construction Costs	MCA	MCA					MCA			MCA				
	Disruption Costs		MCA					MCA							
	Land and Property Costs		MCA					MCA							
Recurring	Maintenance Costs	MCA	MCA					MCA			MCA				
	Operating Costs							MCA			MCA				
	Vehicle Operating Costs	MCA	MCA					MCA			MCA				
	Revenues	MCA						MCA							
	Passenger Cost Savings							MCA							
	Time Savings	MCA	MCA					MCA			MCA				
	Safety	MCA	MCA					MCA			MCA				
	Service Level	MCA						MCA							
	Information							MCA							
	Enforcement														
	Financing / Taxation							MCA							
ENVIRONMENTAL IMPACTS															
	Noise	MCA	MCA					MCA			MCA				
	Vibration		MCA												
	Air Pollution - Local	MCA	MCA					MCA			MCPA				
	Air Pollution - Global	MCA	MCA					MCA							
	Severance	MCA													
	Visual Intrusion							MCA							
	Loss of Important Sites		MCA												
	Resource Consumption							MCA							
	Landscape	MCA													
	Ground / Water Pollution	MCA						MCA							
SOCIO-ECONOMIC IMPACTS															
	Land Use	MCA						MCA			MCA				
	Economic Development	MCA	MCA					MCA			MCA				
	Employment		MCA					MCA							
	Economic & Social Cohesion							MCA							
	International Traffic							MCA							
	Interoperability							MCA							
	Regional Policy		MCA					MCA			MCA				
	Conformity to Sector Plans		MCA												
	Peripherality/Distribution							MCA							

Key: CBA (Monetised Impacts) — Measured impacts — Qualitative Assessment — **MCA** - included in Multi-Crtieria Analysis

Note: It is understood that Luxembourg has no tradition of formal project appraisal in either the CBA or MCA paradigm.

The current state of the art with respect to appraisal frameworks is therefore highly developed with a degree of sophistication nonetheless tempered by the need for a framework to be pragmatic and politically acceptable.

To the best of our knowledge, a historical comparison on the structure of appraisal frameworks in Europe thirty years ago has not been carried out and was not in existence in the early seventies. Moreover, at that time the easy international channels of communication and principles of openness and transparency had yet to be established. It is therefore only possible to speculate on the extent to which different national frameworks have evolved from perhaps something very basic and limited to their current state. It is almost certain, however, that changing political and social climates will have played a significant role in the process (as is seen to be the case for the UK). With that perspective, the evolving political and social context at the Community wide level is sure to have some influence on the development of both individual national frameworks and any Community wide appraisal guidelines.

Considering appraisal guidelines at the European Community level, one strand of recent appraisal research has grown largely from the development of ideas established in the EURET 1.1 Concerted Action report, *Cost-Benefit and Multi-Criteria Analysis for New Road Construction (*Mackie *et al*., 1994*).* This focused on the appraisal of road schemes specifically and a subsequent series of APAS studies broadened the coverage of appraisal procedures to incorporate rail, inland waterway and nodal centres for passengers and goods. Following this, an expert group, the Transport Investment Evaluation (TIE) Group, developed a summary and synthesis of the four APAS reports and the EURET report, as well as other relevant APAS studies such as the one concerned with evaluation of Advanced Transport Telematics projects (Beuthe *et al*, 1995). In common with these previous reports, the TIE report (Bentzen *et al*., 1995) saw a joint CBA/MCA model as the most effective way to pursue project evaluation.

Since those studies, a number of Fourth Framework projects have addressed both project appraisal and policy appraisal. There are other distinctions to be made between studies but for simplicity, the project appraisal studies include EUNET, CODE-TEN and MAESTRO (addressing TENs, Eastern Europe and demonstration examples, respectively), whilst the principal policy appraisal study is TENASSES. The focus of the latter is to assess the extent to which a given transportation project achieves, or constrains, explicit policy objectives. In addition, PROFIT is examining the potential role and implementation of Public-Private Partnerships in facilitating the development of transport infrastructure at a European level. All of these have been targeted at the development of EU Common Transport Policy or at the process of making decisions about the best use of resources amongst the TEN programme. Several projects have had the development of decision support software as part of their goal and this has served to draw attention to pragmatic as well as conceptual issues.

At the European level, appraisal *practice* is still very much at its formative stage and informed both by research carried out under the Fourth Framework and by techniques and practice at the national level. Progress towards the greater use of recommended appraisal guidelines depends not only on the technical integrity of the guidelines, but on a host of additional factors including those based on politics, pragmatic constraints and historical tradition. Despite these difficulties, it is becoming increasingly desirable to share best practice appraisal principles at the European level.

It is clear the different traditions in transport appraisal practice persist in different countries, but there are also many similarities which present initial support for common guidelines:

– In all countries, appraisal is used for prioritising projects, making recommendations and for evaluating alternative options (for the same project) but not for making a final decision. Implicit in all national appraisal frameworks is recognition that, over and above the appraisal results, an additional series of political, cultural and other priorities must be weighed into the final decision on project approval (see, for example, Secrétaire d'Etat, France, 1995). In theory there is therefore a separation between the roles of the decision-maker (whether an individual or a committee) and the analyst. In practice, however the distinction may not be so clear. The point at which political, cultural and other priorities enter the process is likely to vary between countries with, for example, variations in the use of public consultation, local enquiry committees and so on. Whilst the recognition of the difference between analysis and decision making provides a point of commonality across national frameworks, it may also provide a potential source of division in establishing common guidelines.

– There is a growing trend towards multi-modality arising from an increasing priority, both the national and international level, to establish an integrated transport system. This in turn has driven the need to design appraisal frameworks that simultaneously cover several modes and mode interchanges. A specific example is the UK Guidance on Methodology for Multi-Modal Studies (MVA et al, 1999). Arising from a multi-modal outlook is the need to define new impacts, generic measurement methods and reconcile some of the theoretical problems raised. An example of the latter is the case where the use in evaluation of different values of time by mode in the urban context can lead to public transport improvements apparently having net disbenefits rather than benefits.

– The use of CBA within the appraisal framework by the majority of European countries provides a potential starting point for any common guidelines eventually produced.

These changes in the state of the art and in current best practice have both been driven by and are feeding back into the changing needs and perspectives of decision-makers in Europe and in national governments.

3. THE TREATMENT OF PROJECT IMPACTS

In this section, we ask what progress has been made towards the treatment of transport impacts within the overall CBA/MCA framework. How consistent is practice in different countries, and what is the pace of change? The answers to these questions have implications for appraisal at the European level – if appraisal practice is similar in most countries, it becomes possible to adapt the same practice for application at the European level. But if appraisal at the national level is very different, then issues arise of the relations and consistency between national appraisal and EU level appraisal of projects of European interest. In this section, the state of the art of valuation is reviewed considering direct transport impacts, environmental impacts and wider policy impacts.

3.1 Direct transport benefits – travel time savings

Understanding of the value of travel time savings has come a long way since the pioneering works of the late 1950s and 1960s, in which the behavioural foundations were explored and numerical values were debated (Beesley, 1965 is a key contemporary reference; Waters, 1993 and Wardman, 1998 give a fuller historical survey). From the start, it was clear that time savings would have major significance in the appraisal of new highways and publicly-owned rail lines. In the M1 motorway study (Coburn, Beesley and Reynolds, 1960), time savings accounted for between 64% and 78% of the first year gross benefits, depending on the value per hour of working time used. Later, widely quoted data suggested time savings comprised on average 80% of quantified benefits for an average UK road improvement scheme (DoE, 1976). A review of European Investment Bank appraisals of transport projects found the same percentage (Vilain, 1996).

It was also clear, however, that the magnitude of time benefits in the early transport CBAs was heavily dependent on assumptions made about issues such as:

– the ratio of non-working to working time values - as high as 70% in some early studies such as Foster and Beesley (1963)
– relative values placed on various aspects of travel - including walking, waiting and travelling in-vehicle;
– the variation of values of time with income; and
– the apparent variation of values of time by mode.

Thirty years later, much light has been shed on these and some of the other issues that faced the early authors. In 1996, journey time savings time savings were included in transport infrastructure investment appraisal in all the EU member states surveyed within the EUNET project (table 1). Whilst not all countries use separate appraisal values for working and non-working time, a majority do so. The non-working time values equate on average to just over 20% of the value for working time (the range is from 10-50%) and this in itself illustrates an important reason for separating the two: using an averaged value would distort the results wherever the proportions of working and non-working travellers were different from the ‘average’ situation. Many of these European non-working values - which include commuting and leisure trip purposes - are derived from research based in random utility theory (MVA, ITS and TSU, 1987 gives a comprehensive account).

Focussing on non-working time only for reasons of space, table 2 shows the range of values after adjusting to resource cost for those countries which use a separate appraisal value of non-working time. Quite a wide spread of values is observed, which highlights one of the key problems in European level appraisal. This is the tension between the wish to apply national (or even local) values in order to reflect consumer preferences, and on the other hand the desire for an even-handed approach to the allocation of EU transport resources between countries without good reason. Some working solutions, including a set of weighted average EU-level values, are proposed in EUNET (Nellthorp, Bristow and Mackie, 1998), but both policy and research questions remain.

Table 2. **Appraisal values of non-working time, 1995 prices**

Value of Non-Working Time, (ECU/hr)	Countries
1.5 - 3.5	Finland, Portugal
3.6 - 4.5	Denmark, Ireland, Sweden, United Kingdom
4.6 - 8.0	Germany, Italy, Netherlands

Source: Nellthorp, Bristow and Mackie, 1998; exchange rates from Eurostat. Base years differ. Other countries use averaged working/non-working values.

For non-working time, the question of disaggregation is one that also needs to be addressed. There is ample theoretical and empirical evidence that Values of Time (VOTs) vary with personal incomes, indeed the Dutch Government favour the disaggregation of non-working VOT by income group in appraisal (Kleijn, 1996). Other Governments, including the UK, currently favour the use of behavioural values of non-working time for forecasting, differentiated as appropriate, with standard average values of non-working time for evaluation (DETR, 1999). This policy has recently been questioned however (Sugden, 1978).

Disaggegation of appraisal values of non-working time by mode is often discouraged (e.g. DETR, 1999), since the variation in behavioural values by mode is believed to reflect the attraction of higher or lower-VOT individuals to faster or slower modes ('self-selectivity'). Insofar as VOT is a function of income, there is clearly an equity issue involved in attaching different non-working time values to different modes of transport. Instead, a standard appraisal value taken as a weighted average across modes is adopted. Other disaggregations identified include by trip length (e.g. Swedish rail appraisal – Regional vs Inter-Regional Trips), and by class of travel (French rail). Each of these has some basis in behavioural evidence, but to what extent they are important is unclear, and in the case of 'class of travel' the equity questions raised in relation to income groups arises again.

In the last decade, a number of value of time studies have been conducted in Europe, including in the Netherlands (Gunn and Rohr, 1996), Norway (Ramjerdi, et al 1997), Sweden (Alger et al, 1996) and the UK (Gunn, Bradley and Rohr, 1996). A meta-analysis of values of time derived from 105 travel demand studies using revealed preference and/or stated preference methods is also a useful source (Wardman, 1998). It now seems clear that walking, waiting and interchange should be valued significantly more highly than in-vehicle time - probably a factor of between 1.5 and 2.0 times the in-vehicle time value.

These studies have left many empirical issues unresolved, not least of which is the question of the income elasticity of the values of time, and hence their projected growth rate over time. There is also a lack of consensus on the principles governing the use of appraisal values where international projects or projects involving significant international traffic are concerned. There are some conflicts of national appraisal practice to be addressed and this is seen even more clearly in the next section.

3.2 Direct Transport Benefits – Safety

The valuation of accident savings has undergone a transformation since the mid-1980s, owing to the development and widespread acceptance of monetary values based on individuals' willingness-to-pay to avoid accidents. Jones-Lee, 1989 sets out the theory; Persson and Ödegaard, 1995 and

Nellthorp, Bristow and Mackie, 1998 give a European perspective on its implementation in national-level appraisal procedures. Previously, values per casualty (i.e. per person injured or killed) had been based largely on measures of lost output - that is the average reduction in GDP due to the injury or death an individual member of the workforce. This was augmented in some cases by allowances for 'human costs' or 'pain, grief and suffering'. Willingness-to-pay methods bring these components together into an overall value per casualty. Their implementation often led to a significant increase in safety values in appraisal. For example, the UK fatality value rose from £180 000 to £500 000 at 1985 prices, or approximately 1.5 million euro in current prices.

Fatal casualty values in the EU member states are shown in table 3. The principal challenge in searching for a common European approach is to address the large discrepancy between the appraisal values supplied. To give an example, after adjusting for price inflation but not for any other differences, the appraisal values for a (statistical) fatality differed between the two extreme cases of Portugal and Sweden by a factor of 48. This, it turned out, was largely reflective of fundamental differences in definition and measurement.

Amongst the various components within the value of a fatality the 'human costs' dominate. In the case of Denmark, these components account for two thirds of the appraisal value of a fatality. Not all member states include these components in their definition, however. In table 3, in those countries marked with an asterisk (*), welfare/human costs are included within the definition of the cost of a fatality, whereas in those not marked, it is understood that a narrower definition is used, and their values are amongst the lowest. The relationship between inclusion/exclusion of human costs and high/low values is readily apparent. Note that the Netherlands also excludes the human costs from the CBA because these are placed separately in the MCA instead.

Table 3. **Appraisal values of a fatality, 1995 prices**

Value of a Fatality, ECU	**Countries**
35 000 - 199 000	Greece, Portugal, Spain, Netherlands
200 000 - 749 000	Belgium*, Denmark*, France*
750 000 - 1 600 000	Austria*, Finland*, Germany*, Ireland*, Sweden*, UK*

*Source: Nellthorp, Bristow and Mackie, 1998; exchange rates from Eurostat. Values given are at 1995 prices and values, although original base years differ. For the meaning of * see text. Data is lacking for Italy.*

Adjustments can be made to put the appraisal values on a common basis in terms of definition and measurement, as a result of which the range of fatality values is reduced to a factor of approximately 4.5 from the factor of 48 previously mentioned.

Other factors that could be contributing to the range of values include:

- variations in income per capita between member states, which would impact on individuals' ability /willingness to pay for safety;
- cultural differences in attitudes to risk and to loss of life, which would affect individuals' tastes and preferences for accident reducing measures, or the attitudes of governments;

– remaining definitional differences – in particular, the inclusion or exclusion of legal costs, delays to other vehicles, police, fire and rescue services and other public sector costs from casualty-related costs; and
– the nature of the measurement methods used – e.g. problems of bias in willingness to pay measures, or of market imperfections where insurance compensation payments are used as a proxy for accident costs.

What are the implications for European appraisal, say of the TENs? Given the information gathered, some adjustment could be made to values (as in EUNET, Nellthorp, Bristow and Mackie, 1998) to take into account the inclusion/exclusion of human costs (and some of the factors raised above). The case for adjusting values within or between countries to allow for variations in incomes is obviously controversial.

It is also argued, however, that cost-benefit analysis should respect differences in the preferences of groups of individuals where possible, since these affect total willingness-to-pay. For this reason, some residual variation in country values is to be expected. This would need to be explored further if consistent multi-country appraisal was felt to be worth undertaking.

3.3 Environmental impacts - extensions of CBA

By the mid-1990s in the EU15, decisions on transport infrastructure investment were being made with the benefit of environmental impact information. These practices have been reinforced by EC Directives (EC 1985; EC, 1987), which require a formal environmental impact assessment (EIA) for larger projects including highways, ports and airports.

In transport project appraisal at the national level, the EIA is usually summarised - either descriptively or using a limited set of quantitative indicators - before being presented alongside the direct transport benefits and any other impacts being taken into account. Table 1 shows how different member states treat a selection of ten different environmental effects. It is clear from the table that quantitative measures have been accepted far more readily for some impacts (e.g. noise and air pollution) than for others (e.g. landscape and the loss of important sites).

Some member states have gone further by placing values or weights on the quantified environmental effects. These cases are indicated either by a red cell, indicating that the effect is given a monetary value and included in CBA, or by a label 'MCA', which indicates that the effect is given a numerical weight and included in the total multi-criteria score for the project. Amongst the countries adopting an explicit money value for at least one environmental impact are Belgium, Denmark, Finland, France, Germany, Portugal, Spain and Sweden. Countries building environmental impacts into the MCA include Austria, Belgium, Greece and the Netherlands. The remaining countries that have held back from such explicit weighting are Ireland, Italy and the UK. This diversity of appraisal practice is partly a symptom of the evolving state of the art in environmental valuation - so that 'best practice' keeps changing in each member state. It is also partly a symptom of the differences of view amongst the member states (which should not be exaggerated but which do exist) about the quality of the evidence and the balance of advantage in appraisal of monetising environmental impacts. The following paragraphs give a thumbnail sketch of the current position regarding noise, air pollution, and other impacts for which the assessment is necessarily more subjective.

3.3.1 Noise

Six of the EU15 countries have adopted monetary values for transport noise (see table 1) based either on hedonic pricing approaches or avoidance cost measures - such as the cost of sound-absorbing windows. Whilst the latter are relatively easy to calculate and are in use in Germany and Spain (and possibly elsewhere) they are open to the criticism that they do not necessarily reflect willingness-to-pay. The hedonic price approach is therefore conceptually preferable.

A seminal study was that by Soguel (1994) - a hedonic analysis of property rents and the impact of road noise, whose results have been shown to be comparable with other contemporary studies (ECMT, 1998). Soguel's expression of the values in units of 'dB(A) 16 hour Leq' means that they are applicable to modes of transport producing intermittent noise (e.g. rail or air) as well as to the continuous noise of roads. Furthermore, perhaps surprisingly, the value of a 1dB(A) noise change increases only very slightly with the pre-existing level of noise, suggesting that the same appraisal values may be applied to noise changes experienced by individuals in any initial setting. Not all researchers concur with this result, however, and transferability remains a live issue for noise valuation. Table 4 shows how values may vary by country (ECMT analysis). The contrast between this range of noise values and the earlier range of safety values helps to emphasise the wide spread of the values for safety in different parts of Europe.

For projects with localised effects it is probably preferable to carry out location-specific studies (using hedonic pricing or stated preference techniques) in order to validate the use of Soguel/ECMT's results and ensure that variations in preferences are being taken properly into account. The existence of a rule-of-thumb value, however, is likely to be extremely useful in early-stages appraisals.

Table 4. **Monetary values for noise reduction**

Location	Value, 1991 Euro per person per dB per annum
EU Average	20.9
Range	17.2 (Greece) to 22.4 (Luxembourg)

Source: ECMT, 1998; authors' analysis.

3.3.2 Local and regional air pollution

For local and regional air pollution, part of the achievement of recent research has been to isolate more clearly which are the most important pollutants (in terms of their impact on people and the environment) and to clarify how the impact varies depending upon where the emissions occur. Amongst the key findings from this field of research are that:

- *particulates* are the most significant local air pollutant;
- damage costs are much higher per unit mass of pollutant emitted in urban areas than for extra-urban areas (by a factor of up to 5 for smaller cities and as much as 50 for larger cities such as Paris or London), so in project appraisal it is essential to separate urban from extra-urban traffic before the valuation stage; and

– calculation of the total environmental damage due to transport needs to include the whole fuel cycle, including electricity generation facilities for electric vehicles and the processing of fossil fuels (CEC, 1995) - the location of these facilities does not feature in a conventional transport model, so something more comprehensive may be needed in order to compare fairly the emissions of different transport modes.

As with noise, several meta-analyses (including ECMT, 1998; Bleijenberg, van den Berg and de Wit, 1994; Tinch, 1996) have added to confidence in the range of values being identified. There remain some differences between studies, potentially due to differences in population density, income, preferences and other contextual factors, and to variations in the evaluation methods adopted. The degree of consensus has proved sufficient however, to persuade the governments of Belgium, Denmark, Finland, France, Germany, Portugal and Sweden to adopt money values for changes in air pollution, in their appraisal of transport infrastructure projects. Table 5 summarises some of the 'best estimate' values emerging.

Table 5. **Monetary values for reductions in air pollution**

Pollutant	**Value, 1995 Euro per kg reduction in emissions**	
	Urban areas	**Extra-urban areas**
Particulates $PM_{2.5}$	185 (EUNET)	19 (EUNET); 0 (rural areas - ECMT)
NO_x	4.5 (EUNET)	
SO_2	1.7 (EUNET)	

Sources: Values drawn from Nellthorp, Bristow and Mackie, 1998; ECMT (1998).

Values given in table 5 are based on estimated damage valued using willingness to pay based methods. Marginal prevention costs do not necessarily equate to the value of damage inflicted, so can be viewed as a second-best source of values for appraisal purposes. The confidence intervals associated with the values in table 5 are explored in Bickel *et al.* (1997), and are in fact extremely wide. For example, for particulates we can only be roughly 68% confident that the urban value lies in the range 46 to 740 euro per kg. Given this level of uncertainty, sensitivity testing is highly desirable as part of any project appraisal using these values. Note that the uncertainty problem is concealed if money values are not used, but it does not go away.

3.3.3 Climate change

For climate change, key studies by INFRAS/IWW (1995), Cline (1992), Fankhauser (1994), Maddison (1994) and others point to a central estimate of 50 Euro per tonne of CO_2 emitted, with the convenient feature (from an appraisal point of view) that it is unimportant whereabouts the emissions occur. In this case the confidence limits are even wider, with Bickel et al (1997) reporting only 68% confidence that the value lies between 4.2 and 600 Euro per tonne, so again sensitivity testing will be absolutely essential.

3.3.4 More subjective environmental impacts

Finally, more subjective areas of environmental quality have also been shown to be amenable to monetary valuation and inclusion in CBA. A study by Walker (1997) examined the willingness to pay of individuals in central Oxford for measures which would reduce traffic levels and improve the street environment. Significant valuations were found and the results were included with the CBA submitted for decision by central government. A similar experience with Midland Metro in Birmingham (Medhurst, 1997) is also encouraging about the acceptability of environmental values to decision makers in national governments.

3.3.5 European-level appraisal

Environmental valuation has been advocated in the context of Trans-European Networks and is also being developed for use by the European Conference of Ministers of Transport (ECMT) (see Perkins, 1997). Again, however, there is scope for disagreement between the EU and the various member states over what the money values should be and, more fundamentally, the legitimacy of monetising impacts such as climate change at all. The state of the art in valuing the environmental impacts of transport is therefore a sensitive area of current research. We would finally draw attention once again to the confidence intervals found for air pollution values. Whilst these are very wide, they provide the opportunity for informed sensitivity testing which will help to inform future discussions about whether investment funds are best spent on new infrastructure or other aspects of transport service delivery, and what the optimal balance may be between the modes.

3.4 Wider policy impacts

When moving from the direct transport and environmental impacts of infrastructure projects in the wider policy impacts, we enter an arena which is both fraught with technical and theoretical difficulties and highly politicised. A key problem for appraisal is that the area of greatest political interest – the impact of infrastructure on economic performance – is precisely the area of greatest technical weakness within the appraisal.

The wider policy impacts that are most often mentioned within transport appraisal are: improving accessibility, promoting economic regeneration and/or economic competitiveness. In the EU context, additional wider policy impacts include: reducing peripherality, promoting social cohesion, eliminating or reducing barriers such as border crossing costs (which may have been artificially elevated by past political or technical decisions), and promoting interoperability.

The principal technical difficulties that follow are:

- Operationalising the concepts – creating appropriate indicators of change in, for example, peripherality or social cohesion, which are capable of being described, measured, modelled and predicted in an appraisal context. This is very demanding, and in some cases it is not clear that the impacts have been specified sufficiently clearly to be capable of measurement at the project level, much less valued in monetary terms.

- The Seamless Framework – given that some impacts are dealt with in the CBA, and others within the MCA, there is a need for clarity within the Framework as a whole. Some of the wider policy impacts are really there because of incompleteness or deficiency of the cost-benefit analysis. For example, many CBAs contain either no model of the slow modes and public transport, or only a very inadequate model. In this situation, recording within the 'accessibility' entry an assessment of the impacts on pedestrians and cyclists or people with disabilities – groups not properly modelled in the CBA – is completely legitimate.

- Double Counting **–** however there are other cases where the approach of considering the direct transport impacts in the CBA and the wider policy impacts in the MCA creates a huge risk of double or even treble counting. A transport project that reduces direct transport costs will also promote accessibility and maybe also economic regeneration. The issue of distinguishing wider policy impacts which are transferred from the direct impacts from effects that are genuinely additional to the primary benefits is a big one (for an extended review see SACTRA 1999).

- The Decision Hierarchy **–** in practice, major projects may be appraised at several different spatial levels, regional, national and international. The project impacts may be different depending on the spatial level, but also the relative weights on the project impacts may vary according to the perspective taken. This creates further risks of overlapping benefits and double counting at different stages in the appraisal process. For example, a scheme with significant transport and regeneration impacts from the regional perspective may also be seen as promoting the EUs goal of reducing peripherality. Is there additionality here? Particularly if financial contributions from certain institutions depend on the extent to which projects achieve certain objectives, consistency at all levels of the appraisal hierarchy becomes crucial.

Across such a broad field, the state of the art cannot be fully reviewed, but probably the economic indicator of leading interest is employment effects.

3.5 Employment effects

The creation and safeguarding of employment is an objective of the European Structural Funds. It is therefore of policy interest whether expenditure on Trans-European Networks as a whole or on specific schemes leads to a change in the level or structure of employment. In practice, however, there is a substantial forecasting issue. One of the main channels through which new transport infrastructure is often argued to influence economic performance is the reduction of transport costs to a peripheral region with unemployed labour. The cost reduction for exporters from the region provides a stimulus to business activity there and to inward investment. The costs of exporters from the 'centre' to the peripheral region are, however, also reduced: their market area is effectively widened and for a producer the arguments in favour of centralisation of employment are strengthened. The balance between these forces depends upon a range of economic factors, including the endowments of resources in the areas concerned, which cannot be determined without a careful analysis across the sectors of the economy.

Table 1 shows that seven of the member states (i.e. less than half) currently attempt to forecast these employment impacts in a quantitative fashion. Germany has a standardised and rigorous approach using input-output tables (PLANCO et al, 1993). Belgium has used input-output analysis to estimate value added as well as employment, but in a specific sector – road haulage – which limits applicability. Others rely on a range of economic impact assessment techniques that it would be hard to generalise for use at the European level given the diverse assumptions made.

Valuation of employment impacts is attempted only in Germany, Greece and Spain. Germany bases its 'value per job created' on the alternative cost to the taxpayer of creating one job by other means. Ex post evaluation of an EC funded regional programme for 1980-89 showed the investment per job created rising from around 81.000 ECU in 1980 to 154.000 ECU in 1989. Assuming that on average a 15% investment subsidy was required, and then annualising the costs, gives a ‘value per job created per annum’ of 9.900 ECU in the former Federal republic, or 13.000 ECU in the former East Germany, where conditions for job creation are regarded as less favourable.

Our assessment is that the linkages between transport, and overall economic and social performance are poorly understood. But it does not follow from that that they should therefore be excluded from the appraisal framework, especially since they are precisely the matters of greatest concern to the politicians. What is important is that some sort of coherent, consistent, auditable method is used to assess these impacts, and that they should be presented in ways which facilitate the assessment process rather than obscuring it. A good, well-judged description of the likely impact, within an overall multi-criteria assessment framework, is infinitely preferable to a poorly-based numerical value in a cost-benefit table.

To summarise this section as a whole, on the direct transport impacts much technical work has been done to refine the values. The conventions and values used differ between countries, but the principle of valuing the direct transport impacts in monetary terms is generally accepted. Many issues of application of these principles remain open, however. The current UK debate about whether rail fatalities and road fatalities should have the same appraisal values is just one of these. In the environmental field, a lot of work has been done with a fair degree of progress towards measuring the impacts, but less than might have been expected thirty years ago towards finding money values for use in appraisal. The wider policy impacts are the most acute problem area since even a convincing framework for dealing with them which is both logical and practical still seems some way off.

4. PRESENTING THE APPRAISAL RESULTS

Given that the appraisal framework, including the treatment of individual impacts has extended and developed over the last thirty years, the need to consider storage and presentation of the results has also become an important issue. Increased sophistication and complexity brings with it increasing data requirements. Not only is there a need to be able to store and retrieve parts of this mass of data quickly for review, but alongside this is the natural limit to the amount of information a single user can visually assess and mentally process in a single presentation. This in turn suggests a need for a systemised delivery of information and flexibility in the range of summary or aggregate statistics available. Where data or appraisal processes are partly computerised, there may also be the need to address potential concerns of a lack of transparency or 'black box' nature. There may also be barriers to overcome such as fundamental dislike of technology and a sense of 'loss of control' by the user. These factors prompt this review of the current demands and state of the art in presentation of appraisal results.

Recent developments imply that the user requirements include:

- providing immediate access to a stored background of disaggregate information according to groups affected such as mode, investor, benefits over time and so on;
- allowing sensitivity testing on assumed parameters such as growth and provide revised appraisal outputs;

– giving a range of summary outputs likely to be of interest to different groups involved in the overall appraisal process;
– providing a high standard of visual presentation on a large number of data, options and summary outputs in a form which is clear, concise, transparent and assists the decision making process in a digestible and user-friendly format.

Several examples now exist of recommended presentational formats for appraisal outputs based on documented or computerised materials. The Appraisal Summary Table (AST) used in the UK trunk road scheme assessment process is representative of the former (DETR, 1991). The AST is a one-page summary of the main economic, environmental and social impacts of the trunk road scheme, and the stated aims in the use of the AST are to encompass both understanding the problem and providing summary information. In brief, its purpose is thus to:

– assist understanding of the problem and ask what priority it deserves;
– identify a range of options;
– appraise options to determine the extent to which they meet the UK Government's objectives as cost efficiently as possible.

The overall design of the table is one that could be readily adapted for use in other appraisal contexts and includes the facility to store an overall summary measure (either monetary or qualitative as the background guidelines recommend) together with supportive qualitative remarks for each impact.

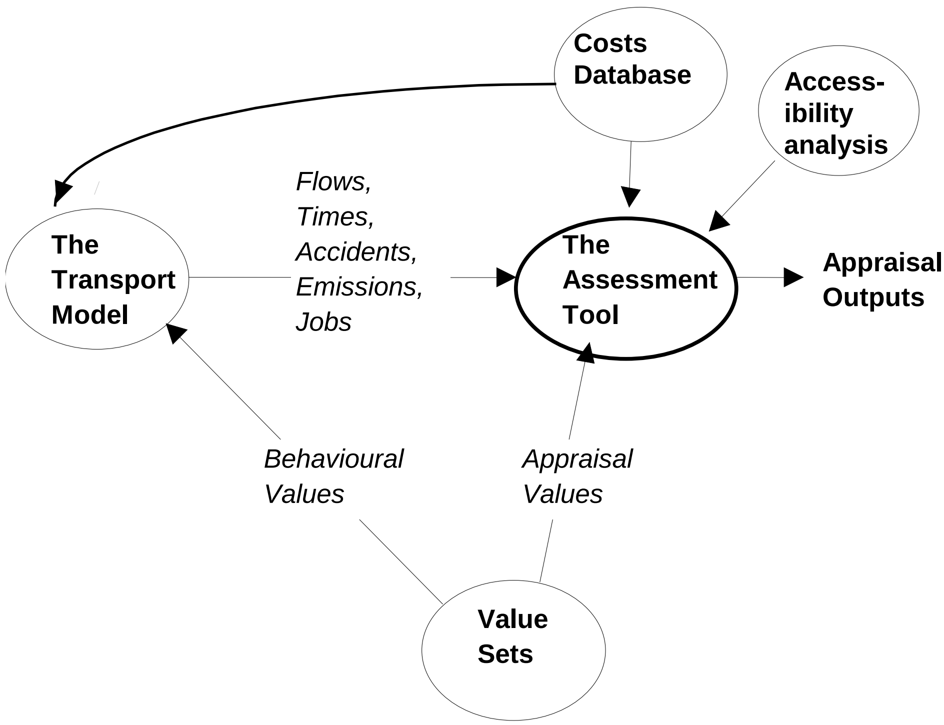
The use of a written document to store and present outputs carries certain limitations and there is increasing interest in and support for the idea of computerised presentational tools. One specialised example of a software tool focused on MCA decision support is MUSTARD (Scannella and Beuthe, 1999). This tool has been designed to help a decision maker in situations where there is a need to rank or prioritise a large number of competing schemes with a relatively small number of impacts to consider. It has a particularly sophisticated range of facilities to carry out sensitivity testing where a decision maker is uncertain in their priorities.

A more general appraisal tool is the one developed and prototyped within the EU funded EUNET project (Grant-Muller *et al.* [1998]). The tool represents the implementation of the overall recommended EUNET appraisal methodology, providing a framework that draws together both CBA and MCA outputs to provide an overall summary measure for schemes. A summary of the data flows input to the tool is given in Figure 1 below:

Internally the tool consists of five modules; an input module, a cost benefit analysis module, a basic financial appraisal module, a multi-criteria analysis module and an output module. Whilst a CBA alone could be used for assessment, a rigorous interface between all modules has been established to allow the decision maker full use of all the recommended impact criteria in assessment. The software has been developed in a Windows environment allowing the user access not only to overall project scores and rankings, but also disaggregate outputs, summary tables, statistics and graphs. An advantage of a computerised facility such as the EUNET tool is that it allows a considerable degree of flexibility in terms of sensitivity testing on parameters, accessing dissagregate information or summary tables which are user specified.

Computerised storage and presentation of appraisal information represents a clear step forward from current practice and one which would have been impossible thirty years ago. This represents only one challenge for the future of appraisal and a more general policy decision is needed on the extent to which this can be more widely utilised. Further appraisal challenges of a more theoretical and conceptual nature are discussed in section V below.

Figure 1. **Data Flows to the EUNET assessment tool**



5. NEW CHALLENGES FOR APPRAISAL

During the last twenty five years, an interacting set of political, economic and social development have occurred, which have combined to change the context within which appraisal takes place. These include:

- greater attention to the linkages between transport and the environment and other broader policy;
- a move from a project focus to a policy focus, creating the need for Common Appraisal Framework;
- increased computing power, facilitating increased capability for information processing (but have interpretation skills kept pace?);
- much greater social awareness, and therefore need to present project and policy options to an informed public;

- a move from national government responsibility for transport with single level appraisal to a mixture of local, regional, national and international responsibility with multi-level appraisal;
- a move towards privatisation and public-private partnership creating need for explicit assessment of the impacts on individual agencies, operators etc within the overall appraisal.

What does this imply about outstanding research and development issues concerning the nature of support for intelligent decision making and the role of appraisal within it? Here we identify six areas.

5.1 Indicators and double-counting

Many of the factors that are seen as of growing social and political importance to transport sector decision-making are not readily measurable. Indeed, many are proving elusive even as far as definition is concerned. Some are primarily project-level variables, such as community severance or, perhaps, social exclusion. Others are clearly strategic: cohesion, inter-operability, etc. In both cases, the definition of such indicators, linking them to appropriate ways of categorisation or measurement, and establishing money values, weights or other ways of facilitating their aggregation into overall indicators of project or policy performance are major theoretical and practical challenges. Many of these important social and similar impacts readily double-count with each other, or with other dimensions already incorporated in conventional CBA, which provides a further challenge.

5.2 Cost-benefit analysis and multi-criteria analysis

The boundaries of CBA have slowly expanded, as more of the impacts of typical transport projects become capable of being monetised. Where to place the border between the two, when to shift it and in what circumstances will continue to pose challenges for theoreticians and practitioners alike. There are issues too about the nature of the MCA modelling component. Should it be separate from the CBA, or integrated? If so, how and how fully? Should the MCA simply mimic the CBA and use a simple linear additive format or should it seek to capture within the MCA procedure itself other features of the real-world decision making environment, such as uncertainty, or the search for consensus among different stakeholder groups? Where is the balance best set between model complexity and transparency to users and the concerned public?

5.3 Communication

Although the changes may occur at varying pace within different parts of the hierarchy, discussions of transport interventions are likely to become increasingly multi-tiered. This is occurring not simply because of EU concerns about transport strategy, but also following from increased emphasis on regionalisation within member states and so on, down to the level of quite localised stakeholder groups. If such a planning process is to work well, effective communication between tiers is critical. This affects appraisal models, as mentioned above, but also has wider implications for decision-making processes. In particular, the on-going tension between demand for simplicity to facilitate wide communication and demand for sophistication in modelling which typically brings complexity remains an unresolved question. In general, there are many outstanding questions arising from the need to effect informed decision-making in a multi-tiered decision making environment.

5.4 Uncertainty

Uncertainty has always been, and remains, a key concern in appraisal. Typically, it has been characterised as deriving from lack of accurate knowledge of: the external economic environment; and/or model structures; and/or model parameter values. A new feature, however, of the developing decision making environment is policy uncertainty. The emergence of a potentially powerful policy-forming body, in the shape of the European Commission, has enhanced the potential to influence the course of events via Europe-wide policy measures. From the perspective of transport sector appraisal, there is thus a further dimension of uncertainty, about how precisely that policy influence may be used. Such influence may derive from policies targeted at the transport sector itself, or any of a number of other sectors that interact significantly with transport. How to reflect this form of uncertainty in the scenarios or other tools that are used to try to bring recognition of uncertainty into project appraisal is unclear.

5.5 The private sector

Increasing involvement of the private sector seems essential to many of the policy ambitions for expansion of European transport capacity. If this is to be achieved, then project designers need to know how best to set up projects that will both achieve their social objectives and appeal to private sector finance. Familiarity with the private sector's perspective on what constitutes an attractive project is still not high among transport planners as a whole. From the point of view of the contribution of appraisal to intelligent decision making, one particular need is improved modelling. Combined traffic and evaluation models that are sensitive to factors such as varying toll levels and that successfully co-ordinate the behavioural inputs underlying traffic models and the resource inputs relevant to evaluation, are urgently needed.

5.6 Exploiting developments in computer power

To deliver the integration referred to above between traffic and appraisal modelling will require full exploitation of developments in computer capability. A suite of procedures that can move seamlessly between levels of spatial aggregation and can be applied throughout the planning process, from sketch planning through to final, formal evaluation, would necessarily need to take full advantage of the continuing changes in computer power. Additionally, however, more radical options are becoming feasible. For example, we are only just now beginning to come to terms with what GIS might bring to aspects of planning and evaluation. Potential also exists to exploit more fully the developing ability to create visual images to stimulate discussion and evaluation of different project designs and to visualise the outcome of appraisal processes in new and more informative ways.

6. CONCLUDING DISCUSSION

Thirty years on from the development of transport project appraisal at an operational level, a considerable amount of progress has been made and a number of issues remain. Rather than attempting to summarise the totality of this, we conclude with a few key points.

First, the art of appraisal has developed at the technical level. More is known now about the measurement and valuation of impacts. Appraisal frameworks have been progressively developed, and modern computing power makes possible the implementation of various combinations of CBA and MCA within an overall framework, of which the EUNET tool is a particular example.

Secondly, the context within which appraisal is used has become significantly more challenging. The multi-level, multi-agency dimensions, the need for appraisal to speak to the public as well as the professional, the need for consideration of a wide range of social, economic and environmental impacts all mean that the nature of the problem to which appraisal is addressed is now more testing.

Thirdly, although there is a broad similarity between the appraisal approaches used by different countries in Western Europe, there are many points of difference. This is not surprising given that the countries have different traditions of thought in political economy, different perspectives and cultural values, and different institutional arrangements and therefore uses for appraisal information.

Fourthly, there remains an issue about the role of appraisal in decision-making, in other words where the boundary lies between the technical process of decision support and the political process of decision making. The CBA plus Framework approach allows the decision maker to weigh together the CBA with the other elements in the framework in the process of arriving at a decision. A comprehensive MCA, as in the objectives-led approach, could be argued to reduce decision-makers discretion by applying fixed weights to the full range of impacts. The acceptability of this depends partly on the quality of the data and weights used, and partly on the roles assigned to the technician and the politician in the decision process.

Fifthly, the shape of an appraisal regime is crucially conditioned by the political system within which it operates. After several years of involvement in the European appraisal scene, we remain unclear about the fundamental political model for which the appraisal research work being undertaken for the EU is designed. This is perhaps not surprising because, it touches on issues of primacy and subsidiarity that go to the heart of European policy-making. The problem can be put this way. One approach to transport infrastructure policy – and hence to the appraisal regime – would be to assign prime responsibility to national governments (or, for border crossing projects, to groups of national governments). The EU interest would enter in as much as these essentially national projects had beneficial or adverse impacts at European level, beyond the ambit of national Governments. European funding would take the form of top-ups to national funding where projects supported identified pan-European goals. The implications for appraisal would then be clear – the basic appraisal would be at national level, following national appraisal principles, with a submission to Brussels relating to those aspects considered to have wider European impacts. There would be no reason or need for uniformity of appraisal practice between Member states.

The alternative is a more unified approach in which at the limit all projects 'of European interest' – say initially the TENs – are subject to a standard form of appraisal so that priorities can be determined for the use of scarce funding resources. This raises philosophical and practical problems encapsulated in the phrase – whose values? Should local values be used, reflecting the willingness to pay of the consumers affected? Or should pan-European values be used? Is there a need, in this case, for complete harmonisation of investment appraisal of projects of European interest? The answers to these questions do not lie in the technical arena. As with many appraisal questions, the devil is in the politics.

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Annex 3

TRANSPORT AND ECONOMIC GROWTH

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1. ABSTRACT

There is a perceived wisdom that transport provision (especially of roads) is an essential pre-requisite for economic growth which has tended to justify a "predict and provide" approach to the provision of roads. The evidence is much more mixed, GDP growth has been a good predictor of both passenger and freight growth, at least until recently, leading to speculation that there might be an optimum "transport intensity" of the economy. This has become a potential objective for sustainable transport policies to try and reduce transport intensity, i.e. seek ways of reducing the amount of transport which is necessary to sustain a given level of GDP. There remain, however, many instances of where specific provision has not led to the economic growth which was confidently expected, despite traffic growth which exceeded forecast levels. How should governments and other providers respond to this situation, and in particular should they, and if so how, introduce better measurement of the wider economic effects of transport improvements into investment appraisal? How do these effects relate to other external effects of transport, for example, on the environment?

This paper will report on an approach to these issues based on a recent report on *Transport and the Economy* by the U.K. Standing Advisory Committee on Trunk Road Assessment (of which the author was a member). The key points which this Report brings out are the lack of any general solution to the issue, the importance of considering the extent of imperfect competition in the sectors using transport, the importance of distinguishing the redistributive effects from the net impacts and the incidence of the "two-way road" effect where transport improvements sought by a region may work against its best interests, and the need to demonstrate clearly the relationship between the wider economic and environmental impacts of any proposal.

2. BACKGROUND

The debate on the link between transport and economic growth has a long history. On the one hand there is the argument that there is such an obvious logical link (economic growth requires trade, trade requires transport) that it is not a subject of any great interest. This tends to go hand in hand with the argument that transport is simply a derived demand and therefore any empirical evidence on the correlation between transport growth and economic growth is largely meaningless as it is an identity.

Empirically we can observe a remarkable constancy in the relationship between transport growth (both passenger and freight kilometres) and economic growth over the long period in many countries. This is particularly remarkable given the technical changes which have occurred in transport by all modes over the years. It might be expected that if transport is only a means to an end, if it can be economised then we should expect to see a reduction in the amount of transport necessary to achieve a given level of welfare.

However, it appears that transport faces both a strong positive income elasticity of demand and an overall price elasticity not far from unity. There is a suggestion that in terms of both money and time budgets there is a given (proportional) allocation to transport. As transport has become cheaper and easier, people have travelled for the same time and spent the same proportion of their budget, but have therefore travelled further. Hence we see people living further from their place of work; even the telecommuter spends about the same time in the week travelling as the daily commuter, taking the benefits of the telecommuting freedom to live in a better area. Likewise they travel further for their main holiday, fifty years ago it was to the nearest coastal resort, now it is often half way round the world. Freight transport faces the same change as firms seek wider markets and wider sources of supply.

If this general pattern is true then we are faced with the problem that the increasing demand for transport to maintain and expand economic welfare will lead more rapidly to a conflict with the overall sustainability of the economy. Transport generates substantial externalities, both to other users in the form of congestion if they expansion of capacity cannot keep pace with demand, and to non-users through carbon emissions and local air and noise pollution. Transport is the major single generator of global warming emissions. Transport infrastructure is also one of the major items of public capital expenditure. Governments, increasingly concerned about budgetary balance as a control on inflation and dues to worries about the crowding out of private investment through higher taxes and higher interest rates, have looked to savings on such expenditure as a means of exercising budgetary restraint.

Thus we are faced with the situation that there is increasing pressure for a reduction in the rate of growth of transport. The question is whether this can be achieved without also placing serious restraint on the rate of growth of the economy overall. To understand this we need to go back and understand much more clearly the nature of the relationship between transport and the rest of the economy. In the remainder of this paper we look first, in section 3, at some evidence on transport and economic growth. In section 4 we address the theoretical issues. In section 5 we examine ways of assessing the wider economic significance of transport interventions, whether through investment or through systems of traffic restraint.

3. SOME EVIDENCE

That GDP and traffic growth have developed in parallel is not in much doubt over the long term. Passenger traffic (passenger-km) displays an income elasticity of a little more than unity, freight traffic (tonne-km) an elasticity close to unity. For passenger traffic this reflects a roughly constant propensity to make journeys, and a fairly constant time budget devoted to travel, but a very substantial growth in the average length of journeys. Although there is also a switch between journey purposes, the increase in journey length is associated with most journey purposes. In most developed countries we now travel further to work, to shop and to play.

Of course the even more remarkable change is the switch in the mode of transport used – the motorization of modern life. It is this observation of the growth in car traffic that makes us believe that we are making many more journeys than we actually are. The question thus is how far does this increase reflect a genuine desire for more mobility, how far is it a response to changing patterns of land use permitted by increased access to the car, how far is it yet another reflection of the presumed value placed by consumers on the existence of variety?

Figure 1 summarises the basic information for the UK over a 30 year period. Note particularly how closely the growth of heavy goods vehicle traffic tracks the GDP growth whilst cars and light goods vehicles are growing much more rapidly. Although the rate of growth relative to GDP growth is falling over the period to 1980 it increases again in the 1980s and 1990s with an excess of traffic growth over GDP growth of around 0.5 percentage points per annum. There is, however, more of a break in the pattern for freight in the 1985-95 period when after a long period of an average 0.2 percentage points slower growth in freight traffic, it suddenly increased to a growth of up to 0.4 percentage points faster. This occurred during a period of relatively slow economic growth and might suggest that changes in spatial patterns of economic activity made during the previous period could not easily be altered when economic conditions were less favourable.

If we explore the pattern for other European Union countries, there are some detailed differences, but with the exception of Italy, freight traffic growth is reasonably close to GDP growth whilst all countries show a much faster overall rate of car traffic growth than GDP growth.

Figures 2 and 3 show a basic international comparison of traffic intensity, measured as road traffic levels relative to GDP. There are some obvious differences which relate to geography and the spatial structure of the various economies. Compare for example the freight figures for the US and Belgium, one a large country where we would expect to find a high level of traffic necessary to support a given level of GDP, the other a small economy where we would expect a much lower level, but in fact observe an above average level due it is expected to the large amount of transit traffic caused by Belgium's central geographical situation in Europe. This shows that it is not just domestic GDP which is a critical determinant of traffic levels.

For the EU countries, Figures 4 to 6 show the relationship between traffic intensity and GDP/capita. There is a slight but significant negative relationship observable suggesting that there may be a saturation level of traffic, similar to the saturation levels found in predicting car ownership. The correlation coefficients for car traffic, passenger traffic and freight traffic, respectively are -0.31, -0.35 and -0.39 and the estimated elasticities with respect to GDP/head are -0.25, -0.30 and -0.91. This suggests that freight traffic intensity falls at approximately the same rate as income levels rise, confirming the income elasticity of around unity or little below reported above. Passenger traffic is more worrying however since the rate of growth of such traffic is so strong as to lead to only a 25 to 30 per cent fall in intensity for any given rise in income.

However, this does not imply that traffic will not continue to grow at a rate close to that of GDP, just that any excess will become smaller over time. This, however, ignores the extent to which geographical and spatial structure differences between countries may be amore important influence than any general relationship between the level of economic activity and the transport necessary to sustain it. We need to explore these links more formally before drawing any conclusions from this evidence.

4. A CONCEPTUAL MODEL OF TRANSPORT AND GROWTH

In this section we set out some of the issues which need to be addressed in building a more formal model of transport and economic growth. We shall address this in three broad sections dealing with the aggregate macroeconomics issue, the microeconomic efficiency issues and the spatial issues. First, however, we need to address some questions of definition.

4.1 Some definitions

Our aim is to assess ways in which changes in the transport sector can affect economic growth. Principally our interest is twofold, are there selective interventions in transport which can promote both the level and rate of economic growth (the competitiveness question) and is it possible to act to constrain the rate of traffic growth without harming the overall economic performance of the economy (the sustainability question)? But what do we mean by the transport sector and what are the appropriate interventions which need to be considered?

It is clear that much of the literature does confuse the issue of what is meant by the transport sector. Some studies look exclusively at infrastructure investment, others look at all public expenditure on transport (including physical investment, subsidies to operators and the direct provision of transport services). Here we include all of these, but we also need to consider the conditions under which all transport services are provided, both "public" transport (whether provided by the public or private sectors) and private transport. Regulation, direct charging for the use of infrastructure and taxation (whether or not related directly to the externalities caused by transport) are all elements in this. Since overstretched infrastructure, being used at or above its nominal capacity, is seen as the typical transport problem, it is particularly important to examine the pricing regime at which this is provided before examining the impact of infrastructure investment. Since overstretched infrastructure typically does not work at its theoretical capacity due to degradation and maintenance problems it is important also to consider this element of transport provision.

Likewise there is a tendency to concentrate on the roads problem as the infrastructure capacity problems. The public transport sector is seen more as an organisational problem, how to reduce the cost to the public sector of maintaining the minimum level of accessibility to transport consistent with an acceptable minimum level of social exclusion (what might be termed "social sustainability")? We shall look less at this issue, but nevertheless it is important to introduce the concept of efficiency right across the transport sector with all sectors treated on the same basis. Hence we need to be aware of the extent of competition within the transport sector since this will affect the relationship of price to cost in this sub-sector and the relative prices at which different, potentially competing, services will be offered.

We are using here the generic term "interventions" to include all possible types of public policy towards transport. The underlying assumption is that various types of market failure will lead to an unregulated free market producing sub-optimal levels of transport. That sub-optimality is with respect to both the competitiveness and the sustainability question. Whatever the competitive situation and conditions of supply within any one sub-sector (e.g. urban public transport, inter-city rail transport, car, etc.) there will be problems of competition between sub-sectors. Thus governments will need to intervene to avoid an excessive dead-weight cost from this market failure in the transport market as a whole. Such intervention could be direct supply, of either or both infrastructure and services on that infrastructure, it could be the application of various forms of taxation or direct pricing to ensure prices perceived by users reflect adequate marginal social costs, or it could be various forms of control or regulation designed to achieve the outcome of an optimal charging system without the (political) cost and technical complexity of introducing a workable system.

It is a premise of this paper that all interventions need to be treated in an identical way, the cost and benefits calculated and the impact on the system assessed. All too often one system of appraisal and evaluation is used for additions to a road infrastructure network and an entirely different method of assessment to the introduction of second-best attempts at an optimal charging system, for example, a parking charge, or the provision of subsidy to public transport. In addition to these examples, interventions could include the restriction of access to certain roads or traffic lanes (including toll lanes or high occupancy vehicle lanes), traffic management systems (including real-time intelligent transport information systems), various combinations of fuel taxes, zonal or cordon pricing systems or full marginal social cost (electronic road pricing) charging.

4.2 Transport and growth: the aggregate approach

The aggregate approach to transport and growth is to treat transport as a variable in the overall determination of economic growth. There are three basic ways in which transport can fit into a typical growth model: as investment and productivity enhancement, as a contributor to market integration and as an endogenous contribution to total factor productivity.

4.2.1 Investment and productivity: the Aschauer debate

The direct investment approach is the most familiar and has been the subject of much debate over the past decade following the contribution of Aschauer (see Aschauer,1989, for an initial description and Munnell, 1992, Gramlich, 1994 and Transportation Research Board, 1997, for good reviews of the subsequent debate). Essentially this approach takes the main contribution of infrastructure as a direct injection into the economy, modelled as an additional factor in the aggregate production function, which has the effect both of increasing the level of economic activity and of enhancing the productivity of private capital. This is achieved through public infrastructure acting as a public good; better roads mean more efficient firms.

The argument against public infrastructure, whether directly provided by the public sector or provided by the private sector but subsidised or guaranteed by the public sector, is that its initial impact would be to crowd out private investment by raising either or both the level of taxation and the interest rate. It was this belief which led to the downturn in public infrastructure investment in many countries in the late 1970s and early 1980s, a downturn which also caused the development of maintenance backlogs which are affecting the quality of service provided by existing infrastructure today.

What Aschauer attempted to show econometrically, using a Cobb-Douglas production function with infrastructure as an additional input to labour and private capital, was that the output elasticity of the infrastructure input was so large, values of 0.4 to 0.5 were estimated, that the social rate of return would be in excess of 100% on such investment. This implied that infrastructure investment must be an important source of economic growth, which would, in the long run, more than outweigh any short-run crowding out. The attempts by governments to control public sector budgets by restricting public investment in infrastructure were thus seen as counter-productive and made the situation more difficult. By increasing public investment they could have increased economic growth which would have enhanced private sector productivity and more than paid for itself in higher long run growth levels.

This approach is open to criticism, both on econometric and methodological grounds[2]. The correlations could be spurious, and the equations mis-specified. More sophisticated approaches (e.g. Lau and Sin, 1997) suggest output elasticities of the order of 0.1. There is also the problem of measuring the true value of public infrastructure, given the difficulty of measuring the true cost of capital to the public sector; if the shadow price of public investment is underestimated then the output elasticity of that capital will appear to be much higher.

This debate and the search for more refined methods of trying to measure public infrastructure capital and to capture its overall impact will clearly continue. The best that can be said with any confidence is that infrastructure investment will have a modest positive contribution on economic growth, but that the more accurately are the opportunity costs measured, the less attractive return infrastructure investment offers than other types of public investment expenditure, especially education and training to enhance human capital.

It should be noted that we have been discussing here the aggregate contribution of infrastructure to overall economic growth in a closed economy. We shall deal later with the question of how far differential investment in infrastructure can lead to changes in the relative economic performance of different regions.

4.2.2 Transport and market integration

Secondly, we consider the impact of transport investment on market integration at the aggregate level. By this we mean that reduced transport costs enhance export opportunities and hence lead to increased output, but also introduce the threat of import competition which leads to restructuring and increasing efficiency in industry to reduce production costs. The process is analogous to that which is argued to happen as a result of the removal or reduction of tariffs or non-tariff barriers. Often the argument stops at that point, or even earlier at the recognition of increased exports without even considering the two-way impact of transport cost reductions (an issue we shall return to later). Lower transport costs may also have the effect of widening labour market areas (and the markets for other factors) leading to a reduction in factor costs.

There are, however, some important feedback effects in this system. First, there is the impact of increased production on factor markets. If there are bottlenecks in factor markets such as full employment of labour or a shortage of developable land then the impact of the attempt to increase production will be increasing factor prices and a countervailing impact on costs and hence competitiveness. The upward pressure on wages may of course induce either or both inward migration to a region or increased inward commuting. Secondly, the increase economic activity resulting from the lower transport costs leads to an increased demand for transport which can lead to congestion on the network and hence to an increase in transport costs. This is part of the argument for needing to consider induced traffic when appraising transport investments. If it is assumed that the overall level of traffic is given independently of the changes in costs in the system this could lead to an over-estimate of the benefits of a given improvement (SACTRA, 1994).

4.2.3 Transport and endogenous growth

The arguments so far have related to impacts on the *level* of economic activity. The final set of arguments relates to possible impacts on the *rate* of economic growth. This involves the instruction of arguments from the endogenous growth literature which says that certain changes will lead to a continuing increase in the rate of growth in the economy, rather than a shock to the system which shifts the level upwards but ultimately leads to a return to an exogenously given underlying rate of growth. This requires us to argue that improving transport has an impact on the process of industrial restructuring through the entry and exit of firms and the seeking of wider markets, on the rate of innovation and technology transfer (e.g. through the parallel improvement in flows of information) and hence on the growth of total factor productivity.

Underlying this argument is a belief that the transport-using sectors are inherently imperfectly competitive, contrary to the usual (often implicit) assumption that transport is serving essentially perfectly competitive industries. In such a case, all users of transport will be prepared to pay exactly the value of the transport service to them, the price at which transport is provided is thus a good indication of the value of transport to the economy as a whole. We shall examine the implications of this argument in more detail in the following section of the paper.

4.3 Microeconomic efficiency

The conventional assumption in evaluating transport improvements has been that the sectors using transport are perfectly competitive. This has the effect that any change in transport costs will be immediately passed through into the prices charged by these firms and hence the true value to the economy of any transport improvement is measured directly by the willingness to pay for use of the transport system.. Thus appraisal of any transport improvement has only to measure accurately the transport demand function and these transport user benefits will be a complete and accurate measure of the full economic value (Dodgson, 1973, Jara-Diaz, 1986).

Suppose that there are firms in the transport using sector which are in imperfectly competitive markets. The key feature of such firms will be that their prices do not directly reflect costs. Imperfectly competitive firms engaged in rent seeking behaviour will thus be able to benefit from transport cost reductions without passing these benefits on to their customers, as long as this does not induce increased competition from firms in the same sector located in other regions or new entrants into the sector locally. The problem is that this behaviour is not predictable analytically.

More importantly, however, such a situation shows how firms may well have a vested interest in not seeking transport improvements since poor transport access to a market can act as a very effective barrier to competition from outside (see Hotelling, 1929, for an early graphic exposition of this effect). As long as a firm can gain sufficient scale economies within the local market there is no incentive to seek transport cost reductions. In such circumstances the benefits of a transport cost reducing measure will not be measured accurately by the transport user benefits. Since the lowering of a transport cost barrier may have the effect of increasing competition, the impact on prices may be greater than the cost reduction and hence the total benefit to consumers larger than the conventionally measured transport-user benefits. Whether this will happen, and by how much, will depend on the availability of scale economies and the ability of the local firm to maintain entry barriers in the absence of transport cost barriers.

Under various different assumptions concerning the demand elasticity facing the transport-using firm, the extent of market power, the extent of linkages and agglomeration effects, Venables and

Gasiorek (1999) have shown that these benefits could be anything up to 40% of the conventionally measured benefits[3]. Interestingly they also demonstrate that there can be circumstances, where firms in a sector are charging a price below marginal social costs, in which the conventional user benefits would overestimate the wider benefits. In such cases the transport improvement would go to support, for example, an existing subsidy, which may have been given to compensate for poor access to markets and which should clearly be removed if that access is improved.

4.4 Spatial implications

In the discussion above we have mainly considered the impact of a transport improvement on an individual region taken largely in isolation, expect for its competitive position with the rest of the world in terms of export and imports. We now need to examine the possible impacts of a given change in transport provision on two or more different regions, especially in cases where there exist different conditions of supply.

There are three main stages in examining the spatial implications. First, we look at the competition between firms within the transport-using sector, secondly we look at the implications for the local labour markets and thirdly at the land and property markets.

4.4.1 Spatial competition

The spatial competition effects are best dealt with in the framework of the “new economic geography” (Krugman, 1991, 1998b). As shown above this stresses the importance of the interaction between one the one hand market size and scale economies and on the other the costs of transport. We need to add to this the conventional explanation for the concentration of economic activity, the existence of agglomeration and urbanisation externalities. Once the existence of scale economies leads to market dominance by a firm in a particular location with a growing market area, there will be forces leading to the concentration of other firms in that same location.[4] The forces external to the firm but internal to the industry will include the specialisation of labour and of suppliers, training providers, providers of finance etc. - the industrial district originally identified long ago by Marshall (1920). In addition external to the industry are all the factors relating to the process of urbanisation, acting as public goods to firms, efficient local public transport, generic education and training (Glaeser, 1998).

All of these forces are essentially non-linear and non-monotonic. Thus increasing concentrations of industries lead to diseconomies or urbanisation, not just the exhaustion of economies and the increasing marginal costs of providing additional services, but also other disbenefits which arise with larger urban areas, such as crime, environmental degradation etc. These lead to ambiguities in the impact of a transport improvement on the relative performance of different regions (see Venables and Gasiorek, 1999). Where scale economies dominate, any reduction in transport costs may lead to a concentration of economic activity in larger core regions up to the point where diseconomies from agglomeration set in. If one region has lower input costs (e.g. wages or rents), which compensate for a lack of scale economies, then deconcentration rather concentration may occur.

However, large changes in transport costs may produce indeterminate effects and this is the real insight of this approach. Then existence of U-shaped relationships from the interaction of the various factors can mean that a given reduction in transport costs at one level of such costs or with one level of scale economies can produce completely different overall impacts on the distribution of economic activity from the same reduction at different initial parameter values. Thus we can observe simultaneously increasing agglomeration of industries but a decrease in concentration and regional specialisation in some economies and the reverse in others (Krugman, 1998a, Brülhart, 1998).

The most important insight is, however, to examine the general equilibrium effects on a region, allowing for the linkages both between and within sectors, sectors which have differing needs for transport, differing degrees of competitive power and differing spatial markets. If regions are symmetrical (identical) then generally the benefits will be seen to be larger in both regions than in a simple model because of the allowance for the linkages, although most of these increased benefits should be picked up in a standard cost-benefit model which allows for induced traffic. If the linkages between sectors are weak, however, then there is a stronger probability of agglomeration within individual sectors within one or the other region. This can lead to asymmetric effects with one region gaining at the expense of the other.

4.4.2 Regional impacts

Venables and Gasiorek (1999) use a simple stylised model of geography with two or three regions. Each region has two transport-using sectors, one of which typically displays imperfect competition, the other is perfectly competitive. The labour markets in each region are assumed to be perfectly competitive and to clear. The transport sector benefits from an improvement which reduces the costs of transport between the regions. We consider four cases which summarise the main types of differential regional effects of interest: the centre-periphery case; the production diversion case; the three region centre-periphery case; and the three region network case.

The centre-periphery case considers the consequences of an improvement between a large central region and a smaller more peripheral region. Such a case typically starts with a concentration of activity in the central region because of the scale economies. Except in the case of very high initial transport costs, improvements tend to reduce the output and wage differentials between the regions. There is a theoretical case for an inverse U-shaped relationship between transport costs and regional inequalities such that from a situation of very high transport costs, a reduction can initially lead to increases in inequalities as the scale economies in the central region overcome the initially prohibitive transport costs, but further reductions beyond a certain level would lead to the expected reduction in inequality. Very large reductions in transport costs from a high initial level could lead to either increases or reductions in inequality.

The production diversion case considers the case of three initially identical regions in which there is an improvement of transport between any two, but not with the third. Starting from a position where the three regions have identical levels of output and wages, the improvement between the two regions gradually concentrates more activity in these at the expense of the third with substantial wage differentials opening up. The welfare gains in the benefiting regions more than outweigh the much smaller reductions in the third region.

The three region centre-periphery case considers the case of three regions lying along a single corridor, where an improvement takes place between two of the regions, one central and the other peripheral, but not between the centre and the third region. In such a case the locational advantage of the centrally located region would have led to a greater share of regional production and higher wages at any reasonable level of transport costs. The effect of reducing transport costs between one peripheral region and the centre is to shift production towards, and increase wage rates in, that peripheral region at the expense of the other peripheral region. There is little effect on the central region. However, in this case, all regions make a welfare gain, most for the peripheral region whose transport connections are improved, rather less for the central region and less again (but still positive) for the non-connected region which clearly benefits from the overall reduction in transport costs in the network.

The three region network case considers the same geography as the previous example, but in the case where both links are improved. In this case, for similar reasons as in the previous case, both peripheral regions benefit at the expense of the centre region for which the initial dominant position is reduced. Both peripheral regions make substantial welfare gains and rather higher ratios of total benefits to transport benefits are achieved. The overall improvement in welfare from improving both links is greater than the sum of the improvements associated with each link independently as the effect is to enlarge the total market.

The overall conclusion of this consideration of geographical effects is that transport improvements may generate either increases or decreases in regional inequalities depending on their incidence on particular regions and on the initial level of transport costs. Transport improvements may be a way of reducing inequalities, but the effects do depend on other factors leading to agglomeration; stable regional industrial structures can become suddenly unstable at critical levels of transport costs. Again this suggests that there is no simple rule which can be applied to predict the regional outcomes of transport projects; the outcome will depend on a particular set of regional and sectoral circumstances. There do, however, seem to be quite strong grounds for expecting substantial effects from the development of networks, so-called super-additivity effects.

4.4.3 Transport and labour markets

Thus far we have assumed a neutral impact of the labour and land markets, effectively they are assumed to be in perfect competition and to adjust quickly and efficiently into equilibrium.

Transport interacts with the labour market in two major ways for our analysis. First, labour is a major input to all activities and is, in most cases, locationally specific in that it has to be physically present for the activity to take place. Secondly, transport affects labour both as an input to production (commuting), and as an input to other activities (social, leisure, etc.) which constitute the final demand for activities.

Consider a transport scheme which reduces commuting costs in an area, this could have two complementary types of response. First, there is a commuting response which causes labour markets to increase in size. As transport costs fall the search area for jobs increases and workers are prepared to make longer journeys for the same generalised cost (i.e. money price plus the cost of time spent in commuting). Labour market areas thus tend to become larger. This introduces more competition from outside a given region for jobs inside, which would have the effect of depressing wages, but also opens up opportunities in other regions to workers from within the region, which could have the effect of bidding up wages as firms seek to retain staff. The impact on unemployment and on nominal wages is thus ambiguous depending on the relative characteristics of workers and jobs in the different regions.

The impact on any one region may be ambiguous depending on the relative size of these effects, whether the region is a net importer or exporter of labour. Reductions in transport costs may be expected to lead generally to a reduction in both intra- and inter-regional variations in wage levels if labour markets are assumed to be reasonably perfect. Where there is persistent stickiness in wages this may be less true. The overall effect could be ambiguous in a way analogous to the behaviour of product markets.

Secondly, there is a migration response. The impact of lower commuting costs may cause migration into the region from those employed in other regions searching for higher real incomes due to lower house prices or improved living conditions. This increased local labour supply may also put pressure on wages and/or unemployment in the local labour markets, whilst at the same time placing upward pressure on local house prices which will have a downward impact on real wages. This may or may not outweigh any increase in nominal wages from the increased competition for local labour from outside the region. Falling real wages may lead to outmigration and counter balance the increased labour supply.

Any change in real wages may impact on firms' unit labour costs and their competitiveness which impacts on labour demand which through interaction with labour supply feeds back to nominal wages. A further feedback loop is that increased commuting may lead to congestion effects and this will reduce the benefits of the initial transport improvement. This complex set of interactions shows clearly how the actual outcome may involve a balance of different responses to any given initial change working through parallel responses in both the labour and housing markets. In particular much will depend on the degree of slack in both of these markets which will determine whether prices change rapidly or slowly.

The increased size of labour markets is a natural parallel in the input market to the normal market size effect in output markets claimed for transport improvements. This again raises a number of complex issues. First, labour markets cannot be treated independently of other markets, particularly that for housing. The housing market is known to display fairly close relationships with transport improvements and it may be that much of the potential gain is captured in the housing market rather than in the labour market. Secondly, labour markets overlap, not least in the increasing importance of the multi-worker household.

It may be that the constraints of the housing market are a more serious determinant of commuting change as a substitute for migration even in the longer term. Recent evidence for the U.K. by Cameron and Muellbauer (1998) suggests that the housing market has a strong effect on decisions to migrate between regions. High relative house prices discourage in-migration, though expectations of future house price rises may encourage it. Increasing owner occupation has reinforced this effect. Because of this, differential labour market effects in contiguous regions lead to commuting being substituted for migration, and for nearby regions there is a stronger labour market effect on commuting decisions and a stronger housing market effect on migration decisions (see also Gordon, 1975; Molho, 1982; Jackman and Savouri, 1992).

These findings are important since they suggest that improvements to transport between labour market areas may have both commuting and migration impacts which could work differently according to the existing relative states of the labour and housing markets in the regions affected. In some circumstances attempts to use transport to open up labour markets may have perverse effects if the housing market is not flexible.

4.4.4. The role of the land and property market

This suggests a need to look more closely at the workings of the land market. There is a long tradition of relating land values to transport costs. From the early work of von Thünen (1826) this 'trade-off' approach shows how the increased costs of access as one moves further from a market centre lead to a reduction in the price which potential users will bid for the use of land at a particular location. In equilibrium the total value of land rents in a market will equal the sum of all the transport costs such that there is a clear link between the quality of an area's transport and the total price of land.

If transport is improved, the value of land at a particular location will rise and since there is an incentive, both for individuals to move outwards looking for cheaper land and for more land to be converted to urban use at the margin, the urban area will increase in size. It is also suggested in such urban models that, if the transport costs fall faster than the costs for the use of land rise (e.g., because land can be developed at increasing densities), the overall urban cost of living will fall (i.e., real wages rise) and workers will be induced to move into the city. Thus transport improvements can be seen as an agent of urban growth. Although this is an accepted theoretical proposition, it has been difficult to produce convincing empirical evidence, in particular it is difficult to ascribe specific impacts to specific transport improvements.

4.5 Some conclusions on a conceptual model

The above discussion suggests three broad elements which are important in conceptualising the problem of the relationship between transport and economic growth: the role of imperfect competition; the importance of general equilibrium; and the need for disaggregation.

Imperfect competition is relevant in both the transport using markets and the transport providing markets. In the transport using markets the relevance is the extent to which departures of price from marginal cost (and wage levels from the value of marginal product) leads to a gap between the willingness to pay for transport and the actual price paid. This can occur both ways, where price is greater than marginal cost the likelihood is that transport improvements will have a greater value than conventionally assumed, where price is less than marginal cost they may have a smaller value. In the transport providing sector there are two elements of imperfection, one is the competitive structure of the market between different firms (both within and between modes) which again leads to prices not reflecting marginal private costs directly, the second is the problem of market failure with respect to the external effects of transport. Thus again, simply taking the observed price at which transport is sold in the market may either over or undervalue the benefits to any improvement.

Table 1 summarises the various arguments advanced in this section. It shows the way in which different possible outcomes will emerge from different combinations of market imperfections in the transport providing sector (the rows) and the transport using sector (the columns). These two effects will interact, it is conceivable that any of the nine cases identified in Table 1 may occur. The central cell, five, is the pure case assumed by conventional cost benefits analyses of transport in which all externalities in transport have been fully internalised and that transport serves perfectly competitive sectors. Some, possibly the more likely cases, will give the uncertain outcomes in cells three (top right) and seven (bottom left).

The work of Venables and Gasiorek (1999) has demonstrated the importance of a general equilibrium framework which allows for linkages both within and between sectors. These linkages are the critical elements through which the firms' responses to a change in transport provision are transmitted. Where firms in different sectors have different degrees of competition this will produce different transmission mechanisms. The stronger the linkages, the more widespread will be the impact and thus the greater the chance of unmeasured benefits.

Within the general equilibrium approach the key role of labour markets has emerged. In the earlier work of Krugman a mobile labour force provided the adjustment mechanism by which wages and prices adjusted (e.g. Krugman, 1991b). The application of such models to stickier labour markets in Europe, both within and between countries led to the development of the linkages within and between sectors as the equilibrating mechanism (see, for example, Venables, 1995). However, it is now clear that simply assuming that labour markets clear internally within a region is not an adequate explanation. In a dynamic model, the labour market forces for both temporary and permanent movement, whether or not that movement actually occurs, are string and need to be accounted for. The key issue here is the extent to which enhancements to productivity (for example, those implicit in transport time savings) are taken in increased wages or increased employment (Lee and Pesaran, 1993)

However, it is also increasingly clear that there are too many conflicting forces to be able to distinguish all these effects at an aggregate level, even at an aggregate regional level. The need for disaggregation in the evaluation of transport changes has been expressed strongly by Gramlich (1994) in his commentary on the Aschauer debate. However, it goes further than the problem of identifying the actual impact of a transport change beyond the value of the capital investment. We need to be aware of the relative sectoral and spatial impacts of a change. For example, a given transport interventions may impact very differently on different sectors according both to the overall contribution of transport to value-added and the relative location of markets; compare, for example, the cement and semi-conductor industries. However, different transport interventions designed to achieve the same end goal (for example, a comparison of a policy to introduce road pricing and one to subsidise rail transport as a second-best intervention) may have very different impacts on any one sector depending to its ability to switch modes or change market areas.

5. TOWARDS THE EVALUATION OF WIDER ECONOMIC EFFECTS

In the previous section we have reviewed at length the interactions between the different factors when there is a change in transport provision. We have shown how this is both complex, and difficult to predict, on *a priori* grounds - the final outcome both as to whether there are wider economic effects which will change the level or rate of growth of the economy and, if so, how large these are is likely to be an empirical question the answer to which will be highly case dependent. In this section we look towards ways of limiting this complexity and producing some guidance on the evaluation of the way a given project may have an impact.

First, consider the objectives of a transport sector intervention. This can have a number of differing goals: as a means of correcting imperfections within the operation of transport sector; as a means of correcting imperfections due to the external environmental impacts of the transport sector, as a means of contributing to the overall growth of the economy (at national, regional or local level); as a means of redistributing economic activity between different groups (social inclusion) or regions (cohesion).

The analysis above suggests that transport sector interventions will be much more limited in their usefulness as instruments to achieve wider economic growth or redistribution objectives than transport sector efficiency and sustainability objectives. This suggests a limited role for transport interventions as a means of achieving policy objectives in these areas. However, there could be cases where transport interventions will have impacts which need to be taken into account. There is no general rule which implies that transport investments will necessarily enhance economic growth and improve cohesion and that interventions which aim to improve environmental sustainability by raising transport prices will necessarily harm economic welfare. In this sense transport growth and economic growth appear to be able to be decoupled, but this will require a case by case analysis to examine the sectoral and spatial distribution of market imperfections in transport-using sectors.

How should such an analysis be constructed? In an ideal world detailed regional input-output information would enable us to identify both the importance of transport in the value-added of each sector and the degree of deviation of that sector's prices from marginal costs as an indicator of the degree of imperfect competition (see Harris, 1999, Davies, 1999). Such information on a multi-regional basis would also enable identification of trade flows by sector, which could then be linked to traffic flow data and a link between the transport and wider economy models established. Such data is typically not available in most countries in sufficient detail although attempts have been made to build models which do allow for regional variations in input-output relationships to model the possible impacts of transport investments (see, for example, Rietveld, 1989; Jensen-Butler and Madsen, 1996). The problem with such an approach is that the standard input-output analysis assumes fixed Leontief technical coefficients when we need to examine how firms respond to changing effective transport prices through input substitution as well as output effects.

Computable general equilibrium modelling offers an approach which can deal with these factors more effectively, although typically at some greater remove from real data. Venables and Gasiorek (1999) use a computable general equilibrium model to explore the relationships discussed above and this approach has been widely used to explore the effects of changing international trade barriers (see for example, Gasiorek *et al*, 1991; Bröcker, 1998a) and increasingly to examine some of the more macroeconomic consequences of major European transport infrastructure investments (Bröcker, 1998b, c). The problem faced here is the data requirements to be able to apply such a model at a geographical scale below that for example explored by Bröcker. Calibration of the model requires correct identification of the relevant elasticities. This type of approach may, therefore, be employable only at the fairly aggregate macro-level to explore the wider effects of broad policy measures, and not at the local level to examine the impacts of individual investments or implementation of local policy. It may, however, give general guidance as to the sort of industrial or spatial structures at a regional or local level where imperfect competition could pose a significant problem,

A step by step approach is suggested. At the first stage the key issue is to identify the objective of an individual transport intervention. However, this is to assess the efficacy of the intervention in achieving its stated aim, not only projects which are claimed to have wider economic effects should be assessed against a fuller set of criteria than just the transport impacts. It is important to assess whether other projects may have wider impacts, including those which may have negative impacts on the wider economy.

Secondly, the spatial impact of the project has to be established. It is particularly important to ensure that all potentially affected regions or areas are included - too often studies are undertaken only for the immediate vicinity of a project (or for the government authority area which is responsible for the decision) and this will ignore the redistributive (two-way road) effects which the project may have.

Thirdly, the sectoral impact of the project has to be established. This is partly about traffic mix: freight or passenger, work or leisure travel etc., but also about which industries are affected; whether these are industries which have large transport costs relative to value-added and the price/cost margin in the sector. This establishes the extent to which a project may have wider impacts than just the measured transport benefits, those in columns 1 or 3 of Table 1.

It is important to note, however, that Table 1 is about the interaction between sectors, not about the definition of projects or areas. Projects or areas will typically be a weighted sum of a set of interactions which fall into different cells of Table 1. This weighting may in many cases be endogenous and thus change as a result of a project as sectors expand or contract or relocate in response to changes in transport provision, transport characteristics and competition within the sectors.

6. CONCLUSIONS

This paper has had the aim of summarising the arguments which can be used to link transport and economic growth and suggesting the elements of a conceptual model to address these issues. This is a complex and diverse area, which has suffered from misunderstanding on the nature of the relationships involved and a failure in policy terms to make the right linkages between policy instruments and policy objectives.

The main conclusion we can draw from this review is that conventional evaluation tools do run the risk of mis-estimating the total economic benefits from transport interventions of all types, but that these mis-estimates could be either over- or under-estimates of the true situation. Whilst there are cases where wider benefits can be identified than those which would be produced by a conventional transport cost-benefit analysis, there are also circumstances where this may not be the case, and even ones where the conventional approach may fail to identify real economic costs from an intervention.

For policy this has a number of important implications. First, much more care is needed to define the conditions surrounding a particular project, whether an investment or a traffic restraint or pricing measure, there is no general formula which can be applied. Secondly, it is equally clear that any intervention which enhances transport provision or its conditions of supply does not automatically guarantee an increase in economic growth and that any restraint measure does not automatically impede economic growth. It is just as possible that socially optimal pricing of transport increases efficiency and promotes reorganisation within the transport sector sufficiently to enhance the rate of economic growth as would the provision of additional infrastructure. Thirdly, whilst there is an argument that improving transport would tend to reduce the barriers behind which inefficiency and imperfect competition can be defended, it also seems likely that using transport alone to improve competition in the economy as a whole (particularly in a developed economy with a high level of transport provision) would be an expensive option.

NOTES

1. This paper is based heavily on discussions whilst the author was a member of the United Kingdom Standing Advisory Committee on Trunk Road Assessment and draws from its report *Transport and the Economy* (SACTRA, 1999). Interpretations in this paper are those of the author and should not be ascribed to the Committee or the Department of the Environment, Transport and the Regions. This paper was prepared whilst the author was Visiting Professor at The Institute of Transport Studies, University of Sydney, NSW, Australia, to whom he is grateful for the provision of facilities.

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2. For alternative models see, for example, Ford and Poret (1991), Lynde and Richmond (1993) and, at a regional level, Duffy-Deno and Eberts (1991), Holtz-Eakin (1993), Holtz-Eakin and Schwartz (1995), Holtz-Eakin and Lovely (1996), Hulten and Schwab (1991), Munnell (1990).

3. This figure is highly dependent on the assumptions made concerning demand elasticities and market power (price/cost margins), in comments on the Venables and Gasiorek work, Newbery (1999) and Davies (1999) have produced figures for the additional benefits of 2.5% and 12% respectively. Bröcker (1998c) finds a figure of 5-10% for a plausible range of values of price/cost margins.

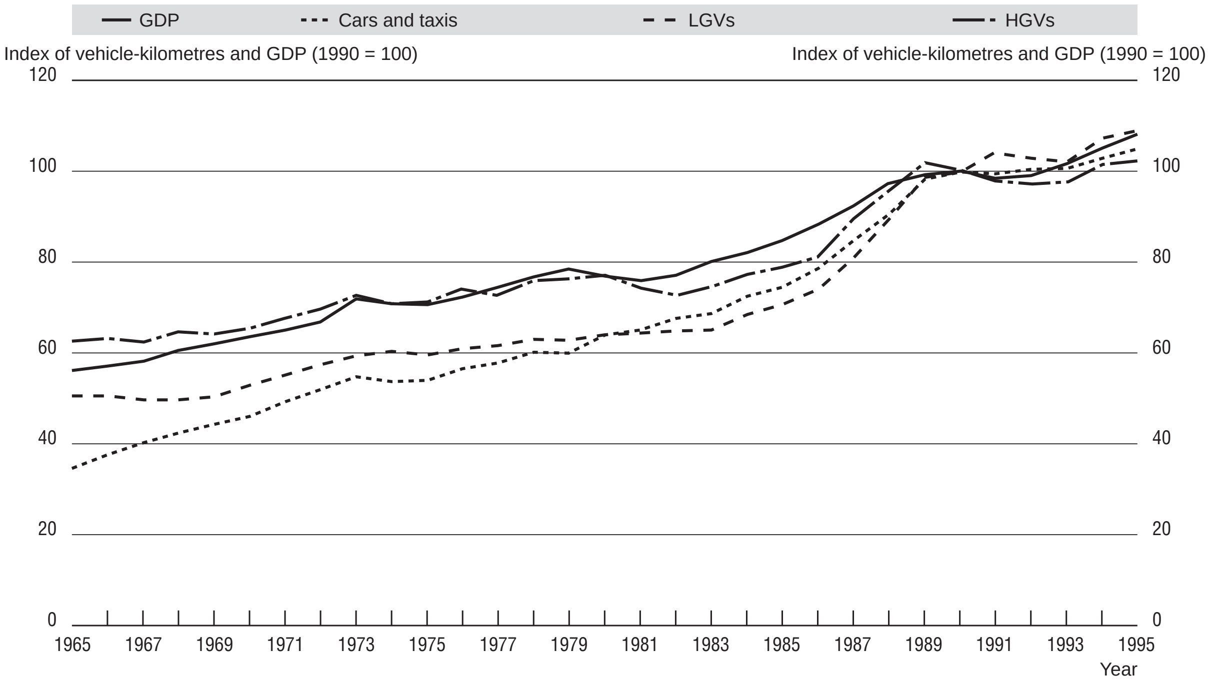
4. See Fujita *et al* (1999) for a full description.

Table 1. **The interaction of imperfect competition and external costs on the evaluation of transport projects**

	Transport-Using Sector		
Transport Sector	**p < mc (pmb > smb)** *subsidies*	**p = mc (pmb = smb)** *perfect competition*	**p > mc (pmb < smb)** *imperfect competition*
p < lrmsc *adverse externalities* *congestion* *user charges too low*	**Cell One: B < 1** Negative external effects exacerbated by overvalued output in transport-using sector; may be substantial benefits from reducing use	**Cell Two: B < 1** Traditional external effects case; no offset from transport- using sector; conventional CBA overestimates total economic benefits.	**Cell Three: B = ?** Transport and transport-using sector benefits are of opposite sign. CBA is appropriate in transport sector if adjusted to allow for externalities but not on implications of imperfect markets.
p = lrmsc *non externalities* *optimal capacity* *user charges correct*	**Cell Four: B < 1** Subsidy to transport-using sector means total economic benefits < transport benefits Conventional CBA overestimates the value of transport improvements.	**Cell Five: B = 1** No market failure. Economic benefits equal transport benefits; conventional CBA fully adequate.	**Cell Six: B > 1** Extra output in transport-using sector and job creation in assisted areas; total economic benefits exceed transport benefits.
p > lrmsc *positive externalities* *spare capacity* *user charges too high*	**Cell Seven: B = ?** Transport benefits and transport-using sector benefits are of opposite sign for conventional CBA. Indeterminate case.	**Cell Eight: B > 1** No market failure in transport-using sector; standard case for expanding transport usage by reducing user charges.	**Cell Nine: B > 1** Spare capacity in the transport sector and transport benefits understate total economic benefits; reduction in user charges may give big welfare gains.

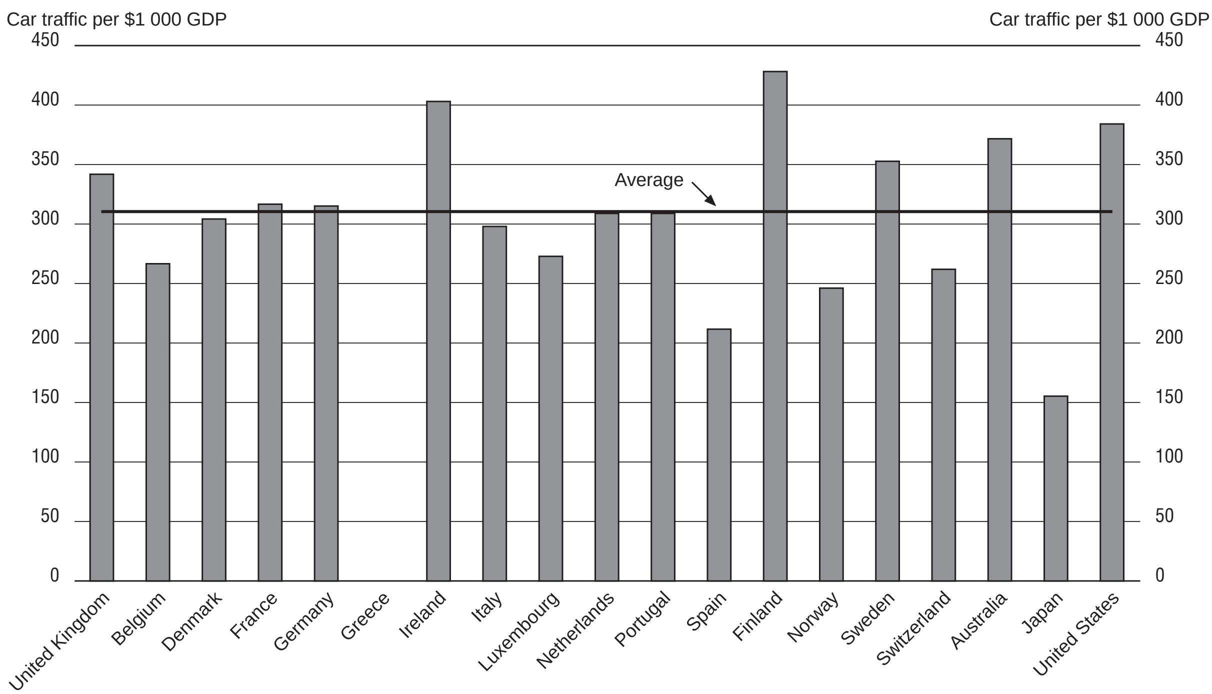
Note: **B** is expected value of total benefits relative to those measured by a conventional transport CBA.
Pmb = private marginal benefit; mc = marginal cost; smb = social marginal benefit; lrmsc = long run marginal social cost; p = price
Source: Amended from SACTRA (1999), Table 4.2.

Figure 1. **Road traffic and GDP: United Kingdom (1965-1995)**



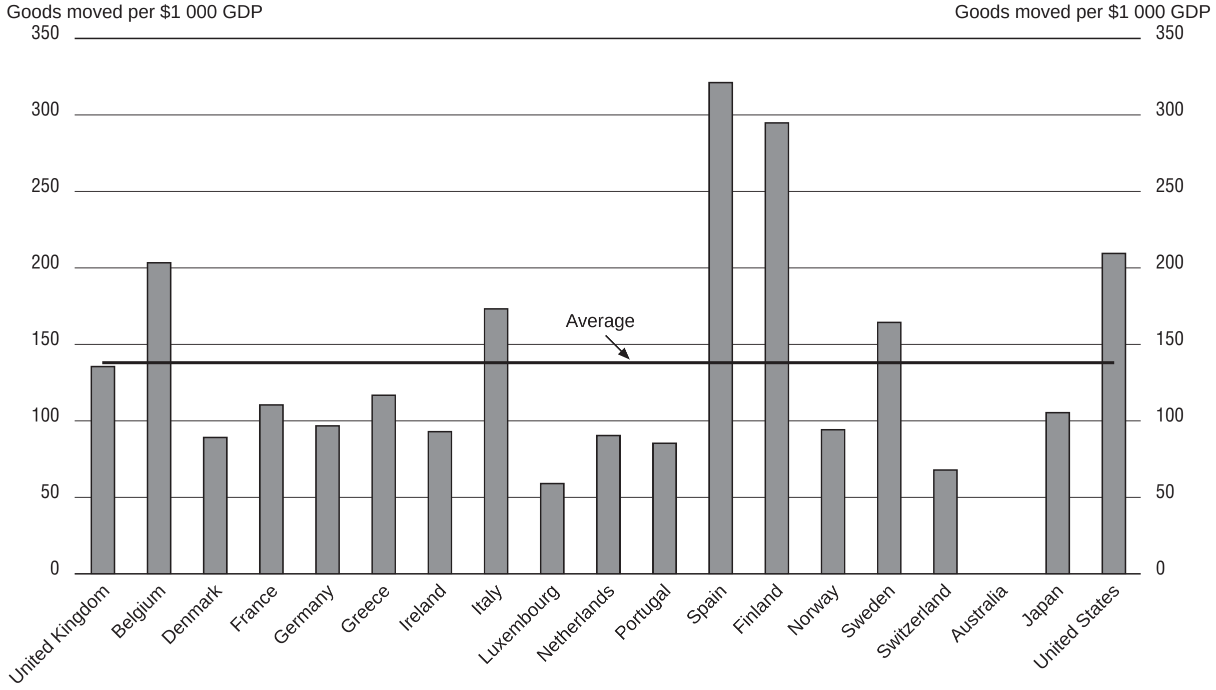
Source: Transport Statistics, Great Britain, 1997.

Figure 2. **Car traffic per $1 000 GDP (1994)**



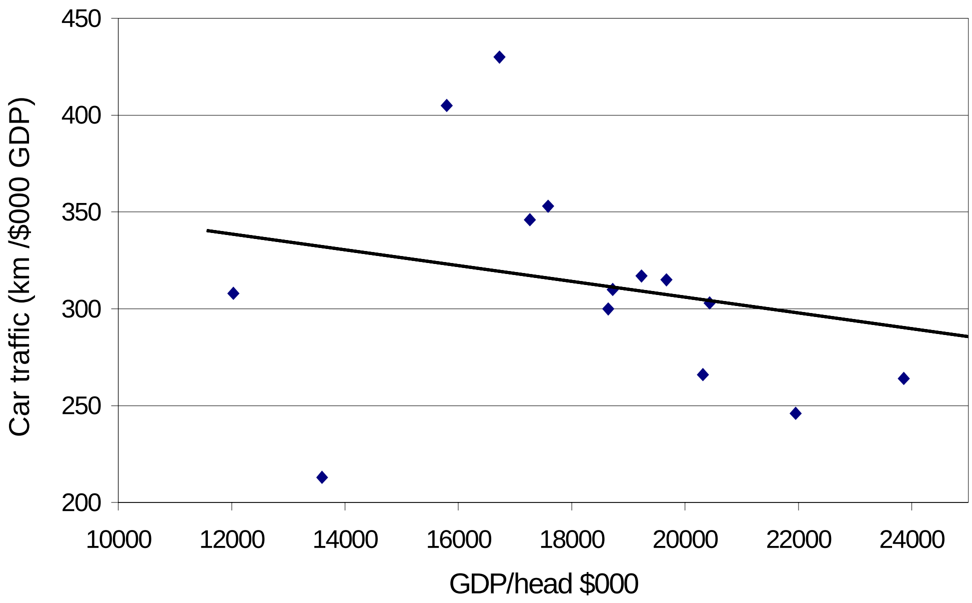
Source: National Road Traffic Forecast (GB) 1997, Transport Statistics, Great Britain, 1997.

Figure 3. **Goods moved per $1 000 GDP (1994)**



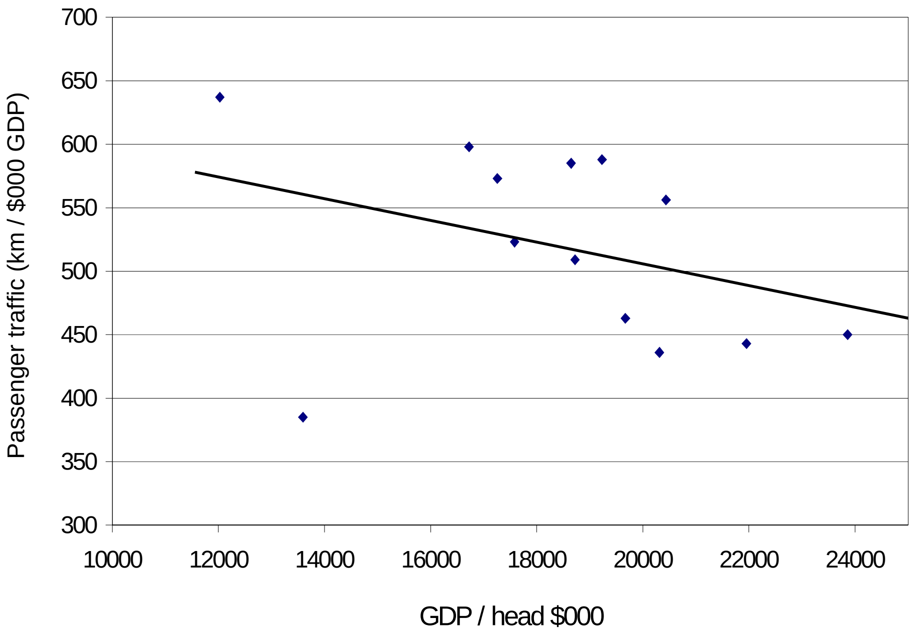
Source: National Road Traffic Forecast (GB) 1997, Transport Statistics, Great Britain, 1997.

Figure 4. **Car traffic intensity by GDP per capita**



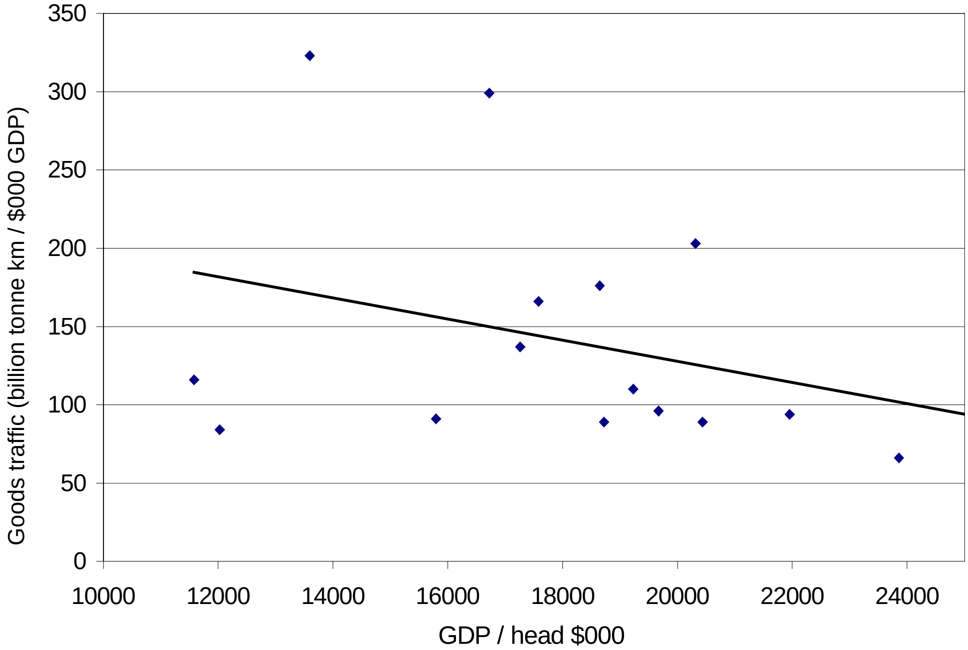
Source: National Road Traffic Forecast (GB) 1997, Transport Statistics Great Britain, 1997.

Figure 5. **All passenger traffic intensity by GDP per capita**



Source: National Road Traffic Forecast (GB) 1997, Transport Statistics Great Britain, 1997.

Figure 6. **Freight traffic intensity by GDP per capita**



Source: National Road Traffic Forecast (GB) 1997, Transport Statistics Great Britain, 1997.

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Annex 4

SIZE, SPRAWL, SPEED AND THE EFFICIENCY OF CITIES

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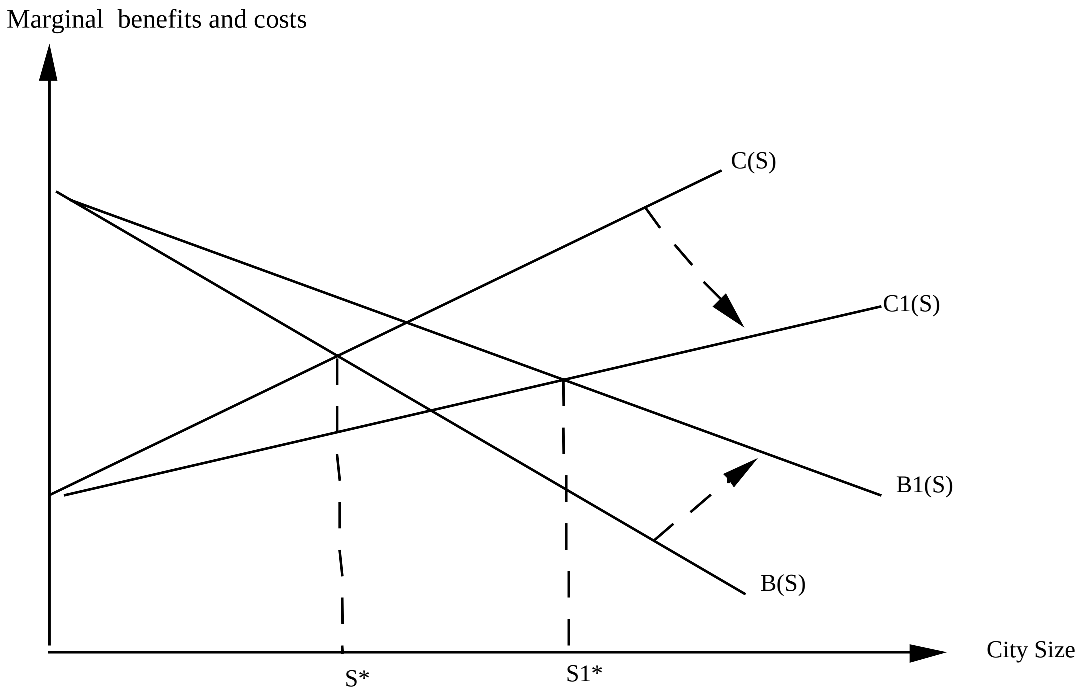
INTRODUCTION

Some cities are more efficient than other. Why? At a time when most people live and most activities take place in cities, identifying the determinants of the efficiency of cities is of importance not only for city planners, but for also for macro-economists. This paper considers three potential determinants of urban efficiency, the three « S »: the *size* of the city, the *speed* at which people and goods are moved in the city, and the *sprawl* or the relative location of jobs and homes in the city. It tries to measure the relative contribution of these three determinants. In this paper, efficiency is in general defined as labour productivity, that is output per worker. Total productivity would be a better indicator of efficiency, but data on total productivity of cities is difficult, not to say impossible, to obtain; in addition a study on the « surproductivity » of Paris relative to the rest of France (the ratio of Paris productivity to the productivity of the rest of France), in which total productivity was estimated, showed that labour surproductivity was a very good estimator of total surproductivity (Rousseau 1995).

The relationship between urban productivity and urban size has been recognized and studied for a long time. In a seminal contribution, Alonso (1971) developed a model that assumed that both benefits and costs increased with city size, with the benefit curve increasing less and less and the cost curve increasing more and more. It follows that there is a city size for which the difference between benefits and costs, also called the net benefit, is maximal, and which is the so-called optimal size of cities. In marginal terms, there is a downward sloping marginal benefit curve B(S) and an upward sloping marginal cost curve C(S): the point at which they intersect defines the optimal size S* of cities, as represented in Figure 1.

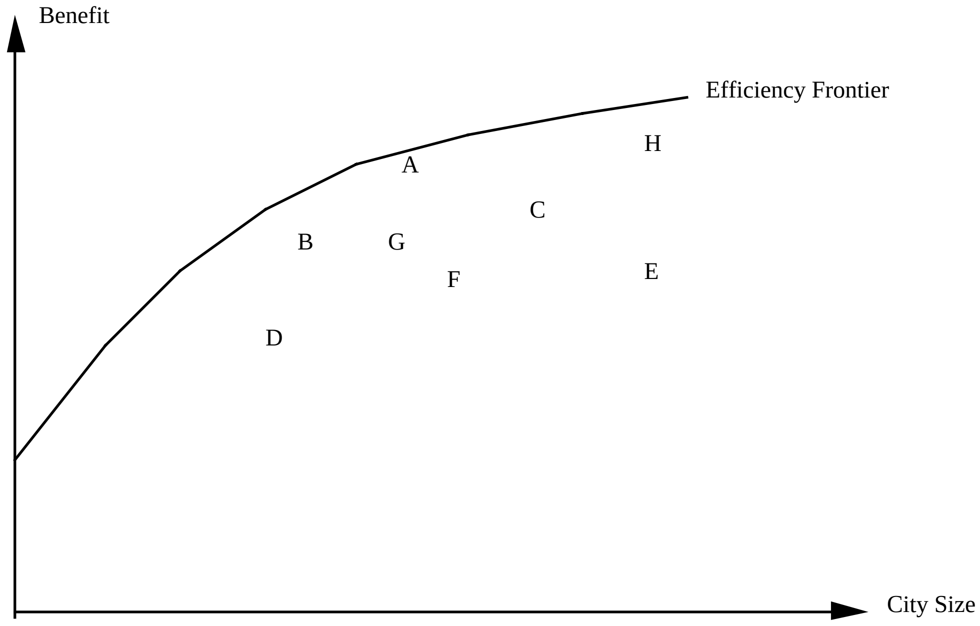
Figure 1. **Optimal city size as a function of city management**



This simple and elegant model had the great advantage of drawing attention to the obvious, but often forgotten, fact that larger cities have benefits as well as costs. But it ignored a key dimension: the management of cities, that modifies the benefit and cost curves. Not all cities are equally well managed. Tokyo, the largest world city, is probably not too large, because it is reasonably well managed. There are, in some parts of the world, cities of 200 000 people which are definitely too large, because they are very poorly managed. Good management can —and should— lower the marginal cost curve and turn it into C1(S) and raise the marginal benefit cost curve to B1(S). The intersection of these curves defines a new optimal size S1* much to the right of S*. Good management can therefore increase indefinitely the « optimal » size of a city.

Another way to tell the same story is to consider that the benefits associated with city size are only potential, that they are contingent upon the quality of management. City size would therefore define an efficiency frontier, with effective efficiency often significantly below this frontier, as suggested in Figure 2. The distance between a particular point (that is a city) and the frontier is a measure of the quality of its management.

Figure 2. **Urban efficiency as a function of city size**



One way to give some flesh to these rather abstract constructs is to identify mechanisms by which « management » can influence productivity. The hypothesis put forward here — and tested — is that the efficiency of the transport system (in short: speed) and the relative location of jobs and homes (in short: sprawl), which are the output of transport policies and urban policies respectively, combine with city size to determine the effective size of the labour market. This effective size of the labour market - the number of jobs that can, on average, be reached in less than t minutes - is in turn is a major explanation of labour productivity.

The first of these relationships is rather self evident. The closer people are from the jobs, all other things equal, the larger the effective labour market; similarly the higher the speed at which people go to their jobs, the larger the effective labour market; and the larger the city size, all other things constant, the larger the effective labour market.

The second relationship is also easy to understand. A larger effective labour market makes it easier for enterprises to find the skills they need, and for workers to find the jobs they want. What counts therefore is not only the size of the city, but the effective labour market size. In a small city, the effective labour market at let us say 40 minutes is about equal to the number of jobs/workers. Every worker can access all the jobs in less than 40 minutes. Not so in a large city. Many workers cannot access many of the city jobs in less than 60 minutes, and the effective size of the labour market is only a fraction of the total number of jobs/workers, a fraction that varies with transport and land use patterns, that is with urban management.

1.1 Measuring the effective labour market size

Let us consider an agglomeration divided in n zones labelled 1, 2, .. i, .. j, ... n. The larger the number of zones, the better. We have:

W_i = the number of workers located in zone i, with $\Sigma_i W_i = W$;
J_i = the number of jobs located in zone i, with $\Sigma_i J_i = J$;
T_{ij} = the time it takes to go from zone i to zone j;

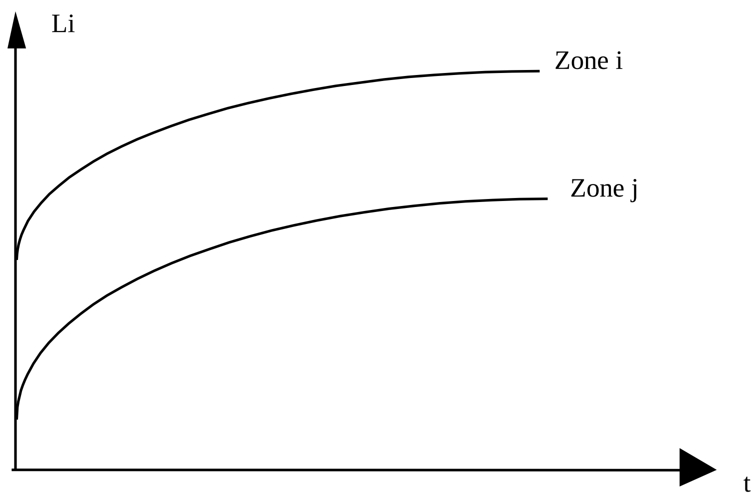
The effective size of the labour market at t minutes can be defined either from the viewpoint of workers or from the viewpoint of enterprises:

L(t) = the effective size of the labour market for workers (labourers);
E(t) = the effective size of the labour market for enterprises;
$L_i(t)$ = the effective size of the labour market for the workers of zone i.

For a given zone i, we have:

$$L_i(t) = \Sigma_i J_i \text{ for j such that Tij} < t$$

Figure 3. **Effective size of the labour market ($L_i(t)$) as a function of time (t) and zone (i)**



For a given agglomeration, $L_i(t)$ is a function of t, and varies with each zone i. To take an example, for a zone located in downtown Paris, $L_{center}(60)$ is equal to about 4 million jobs and $L_{center}(45)$ to 2.7 million, whereas for a zone located in the periphery at about 30km of the center, $L_{periph}(60)$ is about 2.9 million and $L_{periph}(45)$ only 1.2 million. This is illustrated in Figure 3, in which zone i is a centrally located zone whereas zone j is a peripherally located zone.

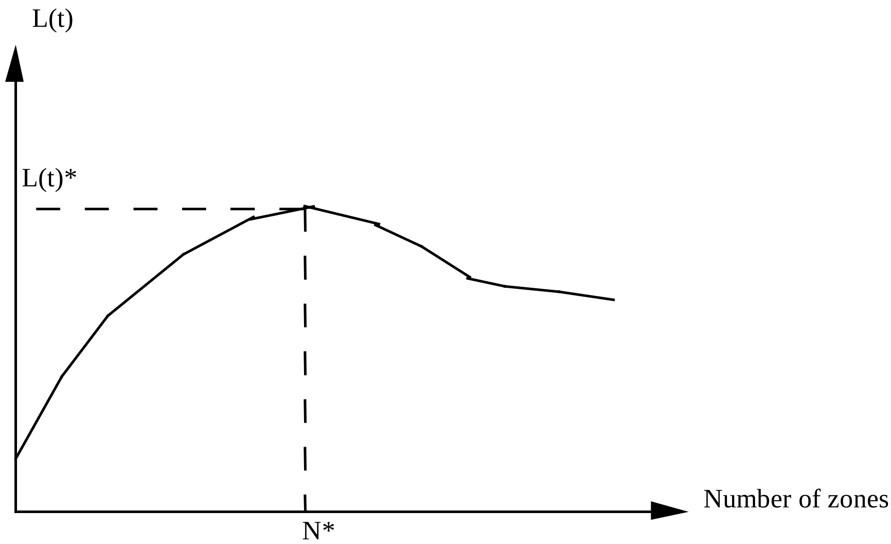
For the entire agglomeration, the effective size of the labour market is the weighted average of the labour market size of all zones, weighted by the relative number of workers in each zone:

$$L(t) = \Sigma_i L_i(t)*W_i/W$$

$$L(t) = \Sigma_i\Sigma_j J_i*W_i/W \text{ for j such that } T_{ij}<t$$

For a given travel time t, the effective size of the labour market is a function of the area considered or of the number of zones taken into consideration. However, it is interesting to note that this function has a maximum. When only a few zones are considered, the labour market size is bound to be small. As the number of zones increases, so does the labour market size. But there comes a time when increasing the area no longer increases the labour market size. This is because the labour market size of each of the peripheral zones which are added tends to be small, and to push the average down. One can therefore define the geographical size N* of the agglomeration for which the effective labour market size is maximized and equal to L*. This is represented in Figure 4.

Figure 4. **Effective size of the labour market as a function of area size**



To again take the example of Paris, for the entire agglomeration L(60), the effective size of the labour market at 60 minutes, is about 2.7 million jobs, whereas L(45) is about 1.2 million jobs. The largest effective size of the market at 60 minutes L(60)* is 3.1 million and for 45 minutes L(45)* it is 2 million.

Similar concepts, measures, and relations can be developed for E(t), the effective size of the labour market from the viewpoint of enterprises:

$$E_i(t) = \Sigma_j W_j \text{ with j such that } T_{ij} < t$$

$$E(t) = \Sigma_t E_i(t) * J_i / J$$

1.2 Relationship between productivity and labour market size

The hypothesis that the productivity of a city is a function of the effective labour market size of the city is supported by the few case studies that we have conducted on this topic. A first study compares three Korean cities: Seoul, Busan and Daegu. Table 1 presents the relevant data.

Table 1. **Productivity and effective size of the labour market, three Korean cities circa 1990**

	Population (in 1000)	Employment (in 1000)	L (60) (in 1000)	E (60) (in 1000)	Productivity (in 1000 won)
Seoul (1987)	16 792	5 697	2 911	3 165	13 984
Busan (1994)	4 187	1 762	1 361	1 352	10 588
Daegu (1987)	2 107	807	754	755	9 932

Notes:
L(60) = Effective size of the labour market at 60 minutes from the viewpoint of workers;
E(60)=Effective size of the labour market at 60 minutes from the viewpoint of enterprises; productivity numbers are for the same year 1992. Productivity is the output per worker.

The first two columns are mostly for reference. A comparison of the second with the third and fourth columns shows that in large cities, the effective size of a labour market is very different from the total number of jobs in the city. In Seoul, the average worker has in 60 minutes access to only 51% of all the jobs offered by the city; and the average enterprise has 56% of all the workers at less than 60 minutes. In a smaller city like Daegu, these percentages are much higher: 93%. What matters here for our purpose is the relationship between the last column, productivity (output per worker), and the two previous columns, effective size of the labour market. This relationship appears to be significant. We have:

$$\text{Ln Productivity} = \underset{(17.2)}{7.5} + \underset{(4.1)}{0.24}*\text{Ln L}(60) \qquad R2=0.97$$

Three points are not much to run a regression, and the coefficient 0.24, the elasticity of productivity with respect to L(60), the effective size of the labour market from the viewpoint of workers, must be taken with care. It suggests that a 10% increase in the labour market size is accompanied by a 2.4% increase in productivity and therefore in output.

A second study compares 22 French cities, excluding Paris, for which transport surveys were available, making it possible to calculate effective labour market sizes. The city productivity index utilized takes into account differences in the activity mix, by means of a sort of shift-share analysis, so as to retain « pure » estimates of output, and hence of productivities. To be more rigorous, let:

Y_k = output of city k;
$L_{s,k}$ = Labour force in sector s in city k;
L_s = Labour force in sector s in France ($L_s = \Sigma_k L_{s,k}$);
Y_s = Output of sector s in France;
$p_s = Y_s / L_s$ = productivity of sector s in France;
Y_k^* = Implicit output of city k ($Y_k^* = \Sigma_s L_{s,k} * p_s$);
p_k = pure or relative or adjusted productivity of city k ($p_k = Y_k / \Sigma_s L_{s,k} * p_s$)

The pure or relative productivity of a city k is equal to its actual output Y_k divided by its implicit output Y_k^*. The implicit output is defined as the output that would prevail in the city if labour productivity in each of the sectors of that city were that prevailing in the country as a whole. Take a city k. The structure of the labour force in that city is known. So is the output per worker in each of the sectors at the national level. One can figure out what the city output would be if the city productivity in each of the sectors was that prevailing at the national level. Let us assume it would be 100 mF. It turns out to be 120 mF, because city k is more reproductive than the average. Its relative labour productivity is then 1.2.

Table 2 presents the relationships established between productivity and labour market size.

Table 2. **Elasticities of productivity with respect to labour market size, 22 French cities, circa 1990**

Type of Labour Market	Elasticity	T values	Intercept	R2
From the viewpoint of workers				
At 20 minutes (L(20))	0.24	5.1	9.17	0.56
At 25 minutes (L(25))	0.18	4.5	9.76	0.50
At 30 minutes (L(30))	0.15	4.1	10.1	0.46
From the view point of enterprises				
At 20 minutes (E(20))	0.18	4.2	9.9	0.46
At 25 minutes (E(25))	0.15	4.1	10.1	0.46
At 30 minutes (E(30))	0.13	3.9	10.6	0.43

Note: Elasticity is the value of b in: Ln productivity = a + b*Ln labour market size.

The relationship seems quite robust. A larger size of the effective labour market size results in a higher productivity. The elasticities are greater for 20 minutes labour markets than for 25 or 30 minutes labour market. They are also greater for the labour market from the view point of workers. These elasticities vary from 0.13 to 0.24. An elasticity of 0.18 seems a reasonable order of magnitude. When the labour market size increases by 10%, productivity —and therefore output— increases by slightly less than 2%.

1.3 Measuring sprawl (D)

Our hypothesis is that the effective size of the labour market is a function of the geography of the area, that is the relative location of jobs and homes, in short its sprawl, and of the efficiency of the transport sector, the speed at which trips are made. These two concepts must be defined more precisely.

Sprawl is defined here as the average potential job-home distance. Let:

L_i, W_i, L, and W be defined as above;
d_{ij} = the Cartesian distance between zone i and zone j, in km;
DE_i = the potential job-home distance for the enterprises of zone i, in km;
DL_i= the potential home-job distance for the workers of zone i, in km;
D = the potential job-home (or home-job) distance for the agglomeration, in km.

We have:

$$DE_i = \Sigma_j d_{ij} * L_j / L$$

which is the average distance to workers for the enterprises of zone i weighted by the number of potential workers in each zone j. DE_i varies with the zone considered, and it is an increasing function of the distance of zone i to the centre. In the case of Paris, for instance, it is 7.3 km for the central zones, and over 70 km for the peripheral zones.

We then have:

$$D = \Sigma_i DE_i * W_i / W$$

$$D = \Sigma_i \Sigma_j d_{ij} * L_j * W_i / L * W$$

DL_i can be defined in the same way, and it can be shown that

$$\Sigma_i DL_i = \Sigma_i DE_i = D$$

In the sample of French cities for which this indicator was calculated, the average potential job-home distance is 6.4 km. It is of course larger than the average effective job-home distance, which is 3.3 km, because people do not take jobs randomly but chose jobs closer to their home, all other things equal. There are great variations between cities, even between cities of a similar population size. D varies from 3.3 km in Amiens to 11 km in Lille. Valenciennes and Grenoble have about similar population sizes (around 340 000 inh.), but D is 9.7 in Valenciennes and only 5.0 in Grenoble. In the case of Paris, D is equal to 23.0 km and the effective job-home distance to 9.8 km.

Other indicators of "sprawl", such as density gradients of population or employment, could be defined and utilized. We preferred our "potential job-home" concept, however, for two reasons. One is that it does not imply any hypothesis on the shape of the city. The other is that it lends itself more readily to the analysis undertaken.

1.4 Measuring speed (V)

The efficiency of the transport system in a city is defined as the average speed at which people go from origin to destination in that city. Transport surveys record the time Tij it takes to go from zone i to zone j. The distance dij between zone i and zone j is the Cartesian distance, as the crow flies. Not all pairs of (i,j) are documented, but a sufficiently large number is, since the number of households surveyed is usually in the thousands, and reaches 20,000 in the case of Paris. Speed V is therefore:

$$V = \Sigma_{ij} d_{ij} / \Sigma_{ij} T_{ij}$$

The speed thus defined is not the speed at which people actually drive their cars or ride buses, for two reasons. It takes into account the availability of roads and bridges as well as the topography of the area. A new bridge over a river, that shortens the actual distance travelled, even if actual speeds in the city are not modified, will increase the value of V. Then, the time Tij used is the total time it takes to go form origin to destination, including access time to an from a car or to and from a transit terminal.

Speed thus defined was calculated for our sample of 22 French cities, and for Paris, by mode (car, transit), by areas (downtown, rest of the area) and by trip purpose (work, non work). The main findings are presented in Table 3.

Table 3. **Transport speeds in France circa 1990**

	Paris (km/hour)	**23 French cities (km/hour)**
All trips	13.9	13.2
Private cars trips	16.3	15.3
Transit trips	11.6	8.5
Downtown trips	6.5	6.3
Journey to work trips		14.4
Other purposes trips		12.7
Peak-hour trips		13.1
Off-peak hour trips		13.2

Note: Speed is defined as distance as the crow flies divided by total time of transportation, including access time.

The average speed appears to be 13.2 km/hour for the 22 French cities, and slightly faster for Paris (13.9). Speed is nearly twice as high for private car transportation (15.3) than for transit (8.46), particularly in the case of Paris. It is much smaller for downtown transport (6.3) than for the entire agglomeration (13.2). Surprisingly enough, speed is higher for journey-to-work trips than for other purposes trips, and also for peak-hour trips. The explanation of this apparent paradox is twofold. First, the share of the faster mode (the car) is larger in journey-to-work trips. Second, journey-to-work trips are longer, and as a consequence faster, than trips undertaken for other purposes. The same observations apply to the comparison of peak and off-peak trips, which are carried out at about the same speed.

Average speed varies from city to city, and as a function of city size. Except for the three largest French cities (Lyons, Marseilles and Lille), speed increases with the size of the agglomeration, probably because longer, and faster, trips weight more in larger agglomerations.

1.5 Explaining the effective size of the labour market

For an agglomeration of a given size (S), the effective size of the labour market (E or L) will be negatively affected by sprawl (D) and positively affected by speed (V):

$$E \text{ (or } L) = f(S, D, V)$$

Table 4 presents the coefficients of the regression analysis conducted for L(25) and E(25).

Table 4. **Coefficients of regression analysis explaining efficiency by size, sprawl and speed 22 French cities, Circa 1990**

Dependent Variable	Intercept	Size (S)	Sprawl (D)	Speed (V)	R2	Form
(1) L(25)	-91.0 (-2.9)	0.202 (9.3)	-16.87 (-4.32)	16.04 (4.67)	0.89	Linear
(2) E(25)	-42.5 (-1.31)	0.183 (8.22)	-15.00 (-3.73)	12.36 (3.46)	0.86	Linear
(3) L(25)	-4.29 (-2.29)	1.07 (8.30)	-1.17 (-3.75)	1.79	0.88	Log-Log
(4) E(25)	-2.86 (-2.29)	0.97 (8.27)	-1.12 (-3.93)	1.46 (2.90)	0.87	Log-Log

Notes : L(25) is the effective labour size of the labour market at 25 minutes from the view point of workers; R(25) is the same concept from the view point of enterprises; Size is the population of the agglomerations, in 1,000; Sprawl is the average potential job-home distance; speed is the average speed as defined in the text; number in parentheses are the T values.

The model explains fairly well the labour market size, both in its linear form and in its exponential form. R2 are high, all explanatory variables are highly significant and of the expected signs. Four points stand out.

The elasticities of labour market size to population is close to 1. This is to be expected. When the size of a city increases by 10%, the effective size of the labour market also increases by about 10%. The 0.20 or 0.18 coefficients of the linear regressions (1) and (2) can be interpreted as activity ratios. When the city size increases by 100 persons, the labour market increases by about 20 jobs and 18 workers within 25 minutes.

The elasticities of labour market size with respect to sprawl are -1.12 and -1.17. When the average potential job-home distance increases by 10%, the effective size of the labour market decreases by about 11.5%. What equations (1) and (2) tells us is that when the job-home distance increases by one km, the size of the labour market at 25 minutes is reduced by about 16 000 jobs, all other things equal.

The elasticities of labour market size with respect to average transport speed are 1.46 and 1.79. This means that a 10% increase in average speed, all other things constant, leads to a 15-18% increase in the labour market size.

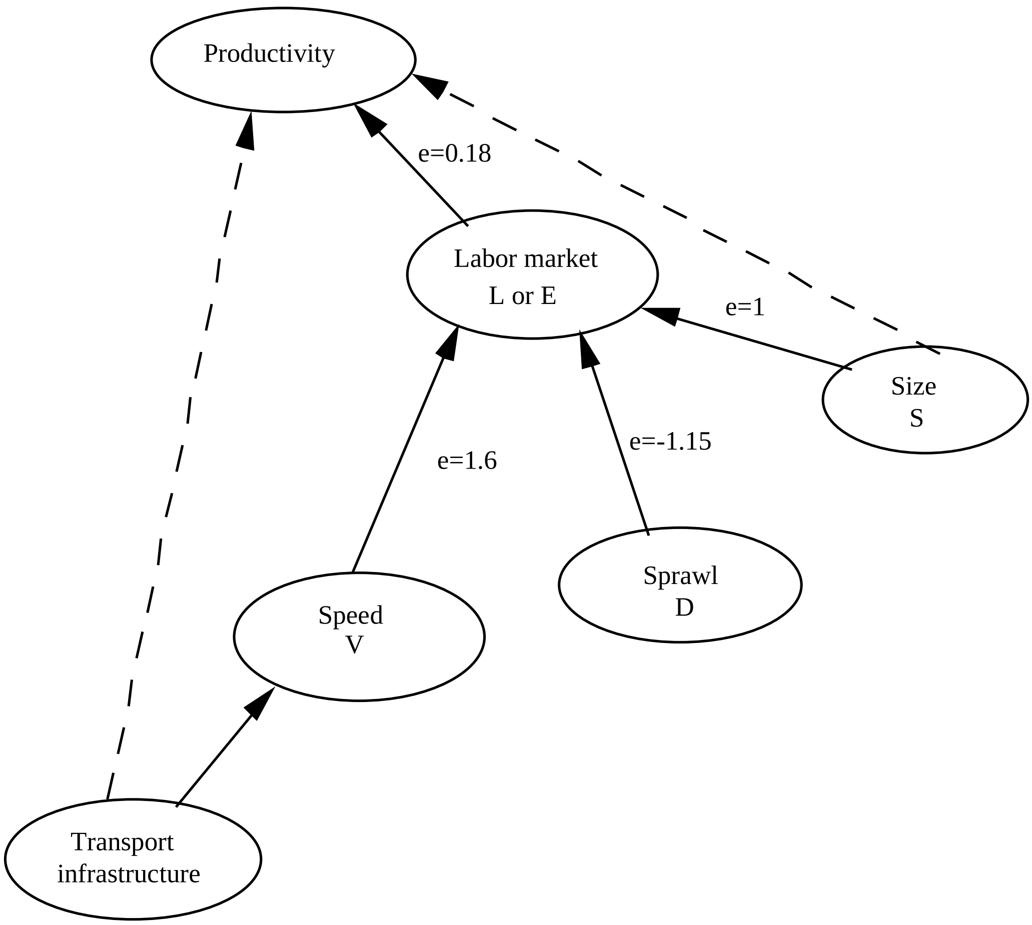
It also appears that the labour market from the view point of workers is more elastic to size, sprawl or speed than the labour market from the view point of enterprises. This is probably because workers homes are more dispersed than enterprises. It means that workers tend to gain more than enterprises when a city grows, when sprawl is contained and when transport improvements are made.

Regressions not reported in Table 4 also suggest that elasticities are more important when the labour market is defined at 20 minutes than when it is defined at 25 minutes or at 30 minutes.

2. CONCLUSION

The - admittedly limited - data supports the theory that the efficiency of a city is a function of the effective size of its labour market, and that this labour market size is itself a function of the overall size of the city, but also of its sprawl and of the speed at which trips in the city are made. Elasticities reflecting these relationships have been produced. They are shown in Figure 5.

Figure 5 . **Efficiency of cities**



The findings of the econometric analysis conducted on 22 French cities are very much in line with the non econometric conclusions of a comparison of Paris and London (CEBR & OEIL, 1997) with which the authors were associated. Such a comparison is delicate because it is relatively easy to tell where the Paris agglomeration ends, but difficult to find out where the London agglomeration ends. The study showed that, by and large, Paris is more productive than London, or more precisely that the ratio of Paris productivity to France productivity is greater than the ratio of London productivity to the UK productivity. This is associated with, and according to us explained by, a much larger effective labour market size in Paris. This in turn is explained by the fact that London is at the same time more widespread and less transport-efficient than Paris. Our indicator for sprawl (or any indicator of sprawl for that matter) is much larger for London than for Paris. Transport speed is greater in Paris than in London. The latter is explained by the marked difference in transport infrastructure spending patterns over the past decades: Paris has invested much more than London, in public transportation and even more so perhaps in roads.

Let us assume that speed, the efficiency of the transport system, is, at least in part, explained by the transportation infrastructure endowment of cities. The dotted lines of Figure 5 refer to the fairly traditional analysis relating infrastructure endowment and productivity, for one, or city size and productivity, for the other. These traditional relationships, which are strong and well established, have been criticised for their « black box » nature. What we have done has been to lift the top of the black box, and to have a look at what is inside.

We found that, as could easily be expected, urban policies and transport policies play a significant and measurable role in determining the efficiency of an agglomeration. Containing sprawl, and improving transportation speed in a city both increase the productivity and therefore the output of the city. One can even estimate the magnitude of this contribution. Increasing speed in a city by 10% increases productivity by 2.9%. This finding is established on a cross-section analysis. Its extrapolation for time-series analysis is not fully warranted. But it is established all other things constant and what happens over space probably gives us an idea of what happens over time. Assuming this, if we could know by how much a given transport investment increases transport speed, we could use this relationship to estimate the rate of return of the investment.

This can be attempted on the case of Paris. In another paper (Prud'homme, 1998), we estimated that transport investments undertaken in the Paris area over the 1983-91 period, for an (after tax) amount of 45 billion francs, increased traffic speed by about 5%, relative to what would have happened in the absence of such investments. If we use this 0.29 elasticity, this means that productivity and output in Paris was increased by about 1.44% as a result of transport investments. This represents an increase in output of about 29 billion francs, which would translate into a 64% immediate rate of return[1]. This is a very high rate indeed, although one which is in line with some of the estimates produced by cost-benefit analysis of transport projects in the Paris region and also by some of the estimates produced by production function analysis. It could also be that the elasticities calculated on the basis of 22 French cities (excluding Paris) cannot easily be extrapolated to the case of Paris, which is much larger that these cities.

This analysis could be refined and expanded. More such studies would required to find out whether the elasticites put forward are sufficiently robust. One could also take into account the size of « activity market », in addition to the labour market, defined as the number of jobs which can be accessed in less than t minutes from the viewpoint of enterprises, to reflect the fact that the ease with which enterprises deal with each other can contribute to productivity. This activity market size would be explained by the efficiency of the transport system (the speed) and by the job-to-job potential distance. One could also differentiate between types of jobs, and identify, then study, different labour markets and their sizes. One could also replace the rather crude concept of a labour market at t minutes by more sophisticated indicators of accessibility. Finally, one could, and should, explore the relationship that exists between speed and sprawl.

Note

1. The immediate rate of return of an investment I producing a yearly benefit B during the first year is defined as B/I. Under reasonable assumptions (about the rate at which B increases over time), the immediate rate of return can be shown not to be very different from the standard internal rate of return, the rate that equalizes the discounted flows of investments and of benefits.

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Annex 5

EXTERNAL COSTS AND EXTERNAL BENEFITS

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In order to harmonise conditions for competition between the transport modes, it is necessary to internalize external costs (emissions, noise, and accidents). Such an internalization strategy leads to the true costs of the transport modes. That means for freight transport that road freight transport will loose market shares in favour of rail and inland navigation. In passenger transport there will be increasing markets share for rail and urban public transport. However, despite numerous empirical studies (Infras/IWW, 1995; European Commission, 1995; CEMT, 1998), there are up to now no practicable estimations of the external costs. Disputed is above all, which costs are already internalized. Obviously, parts of the insurance payments of the road users are already internalized. Likewise, parts of the emission costs are also internalized. The reason therefore is that the road users, which cause these externalities, are at the same time victims. External costs exist only for third parties, which are definitely not road users. Furthermore, it is unclear to what extent external costs are only caused because of insufficient provision of road infrastructure by the government. Hence, the government itself is a responsible party for the external costs of road traffic.

Newer studies made attentive that traffic produces not only external costs, but also external benefits (Baum, Behnke, 1997; Baum *et al.*, 1998). The benefits of transport activities are for example increases of productivity caused by an intensified division of labour, market extensions and market exploitations, increased technical and economic knowledge by spatial division of labour, exploitation of new resources and materials, accelerations of structural change, increased competitiveness in international trade.

It is controversial, how these benefits have to be considered for determining the overall optimal mobility of the economy. The crucial question is whether the external costs must be balanced with the external benefits. Especially, if the external benefits are larger than the external costs, it must be clarified whether in such case subsidies have to be paid. Partly it is argued that transport activities create economic benefits, but these benefits would be internalized by the price and market system (Rothengatter, 1994; Hanson, Markham, 1992; European Commission, 1995). Therefore, the benefits have found their incidence and they are irrelevant for the decisions of the transportation policy. Otherwise, analyses of market interdependencies in modern economics reveal that parts of the benefits are not only passed by markets but also by other kinds of real transfer-mechanism and these benefits are definitely externalities (Laffont, 1987; Schulz, 1996; Greenwald, Stiglitz, 1988).

Technological external benefits, which are not passed by market mechanism, arise in following situations:

- A firm opens up an export market. With that, the foreign market is opened for the domestic industries. The opening of the export market is only possible even if the exports are transported. Therefore, a part of the benefits, which are caused by the opening of the export market, must be taken into account to traffic.
- Because of the spatial mobility of workers, it is possible for a firm to hire employees with higher qualifications. Their higher productivity increases also the efficiency of other enterprises.
- Economies of scale can only be reached, if the spatial extension of markets is enabled by transport performances. External benefits occur, if the market size reaches a certain dimension so that for the manufacturers of other goods new manufacturing technologies become profitable.

- The agglomeration of economical activities creates technological externalities. Agglomerations are only possible as a result of the markets developed by traffic; otherwise, production sites would have to be distributed spatially according to the demand.
- Wealth and growth depend essentially on the scale, direction, and availability of technological knowledge. The origin and destination of innovations are determined by, among others, the traffic and communication options of an economy. Innovations create technical knowledge, which can be used by others without paying the innovator. Technical knowledge is therefore combined with the externalities in a non-market exchange relation.

These examples show that the external benefits of traffic do exist. The "new growth theory" developed in the USA concludes that such positive externalities, which are provided virtually free of charge for the economic system, are the actual motor of growth and wealth of society (Habakkuk, 1962; Binswanger, David, 1974; Lucas, 1988; Romer, 1990). Since such positive effects in many cases can occur only when traffic services are possible, at least a part of the external benefits have to be assigned to traffic.

So far, however, valid estimations of the external benefits are still missing. First estimations attempts, which use the "growth account approach", exist for Germany (Baum, 1998).

Due to statistic investigations in the period from 1950 to 1990 it is estimated that the overall economic benefits (that means external and internal benefits) of traffic make 49% out of the increase of the overall growth of national income (= 776 billion DM of the growth of 1600 billion DM from 1950 to 1990). Road transport is responsible for more than the half of this increase (26.1% = 415 billion DM). The share of the external benefits becomes estimated on 50% (=191 billion DM).

This estimation approach is a first model of benefit quantification, which has to be substantiated by further research studies. After confronting costs and benefits, it is necessary to balance the external costs with the external benefits and then to prove if there is any justification for internalizing external costs.

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Annex 6

THE NEW GUIDE TO ASSESS ROAD INVESTMENT PROJECTS

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The French Ministry of transport published on 20 October 1998 a new guideline to assess the road investment projects in inter-city areas from an economic point of view. This guideline is a transportation planning method implemented to optimise the choice of investment.

With regard to the previous guideline, this one proposes undertaking the economic assessment on two different topics:

- an appraisal of effects in monetary terms
- an appraisal of effects that cannot be valued in monetary terms.

To determine the effects in monetary terms, a cost benefit analysis is implemented. But the originality of this guideline is that the economic consequences on other modes of transport are estimated especially when a motorway is expected to compete with a railway line. Furthermore, some environmental effects are assessed in monetary terms, particularly the impact of road projects on noise, air pollution and green house effect.

However, the above approach does not include the spatial distribution of the economic effects. Therefore, an appraisal of the consequences of the projects on the regions is carried out. This non-monetary approach attempts to estimate the impact of the project on employment during construction and operation. Moreover, the effects of the project on changes of accessibility are calculated for each area newly served. The indicator used enables estimation of the change of market size on companies generated by a new road.

An approach is also proposed to assess the consequences of the new road on the intensification of competition between companies due to accessibility gains which bring markets closer.

1. MONETARY EFFECTS

1.1 Collective surplus criterion

Transport facilities are considered as public property. In this respect they can be used simultaneously by several economic agents. Once they are made available to one agent, they are in fact available to all agents. The property cannot be transferred or divided as no one may appropriate it. It is also noted that consumption of one additional unit of this property by one agent does not reduce consumption and does not create any additional cost for the other agents as long as one is below capacity limits.

In economic terms, this means a zero marginal cost. On the other hand when the capacity limits are reached any additional consumer gives rise to a cost increase and limit consumption of the other agents. In the area of roads, the congestion phenomenon illustrates the fact that road use by one individual can influence the satisfaction level of another individual. Consequently, an external factor intervenes, i.e. use of the public property by an economic agent modifies the satisfaction level of other economic agents. This is why when trying to evaluate the collective interest of a public property and road investment in particular, one must take into account the varied levels of satisfaction of all the economic agents (users, State, transport systems operators, residents).

1.1.1 Evaluation of the surplus for the community

The surplus for the community is equal to the sum of the surplus of each agent concerned by the project. This entails users, State, road concessionary companies, operators of other modes of transport and residents.

Benefits for the users

When the level of the road supply is improved, the users are the first to benefit as driving costs will decrease. Driving costs include expenditure on petrol, tolls, vehicle wear and tear, travel time, uncomfort.

$C = m + t.H + i.L$ with:

C	:	driving cost
m	:	expenditure on petrol, tolls, vehicle wear and tear
t	:	travel time
H	:	value of time
i	:	surcharge of uncomfort
L	:	journey length

It is assumed that all users have identical driving costs. If driving conditions are improved, driving costs will decrease and the number of users will tend to increase and vice versa.

The variation in surplus for users is evaluated approximately at:

$$A = No\,(Co - C1) + (N1 - No)\,\frac{(Co - C1)}{2}$$

No (Co-C1) represents the advantage for users using the road prior to improving the route

$(N1 - No)\,\frac{(Co - C1)}{2}$ represents the benefit for new users who were not previously travelling and who, in view of the reduction of driving costs, travel more or have switched from other modes of transport. These new users constitute generated traffic and the advantage for them is taken as equal to half of the difference in driving costs.

Benefits for the state

The benefits considered by the users and on the basis of which they make decisions must be corrected to take into account satisfying specific State needs. For instance, the benefit obtained for users by the project must be:

- reduced by taxes on petrol and possible toll costs which are in fact transfers;
- increased by the collective cost of accidents.

In fact, it is evident that although the user integrates in his behaviour, to an certain extent, a subjective value allocated to safety, firstly, he will not, as a road user, fully bear the State expenditure in terms of health and secondly the price of human life can only be determined by a collective social evaluation.

Benefit for the road concessionary company

If the infrastructure is conceded to an operator (private or public company) the latter is responsible for all or part of the investment expenditure in the form of a loan and/or contribution in equity and expected future flows of revenue obtained from toll income after deduction of maintenance and operating costs.

Consequences for operators of other modes of transport

As it is a matter of inter-city links, one should reason in terms of competition between different modes. Initially, competition can be assessed on the basis of respective travel times of the different modes when the latter are more or less equivalent. However, this is just one element of choice made by the users whereby other features of their journeys are considered such as lack of comfort, safety, price, frequency, interruption of service which should be taken into account in the evaluation process when deemed relevant.

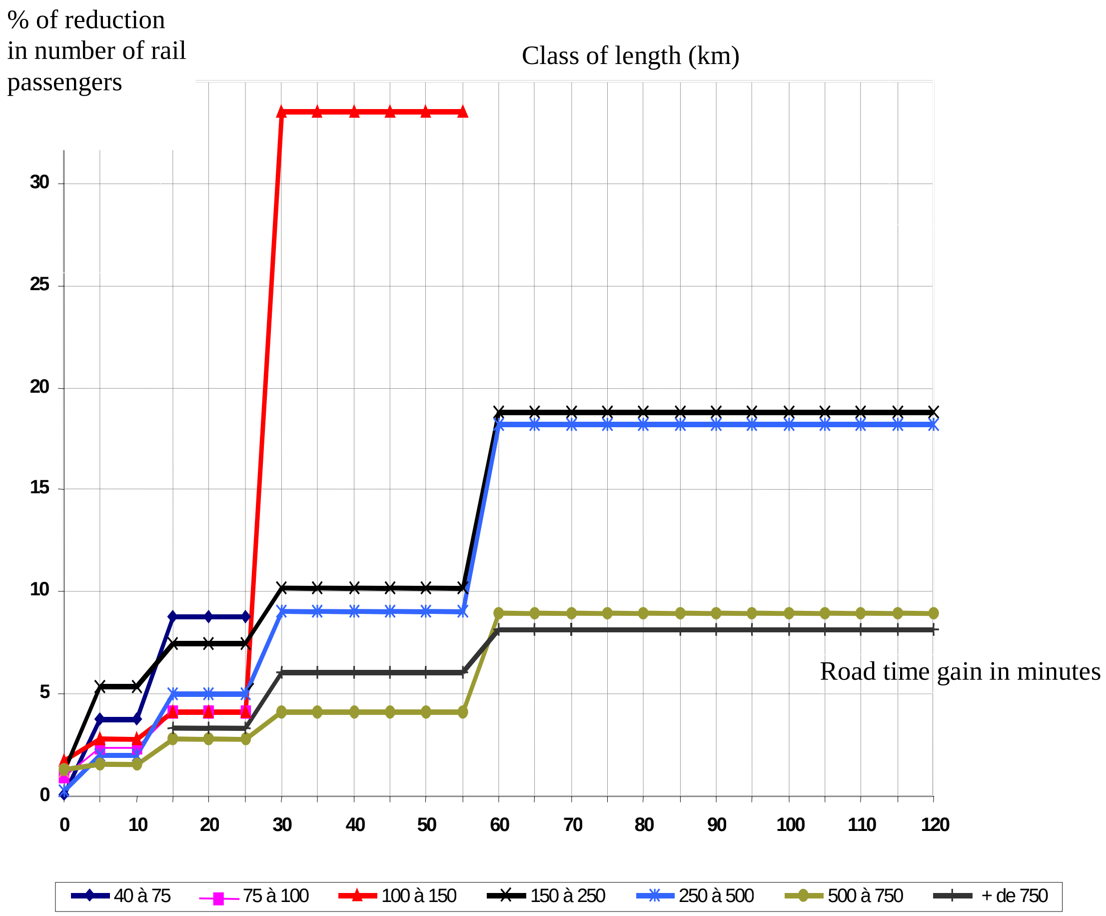
But road projects can also be associated with other modes of transport (road accesses governing the performance of combined transport platforms, access to TGV station terminals or airports, for instance).

It was noted that an improvement in rail transport had little effect in terms of volume of road traffic diverted (e.g. 3 to 5% of traffic from the A6 motorway was diverted to the South East TGV) but the effect was more noticeable in terms of toll income with respect to long journeys.

Diversion of rail traffic

The elements in the graphic below, established with the MATISSE model developed by I.N.R.E.T.S provides an initial idea of rail traffic losses possible on links greater than 40 kilometres as a function of road time gains and length of flows.

Effect on rail traffic of road and motorway improvements by classes of origin-destination links



Financial repercussions on the rail mode

This is restricted to the evaluation of variations in net income from rail transport within the framework of construction of a motorway or major road development.

For one-year t, the variation in net income is expressed as follows:

$\Delta R = N_f * (C_{marg\ t} - R_t)$ where:

Nf: number of users who switched from rail to road

C_{marg} : marginal cost of maintenance and operation per user for the rail operator

Rt: average income per passenger for the rail operator (including any compensations), corresponding to each line in competition.

(year 94, in Francs 94 in passenger-km)	**Main lines**	**TER Regional lines**	**All**
Unit sales income	0.41	0.51	0.43
Unit price compensations	0.06	0.15	0.07
Average unit income	0.47	0.66	0.49

1.1.2 Global net benefit provided by project

$$S = No\ (Co - C1) + (N1 - No)\ \frac{(Co - C1)}{2} + \Delta P + \Delta X + \Delta S + \Delta R + \Delta E$$

ΔP : variation in amount from tolls possibly collected
ΔX : variation in amount of taxes on petrol
ΔS : variation in cost of accidents.
ΔR : variation in net income excluding tax from rail transport
ΔE : maintenance and operating costs excluding tax

1.1.3 Costs of project

Project costs are considered to include expenditure on design, land acquisition, major repair work but also maintenance and operation.

Estimation of project

This refers to total cost including tax in current French Francs for the year in which the development plan is presented as shown in administrative documents at the different stages of the project

Investment cost of the project

This is current value sum of expenditure including tax for design, land acquisition, works including subsequent additional improvements and major repairs. This cost C is calculated in Francs 1994 according to the forecast scheduling of the different expenses and discounted to value in the last year of works or the year prior to start-up.

$$\mathbf{C = D + R}$$

$$\mathbf{D} = \sum_{t=1}^{n} D_{\mathbf{t}}\ \mathbf{(1 + i)^{n-t}}$$ D: cost of construction discounted

$$\mathbf{R} = \sum_{t=1}^{\infty} \frac{R_t}{(1+i)^t}$$ R: cost of major repairs discounted

D_t : construction costs planned for year t

i : Discount rate by the “*Commissariat Général du Plan*” (French Planning Authority).
n : Number of years for design phase, land acquisition and works.
R_t : Costs of major repairs at year t.

Operating and maintenance costs

Annual operating and maintenance costs are evaluated according to indications in appendix 1. The sum of these costs is discounted according to the following equation:

$$\mathbf{E} = \sum_{t=1}^{\infty} \frac{e_t}{(1+i)^t}$$

e_t: operating and maintenance costs at year t.

1.1.4 Evaluation of benefits

Types of benefits

Benefits for which prices exist in the market

The value of these benefits is determined directly by market prices. Naturally, there is no problem assessing the monetary value of these advantages. For the users, they are vehicle-running costs: wear and tear, maintenance, petrol, possible tolls. For the State and concessionary companies, these advantages are specific taxes on petrol and toll income.

Benefits for which prices can be imputed from quasi observations

On the other hand, non-commercial benefits are benefits which cannot be directly translated by a market price: gains in time, safety, variation in convenience as perceived by the users. In order to be able to compare them with previous benefits, these terms are expressed in monetary terms by means of unit values of accidents, time and convenience.

Evaluations adopted

Safety value: cost of human life

The method used to determine the cost of human life is that of human capital. An attempt is made to determine the cost to the community of the loss of a human life. Several elements are considered:

Commercial elements:

- net loss of production borne by the community following the death of an individual. Every individual generates material or moral wealth. Their disappearance results in a loss of earnings for the community.
- direct losses linked to medical expenses (first aid, emergency care) general expenses incurred by police, justice, insurance, cost of material damage (vehicles, public property) and transportation costs.

Non commercial elements:

This entails assessment of non-economic damage linked to loss of an individual. In the case of death this is moral damage (premium doloris) of close family and in the case of injury the premium doloris and aesthetic damage. The Courts determine these attacks on physical and moral integrity of the individual.

Average value of cost of human life in Francs
1990 and average costs of injuries

Cost element	Killed	Serious casualty	Slight casualty	"average" casualty
Loss of production	2 884 700	225 000	0	92 700
Medical, social, material costs	12 100	28 200	10 400	17 700
Total commercial costs	3 107 800	325 000	69 500	174 700
Total non commercial costs	150 600	13 700	2 900	7 400
Total	**3 258 000**	**338 700**	**72 400**	**182 100**

Based on this method, the following values emerge in 1994 Francs:

Killed:	3 700 000
Serious casualty:	381 000
Slight casualty:	81 000
Material damage:	20 600

Costs of lack of safety are deduced on different types of roads indicated in appendix 2.

Costs of lack of safety are increased up to 2025 as final consumption of households per capita, i.e.

- high hypothesis : + 2.4 %/year (geometric rate)
- medium hypothesis: + 2.1 %/year (geometric rate)
- low hypothesis: + 1.7 %/year (geometric rate)

Value of time and lack of comfort

We differentiate between private cars and heavy goods vehicles.

Private cars

As a rule, this value is the one which reveals user behaviour in the choice of route, specifically in the case where this choice must be made between a normal road and a toll motorway. The additional price the user accepts to pay in choosing the second route represents in fact a default estimate of the value this user accords to the advantages of the motorway: time gain, less tiring to drive, safety.

For practical reasons, cost-benefit calculation is presently based on values of time and lack of comfort only applied to all users and all types of trips.

The value of time is closely linked to the assignment model used to recreate the flows observed. The traffic is divided between the two routes according to the following law:

$$\frac{T1}{T2} = \left(\frac{C_2}{C_1}\right)^{\alpha}$$

T1 and T2 are traffic on their competing routes
C1 and C2 are costs of driving on these routes.

Various surveys undertaken on toll motorways and competing motorways have obtained the following values:

a = 10, h = 74 F (1994), i = 0.31 F/veh x km (1994)

In fact, values h and i are not independent and other pairs of h and i values also enable a good reconstitution of the facts observed.

These values revealed by user behaviour are used for traffic assignment studies and to calculate the user evaluation. Furthermore, an increase in the time value and uncomfort of Light Vehicle is applied in the same way as the costs of lack of safety.

Heavy Goods Vehicles

There is less quantified information on behaviour of HGVs than on private vehicles: thus it is difficult to apply to HGVs the previously described method. In fact, such an application is not essential as the very clear-cut "economic" nature of HGVs enables a certain number of hypotheses to be formulated on the operating cost of this traffic:

- the comfort value is zero, simplified hypothesis
- the value of time is equal to the profit made by the company when the latter economises one hour to undertake a given transportation.

The estimation method is based on results of the carriers national professional association (F.N.T.R.) national survey on the cost price of a 40 T group of vehicles. This survey covers about 100 companies. The aim is to estimate the economic advantage for the company procured by a time gain of one hour.

It is assumed that each minute saved has the same economic worth. For one hour saved, the company makes savings on the driver and the vehicle. The time gain can enable the company to save on paying out overtime or travel expenses. This element can be evaluated using the driver's salary as a basis.

However, the time saved can also have an effect on the vehicle. Assuming a company has to undertake a number of fixed trips per year with a fleet of vehicles. If a significant amount of driving time is gained, the company can either increase turnaround or reduce the number of vehicles and make more trips with the remaining vehicles without having to increase the total number of hours worked. If a company owning 10 vehicles can obtain a time gain of 10%, it can provide the same service with

9 vehicles with each one travelling an additional 11% kilometres. Savings are made on insurance, road tax, replacement and financing cost.

The time value for HGVs is thus estimated at 193 F (1994 value).

Appendix 3 summarises the values of all the calculation parameters.

1.1.5 Economic evaluation criteria

Integration of time factor by discounted cash flow

Discount rate

In the transport sector, costs and benefits of an operation are not simultaneous i.e. they do not appear on the same dates. By definition, investing consists of spending money immediately in order to reap the benefits at a later date.

The discount rate is a conversion rate to discount future cash flows to their present value. Even without monetary erosion, one Franc today generally has a higher value than one Franc in a year's time. This added value is called preference rate for the moment. What is valid for the individual is also valid at a community level.

The financing available for public investments is limited and so they must be put to the best use. The French Planning Authority has shown that national savings were able to finance all public investments which yield 8% per year in inflation adjusted francs. This value represents the discount rate used in France for public investments.

Theoretically, a project should be initiated when its current value evaluation at the selected rate is positive, whereby future profits justify the initial waiver of consumption. In this respect, the public discount rate is theoretically a way of defining an absolute criterion to reject or go ahead with public projects.

Assuming that the value of all the benefits and costs is allocated in the same way by time, one can add up the values obtained each year weighted by the coefficient which integrates discounted cash flow. The current value sum of the benefits is expressed as follows:

$$S = \frac{A1}{(1+a)^1} + \frac{A2}{(1+a)^2} + ... + \frac{An}{(1+a)^n} \quad \text{whereby An is benefit of year n}$$

$\frac{1}{(1+a)}$: discount coefficient

a : discount rate

Discount rate and financing constraint

The discount rate is not an absolute criterion for choosing projects and even more so as the public authorities faced with financing constraints are not always in a position to go ahead with all projects which have a positive current value profit at this rate. As the financing constraint is fixed exogenously in line with cost control objectives of the State, communities or public companies, this necessitates classifying the projects.

This optimum investment programme involves selecting a set of projects which maximise the surplus, taking into account the constraint, on the basis of a rational criterion. Several criteria exist. Therefore, the Boiteux report stated that not all projects showing a positive result could be financed due to lack of resources. "*deciding between projects to be undertaken and projects to be delayed could be based on* ***profit per invested Franc*** *or* ***internal rate of return*** *as both these criteria are closely correlated"*.

Profitability criteria

Net present value (NPV)

This measures the variation in the collective utility of the development project. It is equal to the difference between the net, global benefit and the investment cost with these two components converted to current value on the same reference date (1995 as agreement). The NPV is calculated excluding tax. This indicator is used to compare and select the development project. The selection criterion for a project consists of choosing from those, which have a positive NPV, the one with the maximum current value profit.

$$\mathbf{B_{1995}} = \frac{B_{t_0}}{(1+i)^{t_0-1995}}$$

with

$$\mathbf{B_{to}} = -\mathbf{C}_{ht} + \sum_{t=1}^{\infty} \frac{A_{t_0+t}}{(1+i)^t}$$

with B_{to} : NPV in the year prior to start-up to

C_{ht} : investment cost not including tax

A_{to} + t : net advantage of year to + t

i : discount rate.

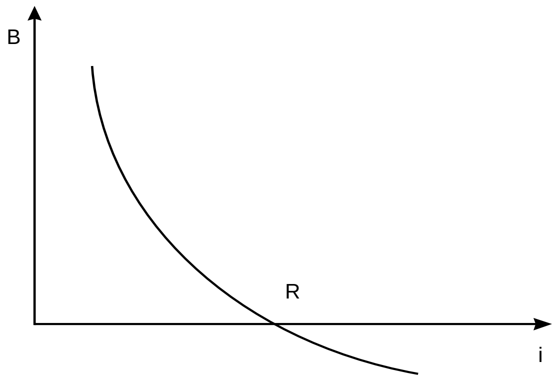
If B > 0, the collective surplus is positive, the operation is financially viable or profitable for the community.

If B < 0 the operation is not profitable on the basis of this criterion. It should be rejected.

To decide between two operations, the most profitable is the one which has the highest B.

Internal rate of return

We have seen that the current value sum of benefits and therefore the NPV depends on the discount rate. The more "i" increases, the more the current value profit decreases. Therefore, there is an "i" value for which the current value profit is zero. This value is called the internal rate of return R. This rate is only of interest if compared with the discount rate.

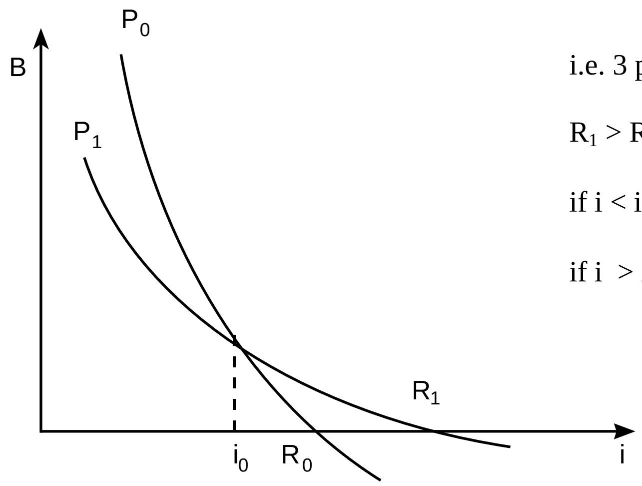


If $i < R \Leftrightarrow B > 0$, the project is profitable

If $i > R \Leftrightarrow B < 0$, the project is not profitable

R depends on project start-up year as the advantages are themselves linked to commissioning. For the same investment cost, R increases if the opening year is delayed as the advantages increase with traffic. The internal rate of return is used to measure the degree of opportunity and also the risk associated with the project. However, it does not enable classification of alternative projects as shown in the next figure.

Classification of projects



i.e. 3 projects P_0 and P_1

$R_1 > R_0$

if $i < i_0 \Rightarrow B_{(P0)} > B_{(P1)}$

if $i > i_0 \Rightarrow B_{(P1)} > B_{(P0)}$

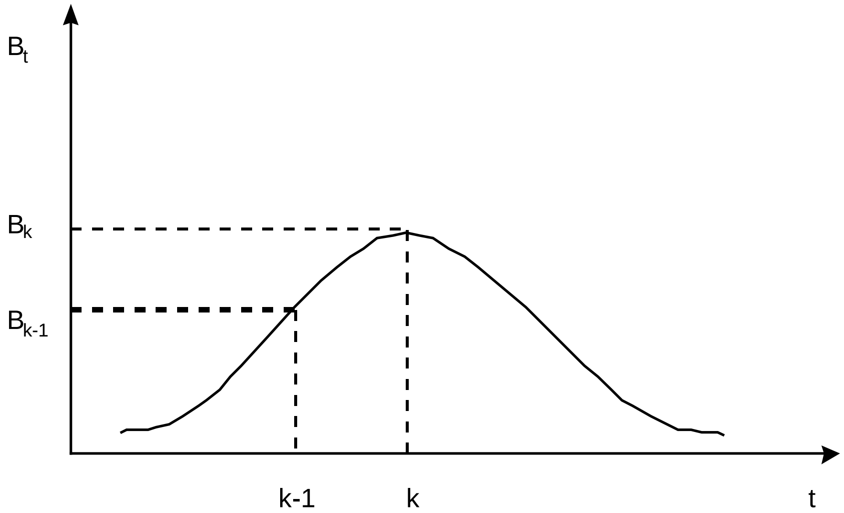
In the above case, the choice depends on the value of the discount rate.

Optimum opening date and first year rate of return

Optimum opening date

Taking the following hypotheses:

- the benefits are independent of the commissioning year;
- the net annual benefits increase with time;
- the investment is made once at the beginning of the period but can be spread over time;
- current value conversion is always done in the same reference year and using infinitesimal calculus, so the NPV reaches a maximum at a given date.



First year rate of return r

By definition, $r = \frac{A_1}{C_{ht}}$

A_1 advantages of year 1
C_{ht} investment cost excluding tax

In k - 1, $\frac{Ak-1}{C} < \frac{Ak}{C}$ as the hypothesis assumes that the benefits increase.

Consequently, it is preferable to await year k to start the operation.

Therefore, when the immediate rate of return at a given date is equal to the discount rate, the profit is maximum. This particular year is the optimum start-up date.

If these hypotheses are not checked, the current value profit may not reach a maximum and there will be no optimum start-up date. Under these conditions, it is necessary to carefully study the chronicle of flows of costs and benefits in order to assess the effects of delaying on the current value profit.

Selection criteria applied to projects with financing constraint

As the capacity for financing investments is limited, the financial resources available are not sufficient to undertake all operations having a positive current value profit. Consequently, projects should be selected which provide the most advantages within a specific budget.

The financing constraint should be integrated in the studies. This generally entails delaying or even rejecting projects, which are not within the financial constraints. One way of integrating the financing constraint in selecting projects is to use the current value profit per invested Franc as a criterion. This is the ratio between the current value profit B_{1995} and the investment cost excluding tax C_{ht}. This indicator is used to classify the different operations of a programme and to just select those which provide the highest B/C_{ht} until the budget expires.

From a practical standpoint, all projects are selected according to their B > O, the optimum date is determined, then for the same date, the projects are classified by $\frac{B}{C}$ in decreasing order until the budget has been used up.

1.2 Integration of certain environmental effects

Within the scope of a monetary approach, only costs in terms of air pollution, greenhouse effect and noise are integrated. This expression in monetary terms represents an initial approach in the current state of the art and will be improved as advances are made in methodology.

1.2.1 Noise

The method consists of taking as a basis the cost of noise in relation to the GDP of a country. It is considered that in France the cost of noise is 0.3% of the GDP. This cost represents the expense of protecting housing for a level of 65 dB (A).

Furthermore, there is an internationally accepted scale which defines the percentage of people feel they are disturbed for each noise level.

Leq dB (A)	< 55	55 - 60	61 - 65	66 - 70	> 70
%	0	5	20	50	100

Therefore, by knowing the number of individuals and noise level they will have to put up with by the project envisaged, one can deduce a representative indicator of the acoustic nuisance created by this project.

But we need to know the cost of unit nuisance i.e. the cost collected by one person throughout one year. In France, the population distribution according to the noise level is as follows (year 1985):

Noise level in Leq dB (A)	< 55	55 - 60	61 - 65	66 - 70	> 70
Population subjected in 10^6	2.6	21.3	16.5	11.1	5.5

It is known that the cost of road noise over the whole country is equal to 0.3% of the GDP i.e. for 1985 11.70 billion Francs i.e. 780 Fr in 1985 per inhabitant.

For 1994, we take the value of 963 Fr/year/inhabitant. This value is indexed on the final consumption of households and increases by 1% per year.

1.2.2 Air pollution

Air pollution comes from different emissions whereby the means of action are diverse:

– A pollution we shall refer to as regional due to nitrogen oxide and sulphur which, even when they are emitted by inter-city traffic, end up reaching the inhabited zones and can cause damage to buildings and people.
– A local pollution: hydrocarbons, carbon monoxide, particles have a very local action: their noxious effect is limited in open country and only really appears in urban areas.

In France, according to the scale chosen, NOx + SO2 is responsible for 26% to 66% of toxicity. The figure of 50% is taken which means that per traffic unit and in terms of toxicity, half the pollution emitted is local and the other half is regional.

Urban traffic produces both types of pollution. Noxiousness of inter-city traffic is apparent through regional pollution and contributes to half of local pollution.

Evaluations of air pollution are very disparate. We have taken a range of values corresponding to evaluation of the cost of damage and an evaluation of cost of avoidance measures.

The values taken are as follows (F/veh/km):

Value 1994

	Open country	Urban area
Light vehicle	0.06 - 0.10	0.07- 0.14
Heavy lorry	0.35 – 0.66	0.48 – 0.88

1.2.3 Greenhouse effect

The economic evaluation of the greenhouse effect has given rise to different approaches:

– evaluation of damage. This type of evaluation exists in the USA and throughout the world but they are riddled with uncertainties if they have not specifically dealt with France.
– macroeconomic cost of measures (essentially taxation) deemed necessary to overcome the problem. This type of evaluation cannot be selected either as the measures deemed necessary vary considerably from one author to another, consequences are not well understood and lastly, it is not easy to transpose consequences calculated in this way (expressed in the form of a reduction of the GDP) to infrastructure choices.

We have taken as a minimum evaluation the tax level proposed by the Commission of the European Communities to limit emissions. The corresponding tax is 70 ECU per tonne of carbon (corresponding to 35 centimes per litre of diesel fuel) i.e. about 450 F, a figure close to the rate proposed by the Commission of the European Community (60 ECU).

Applied to the vehicle, the values are as follows (en F/veh/km):

Value 1994

	Open country	Urban area
Light vehicle	0.025	0.03
Heavy lorry	0.14	0.14

It should be noted that these costs are not integrated in the current value profit but are calculated in a separate module. In fact, they have been determined from the analysis of all studies undertaken on this subject on a European level and contain a certain degree of uncertainty. In spite of this, they do make interesting reading.

1.3 Financial analysis of toll operations

For toll structures, in addition to the evaluation of general interest to the community of the project, there is also an analysis of the financial interest for the operator. This situation represents a significant development in relation to prior methods. In fact, until the end of 1997, development of the motorway system was based on the principle of equalisation. Cash flow surplus produced by the motorway sections already written off and profitable can be used to finance less profitable links with less traffic. Thus with regard to a concessionary company, the financial study consisted of an analysis of the financial feasibility of the project, i.e. the financial impact of the new project on the company whereby a balance was provided by extending the concession period.

Henceforth, the financial cost-benefit analysis is calculated on the project scale on the principle of the private operator trying to obtain a return on equity taking into account his medium and long term strategy and investment yields existing elsewhere.

The State is the conceding authority. It can concede to semi-public Motorway Concessionary Companies or private concessionary companies. It may or may not accept in the concession contract having the risk shared to some degree between the concessionary company and the State (Public-Private partnership).

1.3.1 Economic and financial analysis

Differences

Economic assessment mainly concerns elements which do not have a direct market price (time, comfort, safety, nuisances) whereas the financial assessment only covers financial flows in terms of income and expenditure.

The economic assessment highlights the interest of the works for the community whereas the financial assessment presents the interest both for the conceding authority and for the concessionary company by providing information on financial feasibility.

The economic assessment is made in constant Francs whereas the financial assessment is in current Francs.

Current value accounting uses the rate of the *Commissariat Général du Plan* (French Planning Authority) in the economic assessment whereas it uses an interest rate relevant for this type of project (e.g. that of long term loans) in the financial assessment.

Connections between the two assessments

Construction of a link thanks to tolls is the result of arbitration between:

- the financing constraint which limits the possibilities of making investments which are economically profitable for the community;
- the eviction effect of the toll which reduces the benefit of the works;
- allocation of resources collected from the user rather than the taxpayer which results in a preference for investment which can be financed to the detriment of other solutions which would be more positive in terms of economic outcome for the community.

1.3.2 Indicators of financial profitability

A conceded section generates toll income, which may be topped up with sub-concessionary products and covers the charges of operation and maintenance:

- personnel expenditure (toll staff, operating staff);
- taxes linked to operation (trade tax, VAT, land tax, "regional development" tax);
- road maintenance costs and works termed "major repairs";
- replacement of fixed assets;
- lastly, routine expenses, dubbed "other operating expenses" which specifically cover maintenance of rest areas, plants, toll stations, winter maintenance, overheads of the concession.

The difference between the two is the Gross Operating Result (G.O.R. called Gross Operating Surplus when it is positive) enabling repayment of the capital and financial charges of the loans taken out to finance the works, payment of corporation tax, remuneration of shareholders when the latter have contributed to financing.

The financial calculation reconciles the current value sum of the G.O.R. with the project financing cost at the relevant rate for this type of project. The difference corresponds to the Net Present Value (N.P.V.). For the concession to be exactly balanced out, it just has to be zero (in practice, it should be positive especially as the risk taken is considerable for the shareholders who have bought shares in the company).

The financing cost of the project takes into account the costs of issuing loans and interim interest on sums borrowed during the construction phase which increase accordingly the construction cost. As the case may be, the latter will include additional investments made during the duration of the concession.

The Internal Rate of Return (I.R.R.) is the interest rate which cancels out the N.P.V. Should financing be provided by the loan, it is equal to the long term interest rate of loans used in the current value calculations (in practice, it should be substantially higher than this rate in view of the extent of the concessionary company's risks). The I.R.R. can also be calculated just on the share of financing due by the concessionary company (i.e. excluding a subsidy from the conceding party) and also on any private capital contributions.

The subsidy to top up the concession is the external contribution (from the State, regional communities and users of the former links) cancelling out the N.P.V. It reduces the concessionary company's financing by this amount and refers to the construction cost (and not the financing cost).

Calculation of these indicators enables scenarios to be created to examine in more detail the conditions of such a concession. Therefore, an I.R.R. close to the long-term interest rate will not encourage many private concessionary companies to apply in that they can find more remunerative investments elsewhere. A high subsidy rate will encourage the State to see whether for the same sum it might be possible to effectively improve the link in question without introducing tolls (taking into account the usually higher cost of conceded operations, all things considered).

1.3.3 Arbitration between financial profitability and socio-economic profitability

Should the toll project offer a positive NPV for the community and for the concessionary company, the operation should go ahead as it is not just viable for the community but also for all the economic agents taken separately. If this is not the case, i.e. a negative NPV in view of these criteria, the project should not be accepted.

But the real question in that of arbitration when the operation is profitable from a socio-economic standpoint but is not financially sound. This question can arise when making upstream choices before studies of the infrastructure master plans if the State has decided to undertake works on their own site and is wondering whether to have a toll road or not.

If operating a toll road provides a socio-economic profitability but does not balance out the financing of the operation, then the conceding authority should provide a deficiency subsidy. This situation may appear in a large number of cases for future inter-city motorway projects.

Deficiency subsidy: an economic necessity

The principle of the State contributing to financing toll motorway infrastructures is not a new situation. It is rare to have toll motorways which are self-financing from toll income. In fact, it should be noted that the first toll motorways built in France and run on a concessionary basis were only made possible by repayable short-term loans or allowances in kind. In certain cases, the repayable short-term loans reached up to 30% of the financing cost.

The principle of repayable short-term loans was dropped in 1987 and to date all loans have been completely repaid. At the same time, once the first loans were written off, the concessionary companies were able to use their surplus to finance other less busy links. This practice of assuming responsibility was made possible thanks to the extension of the concession period. Consequently, we have shifted from an explicit public subsidy system to an implicit subsidy system based on inter-dependence between users.

The necessity of the deficiency subsidy is explained by the fact that the transport infrastructure and in particular motorways represent substantial investments made over a fairly long period (often 4 years of works or more) and where traffic is gradually introduced. The result is that for a new operation, the toll income does not usually cover depreciation of loans and financial costs over the planned repayment period and during the concession period taken as 35 years.

The State subsidy is also an indication of national solidarity and an essential way to conduct a regional development policy enabling certain regions to have a certain level of accessibility by road at an acceptable cost for the user.

The State as guarantor of the collective interest

Furthermore, if the State envisages providing a contribution to the toll project in the form of a subsidy to top up the concession, it must examine the alternative uses of this subsidy. Specifically, the State should check whether there are other projects offering a collective profitability at least equivalent to that of the toll project. If there are more profitable projects which the State rejects financing then this results in a lack of earnings for the community corresponding to the opportunity cost of public funds.

An arbitration may have to take place to choose between a toll operation and one or more operations without toll. To do this, the constraints attached to financing toll operations need to be the same as those which exist for financing non-toll operations. As we have seen in the past, it was easier to generate funds for toll infrastructures than for non-toll infrastructures as the financing modes were different and basically watertight. Consequently, there was a constraint specific to each sector and this resulted in guiding the choices in favour of toll operations. If the financing sources are decompartmentalised and we have the same levels of financing constraints the resources will naturally be allocated to projects with the highest socio-economic profitability which guarantees an optimum choice.

The State is also the guarantor of the financial equilibrium of the motorway system currently in place in France. In this respect, it is up to the State to organise competition between the different operators in order to ensure that the contribution it makes provides complementarity between the motorway networks. This can be the case when subsidising links to ease congestion of existing routes.

The search for an appropriate pricing system to optimise allocation of resources

If the budgetary constraint is such that it has a considerable influence on the amount of State subsidy which can be contributed, it might be interesting to adapt the pricing to reduce the deficit and consequently the public subsidy.

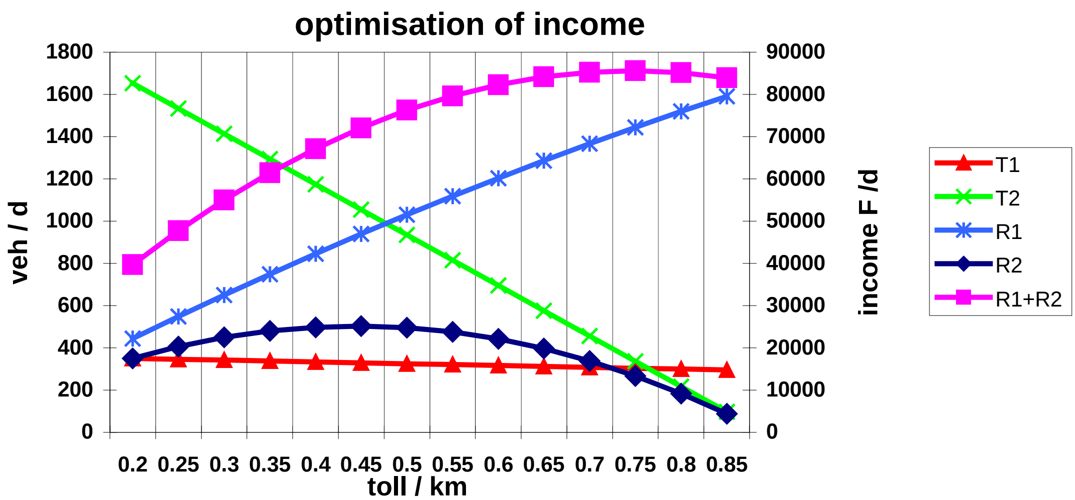
Rather than adopting an average toll level identical for all segments of travel demands, one could use a toll system at different levels according to the customer type with the objective of having the user pay a sum in relation to the utility of the trip.

On inter-city toll motorways, the market share grows with the trip length. This is explained by the type and structure of trips in terms of frequency and reason. Long distance trips of over 200 km are mainly occasional trips which take place several times a year and are essentially for business or holiday travel.

The very high assignment rates noted on long distance trips is indicative of the real utility obtained by the user from the motorway in relation to what he pays. As the benefit gained by the user is much higher than the cost he pays, it would seem fair to set higher prices for long distances.

It should be noted that for this type of trip, there is less toll elasticity than for short distance trips. Increasing the toll price would result in very little traffic loss but above all a marked increase in income.

The financial return on the project would be assured and the State contribution could be reduced accordingly. However, one must not neglect the effect on the collective evaluation and the consequence on the satisfaction level of the user. It is clear that the user's evaluation will be negatively effected by an increase in toll rates. Even if there is less toll elasticity for long distance trips, the increased toll not only increases the cost to the user who continues to use the motorway but turns away some motorway users who opt for the parallel route with the consequences of losses in time and convenience. The safety evaluation is also downgraded. Consequently, if we want the overall evaluation of users and safety to be balanced, we need to associate increased tolls for long distances with a decreased price in relation to the average price for short and medium distances.



Financial return can be improved by a differentiated pricing system based on increased prices for long distance trips and reduced prices for short distance trips. In view of the elasticity of traffic at the toll, the concessionary will witness an improvement in results. If the project requires a State subsidy, the latter will be reduced accordingly. In order for modular pricing to be fully effective, it should be based on time and space to be most suited to the type of individual travel which varies considerably according to the day, the month, destination and reason for travel.

In fact, arbitration between socio-economic profitability and financial return corresponds to a choice of sharing the economic surplus between the user, the concessionary company and the State, i.e. the taxpayer.

The fundamental criterion governing the choice of project remains the socio-economic consequences for the community. For toll operations, a second criterion is the financial return. If the project requires a public subsidy, arbitration is between what the State is ready to accord as a contribution taking into account budgetary constraints and return on equity required by the operator.

Moreover, the economic optimum can be improved by practising a different pricing system according to the different customer segments which would increase the concessionary company's income, reduce the public subsidy and increase the collective results.

1.4 Reference situation

The economic calculation and the financial calculation are, by definition, differential calculations in which we compare two states of the economy, one without project or reference situation and the other with project. Therefore, as highlighted by the report of the French Planning Authority already mentioned, the greatest care must be devoted to determining this issue. The reference situation is the most probable situation in terms of transportation supply and demand in the absence of a project. In the area of roads there is rarely a status quo. Any improvement to the road network not taken into account between the date of the study and the assumed date of project start-up can lead to overestimating transport costs in the reference situation and, consequently, overestimating the share of traffic using the project and thus the economic and financial profitability. This is why the following is integrated in the reference situation:

- works already started;
- projects of the plan contract in progress;
- any project or operating measure which will most probably be implemented before the studied project and which should not be jeopardised by the studied project;
- and more generally any external element to the project having a marked effect on the project.

But there are cases when the envisaged project and operations composing the reference network are not two separate entities.

In addition to the operations mentioned above, the reference situation may also comprise a certain number of operations which are to be maintained, modified, deferred or abandoned if the project is implemented. Basically, the problem is a choice of options. These options are composed firstly of all the operations envisaged if the project is not undertaken and secondly those of the project. These options are compared with a network status corresponding to the situation defined above.

Therefore, careful thought must be given to operations which might not see the light of day if the project is chosen and others which must be undertaken independently of the project.

Furthermore, the reference situation is not necessarily unique and fixed. Before the project start-up, one can have a certain reference situation with a given set of operations or development levels. Subsequently at project implementation, other operations might be launched (new operations or improvements to the existing network) and compete with the project resulting in a risk of loss of customers. In this case, the net present value of the project is calculated, taking into account start-up of subsequent operations.

When working towards a distant deadline, there may be some uncertainty about implementation of a project to be integrated in the reference situation. In this case several reference situations are considered to the extent that these situations can have a significant influence on the project studied.

Lastly projects or pricing measures of operators of other modes of transport are taken into account in the reference situation if they have a substantial effect on the traffic of the studied project.

1.5 Traffic development hypotheses

Hypotheses on traffic development are based on macroeconomic forecasts dealing with the period 1996 - 2020. A scenario favouring balancing out the modal splits is also presented. The long-term traffic predictions correspond to the following scenarios:

Parameters explaining traffic growth	**Low hypothesis 1995-2020**	**Medium hypothesis 1995-2020**	**High hypothesis 1995-2020**
Household revenue			
Annual average growth rate	1.9 %	2.3 %	2.6 %
Annual average growth rate per capita	1.5 %	1.9 %	2.2 %
Gross domestic product			
Annual average growth rate	1.9 %	2.3 %	2.9 %
Average weighted price of petrol			
Average annual growth rate	0.76 %	0.49 %	0.03 %
Car ownership			
Growth 1995-2020	+ 36.5 %	+ 37 %	+ 38 %

Elasticity rates to the different parameters are as follows:

- Household income per capita: + 0.676
- Average weighted price of petrol: - 0.271
- Car ownership: + 0.864

The scenario favouring balancing modal splits is based on the above average hypotheses with the exception of the average weighted price of petrol which will change by 3.78% per year up to 2020.

1.5.1 Case of major projects and long term studies

The growth rates are differentiated according to six types of the following origin-destination links:

For the L.V.: links with a length of less than 20 km
links with a length between 20 and 100 km
links with a length greater than 100 km

For the HGV.: links within France (France-France)
international links (France-abroad)
international transit links through France (abroad-abroad)

The following growth rates are applied through to 2020; they are expressed in annual linear rates base 1995.

Low hypothesis					
LV links < 20 km	LV links of 20 to 100 km	LV links > 100 km	HGV inside France	HGV international route	HGV international transit
1.5 %	2.5 %	3.5 %	0.5 %	4.5 %	5.5 %

Medium hypothesis					
LV links < 20 km	LV links 20 to 100 km	LV links > 100 km	HGV inside France	HGV international route	HGV international transit
2.0 %	3.0 %	4.0 %	1.5 %	6.0 %	7.5 %

High hypothesis					
LV links < 20 km	LV links 20 to 100 km	LV links > 100 km	HGV inside France	HGV international route	HGV international transit
2.5 %	3.5 %	4.5 %	3.0 %	9.0 %	10.5 %

Which corresponds in national average to:

for the low hypothesis:	all 2.4 %:	L.V. : 2.5 %	HGV: 1.7 %
for the medium hypothesis:	all 3 %:	L.V.: 3.0 %	HGV: 2.8 %
for the high hypothesis:	all 3.7 %:	L.V.: 3.5 %	HGV: 4.8 %

In addition, a **test of sensitivity** to the scenario favouring balancing out modal splits is undertaken. The growth rates to apply are as follows:

LV (irrespective of length of links)	HGV inside France	HGV international route	HGV international transit
1.3%	0.5 %	4.5 %	5.5 %

Which corresponds in national average to: all 1.35 %: L.V.: 1.3 % H.G.V. : 1.7 %

The forecasts relating to this last scenario are less accurate than for the low, average and high hypotheses and should therefore be interpreted with caution. In fact, the models use the flexible pricing of petrol observed over the last 25 years for minor price variations. Sensitivity to a constant, substantial increase of prices over a long period has never been observed in the past. Moreover, it would be probable that this price scenario might have an effect on the GDP, growth and car ownership.

There are no macro-economic forecasts available for beyond the year 2020. Under these conditions, we take for each of the distance classes the rates indicated above (base 1995) until they year 2040.

Beyond 2040, we take rates equivalent to half of rates indicated above (base 95).

For most of the major projects and long term studies, the general developments indicated above are to be increased by generated traffic justified by a major modification of traffic conditions.

1.5.2 Case of isolated operations on national roads

(Studies of built-up area bypasses, in situ improvements, overtaking lanes, intersections, safety planning).

In this case, the traffic is not usually broken down into origin-destination flows. In the absence of more detailed knowledge on the traffic structure, we shall take the average rates LV and HGV indicated below corresponding to the average national values:

for the low hypothesis:	all 2.4 %:	LV:	2.5 %	HGV:	1.7 %
for the medium hypothesis:	all 3 %:	LV:	3 %	HGV:	2.8 %
for the high hypothesis:	all 3.7 %:	LV:	3.5 %	HGV:	4.8 %

In addition, the **test of sensitivity** to the scenario favouring balancing out of modal split is undertaken. The growth rates to apply are as follows:

all 1.35 %: LV: 1.3 % HGV: 1.7 %

After the year 2020, we shall proceed in the same way as for major projects

1.5.3 Integration of generated traffic

Generated traffic will be taken into account if opening of the development causes, within the timeframe studied, a major modification of traffic costs. This is the case for instance for **major projects and complex studies**. In most other cases, the traffic generation phenomenon can be discarded. It is agreed that the users of other transport modes, who switch to the road following the opening of a large-scale road development, are counted in the generated traffic.

Traffic generated by the project is equal to the difference between the actual traffic with project implementation and the actual traffic without implementation. It evolves in the same way as the other traffic.

The following formula is applied for each origin-destination flow:

$$\left[\left(\frac{c_0}{c}\right)^{2/3} - 1\right]$$

with

c_0 = traffic cost without project

c = traffic cost with project

2. NON MONETARY EFFECTS

2.1 Effects on accessibility

2.1.1 General principles

Accessibility can be defined as the quantity of goods, services, jobs or volume of population which can be reached by an individual from a given point, taking into account the level of road infrastructures offered, his travel behaviour and attractiveness of possible destinations. The opportunities offered by the region only take on meaning when accompanied by transport conditions enabling access and inversely transport conditions provided by the network are only of interest with regard to destinations served. The accessibility indicator must in fact translate this dual concept and can only be formulated by interpreting mobility behaviour observed.

For a given trip type (tourism, business, personal) we know the attitudes of the individuals to use the road network. In fact, surveys have shown that for the same destination, the volume of trips decreases when the transport cost or travel time increases. This behaviour translates the fact that the utility of trips decreases with transport costs.

Nevertheless, if individual travel it is to satisfy their needs (consume, study, work, relax) which they will find in the destination sought. The individual will be even more satisfied if the offer of goods or services is extensive as the probability of finding the sought after product there is higher. However, any increase in transport time or cost to reach this destination will decrease its attractiveness and therefore the utility of the trip. Thus, the utility level is subject to the distance effect. Each destination is allocated a distance coefficient (attenuation factor of the trip utility) which is deduced from the transport demand function.

Using a reference point i, accessibility to a destination j can be evaluated by:
$Qj \times e^{-\alpha tij}$

Qj : quantity of goods or services present at destination j
$e^{-\alpha tij}$: distance coefficient
tij : travel time between i and j

We then determine accessibility from a zone i to all zones of possible destinations according to the following formula:

$$Ai = \sum_{j} Qj . e^{-\alpha tij}$$

Improvement of the road network will have the effect of varying tij. All things being equal elsewhere, we can thus deduce a variation of Ai.

2.1.2. Application method

Accessibility of a reference zone is assessed in relation to jobs which can be reached in view of a behaviour function for a professional trip. From an economic standpoint, accessibility to employment zones, measured from the number of jobs, is interpreted as an area of potential market for a company located in a given reference zone.

The values of the formula will be as follows:

Qj : number of total jobs in zone j
tij : travel time in hours between i and j
α : 0.47

i.e. : $Aí = \sum_j Qj.e^{-0.47tij}$

The indicator can be used to compare major configuration variants of a development scenario or independent development scenarios. The calculation is undertaken with the reference situation and with the development scenario and we calculate the accessibility variation between the two situations. This indicator which is applied to upstream studies can provide information on integration of regional development objectives.

2.1.3 Practical implementation

Implementation of this method assumes initially that the road network is digitised, split into arcs for which we have the technical characteristics (length, cross section and possibly upward grade, bendiness) and type of highways (motorways, dual carriageways, 3-lane carriageways, other national roads, main county roads, cross-town links, specific toll structures (bridges, tunnels)). A travel time is associated with each arc.

Afterwards, the region is split into zones. An interesting zoning system for this type of study is the one based on the 341 employment zones which cover all the metropolitan territory. The total number of jobs is associated with each zone and each employment zone centroid (centre of gravity of the zone) is linked to the nearest node of the modelled network.

Lastly, we proceed with calculating the travel time between the reference zone and each employment zone. To do this, we can use the traffic modelling software available off the shelf. Firstly, we look for the shortest routes in travel time between the departure zone and the destination zones. Then we obtain a travel time matrix measuring 341 x 341 between employment zones. The rest is just a matrix calculation to obtain the vector accessibility (341 values) for a reference network from the matrix of travel time and number of jobs in each zone (economic weight vector). The same approach is done to test a new project in relation to the reference.

The results are summarised in the form of a table and a map displaying for each zone the gain in accessibility provided by the project.

2.2 Effects on construction, maintenance and operating jobs of major road infrastructures

The economic calculation applied to evaluating and choosing road projects gives priority to the micro-economic analysis in terms of benefits for the user and the community. This somewhat marginal approach assumes a balanced economy. But, when there are considerable macro-economic imbalances, it would seem wise to also examine the impact of projects on these imbalances and particularly on employment.

As combating unemployment is a major concern, design of a major road projects should take into consideration the jobs generated by construction, maintenance and operation.

Thus, the main objective is to estimate the economic impacts of the works; the economic impacts of maintenance and operation of the infrastructure in terms of direct and indirect employment in the areas concerned by the project. Effects and jobs generated linked to an improvement in labour skills and possible new activities are not integrated in this analysis.

The methods and results presented below provide an initial approach and an initial estimate of the problem.

2.2.1 Effects of construction of a major road infrastructure on employment

Jobs created, maintained or concerned?

Work sites involve a whole series of jobs whereby it is difficult to say if they should be considered as created jobs, relocated jobs, long term or short term jobs.

It should be first noted that the number of jobs in the building and civil engineering sector is proportional to the total population of the region in question (labour pool, metropolitan area, county, region). As soon as an "exceptional event" such as a motorway building site appears in this region, local resources in the sector are quickly "saturated" even more so if it is a sparsely populated area. The number and size of local companies are not sufficient to meet requirements of the contracting authority which usually comes from outside the local region.

In this situation, the contracting companies manage their employment policy on these sites according to two basic parameters:

- their human resources management culture (maximised local recruitment or maximised relocated workers, management of staff turnover);
- characteristics of the labour pool (human resources available in the sector, skills and capabilities of local companies).

A relocated job throughout the building site period is not, on a national scale, a created job. But on the local scale, it represents one extra job throughout the works period. Hiring a local unemployed person on the site constitutes a job created for the duration of his work which might be a very short period. On the other hand, using employees from local companies does not constitute a created job on the local scale but it can avoid a redundancy.

When the works are completed, this invariably leads to departure of relocated workers, termination of contracts for workers hired for the duration of the works and for temporary workers and termination of contracts for the local contractors.

Considering the different meanings, the notion of employment cannot be used with the same acceptance as in the usual framework. For this reason, we shall use the notion of **jobs x years** (number of jobs throughout the total works period). The values indicated below are only average estimates of the sector for an average site.

Objectives

There are two types: evaluate in terms of direct and indirect jobs the effects of construction of the project concerned, firstly on the site and secondly off site - compare these effects according to the different options.

Type of effects

Construction of the project will give rise to direct and indirect effects concerning primary contractors and sub-contractors on the site and off the site.

a) Direct jobs linked to the site

Direct jobs comprise the following operations: design, land clearance, earthworks, drainage, engineering structures, pavement, safety equipment, buildings, plantations.

These jobs have been determined by analysing over several sites the breakdown of these different operations and by applying to them site employment ratios according to the costs of the different components of these operations. For a site of 1000 M. Fr excluding tax 1995, we shall take the value of 1100 jobs x years.

b) Direct jobs in head office

They are evaluated at 110 jobs x years for a site of 1000 M Francs excluding tax 1995 for the total duration of the works.

c) Indirect jobs

Jobs linked to manufacture of site supplies

Site supplies mainly concern quarry materials, cement, power, transport, services, steel, wood, equipment, plantations.

Some of the additional site supplies required are imported and the rest is produced on national territory. The corresponding jobs are considered as equivalent to 660 jobs x years for a site of 1000 M Francs excluding tax 1995.

Effects on the economy of pre-site jobs

These jobs correspond to additional production of goods and services used for manufacture of non-imported site supplies (e.g. production of lime for cement or steel for guard rails, diesel fuel for material transport vehicles, prefabricated concrete products). This additional production will in turn create a demand for additional goods required to make them and so on until the effect is exhausted. The additional production is estimated based on a model which simulates impact on each sector of the economy.

These jobs are estimated at 570 jobs x years for 1000 M Francs excluding tax 1995 of works.

d) Jobs linked to distributed revenue (excluding transfer income)

These are effects linked to additional expenditure corresponding to salaries paid during the site and to salaries paid by pre-site activities. This refers to additional business in the areas of food, housing, leisure, transport. Each additional revenue mechanically creates a new consumption according to the marginal propensity to consume and import and thus an additional production which generates new income. The corresponding jobs are estimated at 800 jobs x years for 1 000 M Francs of works excluding tax.

Summary

We shall take the values below for 1 000 M Francs of works excluding tax 1995 and make an estimate for each development scenario.

Direct and indirect jobs estimated over the whole duration of the side for 1 000 M Francs excluding tax 1995

	Jobs x years
Direct jobs	
Jobs on site and at head office	1 210
Indirect jobs	
Jobs linked to manufacture of supplies	660
Jobs upstream of the site	570
Revenue effect	**800**
Total number of jobs	**3 240**

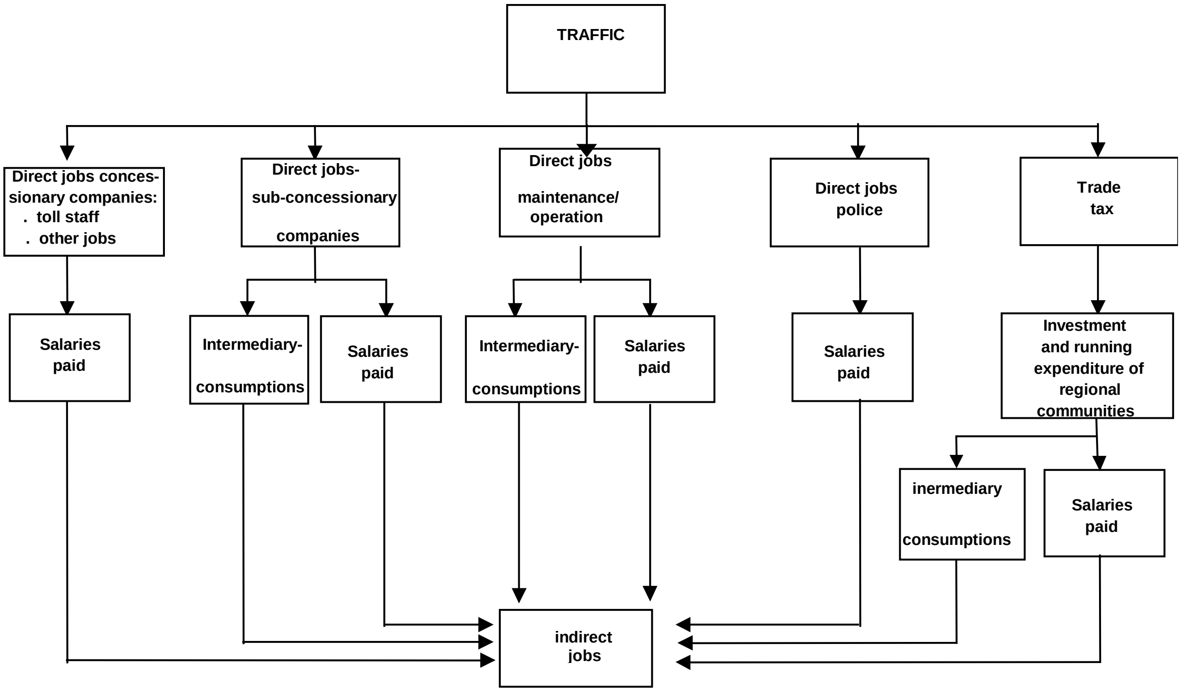
2.3 Effects on jobs of operation and maintenance of a major road infrastructure

2.3.1 Methodological principles

The motorway analysed as a "company" "sells a service" and thus brings in revenue, provides jobs, generates substantial intermediary consumption (which may benefit the region served). It also creates a lot of taxes for the communities it crosses but this point will not be developed in this document. Logically, one can consider that the general activity of the motorway is proportional to the traffic using it and its length.

2.3.2 *General presentation*

Evaluation of jobs linked to maintenance and operation of a road infrastructure



2.3.3 *Approach used*

a) Jobs required to run the motorway (direct jobs)

Jobs are expressed in annual equivalent. They take into account permanent and temporary jobs.

Toll jobs

The number of employees E_p per toll station depends on the output traffic T in veh/d: $\mathbf{E_p = 0.003\ T + 4.5}$. This equation gives good results for inter-city motorways operated in a closed toll system. It was based on current operating modes with little use of electronic tolls.

Other jobs of the concessionary company

This covers jobs in the regional operating divisions, districts and maintenance centres. These jobs are linked to the product of average traffic T in veh/d by the section length (in km) as per the following equation:

$$\mathbf{E_c = 4.6 \times 10^{-5} \times p + 10.63}$$

with $p = \sum TiLi$

with Ti = Average Annual Daily Traffic (AADT) on section i

and Li = section length i.

The average traffic of the section concerned corresponds to the sum of traffic weighted by length of each sub-section, divided by the total project length.

Jobs generated by sales of petrol and related products (sub-concessionary company)

The revenue from this business can be estimated as follows:
R = 0.92 T + 1 038

R : revenue excluding tax in k.F. (value 1995)
T : AADT. 2-way in line with the service area with T > 8 000 veh/d

The number of jobs is determined from the formula :

$$N_e = \frac{Rr}{1000} \times c$$

N_e : number of jobs, c : job coefficient = 0.9

This formula is valid to estimate an average revenue and an average number of jobs when two way traffic is greater than 8000 veh/d. The business concerns service areas on both sides or one service area accessible from the opposite direction which might be the case when there is little traffic.

Jobs generated by catering (sub-concessionary company)

Two types of catering outlets are present on the motorways: restaurants and buffets, set up according to traffic.

AADT 2 way in line with service area	8 000 to 14 000 veh/d	14 000 to 35 000 veh/d	> 35 000 veh/d
Type of outlet	- buffet if access 1 way - restaurant if access 2 ways	- alternatively restaurant every 2 areas and buffet every 2 areas	restaurant at each area

As a function of one way traffic estimated in line with the area, we use the following formulas:

- Restaurant outlets

Rrest = 0.97 x T - 2 445

Rrest : restaurant revenue in k.F. (value 1995), T : AADT 1 way in line with area - T > 4 000 veh/d

$$Erest = \frac{Rrest}{1000} \times c$$

Erest : number of jobs in restaurants, c : employment coefficient = 2.5.

- Buffet outlets

Rbuf = 0.268 x T - 912

Rbuf : buffet revenue in k.F.. (value 1995) ,T : AADT one way in line with area - T > 4 000 veh/d

$$\mathbf{Ebuf} = \frac{RBuf}{1000} \times c$$

Ebuf : number of jobs in buffets, c : job coefficient = 2.2

For restaurants and buffets, the results are multiplied by two to take into account facilities on both sides of the motorway unless the service area is only on one side.

Jobs linked to motorway maintenance works

These jobs consist of work undertaken by companies independent of the infrastructure concessionary company. Expenditure concerns works on carriageways, fixed assets, maintenance of signing.

To evaluate the number of jobs, the following equation is used:

$$\mathbf{E_e = D \times L \times c}$$

E_e : number of annual jobs
L : length of section in km
D : annual expenditure for maintenance work per kilometre
c : job coefficient per M.Fr. of maintenance work excluding tax (1995 value) c = 1.6

Sites	Flat	Valleys	Mountains
D in M.F/km. excl. tax per year	0.230	0.264	0.352

Police jobs

The number of policemen varies according to section length and traffic as per the following formula :
$$\mathbf{E_g = 0.0031 \times L \times \sqrt{traffic} + 12.1}$$

L in km with L > 50 km
Traffic in veh/d with T > 7 000 veh/d.

For lower values of T and L, we take a policeman for 2.5 km.

b) Indirect jobs associated with operating the motorway

Indirect jobs associated with maintenance expenditure

$$E_{ie} = D \times c \times L$$

Eie: number of indirect annual jobs associated with maintenance
D: maintenance expenditure (Refer to above)
c: job coefficient per million of Francs of maintenance works excl. tax c = 1.2
L: section length in km

Jobs generated by intermediary consumption of sub-concessionary companies

$$E_{sc} = CA_{sc} \times e$$

E_{sc} : number of jobs generated by demand of sub-concessionary companies
CA_{sc}: revenue excluding tax of sub-concessionary companies
e : number of jobs per million of Francs generated per activity e = 2

Effects of salaries paid to employees operating the motorway

$$E_i = S \times c \times e$$

c : marginal propensity to consume non imported goods. c = 0.70
e : number of jobs per million Francs spent. e = 2.5

$S = S_1 + S_2 + S_3$ = total net wages paid to employees.

S_1 = 100 000 x N_c N_c : number of jobs of the concessionary and sub-concessionary company
S_2 = 87 000 x E_g E_g : number of policemen
S_3 = 104 000 x E_e E_e : number of jobs in companies providing maintenance work of motorway.

In total over a toll motorway section 100 km long and with 20 000 veh/d, there are 420 direct jobs and 290 indirect jobs

c) Case of non-conceded sections

As an initial approximation, we use the formulas defined for conceded motorways except we do not integrate the toll jobs.

d) Case of conceded sections of less than 50 km (branch or link road)

The number of toll jobs and other jobs of the concessionary company are calculated. For jobs on service areas, the situation on existing areas should be examined. There will be an area on the new section if the distance between one of the ends of the section studied and the nearest existing area is between 45 and 60 km depending on whether the traffic is between 15 000 and 8 000 veh/d.

2.4 Effects of road infrastructures on business and operation of companies in centres accessed

2.4.1 Purpose

The aim is to determine effects associated with opening an infrastructure. This analysis applies to industrial and service companies.

The originality of the approach was the constant concern to only retain effects due to the infrastructure, confirmed in several economic monitoring studies and not all the socio-economic effects noted in the infrastructure environment which are mainly due to other local, regional or national economic factors.

Among the many factors which influence the way companies are run, some deserve an evaluation:

- importance of accessibility gains to deal with a situation of isolation or saturation;
- type of trade and network;
- type of businesses served and current organisation of company;
- type of centre.

The ex post facto monitoring studies have shown that:

a) The companies perceived an economic effect when there was a significant change in the transport offered and accessibility gains. Example: case of a new motorway taking the same route as a road with a very poor service level or the case of a new infrastructure in a saturated zone, in an isolated zone or a zone with difficult winter conditions.

b) There is no identifiable economic effect when the new transport offering does not achieve accessibility gains. Example: case of a new motorway in a mesh network or network with many existing motorways.

c) When there is an accessibility gain, an increase in mobility for "business" reasons and secondarily of HGV traffic ("generated" traffic) was correctly confirmed in all of the before-and-after traffic surveys.

d) There was a time saving and thus accessibility by the new development when the areas were isolated or saturated before opening of the new road.

2.4.2 Objectives

The analysis consists of evaluating the effects of accessibility gains on development of market areas of companies and on their internal operation. As these effects depend on the business sector, positioning of the company in relation to competitors, corporate organisation, the analysis entails identifying companies for which one can expect positive, negative or neutral effects.

Firstly, a statistical analysis is undertaken of the companies located in the zone studied and secondly surveys among a sample of companies to assess the reactions they envisage adopting with regard to the new infrastructure. In addition, a socio-economic diagnosis is also undertaken in each centre to analyse the economic environment of the companies.

Furthermore, the socio-economic diagnosis is cross-referenced with the analysis of global transport flows travelling on the route (traffic survey) prior to opening and analysis of inter-department and inter-region goods flows.

2.4.3 Procedure to adopt

Definition of the study zone

The study zone is the attraction or "influence" zone of the future infrastructure. It is defined in consistency with the flow matrix. It should be noted that the effect can be noted at some distance from the end centres.

General principles (Refer to following flow chart)

The factor prior to any evaluation of effects is **the evaluation of accessibility gain of each centre.**

The principle is to analyse the business sectors by centre and compare the business sectors of each centre with those of other centres served. The type of centre and type of trade are also characterised. To do this, three types of investigation are undertaken:

- characterisation of the zone, centres and business sectors by examining the statistics socio-economic study;
- traffic surveys;
- surveys among the companies.

Determination of centres to study

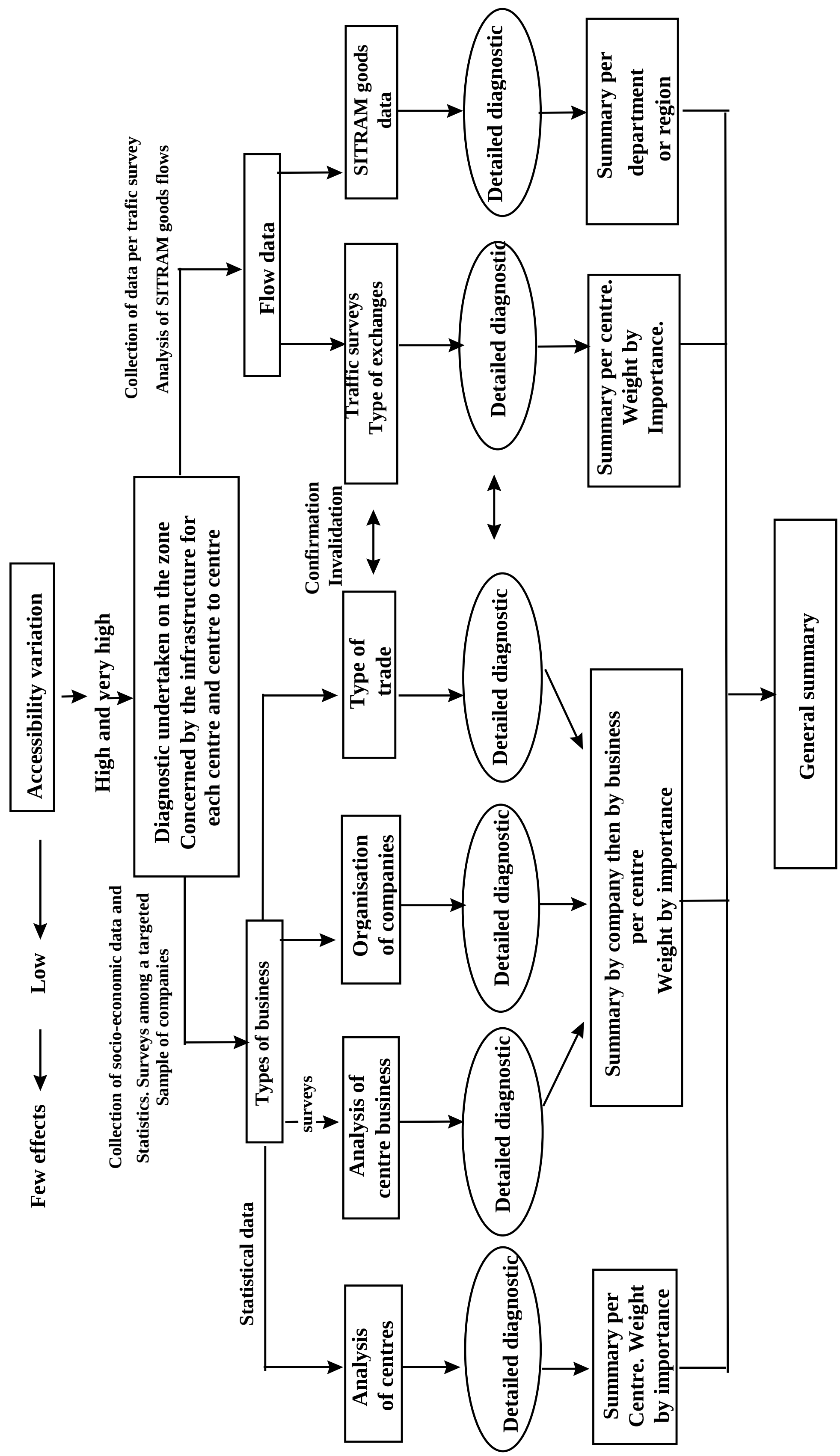
In order to determine centres of the study zone to be taken into consideration, an analysis is made of time gains, isolation, type and extent of trade.

a) Time gains between centres

- the higher it is, the greater the possibility of important effects;
- if it is low, there will be few effects. In this case, the analysis is not necessary.

The accessibility gain is the consequence of:

- a time gain which means more activities can be reached;
- improved reliability in transport time. Example: roads not very practicable at certain periods (winter) or some sectors saturated (around urban zones).



Accessibility variation
High and very high
Low
Few effects
Diagnostic undertaken on the zone
Concerned by the infrastructure for
each centre and centre to centre
Collection of data per trafic survey
Analysis of SITRAM goods flows
Flow data
SITRAM goods data
Traffic surveys
Type of exchanges
Detailed diagnostic
Summary per department or region
Summary per centre. Weight by Importance.
Confirmation
Invalidation
Collection of socio-economic data and
Statistics. Surveys among a targeted
Sample of companies
Types of business
Statistical data
surveys
Type of trade
Organisation of companies
Analysis of centre business
Analysis of centres
Summary by company then by business
per centre
Weight by importance
Summary per Centre. Weight by importance
General summary

The measures or evaluations of travel time of current routes on the network concerned and their comparison with times expected with the new infrastructure determine the predictable time gain. The designer should compare:

- estimated travel time on the current network carrying expected traffic at a certain date;
- travel time on the network with the new infrastructure by the same date.

The absolute and relative value of the time gains are assessed for each of the regional and national flows. As an indication, the following values are taken:

- a time gain (town entrance to town entrance) of less than 10% can be considered as low, greater than 30% as high, greater than 50% as very high;
- and a time gain of less than 20 minutes can be considered as low, 20 minutes to one hour as high and over one hour as very high.

Relative / Absolute	Less than 30 %	Between 30 and 50 %	Higher than 50 %
< 20 minutes	+	++	+++
20 minutes ≤ Δ ≤ 1 hour	++	+++	++++
> 1 hour	+++	++++	+++++

A very high time gain, thus creating a high volume of “generated” traffic causes:

- intensification of flows (particularly for "business" and "trade", secondarily goods flows) and increase in customer base and market areas;
- increase in competition.

b) Enclavement

The enclavement criterion also seems fundamental in the diagnosis. The enclavement is assessed as follows:

- firstly, a comparison is made between goods traded from the centre of the region concerned to centres of regions served by the road with trade from the same centre to other regions. Therefore, little trade with future regions served, compared to trade with other regions in France, could indicate a considerably enclaved area. A marked imbalance between export and imports can be accentuated by increased competition after opening the infrastructure;
- secondly, traffic is analysed on the road based on traffic surveys to determine the extent of flows between urban centres (compared to national averages).

Type and extent of flows and the network

We shall take traffic estimated for economic calculations as a reference.

To know the type of flows implemented by the companies, we use the results of O-D matrices of traffic surveys, which have been used for economic calculations, and then only flows of at least 100 vehicles/day are included.

There are four types of flows (all vehicles):

- local flows (at a distance of less than 20 km): companies hardly use the motorway;
- regional flows (between 20 and 100 km): companies are very interested in the motorway;
- national flows (between 100 and 500 km): companies are interested but although the relative impact is high, it is less tangible;
- international flows or over 500 km: companies are interested but the impact is low.

Lastly, national and international transit whereby the origins and destinations are outside the zone of influence have a very limited economic impact and essentially on companies making a living from passing trade (hotels, restaurants, garages, petrol stations).

Analysis of centres of the zone studied

An economic analysis of the business of each centre served along the route is necessary.

a) Size

It should be compared with the size of other centres studied.

As regards the workings of the company and its location, companies thrive better when they are located inside a major metropolis (presence of a qualified labour pool and competing network of contractors) than when they are in small centres where their business has often been protected by the distance of the competition.

b) Dynamism

A qualitative assessment of the dynamism can be made via:

- development of business activity over the last five years compared to national statistics (this rate may be provided by I.N.S.E.E.) (National Statistics Institute);
- development of failure rate over the last five years compared to national statistics (this rate may be provided by I.N.S.E.E.);
- instigation of measures to promote the opening of the new infrastructure by the local and regional communities (relocation assistance, willingness to attract companies).

A survey is necessary among the regional communities concerned.

Analysis of business in the served areas

a) Market effect

Modifications in accessibility will enable companies to have access to a wider supply of goods, services and potential customers. Consequently, the market areas will be extended. This modification in market areas will, in certain cases, result in market increase and in other cases, an increase in competition with the consequence of a spatial redeployment of the market.

The economic effect will vary according to the centres, types of business and how the business is conducted, ability of company to adapt to changes in the economic situation, technology, customer tastes and according to how the companies perceive their accessibility gains. To analyse this type of effect, companies must be identified whose markets are likely to be modified by the infrastructure.

Type of business of the companies

If the company belongs to a "buoyant" sector or has a monopoly or almost a monopoly in the activity, the new infrastructure is a favourable factor for developing the market.

However, if the company is already present on a national level, accessibility gains will only provide a few additional opportunities in terms of outlets.

For companies with complementary activities (companies belonging to the same group or working in a network) one can expect:

- intensification of flows;
- rationalisation of storage;
- use of closer distribution platforms.

In certain cases, one can also observe an extension of its market area.

Accessibility gains will also have the effect of strengthening competition between companies from different centres serviced by bringing markets closer together. This is the case if we link two centres whose companies produce the same type of goods or services. Some companies will try to maintain their market shares by improving productivity, service provided or by diversifying activities. In other cases, intensification of the competition will have the effect of redistributing the market to the advantage of the most competitive companies or those who are able to adapt quickly to take advantage of the new infrastructure. The possibility of market development will be more or less increased if the company proves to have the ability to adapt to markets and sees the accessibility gains in a positive light.

The **designer** will determine from a statistical analysis whether the centre has companies working in buoyant sectors or not in relation to the national activity and will assess the complementarity or competition of companies by comparing their activity centre to centre.

Companies ability to adapt and anticipate

Surveys undertaken in companies and possibly in the Chambers of Commerce and Industry will provide information on these decisive factors.

The ability of a company to adapt also seems to be an important criterion for development of companies. Companies which in the past were very flexible when faced with economic fluctuations in their activity and were able to adapt to the market by replacing their products or integrating new production techniques are in a better position than the rest to deal with increased competition.

Furthermore, anticipation of the strategy of the companies in relation to accessibility gains is a factor, which explains the effects of market area. If the company considers that the infrastructure will only provide very little accessibility gains in relation to its current market (which may be the case if the company has a nation-wide market) then the probability that its market will increase is lower. On the other hand, the company may envisage implementing an offensive strategy to try and develop markets, for instance by rethinking the marketing policy or internal organisation, by envisaging diversification of products or conducting a prospective marketing study.

b) Effect on reorganisation of companies

Thanks to the infrastructure, the companies organised into groups or working in networks, can create subsidiaries or concentrate their services. They can outsource their stock, work on a just-in-time basis, hence:

- an increase in flows between the different entities
- saved storage space
- gains in operating expenses.

Surveys among the companies

The preceding analysis determines a group of companies likely to be influenced by the arrival of the new infrastructure from which a sample is selected and then questioned.

a) The objectives are to analyse:

- Type of activity (buoyant, fragile).
- Company's sensitivity to accessibility gains.
- Ability to adapt and anticipate.
- Awareness of competition.
- Type of corporate organisation (subsidiaries, just-in-time) and effects on reorganisation.
- Type of flows (short, medium or long distance).

b) Definition of the sample

In order to evaluate several criteria, the designer must conduct surveys among companies in the served centres. He can undertake these surveys either in the form of semi-directive interviews or as postal surveys. Semi-directive interviews, due to their qualitative nature, would seem to provide a good idea of the attitude of the companies in the centre with regard to the new infrastructure together with effects of this infrastructure on the company's economic situation.

The postal survey is less complex to organise but the fact that the response rate is more random (often low) means that the image portrayed by the companies in the centre might not be true to reality. As the postal survey is more directive than the interviews, it runs the risk of a certain bias unless there is a good rate of response.

To define the target group of companies to question, we can consider the following criteria:

- companies in the competing sector sensitive to transport;
- size of companies;
- size of centre.

Interviews at the Chambers of Commerce and Industry will enable classification of types of activities sensitive to transport in order of importance in the centre.

All sectors previously selected must be represented; if possible with a sample for size categories of companies: 6-10 employees, 10-20 employees, 20-50 employees, 50-100 employees, over 100 employees.

Priority is given to the largest companies whereas those with less than five employees are eliminated and those working as a concessionary company (e.g. sale of construction materials).

2.4.4 Summary of statistical analysis and surveys

The relative importance of each company is taken into consideration.

For instance, one can list the number of jobs in companies surveyed by activity and adjust to the total number of jobs in the sector of activity existing in the centre, then:

- list the number of jobs concerned by favourable effects;
- list the number of jobs concerned by unfavourable effects;
- add up by centre the number of jobs with positive effects and the number of jobs with negative effects for all the sectors of activity;
- draw a conclusion on the centre.

Other more qualitative weighting methods making use of an expert vision can be selected.

2.5 Integration of the strategy of local public authorities and assistance measures

2.5.1 Objectives

Analysis of the strategy of local, public authorities is an important phase in evaluating economic effects generated by the projects.

These economic effects are mainly effects of location of business activities and effects on operation and development of the companies' activity. As they are generated effects, they will not appear systematically everywhere at the same time. They are based on the ability of the companies to integrate and make the most of new transport conditions, the economic potential of zones served and the strategy of local authorities to enhance this potential. Moreover, these effects take some time to become apparent and may only be evident several years after opening the infrastructure.

The public authorities can intervene by different actions to enhance the new infrastructure and make the regions served more attractive. The range of actions possible is very wide and we shall not list them in detail here. It might be economic promotion and regional marketing actions, financial incentives. These actions will be determined as the project progresses.

The approach proposed consists, at each phase of the design, in analysing the degree of convergence between the effects expected from the infrastructure project and the elements of the strategy of players on the topics of transport, economic development and organisation of the area. **Therefore, the aim at this point is not to suggest strategies and assistance measures to the authorities concerned.**

If this issue is seen in the context of the evaluation and study process, it would seem preferable to firstly analyse the strategy of the authorities in terms of development of their region before studying the content of this strategy in terms of projects and consider the infrastructure project in a development perspective.

2.5.2 How should the strategy of the local authorities and assistance measures be considered?

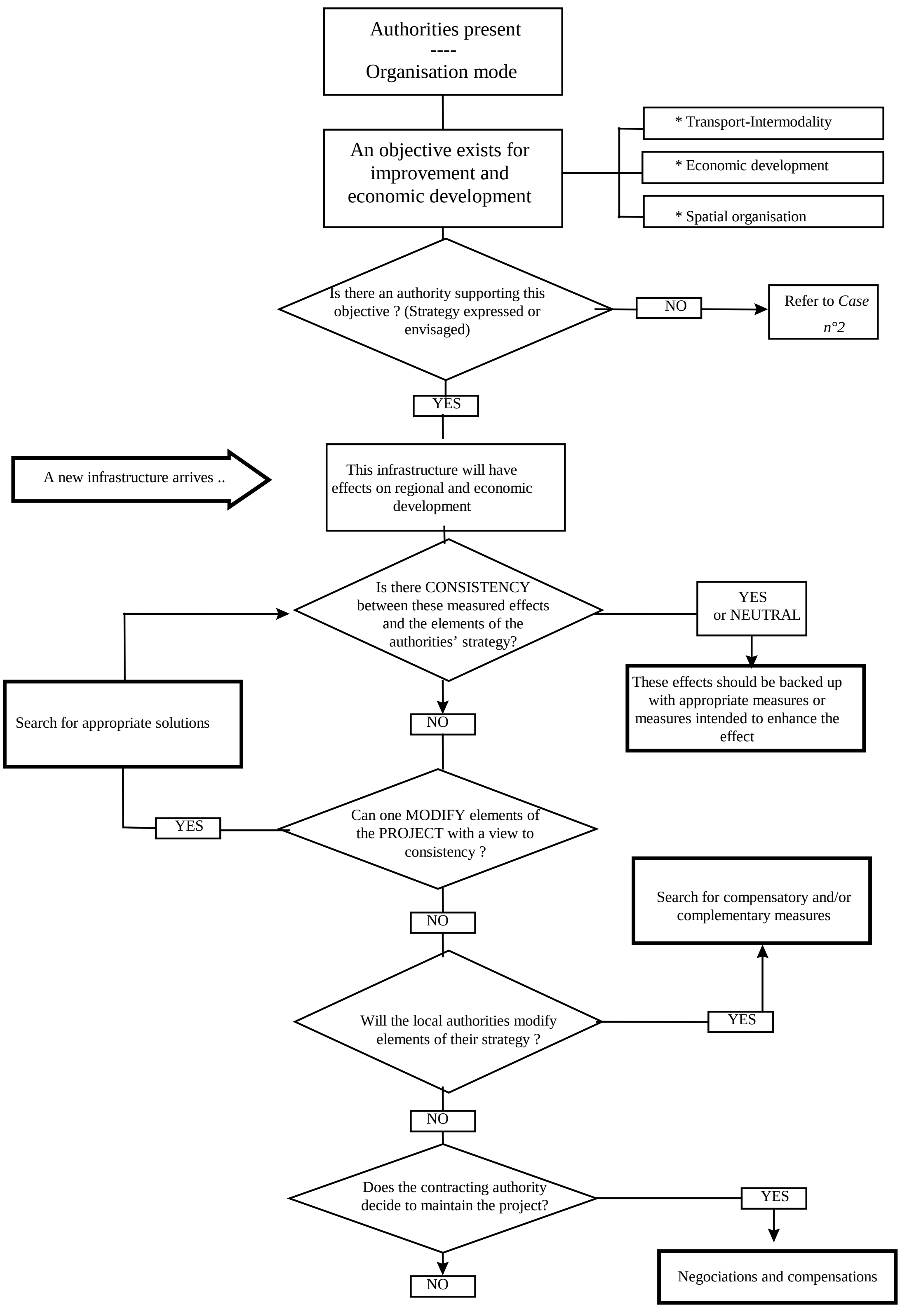
The following diagrams indicate the general approach to follow to assess the convergence of implementation of welcome or assistance measures with the planned infrastructure. The effectiveness and type of such measures depended on the degree of consistency, which may exist between:

- the potential socio-economic effects of the project;
- and the elements of the strategy of local authorities in terms of development of their region.

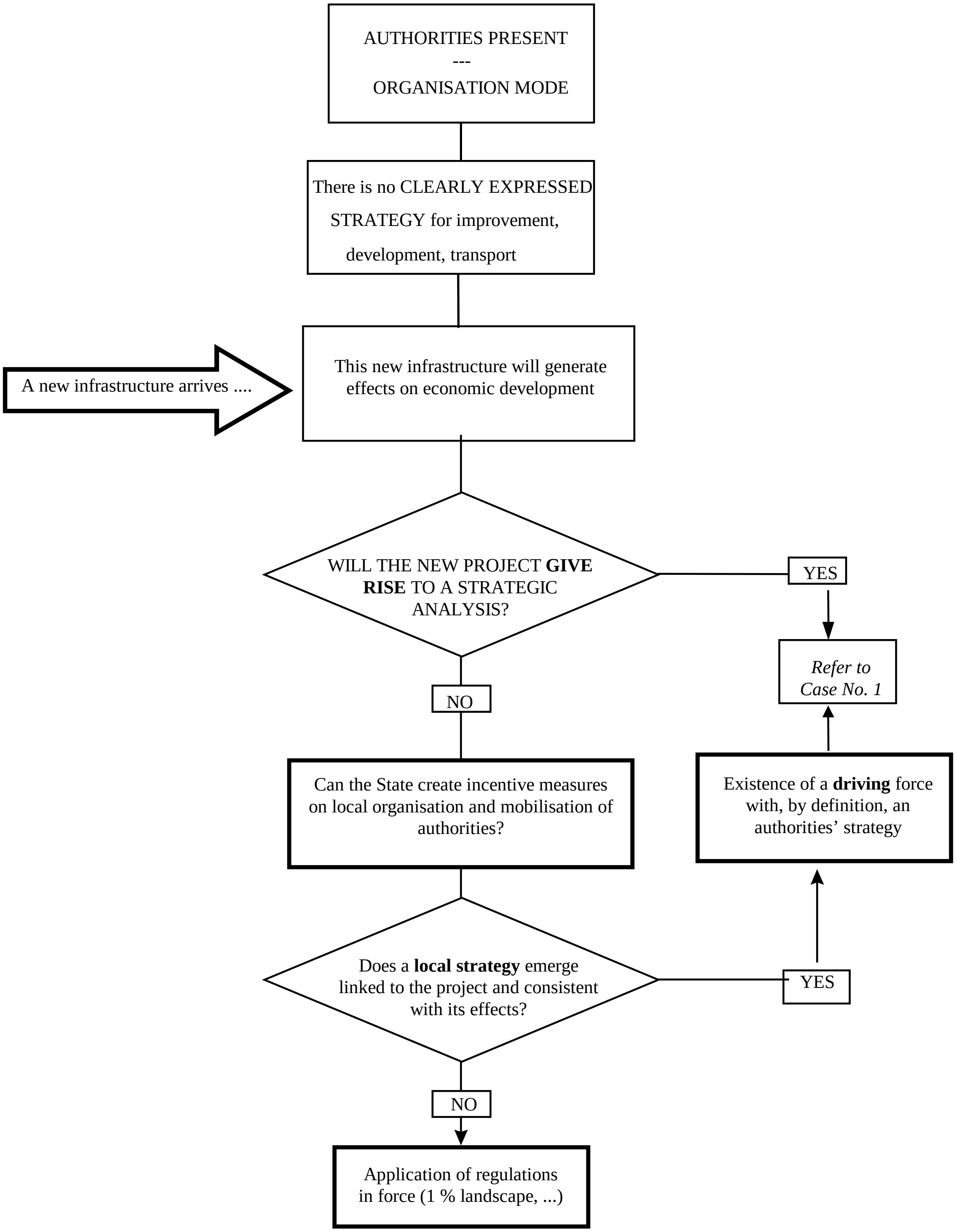
This illustrates the necessity of considering a multi-dimensional approach to regional development, integrating both environmental and socio-economic issues and those concerning transport-infrastructure links.

The first diagram assumes the existence of a clearly defined, local, regional strategy and the second one assumes the absence of such a strategy. The project manager is asked to meet the local public authorities (State, Regions, Counties, Communes or Groups of communes, Associations, etc.) to talk about transport policy, economic development and organisation of the area. The project manager will also study all decisions taken or projects envisaged in these three areas and analyse the consistency between the expected effects of the road project and the expected effects of the local development strategies.

Decision diagram concerning local authorities' strategies
Case No. 1. Existence of a project objective



Decision diagram concerning local authorities' strategies
Case No. 2: No development strategy expressed



Appendix 1

Annual expenditure for maintenance and operations of the conceded network
In 1994 Francs per km

	Mountain	**Valley**	**Plain**
Major repairs	151 000	123 000	101 000
I.M.M.O.S.	85 000	69 000	57 000
I.C.A.S.			
Excluding tax	116 000	72 000	72 000
V.A.T.	23 900	14 800	14 800
Maintenance and operation	610 000	570 000	530 000

Annual expenditure for maintenance and operation of the non conceded network
In 1994 francs per km

	Urban express roads		Link providing continuity of motorway network	Major regional development link		4 lanes 14 m	3 lanes 9 m ou 10.50 m	2 lanes 7 m	2 lanes 6 m
	2 x 3 lanes	2 x 2 lanes		2 x 2 lanes	2 lanes				
Major repairs									
Excluding tax	211 000	142 000	106 000	71 000	35 000	64 000	48 000	32 000	25 000
V.A.T.	43 500	29 000	22 000	14 500	7 000	13 000	10 000	6 500	5 000
Routine maintenance									
Excluding tax	200 000	150 000	70 000	50 000	30 000	60 000	45 000	30 000	20 000
V.A.T.	22 000	16 500	7 700	5 500	3 300	6 600	5 000	3 300	2 200
Winter service: H1,H2									
Excluding tax	5 500	5 500	5 500	5 500	3 600	5 500	5 500	3 600	3 600
V.A.T.	600	600	600	600	400	600	600	400	400
H3									
Excluding tax	14 500	14 500	14 500	14 500	5 500	10 900	8 200	5 500	5 500
V.A.T.	1 600	1 600	1 600	1 600	600	1 200	900	600	600
H4									
Excluding tax	21 800	21 800	21 800	21 800	12 700	21 800	17 300	12 700	12 700
V.A.T.	2 400	2 400	2 400	2 400	1 400	2 400	1 900	1 400	1 400

H1, H2, H3, H4 are winter service levels according to the different climatic zones.

Appendix **2**

Cost of lack of safety for a rural road link

	Number of accidents for10^8 veh x km	Fatalities for 100 accidents	Serious casualties for 100 accidents	Slight casualties for 100 accidents	Cost of lack of safety F/veh x km en 1994 Francs
< 7 m[1]	19.1	17	58	110	0.18
7 m	16.5	19	61	110	0.17
3 lanes 9 m[1]	13.1	21	58	104	0.14
3 lanes 10.50 m	12.4	23	62	108	0.15
4 lanes 14 m[1]	13.8	18	45	118	0.13
2 x 2 lanes[2]	9.6	21	67	102	0.11
7 m express	12	20	60	110	0.13
inter-city artery	8	18	67	102	0.08
motorway [3]	7	11	30	120	0.04

1. These road profiles concern the existing network, they should not be proposed for a future project.

2. Road with junction at grade but comprising a proportion of junctions without crossing of the median strip.

3. Urban and inter-city and 2 x 2 lanes express road.

Appendix 3

Table of unit values

	Physical unit	Unit value in 1994 Francs
Routine maintenance, types, lubricants		
- L.V.	Vehicle x kilometre	0.43
including V.A.T.		0.07
- H.G.V.	Vehicle x kilometre	0.85
Vehicle depreciation		
- L.V.	Vehicle x kilometre	0.14
including V.A.T.		0.02
- H.G.V.	Counted in time units	
Toll (for information)		
- L.V.	Vehicle x kilometre	0.39
- H.G.V.	Vehicle x kilometre	0.75
Fuel		
- L.V.	F/litre	5.18
including excise tax on petroleum products		3.08
including V.A.T		0.88
- H.G.V.	F/litre	3.42
including excise tax on petroleum products		2.20
Time		
- L.V.	Hour / vehicle	74
- H.G.V and buses	Hour / vehicle	193
Uncomfort surcharge (light vehicle only)[4]		
- 7 m ordinary road	vehicle x kilometre	0.31
- 7 m express road	vehicle x kilometre	0.18
- inter-city artery	vehicle x kilometre	0.13
- dual carriageway	vehicle x kilometre	0.04
- motorway	vehicle x kilometre	0

4. Reference year is 1994.

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