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Decoupling Transport from Economic Growth: Towards Transport Sustainability in Europe

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This paper reports on a research project that aimed to identify and assess measures which could be used to reduce travel demand while maintaining economic growth and enhancing environmental quality. The research methodology involved a detailed review of past research; contact with over 600 experts from around Europe and elsewhere for ideas on potential measures; detailed questionnaires from over 100 of these experts; and a series of three panel sessions held in different parts of Europe, each of which involved around 16 experts debating the merits of different measures and identifying case study evidence of their effectiveness. The end result was a shortlist of 13 measures, indicative of broad types, which are considered to be effective, and an indication of their effectiveness if applied across the European Union.

Seven illustrative measures are discussed which stand out from the results as having proven potential (though not necessarily at a European scale) to influence transport intensity and/or unit environmental load whilst not having large detrimental effects on GDP. These are the areas where it is felt that European transport policy could most usefully be focussed in terms of decoupling of transport demand and economic growth.

1. Introduction

This paper reports on a research project that aimed to identify and assess measures which could be used to reduce travel demand while maintaining economic growth and enhancing environmental quality. The paper provides a unique perspective, firstly as it brings together expert opinion on the appropriateness of a range of such measures and secondly as it pulls together available case study material for a group of particularly promising measures and determines their potential effectiveness if applied widely in the European Union. An attempt at validating the conclusions reached on the effectiveness of the measures was made through use of a further set of expert consultations.

The paper is split into a number of sections. Section 2 examines briefly the current trends in freight and passenger travel compared to GDP in the EU and elsewhere and considers current policy directions. This section also outlines arguments over the appropriateness of different measures of economic performance and finally summarises the findings of a range of studies which have identified measures with potential for bringing about decoupling. Section 3 describes the methods used to assess expert opinion and Section 4 the assessment framework used to identify the most promising measures. Section 5 gives a detailed overview of the predicted effectiveness of a shortlist of the most promising measures, while Section 6 describes the process for constructing a final ranking of these measures based on a further expert consultation.

2. Background

There are many well documented problems arising from transport activities that affect sustainability and which impact across a range of scales from local to global. To achieve any degree of sustainability requires at least some consideration of the link between transport demand and economic growth and whether it is desirable and/or possible to decouple the link (i.e. to reduce the transport intensity).

Transport intensity as an aggregate measure of the resource importance of transport in the national economy is initially described in Peake (1994). He suggested the term transport intensity as an analogy with the energy sector (where it had been found a useful indicator of how efficiently energy was being used in production and consumption) and defined it as the ratio of gross mass movement to GDP. Often intensity is separated according to passenger and freight movement into different intensity indices, by using passenger kilometres and tonne kilometres. Figure 1 shows recent trends in freight and passenger transport activity and GDP in the 15 nations of the EU up to 2000.

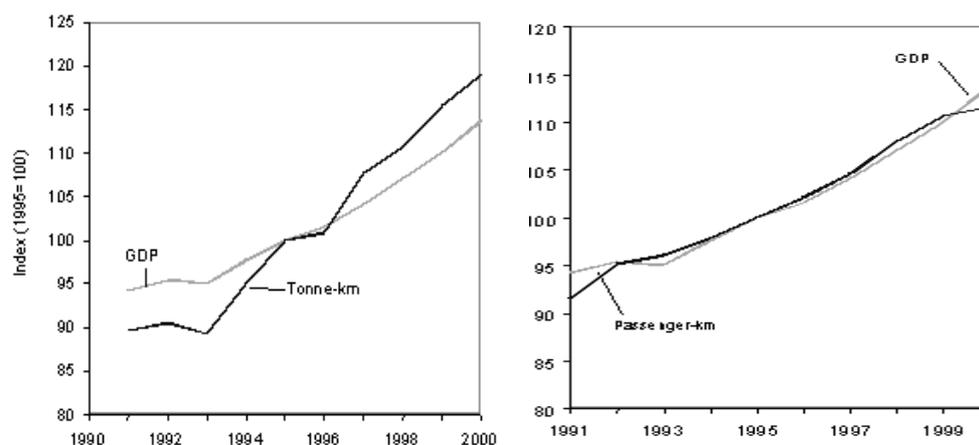


Figure 1. Freight and passenger transport activity and GDP for the EU15 (Source: European Environment Agency Data Service – www.eea.eu.int)

From Figure 1 it is clear that overall in the UK there is a strong link between both freight transport demand and passenger transport demand and GDP. Growth of freight transport demand has exceeded the growth rate of GDP since around 1993, though since the late 1990s the rates have been more closely matched. For passenger transport there has been a very close match with growth rates in GDP throughout the period, though there is an indication in the most recent years that growth rates in passenger transport demand may be slowing compared to GDP.

Most reported work to date on the link between transport growth and economic growth and on decoupling has been done in Europe and it is worth noting that relationships between transport growth and economic growth are not necessarily the same elsewhere. For example, in the United States freight transport intensity in terms of t-km per unit of GDP has been decreasing since the 1960s (Gilbert and Nadeau, 2002). It has been suggested that this finding might partially explain the lower prominence of decoupling research in the US compared to Europe. Elsewhere an initial exploratory study from New Zealand (Ballingall et al, 2003) concludes that “decoupling is virgin territory as far as Australasian research goes” and that in New Zealand there is a lack of ideal data sources from which to conclude whether decoupling is happening or not. A recent OECD (2004) study has shown a close correlation between growth in both passenger and freight transport and economic growth in Japan over the past 2 decades, though overall GDP has been growing faster than transport activity, leading to a slight fall in transport intensity.

A number of authors have questioned the suitability of GDP as a measure of economic activity in the context of examining transport intensity. Gilbert and Nadeau (2002) consider the use of the Genuine Progress Indicator (GPI), whilst Stead (2001) also considers the Index of Sustainable Economic Welfare (ISEW). It is clear from these studies that use of other economic indicators can produce very different findings and conclusions, however GDP continues to have a central role in decoupling work, perhaps mainly due to convenience and consistency (OECD, 2004). GDP will be used throughout the remainder of this paper.

A number of previous studies have considered means by which the relationship between transport growth and economic growth for both the freight and passenger sectors can be

decoupled in the European context. There is also evidence that these issues are starting to come to the fore in policy agendas at both the national and regional scale. In the UK the SACTRA report (SACTRA, 1999) focuses on road traffic growth and provides evidence on the sensitivity of the level of traffic, arising from any particular level of economic activity, to policies having an effect on the price, speed and quality of transport. The report considers the issue of whether policies intended to change the volume of traffic have a favourable or unfavourable economic effect. It concludes that there exists a theoretical basis to identify conditions where measures may increase some direct prices, reduce traffic, reduce resource costs and at the same time have favourable local economic impact, though the selection of specific measures should vary according to circumstances and be the subject of cost-benefit appraisal.

The EU in its 2001 White Paper (CEC, 2001) identified a range of measures designed to gradually break the link between economic growth and transport growth. These they summarise under three main headings; the first focussing on reducing road transport through pricing measures alone, the second again using pricing, but also accompanying measures to increase the efficiency of other modes, and the third an integrated approach, comprising pricing coupled with revitalising alternative modes and targeted investment in the Trans-European Networks.

A number of key other works were examined in advance of the research reported here in order to derive an initial long list of measures which could potentially influence the relationship between transport and economic growth. These included: AVV (2000), Banister and Marshall (2000), Baum (2000), Camagni (1999), DANTE (1998), POSSUM (1998), REDEFINE (1999), START (1999) and Weaver (1998). From the wide range of measures reported in these studies (for a fuller description see SPRITE, 2000), it was possible to identify four general categories of measure. These were:

- Moderating demand growth (for example through measures such as miniaturisation or teleworking).
- Modal shift (for example Green Commuter Plans or parking pricing and control).
- Increasing transport system efficiency (for example by increasing vehicle loading factors or driver information systems).
- Improving vehicles and fuels (for example through improved fuel economy or eco-labelling of vehicles).

Not all influences on transport derive from within the sector itself, and a number of studies have looked outside of the transport sector to examine potential external influences on decoupling. A recent example of this is Stead and Banister (2001) who considered a range of such instruments, but with a particular focus on macro-economic policy, land-use policy and new technological developments. They conclude that such instruments do have the potential to significantly influence transport and that many of the changes in transport patterns in the past few decades are as a result of a combination of both socio-economic and transport factors.

3. Expert consultation

A list of those experts active in the field was put together drawn largely from countries within the EU, but also a few others. The list included academics, but also practitioners from a variety of fields. The experts were approached initially using a questionnaire. The questionnaire was translated into a number of European languages to enable the maximum number of people to respond. Around 600 such experts were identified from the fields of transport, economics, planning and related subjects. 100 responses were received in total from 10 of the 15 EU countries, several other countries and a number of international organisations. Some respondents provided brief (but valuable) summaries of their ideas, others went to great trouble to share their knowledge of the complexities of the issues.

The key questions asked by the questionnaire were 'How can transport growth be separated from economic growth?' and 'How can transport demand be shifted from road and air to environmentally less damaging modes of transport?' This was followed up by a request for a description of the measure or measures proposed with detail about the precise impacts. Respondents were also asked to identify barriers to implementation, probable lag times before the measure could be implemented and the likelihood of such a measure ever becoming reality.

A series of three panel sessions were subsequently held in different locations in Europe which provided a valuable opportunity to complement and validate the initial assessments derived from the literature and the questionnaire survey. The events were attended by experts from across and outside the EU and coming from research, authorities/governments and the industry sector (both transport service suppliers and transport equipment manufacturers). The panel sessions focussed less on individual measures than on the conditions necessary for success, the different problems in different countries and types of location and the need for more information on how systems work, but also provided further insight into the scope and potential of policy measures, the experience so far and the possible barriers and knock-on effects.

The questionnaire and panel respondents provided a specialised understanding of the practical complexities of introducing individual measures and an appreciation of what was needed to combine individual measures into integrated strategies.

There were naturally a range of views presented both in the questionnaires and also at the panel sessions. Overall there was a degree of cautious optimism. It was pointed out that differences in transport intensity between countries at similar levels of economic development show that there is no inevitable link between a particular level of GDP and a particular level of environmental load. It was a key theme – both for personal and freight transport – that the adoption of 'best practice' by all would make a substantial difference to transport intensity. It was thought that the increasing resistance to providing new transport infrastructure and concern over environmental impact is likely to stimulate a search for more efficient use of existing infrastructure. It was also thought that independent technological trends are expected to have an impact on the reduction of transport intensity, in particular technological improvements are expected to have major effects on energy and environmental performance of road vehicles, although concerns still remain for CO₂ emissions.

There were some more negative perspectives. A common theme was that reductions in real cost, which 'best practice' could bring about, may release yet more transport demand unless there are structural changes in the economy and the structure of personal life, perhaps a

recognition that measures need to be combined in mutually supporting strategies. Also the dynamics of demand and supply mechanisms in both transport and general markets puts several constraints on decoupling potential, in particular political barriers to change arising from the vested interest of the transport industry and industry in general. Institutional and cultural barriers and lack of economic incentives for potential investors (as in the case of intermodal nodes) are the main obstacles to be overcome. Air travel was singled out as a serious problem, which requires to be addressed, amongst others the low duty on aircraft fuel.

For some areas there was a degree of uncertainty, for example it was felt that trends in the freight transport sector have moved in different directions. Increase in value density has reduced transport volumes but this has been outweighed by extra transport links, vertical disintegration and increased length of haul.

Several respondents noted the need for education, cultural change and the need for deeper analysis of the relationships between transport, economic growth and the mechanics of urban life. Some went into greater detail on the need to bring home to individuals the long-term problems which will result from their current economic preferences and lifestyles.

A small number of respondents considered that the decoupling agenda was inappropriate and doomed to failure. Some experts considered it to be a simple fact that economic growth and transport growth are inevitably linked and that nothing can be done about that. There were also responses from people who thought that the attempt at decoupling was actually wrong – but for two very different reasons. The extreme ‘pro-market’ view was that decoupling attempts represented an unjustifiable attack on market forces which should be left to operate. In contrast, the ‘sustainability first’ view was that continued promotion of economic growth was misguided and likely to promote global crisis. The dominant policy should therefore be to reduce environmental load and to maximise welfare within that overall constraint.

4. Assessment frame work

To structure the task of identifying the most promising measures, and to enable a consistent assessment of each of the most promising measures to be carried out, a framework for assessment was developed. The criteria for development of this framework were as follows:

- to allow the measures to be assessed against a range of objectives, using appropriate performance indicators;
- to be a simple, useable framework, capable of being applied to the wide range of measures identified in the project;
- to extend beyond transport sector criteria to embrace social and environmental issues/impacts;
- to include indicators with a quantitative basis where possible, whilst recognising that the framework should be open to qualitative assessments where these add value to the quantitative information, or where the evidence is not sufficient to provide defensible quantitative conclusions.

A fuller description of the assessment methodology is given in *SPRITE* (2001).

Shortlisting of measures was carried out by a process of nomination, followed by debate over the suitability of the measures proposed and some revisions to the list. Judgement therefore

played a large role in the selection process, but this judgement was informed by case study evidence available on measures and their potential impact and by the insights of the expert panellists. The shortlisted measures are best seen as a set of illustrative examples of the most promising types of measures that the research has been able to identify. They cover a wide range of different types of measure as this enabled exploration of complementarities between measures, and because it allowed preliminary comparisons to be made between the potential effectiveness of different approaches to the problem.

5. The shortlist of most promising measures

The following sections briefly describe the measures and give some indication of their potential effectiveness in terms of impact on transport intensity, environmental load and emissions of CO₂, where possible at the EU level (where EU is taken to mean the EU15). An indication is also given of any untoward effects of the measures.

5.1 Combined measures to change mobility-related attitudes and traffic behaviour

During 1994 and 1996, a pilot project in the German south-western State of Baden Württemberg, sponsored by the State Ministry for Environment and Transport, investigated the implementation and the impact of persuasive measures for the advancement of a "conscious mobility" of citizens. The basis for the "conscious mobility" concept is the idea that traditional transport and traffic policy instruments alone are not the most effective means of promoting environmentally and socially sustainable traffic development. Instead, the traditional instruments should be accompanied by informational, educational and motivational measures which encourage citizens to adopt more "conscious" travel behaviour patterns.

Table 1. Impact of combined measures

Effect	Comments
Impact on transport intensity	Potential 1.5% reduction in car mileage (at German level); no reason to expect changes in GDP. Based on pilot project and the following assumptions: successful implementation in towns of 10,000-50,000 throughout Germany; average trip distance 10km; occupancy 2pkm/vkm.
Impact on unit environmental load	Potential 5-10% reduction in fuel consumption per car km among the target population - towns of 10,000-50,000 people. Potential exists to extend the 'efficient driving' components of this measure to all drivers (car, bus & goods vehicle) in Germany and beyond. Order of magnitude of potential fuel consumption saving (and corresponding emissions saving) is 5-10%.
Impact on CO2 Emissions	Potential 1-2% reduction (=10.4-19.2million tonnes) in CO ₂ (in Germany) due mainly to more fuel-efficient driving.
Possible unexpected effects	Hard to tell given the lack of evidence on the longevity of any effects. Possible with repeated exposure to messages pushing green travel behaviour that there will be changes in the way that transport is used. It is also possible that the long term effects of repeated messages might be a reaction against the message.

The pilot project (“Mobile Schopfheim”) was carried out in the city of Schopfheim and the neighbouring towns of Maulburg and Hausen (in the Landkreis region of Lörrach, Germany): total population approximately 25,000. Motorised and non-motorised trips were monitored over a 24 month period. Approximately one third of the German population lives in towns with a population between 10,000 and 50,000 for which Schopfheim can be considered to be representative. Table 1 summarises the impacts of the scheme based on results from Prognos (1997a, and b).

5.2 Car sharing as part of combined mobility

This is provided by private and public sector transport operators, with the support and encouragement of the city governments of Zurich and Berlin and, in the Swiss case, the federal government. In Switzerland, the scheme is run by an independent organisation, but in co-operation with the car hire firm Europcar, Swiss Railways and Zurich public transport, under the banner ‘Mobility Car Sharing Switzerland’.

Essentially, this is a combined (inter-modal) transport service for passengers, combining hired private car with public transport for different legs of the same journey. Ticketing and reservations are integrated, providing a single point of sale to the customer. Hire cars are available to pick up or drop off at a large number of locations, particularly in more populous areas and at rail stations.

Table 2. Impact of car-sharing

Effect	Comments
Impact on transport intensity	1% reduction in car mileage at the EU level believed to be a realistic aspiration; no necessary change in GDP. Minor increase in motorcycle mileage. Analysis based on Swiss and German car sharing research (Baum and Pesch, 1995; Muheim and Partner, 1998; and Pesch, 1996).
Impact on unit environmental load	Higher utilisation of the car stock, since hire cars are used more intensively than privately owned cars (15,500km vs 13,000km per annum). This could imply fewer natural resources consumed in car production, although these resources have not been quantified.
Impact on CO ₂ Emissions	Potential 0.2% reduction (=1.4million tonnes) in CO ₂ emissions (in Germany).
Possible unexpected effects	Possible impacts on GDP if successful due to lower requirements for car production, though conversely positive impacts on the economy resulting from reduced individual travel expenditure leading to potential increase in other consumer spending.

5.3 Controlled Parking Zones (CPZs)

Controlled Parking Zones, which simply aim to give appropriate priority to different categories of users, have been in operation across Europe for over forty years. They have gradually developed into instruments of a transport planning policy which combines an acceptance of car ownership for a high proportion of the population with discouragement of car use for certain types of trip, notably short trips, journeys to work and most radial trips, where there are good public transport alternatives. Inner-city suburbs, in particular, benefit through the reduction of ‘railheading’.

The size and design of the CPZ, within which local permit holders are able to park, is an important policy instrument. In particular, account must be taken of local businesses, in order to achieve the objective of curbing travel, while supporting the prosperity and growth of the local economy. Hours of operation, and zone size, are other key variables.

Table 3. Impact of controlled parking zones

Effect	Comments
Impact on transport intensity	Estimated impact is for inner-London only (i.e. the ring outside Central London), based on data for one inner-London borough (London Borough of Camden, 2001a). Figures are 'speculative'. Estimated reduction in car passenger km is approx. 800 million per annum. Equivalent to 500 million car vehicle km per annum, or 0.1% of UK car mileage. An assessment of transferability to other UK cities and the EU would require: data on the extent of similar inner-urban areas; data on the extent of existing parking controls in these areas. Without this assessment, it is uncertain to what extent this is a UK-specific problem.
Impact on unit environmental load	None expected.
Impact on CO2 Emissions	Potential reduction of 160,000 tonnes in inner-London.
Possible unexpected effects	Possible longer term increase in cycling, walking and public transport use as drivers start to realise the restrictions on parking in particular areas.

5.4 Internet shopping: home delivery by supermarkets

Many retail and service organisations are establishing an internet presence, and making their goods and services available via the internet. "All of the 30 largest world retailers [21 of whom have their core market in the EU] have ... website presence" although only 15 [8 in the EU] offer on-line ordering (Retail Monitor International (RMI), 2000). Some goods, such as clothing, have been available via catalogue shopping, utilising the mail and/or telephone for many years.

The highest proportion of internet users in any one country in Europe who shop on-line are from the UK. Despite this, only a tiny percentage (0.4%) of the UK grocery market, which was worth approximately £100bn in 2000, was online. Thus, the online market is worth £400m (628mEUR). This is thought to be the largest online grocery market in the world, given that it exceeds other EU markets (in total) and the US market. UK consumers appear particularly comfortable with credit card payment over the telephone or internet (Eurobarometer, 2000).

Home-delivery from supermarkets has the potential to significantly reduce the number of personal shopping trips, which currently account for 19 percent (Browne, 1999) of personal trips in the UK. However, evidence suggests that in the EU the reduction in car vehicle kilometres is being offset by additional delivery vehicle kilometres. If density of deliveries increases there is clearly potential for this situation to improve, but it is very uncertain whether such changes will occur.

Table 4: Impact of internet shopping and home delivery

Effect	Comments
Impact on transport intensity	The evidence indicates that even in the most developed on-line grocery markets in the EU, the reduction in car vehicle km (on average 9.2km per week) is being fully offset by additional delivery vehicle km, perhaps leading to a small overall increase (Bunney, 1998). It is also possible that the opportunity for internet shopping may generate additional shopping and hence additional delivery km. There is some scope for this balance to improve with market growth, as the density of deliveries increases (Cairns, 1999). However, it is not possible to place a figure on this.
Impact on unit environmental load	None expected.
Impact on CO ₂ Emissions	CO ₂ emissions increase in the short term, although medium-long term prospects may be better if the internet shopping/home delivery market continues to expand, with a greater density of deliveries. Medium-long term effects have not been quantified.
Possible unexpected effects	Possible renaissance of small residential shopping centres as intermediate distribution points for home delivery. Negative effects of double parking.

5.5 Car-free/car-capped housing

This is an urban development policy, which encourages the construction of residential units without off-street parking.

One of the earliest experiments was for a development of 210 residences at Hollerland 7km from the centre of Bremen, a city of 500,000 inhabitants in North Germany. The full implementation of this particular scheme was abandoned in 1996. The failure was attributed to a variety of factors including a general down-turn in the economy, delays in implementing a new tramline to the project area and unease among potential residents about committing themselves permanently to a car-free life in a comparatively suburban location.

Bremen was, however, successful in implementing a more modest 25 unit scheme in the inner city district of Grunenstrasse. Other car-free developments have been introduced at a variety of European locations during the 1990s, for example in Amsterdam, Edinburgh, Freiburg, Hamburg and Vienna.

The London Borough of Camden (UK) has approved 670 units of car free housing since adopting the policy in 1996 (London Borough of Camden, 2001b). Permissions have ranged from single units to developments of over 20. The policy is applied only in Controlled Parking Zones where residents in dwellings without off-street parking can be excluded by legal agreement from rights to acquire permits to park on the street. It has also explored 'car-capped' housing in Controlled Parking Zones, by which off-street parking places are provided, but the residents have no right to on-street parking permits in addition.

Table 5: Impact of car free/car-capped housing

Effect	Comments
Impact on transport intensity	In the London Borough of Camden, car-free housing represents approximately 1% of the housing stock after 5 years with the policy. Based on trip rates and lengths assumed by transport planners, a rough estimate is that the Camden policy may have reduced car passenger km by 5million per annum, or 0.001% of the UK total car km. Extension of the policy from Camden (population 200,000) to the whole central and inner-London area may be expected to increase the impact proportionately. This may be of the order of 0.02% of UK car km. It would be difficult to expand these figures to EU level as their success depends at least in part on existing levels of car free housing in different countries.
Impact on unit environmental load	None expected.
Impact on CO ₂ Emissions	Potential reduction of 1,000 tonnes in the London Borough of Camden (population 200,000).
Possible unexpected effects	As population in such housing increases there will be more support for local services, leading to further reductions in the need for car use. Subsequent improvements to the urban environment may encourage more people to live in the area. More use of public transport outside peaks could improve load factors. Both of these effects could positively reinforce the initial impacts.

5.6 Tradable permits

The concept of tradable permits arose from environmental economics. The most relevant form is the tradable permit to pollute (for example the EU (CEC, 2000) is considering an emissions trading scheme), although tradable permits have also been proposed in Mexico (Goddard, 1997) as an efficient way of managing road vehicle use and have been introduced in Singapore to control vehicle ownership. Despite this there is limited experience of their implementation or development. Their inclusion in the shortlist of the most promising measures is based on understanding of the problem and beliefs about their potential effectiveness, influenced by the judgement of the panel experts.

The attractiveness of tradable permits derives from the control they exert over the total quantity output. In the case of permits to pollute, it is the quantity of emissions that is controlled. Subject to successful enforcement (which is a key implementation issue) tradable permits can limit total emissions so that they are within the threshold that is the carrying capacity of the environment. For CO₂, therefore, tradable permits could be a way to ensure targets are achieved, without draconian command and control measures. Efficiency is achieved through the market in permits, which operates to ensure that users with the most to gain (in terms of willingness-to-pay for permits) get access to the resource. Equity issues may arise, although the initial distribution of the permits could in principle be changed to offset any inequalities in their use.

Key implementation issues clearly include the creation and regulation of the market in permits, the technical ability to monitor emissions throughout the transport sector, and the issue of enforcement. Further discussion follows below. Given lack of research in this area it is impossible to say how effective and publicly acceptable such measures will be, but there is certainly the potential to increase the costs of driving and therefore to influence vehicle kilometres.

Table 6. Impact of tradable permits

Effect	Comments
Impact on transport intensity	Quantitative assessment of the impacts is beyond the scope of research to date. From a qualitative point of view, tradable permits targeted at road users have the potential to increase the cost of driving. Relevant dimensions are car ownership, mileage, departure time, route choice and vehicle type. Demand elasticities will influence the response in traffic levels to each of these dimensions.
Impact on unit environmental load	Qualitative assessment: the greatest effect is expected to be indirect, through the vehicle ownership market and the incentive offered by the permits to purchase cleaner vehicles. Emissions factors also depend upon traffic conditions - if tradable permits are effective in reducing congestion then they can be expected to reduce unit environmental load of vehicle use through this channel as well as vehicle ownership. Quantitative results will depend upon the elasticities used to represent demand and supply responses, and the design of the permit scheme.
Impact on CO ₂ Emissions	Qualitative assessment: both the transport intensity and unit environmental load impacts point towards an overall reduction in CO ₂ emissions. The scale of such a reduction will depend directly upon the quantity of permits issued, if they are permits to pollute. If the permits are denominated in units of distance, the relationship may be more difficult to control.
Possible unexpected effects	Move towards smaller more environmentally friendly vehicles. May be a long term increase in price of vehicles given fewer cars will be sold and suppliers may see the potential for a change in the willingness to pay of the new marginal car user.

5.7 Urban road pricing

The tolling of specific inter-urban highways or of major bridges/tunnels has been extensively applied in a number of EU countries for many years. In contrast, urban road pricing - which is the measure being assessed in this report - has had a long history of academic discussion and study, however it has had much less practical application to date. Major applications include a sophisticated urban road pricing scheme in Singapore, cordon pricing schemes in Trondheim and Bergen and more recently in London.

Given the point at which European policy has reached, this research looked at the potential impact of cordon charges, introduced across the 21 largest cities in the EU, based on the expected impacts of the London scheme. Differences in the ability of freight and passenger traffic to respond to urban road pricing are recognised from the outset. Based on figures on likely changes in traffic levels (MVA, 1995) there is a potential for a 0.2% reduction in car kilometres in the EU if this measure were introduced in the 21 largest cities and a reduction of 2.3 million tonnes of CO₂.

Table 7: Impact of urban road pricing

Effect	Comments
Impact on transport intensity	Potential 0.2% reduction at the EU level if implemented in 21 largest cities. Figures are for cordon-based pricing, not for sophisticated electronic road pricing in the style of Singapore.
Impact on unit environmental load	Qualitative assessment: this impact is minor, but some reductions in the rate of emissions per vehicle km would be expected as a result of less stop/start driving due to reductions in queuing. These small changes have not been quantified here.
Impact on CO ₂ Emissions	Potential reduction of 2.3 million tonnes at the EU level (0.3% of total EU road CO ₂ emissions in 1999) if cordon-pricing applied in the 21 largest cities.
Possible unexpected effects	Possible impacts on regional competition. Movement of firms to cities which do not have pricing schemes implemented.

The actual London scheme was implemented in 2003. A fixed charge of £5 is levied for vehicles entering or moving in the congestion charging (CC) zone during the charging period (0700-1830, M-F) with exemptions (buses, taxis, motorcycles) and discounts (90% for CC zone residents, 100% for blue badge holders). One year after the introduction, congestion has reduced by up to one-third, in terms of time the drivers spend stationary or moving slowly in queues, traffic entering the zone by 18% and traffic circulating within the zone by 15%, all values which are towards the top end of the range of predictions. There is no evidence of systematic increases in traffic outside the charging zone. The increase in bus patronage in the morning peak has been higher than expected (38% against 20%) (Mayor of London and Transport for London, 2004).

5.8 Hydrogen fuel cell vehicles

Vehicles based on hydrogen fuel cells do not emit pollutants at the point of use, though whether pollutants are emitted during their production depends essentially on whether the hydrogen is extracted from fossil fuel sources or from renewable sources.

Hydrogen fuel cell vehicles are not expected to have any effects upon transport intensity, but clearly have the potential to reduce environmental load. The effectiveness of these vehicles in terms of reducing environmental load is limited by market share. Development may be promoted directly through technology/R&D policy and indirectly through incentives/regulation for the use of clean fuel vehicles in future. The Californian Clean Air Act is cited as an example of legislation designed to stimulate this process.

Table 8. Impact of Hydrogen fuel cells

Effect	Comments
Impact on transport intensity	None expected.
Impact on unit environmental load	Local emissions would be reduced by 100%, however this reduction needs to be considered against a background of a decrease in emissions due to tighter emissions standards and greater vehicle efficiency. Assuming 5% market share of Hydrogen fuel cell vehicles by 2020, additional reductions beyond those expected from other technologies of around 1-2.5% of local emissions can be expected (Höpfner, 2000).
Impact on CO ₂ Emissions	Provided that fuel cells were produced using renewable energy only, a potential reduction in CO ₂ emissions for Germany of up to 5% of total car emissions for 2020 (around 6 million tonnes) is possible.
Possible unexpected effects	Development of technology still ongoing – possibility of EU obtaining economic benefits through exporting technological expertise.

5.9 Green Transport and Travel Plans

A Green Travel Plan is a coherent strategy developed by an organisation, which attracts a large number of people on a regular basis from known (or knowable) origins. It aims to accommodate this travel but to (a) reduce the number of vehicle trips which are generated by that use and (b) transfer as many trips as possible to more environmentally friendly modes. They are thus directly targeted at reducing transport intensity.

This particular strand of mobility management has had substantial support over recent years from Governments, who see it as a reasonably painless way of increasing transport efficiency. Green Travel Plans have provided an element of the Netherlands' transport policy since 1989 and, in recent years, have formed part of the thinking of the UK's Department for Transport. In March 1998, the Italian Minister of Environment issued the Decree Ronchi which required all public authorities with over 300 employees and all private enterprise companies with more than 800 employees to appoint a Company Mobility manager, whose responsibility it is to optimise employee travel and reduce car use. Some Local Authorities in the United Kingdom have adopted the concept of green travel plans as a planning tool and make their adoption a condition of development in congested or transport-greedy locations.

UK and Dutch experience is cited in assessing the potential impact of Green Transport and Travel Plans at the European level (Rye and Mcleod, 1998; Rye, 1999; MOMENTUM, 1999). It is generally felt that such measures are essential as part of an integrated strategy to reduce car use, but there is little evidence to suggest that, on their own, they have the potential to bring about significant change.

Table 9: Impact of green transport and travel plans

Effect	Comments
Impact on transport intensity	Qualitative assessment suggests that Green Travel Plans certainly have a role in reducing transport associated with a given level of activity in the context of a given pattern of locations and land use. However, the scale of this impact is difficult to quantify given uncertainty in both take-up rate, longevity of effect and the wide variability in effectiveness.
Impact on unit environmental load	No major impact expected.
Impact on CO2 Emissions	One example of a transport plan applied to a school in North London (Symonds Travers Morgan, 2000) gives an annual reduction of 10 tonnes of CO2 (equivalent to 3 times the average annual emissions from a medium-size car). As a policy, the potential benefits depend upon the number of organisations who would take up Green Transport Plans and the extent to which behaviour would change.
Possible unexpected effects	Difficult to quantify and predict though possibly similar to combined measures.

5.10 High Speed Rail (HSR)

High Speed Rail (services capable of achieving speeds in excess of 250km/h, High Speed Rail) exists in Europe in France, Belgium, Germany, Italy, Spain and Portugal. Given its high speed characteristics over medium inter-urban distances, and the convenience of rail terminals for access to most city centres, HSR has been linked with three specific niche markets: business travel; short stay personal travel; and to a lesser extent holiday travel. Its ability to substitute for air and car travel in these markets has been explored in various research studies. Campenon (1995) suggests that under 300km the motor car dominates, whilst over 1400km air travel dominates. HSR is most suited to the market for travel between these distances.

The impact of completing the European High Speed TEN-T network was assessed using data for 2020 from the STREAMS project (Leitham et al, 1999) and evidence from inter-modal competition studies of HSR implemented so far (Wardman, 1992, 1993; Dom, 1994).

Table 10. Impact of high speed rail

Effect	Comments
Impact on transport intensity	Approximately 4.7%-5.1% reduction in aircraft km at the EU domestic and international level (185million-200million aircraft km). Approximately 0.002%-0.005% reduction in car km at the EU level (86million-191million car km). Approximately 2% increase in rail km at the EU level (100million-200million rail km).
Impact on unit environmental load	The higher speed of HSR is associated with higher emissions factors than for conventional rail, however, this must be set against the mode switch effect. Overall it is estimated that each of the main local pollutants would experience a net reduction.
Impact on CO2 Emissions	The prediction is for a 3.6-5.6million tonne reduction in CO2 emissions per annum at the EU level (0.5-0.7% of total road emissions in 1999).
Possible unexpected effects	If this service establishes a record of reliability and service quality this could lead to further trip generation, modal switch and trip switching. Also longer term possibilities of economic development along HSR corridors and land use changes.

5.11 Electronic offices

Information technology (IT) is increasingly offering a range of opportunities which are expected to have major societal impacts in addition to changes in travel behaviour. IT can affect personal travel through a variety of mechanisms. The focus here is on the mobility impacts that are brought about via changes in working practices and arrangements.

The following categories are identified:

- flexible working arrangements, including teleworking,
- self-employment and non-permanent and part-time working arrangements,
- mobile working,
- internal and external communication in firms substituting for business travel, including teleconferencing.

Evidence is sparse and conflicting, however research suggests that this measure has little scope for reducing transport intensity on its own. IT tends to stimulate communication without increasing the cost or inconvenience of transport (Mokhtarian, 1997; Golob and Regan, 2001). It is not expected that this measure will have any significant effects on environmental load, at least not in the foreseeable future.

Table 11: Impact of electronic offices

Effect	Comments
Impact on transport intensity	Qualitative assessment: evidence suggests there is little scope for this measure to reduce transport intensity when implemented alone, particularly since it stimulates communication without increasing the cost or inconvenience of transport. It is possible that whilst this measure may not reduce travel, it could have an impact on the distribution of travel between off-peak and peak periods.
Impact on unit environmental load	None expected.
Impact on CO2 Emissions	Qualitative assessment: the analysis on transport intensity casts some doubt on the potential for CO2 reduction here.
Possible unexpected effects	Possible long term land-use changes with a movement to more dispersed settlement patterns. Social benefits through increased 'virtual' accessibility to the workplace.

5.12 Road pricing for freight traffic

Very large social costs are caused by road haulage. On one hand there are costs associated with the infrastructure provided. On the other hand there are also substantial external costs due to air pollution, noise pollution, accidents and other forms of environmental damage. Road pricing can help to guarantee cost realism. In addition road pricing could be a supporting measure for modal shift from road to rail.

Tolls for freight traffic exist in various parts of the world, although the charging basis differs. In many European countries there is a flat rate annual charge for HGV use. Another way to charge for the use of roads is to adopt variable charging dependent on the time of day, weight, emissions or distance. Differentiation on a time-of-day basis (e.g. higher prices during peak traffic hours) could in principle permit improvements in the traffic flow and a

more even burden on the road infrastructure. However, distance-based charging is seen as more technically feasible.

The case study which is used as evidence here to illustrate the impacts of road pricing is an *ex ante* study on the Mileage-Related Heavy Vehicle Tax (MRHVT) which replaced the flat-rate heavy traffic tax in Switzerland in January 2001. The Mileage-Related Heavy Vehicle Tax is a comprehensive road-user tax, dependent on distance, weight and emissions, levied on HGVs. This includes road costs (construction, operation and maintenance) and a quantifiable part of the external costs (accidents, noise, and air pollution) (ECOPLAN, 1997).

Table 12: Impact of road pricing for freight

Effect	Comments
Impact on transport intensity	Potential 10-15% reduction in road haulage vehicle km in Switzerland in 2010, based on <i>ex ante</i> modelling of the MRHVT. Rail freight traffic will rise substantially to meet demand – transport intensity effect not assessed quantitatively.
Impact on unit environmental load	Possibly some improvement in emissions factors if congestion reduced – not expected to be large compared with the modal shift effect and not quantified.
Impact on CO ₂ Emissions	The central estimate is a reduction of 370,000-560,000 tonnes in Switzerland in 2010 though the uncertainty associated with this is very large. Additional rail transport emissions have not been taken into account.
Possible unexpected effects	Hypothecation of monies generated to public transport projects. For example the MRHVT project in Switzerland is using funds to part finance Swiss railway development.

5.13 Variable speed limits and control

This measure covers the application of variable speed limits according to the current traffic situation to achieve better network management. Systems exist which capture data related to the current traffic situation to provide the necessary information. Roadside information about variable speed limits is provided through variable message signs (VMS).

Table 13. Impact of variable speed limits and control

Effect	Comments
Impact on transport intensity	None expected. If anything, effects are likely to cause increases in transport intensity as the measure will increase effective capacity of the road network (by 10-20% on highly-loaded sections) and offer quicker/more reliable journey times by road.
Impact on unit environmental load	A “small reduction of local pollutant emissions can be expected due to a more fluent traffic flow”. The quantitative assessment points to reductions – on highly congested parts of the network only – of: 0-3% for NO _x , 8-27% for CO, 6-7% for HC and up to 22% for particulates (Prognos A.G., 1999).
Impact on CO ₂ Emissions	On highly congested parts of the network a reduction of 3-10% CO ₂ might be possible (Prognos A.G., 1999), however overall impact is a balance between the transport intensity effect, which may work against sustainability, and the unit environmental load effect, which is likely to be favourable.
Possible unexpected effects	Difficult to quantify and predict such effects.

As an aid to sustainability, the idea behind this measure is that inefficient driver behaviour is a source of additional emissions. 'Smoothing' the traffic flow is likely to lead to a reduction in the *rate* of emissions. It is not expected that this measure will lead to a reduction in transport intensity. If anything the opposite may be the case as the measure acts to increase the capacity of the road system.

6. Reality check

The final stage of the research was to test the shortlist of the most promising measures with a second round panel comprising selected members from the first round, plus additional representatives from industry and consumer groups. The aim of this was to provide a reality check on the shortlisted measures in terms of their likely acceptability and more specifically to provide comments and views on the measures presented, additions (or subtractions) to the list and to help the research team gain an improved understanding of the potential effectiveness of the measures proposed.

Members of the panel were sent a draft report some time before the panel session was held which contained background to the project, the aims of the panel exercise and detail concerning the evaluation undertaken of each of the shortlisted measures. The actual panel session was held in a central location and took the form of an initial presentation by members of the project team on the outcomes of the project and each of the shortlisted measures. Members of the panel were asked for their views on the appropriateness of the measures and whether the conclusions of the research team on effectiveness were realistic.

An initial conclusion from the panel was that there was no strong feeling that the choice of promising measures was fundamentally wrong, though given that they were chosen as indicative of broad groups of measures, this is perhaps not surprising. Having said this it was clear that most members of the panel had individual views on the relative merits of the different measures, however, whilst it would have been possible to impose some kind of rigid voting system on the panel members, it was felt more useful, given the lack of major differences of opinion, to use the panel to promote discussion and to achieve, where possible, a degree of consensus on the relative merits of each measure. A strong view from the panel was that it was more realistic to place greater emphasis on the development of complementary packages of measures rather than individual measures. For example between urban road pricing (which encourages orbital travel) and controlled parking zones (which help to control orbital route-switching behaviour); and between controlled parking zones and car-free housing as instruments to manage the local street environment. Green Travel Plans and Car Sharing are likely to work best when there are reliable public transport and information systems and a balance of the transport system designed to lean in favour of cyclists and walkers. Clearly this would have to be a major consideration in any future plans to implement such measures, though the evidence on combined impacts is relatively limited. On the basis of the reality check panel and the assessments undertaken it was concluded that a number of the measures in the initial shortlist stood out as having more potential to achieve the decoupling objectives. The others were not rejected as such, rather felt not to offer the same potential (unless as part of a combined strategy), or in a couple of cases it was concluded that there was lack of a reasonable level of case study evidence to be sure. Seven measures stood out as having proven potential (albeit not necessarily at a European scale) to

influence transport intensity and unit environmental load whilst not having large detrimental effects on GDP. These are (in no particular order):

- Combined measures to change mobility-related attitudes and traffic behaviour
- Car sharing as part of combined mobility
- Controlled Parking Zones
- Urban road pricing
- Hydrogen fuel cell vehicles
- High speed rail
- Road pricing for freight traffic.

This final panel session also resulted in the addition of considerable extra evidence on some of the measures and for all measures the suggestion to include in the evaluation the additional consideration of unexpected side effects.

7. Conclusions

The case for decoupling is one which seems obvious to some, but less so to others. It rests, essentially, on a series of limited propositions:

- that the environmental externalities of transport are serious and need to be reduced;
- that single direct measures such as optimal pricing, though theoretically capable of pushing the transport – economy – environment system to a better solution, are in practice unlikely to be implemented fully, quickly enough, and without complementary policy measures;
- that therefore it is legitimate in that context to consider a range of measures which could be helpful either alone or as part of a package.

It has been shown that opinions differ both about the seriousness of transport-related externalities and about the practical feasibility of using direct pricing measures to address them. There is broad, though not universal support among the experts consulted for a policy at EU level which aims for decoupling using a range of measures to support the policy. These measures aim to reduce either the transport intensity of the economy (i.e. transport performance per unit of GDP) or to reduce unit environmental load (i.e. emissions or other negative effects per unit of transport performance).

The strength of the approach outlined in this paper is that it is possible to gain a reasonable understanding of how well the chosen measures have worked (or in one or two cases could work) in the context they have been tried. A weakness is the difficulty of grossing up. It is not always easy to assess the size and range of markets to which a particular policy instrument is transferable. It could be that some instruments depend for their implementation on a particular conjunction of transport and political considerations which are not widely repeated elsewhere. To take an example, whether the model for road user charging should be one which is network wide or at city level or for the centre of the capital city or not at all, is the subject of debate in more than one Member State. Which of these options is ultimately chosen is likely to make a significant difference to the impact of the policy on vehicle kilometres and emissions.

The seven measures chosen are those which the EU could currently most usefully focus its efforts in terms of decoupling. An estimate is provided (albeit based on often incomplete case study evidence) of the scale of possible changes which might be realised given a defined implementation of a particular measure. The EU needs to consider whether the measures suggested here are ones which could successfully be implemented as part of a policy to influence decoupling and whether there are further issues of acceptability to consider. Clearly it will be easier to implement measures such as green transport plans which are based around encouragement of people to change their behaviour, compared to measures which will force a change in behaviour through pricing or other means of control. Of course, ease of implementation does not imply effectiveness. It is noticeable that many of the most promising measures in terms of their decoupling potential are likely to be the most difficult to implement as a result of high public discontent and resultant political wavering.

It is worth noting that some of the measures, for example tradeable permits, appear to have potential to influence transport use, but there is a distinct lack of research to back this up. Such measures certainly have the potential to change the costs of driving and to influence vehicle kilometres.

The measures identified here are illustrative measures, that is, they are examples of different kinds of measures, but in most cases are by no means the only example of each type. Each individual measure has some potential for reducing transport intensity or environmental load, even in isolation. However, for their full impact to be recognised, they have to be incorporated into strategies of measures, which are both mutually supporting in the field for which they were designed and have beneficial, rather than adverse knock-on effects in the wider world. There is a clear message which comes out of all of the aspects of the work undertaken that no one measure alone will make a significant difference, rather there is a need for an integrated approach.

It is naturally more difficult to predict what the gross effects of different packages of measures may be and it is essential to consider the behavioural response to measures and packages of measures when planning their implementation. It is important to recognise that some measures may need to be formed into packages to be fully effective, for example pricing may need to be supported by enhanced provision of alternatives in order to have the desired effect on mode choice, emissions and sustainability. Clearly there is potentially some additive benefit to be gained from packages of complementary measures or measures which affect different aspects of the transport system. Thus, a combination of pricing measures and measures to improve high speed rail systems is likely to have a greater impact than either one measure alone. Also the addition of Green Transport Plans (although of limited benefit alone) or other measures designed to influence attitudes, may be expected to further enhance the decoupling impact.

The EU White Paper on transport (CEC, 2001) acknowledges the need to break the link between transport growth and economic growth. This work has investigated how such a link may be broken. The findings show that at EU level there are considerable potential benefits both in reductions in transport intensity and unit environmental load from various of the measures examined. In terms of transport intensity the most promising measures appear to be Car Sharing which could give as much as a 1% reduction in car mileage at EU level and Combined Measures to change mobility related attitudes and traffic behaviour which could give a 1.5% reduction in car mileage. The transferability of such combined measures to other locations with less existing supportive infrastructure is highly debatable, and it might be

expected that the immediate short term impacts, if applied more generally to the EU, would be significantly less. Such measures, combined with a move towards Hydrogen Cell vehicles would also offer significant reductions in unit environmental load. The Combined Measures approach also has the potential to bring about a 5-10% reduction in fuel consumption per car kilometre.

In terms of impact on CO₂, the measures with most potential are the Combined Measures (around 16 million tonnes for Germany or 1%-2% of total emissions) and Hydrogen fuel cell vehicles (6 million tonnes for Germany) which if applied throughout the EU have the potential to make a considerable impact on levels of Carbon Dioxide emissions from transport. Complementary to these measures would be development of high speed rail (a further 3.6-5.6 million tonnes reduction in the EU) and road pricing for freight transport (perhaps a similar overall reduction in the EU).

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