Decoupling the link between economic growth, transport growth and transport energy consumption in Europe

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Abstract
In the past, it has always been assumed that there is a close relationship between the growth in freight and passenger transport, transport energy consumption and economic growth, at least as measured by Gross Domestic Product (GDP). This raises questions about the underlying rationale for this statistical relationship (if it exists) and, more importantly for sustainable development, whether the relationship will (or should) continue into the future.

The strong premise in this paper is that decoupling economic growth from transport growth is a necessary condition for sustainable development – we need to encourage economic growth (in the widest sense), but with less transport (at least in terms of resource use and environmental impacts). This requirement has now been recognised in a series of policy documents. In the UK, for example, the Standing Advisory Committee on Trunk Road Assessment have examined the issue of transport intensity, the prospects for future improvements and the potential for decoupling transport volumes and economic activity (SACTRA, 1999). At the European level, the 2001 White Paper on Transport states that breaking the link between economic growth and transport growth is central in its proposals (CEC, 2001a), and the EU's sustainable development strategy identifies decoupling transport growth from the growth in Gross Domestic Product as one of its main objectives (CEC, 2001b).

We begin by examining transport and economic trends in Europe and looking at EU policy statements on decoupling. We then discuss the nature of travel and how decoupling can usefully be measured through volumes, distance and efficiency. Possible approaches and strategies for decoupling are then presented, together with a discussion of how these measures might help to decouple transport growth and economic growth. We conclude that, whilst there are a number of strategies which are likely to help to decouple transport growth and economic growth, there are also a number of factors which are hindering the decoupling process. Consequently, decoupling transport growth and economic growth is likely to be a difficult goal to achieve.

Introduction – Trends in Transport and Economic Growth in Europe
A brief overview of trends in transport and economic growth over recent decades is presented below. A more detailed analysis is presented elsewhere (Banister et al, 2000). In terms of passenger transport, the average distance travelled per person per year has doubled in Europe between 1970 and 2000. This was primarily due to people travelling further rather than travelling more frequently. In 1970, the average yearly travel distance was 6 176 kilometres per person and by 2000 was 12 715 kilometres per person. The use of the car grew rapidly over this period and reliance on it continues to increase (Figure 1). Travel by car more than doubled between 1970 and 2000 in Europe and, by 2000, more than three quarters of passenger-kilometres were by car. Air travel, although making up a small proportion of all journeys, is becoming increasingly important in terms of transport energy consumption and emissions. Passenger travel distance by air increased more than seven-fold between

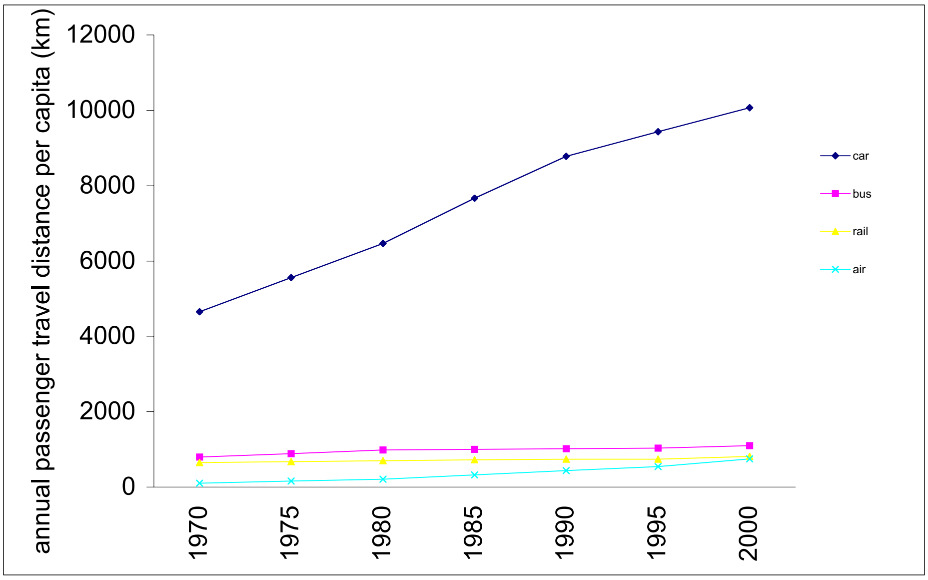

Figure 1. *Trends in passenger transport by mode in Europe, 1970 to 2000.*

1970 and 2000. In 2000, air transport (international civil aviation and domestic air transport) accounted for 14% of all transport energy consumption in the European Union (OECD, 2002).

In terms of freight, the number of tonne-kilometres increased by 119% within the European Union between 1970 and 2000, primarily due to goods being moved further rather than more goods being moved (Whitelegg, 1997). In 2000, the average yearly freight transport distance per capita was 3 581 tonne-kilometres by road, 3 374 tonne-kilometres by sea, 662 tonne-kilometres by rail, 271 tonne-kilometres by inland waterway and 170 tonne-kilometres by pipeline (Figure 2). In 2000, more than 43% of freight-kilometres were moved on roads, compared to 35% in 1970. Freight transport by road increased by 177% in Europe between 1970 and 2000.

As a result of these trends, transport energy consumption per capita more than doubled between 1970 and 2000 (Table 1). However, total energy consumption across all sectors increased by just 19%, as a consequence of a reduction in energy consumption by industry and fairly low growth in the domestic sector. Economic activity increased substantially in all European Member States over recent decades. Between 1970 and 2000, the overall GDP per capita of all 15 European Member States almost doubled in real terms: an average increase of around 2 per cent per year (Table 1). The largest increases in GDP per capita were in Luxembourg, Ireland and Portugal (see also Stead, 2001). Comparing changes in energy growth and economic growth between 1970 and 2000, it appears that transport energy consumption and GDP are strongly tied and, more importantly from a decoupling point of view, that transport energy consumption is growing at a faster rate than economic growth (Figure 3).

Various indicators of transport intensity can be used to examine decoupling. These include the ratios of economic activity with passenger movements, freight movements or a combination of both passenger and freight movements (using the concepts of *net mass movement* [1] and *gross mass movement*,[2] discussed in more detail by Peake, 1994). Three indicators of transport intensity are also presented in Table 1. Between 1970 and 2000, the ratios of GDP per passenger-kilometre, GDP per tonne-kilometre and GDP per net mass movement all decreased since passenger and freight transport grew faster than economic growth (GDP).

Trends in these three indicators across individual European countries show a substantial amount of variation (see Stead, 2001). Most of the 15 EU countries have experienced quite individual trends and few common patterns are obvious, which corresponds with the observation in the SACTRA report (SACTRA, 1999) that '*traffic intensity, however measured, shows very considerable variation from country to country*'. More alarming from a decoupling point of view is the fact that the growth in passenger and freight transport has been higher than economic growth in almost all European countries during the period 1970 to 2000. It seems clear therefore that decoupling transport demand and transport energy from economic growth will not occur by simply allowing the economy to grow, according to the Environmental Kuznets Curve hypothesis (see for example Arrow et al, 1995; IBRD, 1992; Stern et al, 1996).

Decoupling – The Policy Context

The recent European White Paper on Transport Policy identifies decoupling as a *key issue*, arguing that breaking the link between economic growth and transport growth is central in its proposals (CEC, 2001a). This key issue is, however, something of a secondary objective of the document, subservient to primary objective of shifting the modal split from car and air to rail and water. In contrast, the European Commission's Sustainable Development Strategy top headline objective for transport is decoupling transport growth and economic growth (CEC, 2001b).

The European Transport White Paper contains no formal legislative proposals but indicates areas where the Commission intends to initiate action over the next few years. The document sets out more than 60 transport policy measures

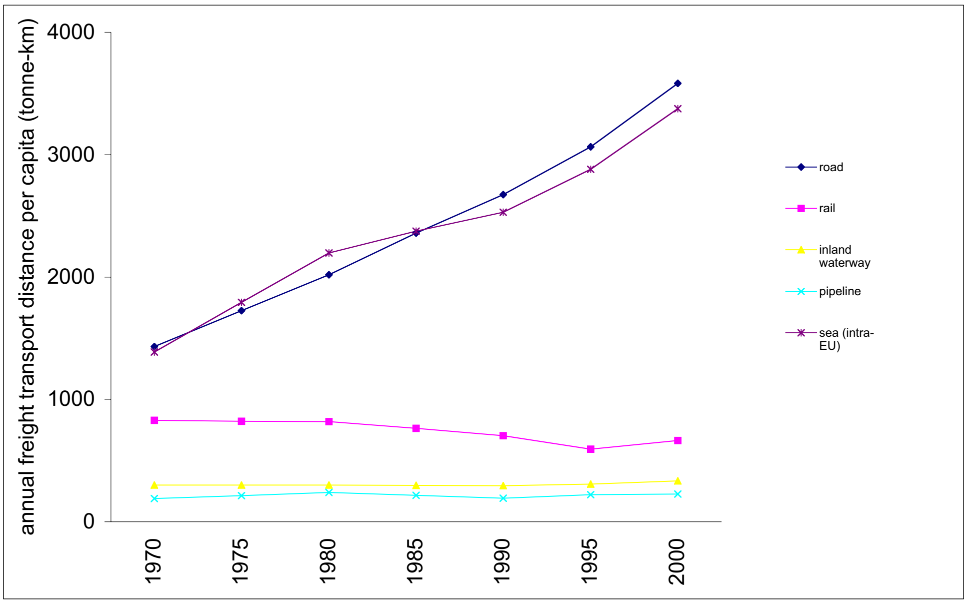

Figure 2. *Trends in freight transport by mode in Europe, 1970 to 2000.*

Table 1. Transport, energy and economic trends in Europe, 1970 to 2000.

	1970	2000	% change 1970-2000
Population (millions) [3]	341	376	11%
GDP (billion US$ constant 1995) [4]	3 333	7 077	112%
Energy consumption by sector (Mtoe)			
• Industry	349	325	-7%
• Transport	140	317	127%
• Other [4]	289	380	32%
• Total	778	1 022	31%
Passenger transport (billion passenger-km)	2 103	4 786	128%
Freight transport (billion tonne-km) [5]	1 407	3 077	119%
PER CAPITA:			
GDP per capita (US$ constant 1995) [4]	12 680	24 049	90%
Energy consumption per capita by sector (toe)			
• Industry	1.03	0.86	-16%
• Transport	0.41	0.84	105%
• Other [6]	0.85	1.01	19%
• Total	2.29	2.72	19%
Travel distance per capita (kilometres per person per year)	6 176	12 715	106%
Freight transport per capita (tonne-km per person per year) [5]	4 132	8 175	98%
Net mass movement per capita (tonne-km per person per year) [1]	4 688	9 319	99%
TRANSPORT INTENSITY RATIOS:			
GDP per passenger-kilometre	2.05	1.89	-7%
GDP per tonne-kilometre	3.07	2.94	-4%
GDP per net mass movement	3.25	3.11	-4%

Sources: European Commission (2002); OECD (1992 and 2002); World Bank (2002).

to be taken at the Community level over the next ten years (Table 2). It also contains an action programme (as an appendix to the main document), which specifies a timetable for the introduction of various policy measures, and proposes a monitoring system, which will be used to make an overall assessment (including economic, social and environmental impacts) of the implementation of the measures advocated in the White Paper.

The White Paper reports that that 28% of CO_2 emissions are now transport related and transport energy consumption is increasing (CEC, 2001a). In 1990, 739 million tonnes of CO_2 were released from the transport sector, rising to

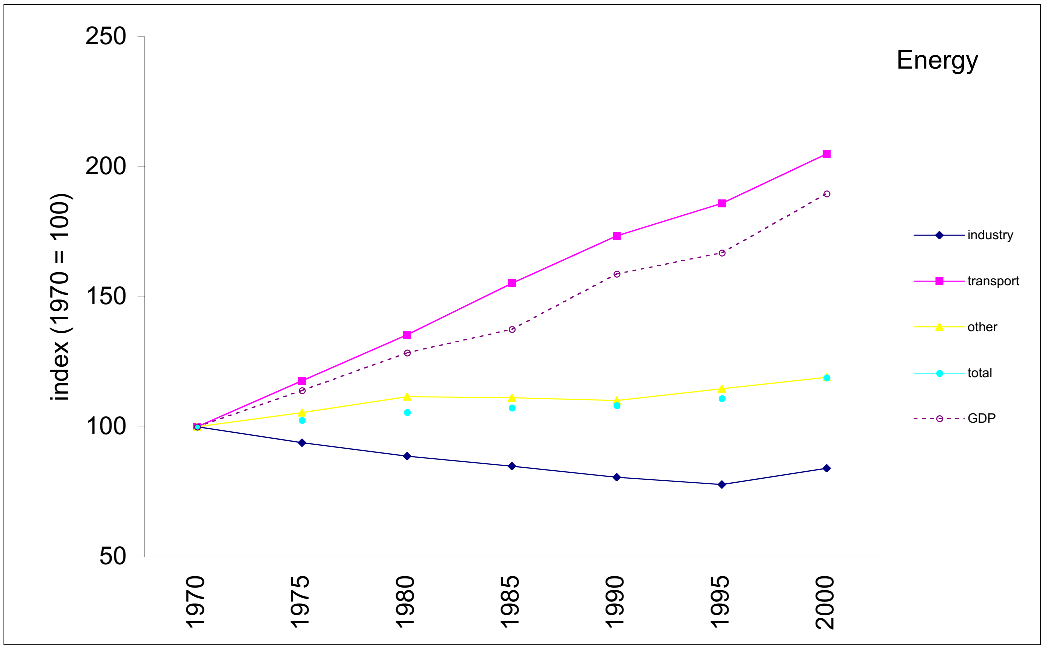

Figure 3. *Trends in energy consumption and economic growth in Europe, 1970 to 2000.*

900 million tonnes in 2000. Further substantial increases are expected in the next decade (1 113 million tonnes by 2010). Road transport accounts for 84% of the 2000 figure, and the total will increase substantially with the enlargement of the EU, even though the levels of motorisation in the accession states is lower. Nevertheless, the White Paper is also optimistic about reducing transport emissions and identifies three types of policy options. The three options comprise: (i) pricing (*Option A*); (ii) pricing and efficiency increases (*Option B*); and (iii) pricing, promotion of alternative modes and targeted investment in the Trans European Networks (*Option C*). The measures in the White Paper build on Option C and aim to return the modal split to 1998 levels in 2010. According to the White Paper, '*by implementing the 60-odd measures set out in the White Paper there will be a marked break in the link between transport growth and economic growth, although without there being any need to restrict the mobility of people and goods*' (CEC, 2001a p11). The White Paper argues that by implementing these measures it will be possible to break the link between transport growth and economic growth without the need to restrict the mobility of people and goods. But it also argues that transport policy alone is not sufficient to tackle current transport problems and advocates an integrated approach with other areas of policy-making, such as economic policy, land-use planning policy, social and education policy and competition policy.

In their analysis of alternative futures, the EU presents their three options against the trend-based future (1998-2010). As can be seen from Table 3, the total passenger-kilometres and tonne-kilometres do not change as compared with the trend, but there are reductions in the vehicle-kilometres for both passenger and freight transport as the impact of pricing, greater efficiency and the other measures take effect. So the transport intensity as conventionally measured is expected to fall over this period. GDP is assumed to increase by 3% per annum (43% over the 12 year period – rather high when compared with performance over recent decades), whilst trends in passenger-kilometres and tonne-kilometres increase by 24% and 38% respectively (Table 4). Transport intensity reduces by 13% for passenger travel and 10% for freight transport. This is where circularity is introduced as the scale of reduction is based on the assumed increase in GDP, which in turn influences the expected growth in passenger and freight travel. Provided that GDP increases at a higher rate than travel, there will of course be some decoupling of transport growth and economic growth (at least in a relative sense if not in absolute terms). From the perspective of sustainable development, however, this is neither sufficient nor desirable, since transport growth, emissions and energy consumption will all continue to increase in the absence of other interventions.

The EU policy options forecast a reduction of vehicle kilometres (both passenger and freight) and the subsequent reductions in CO_2 emissions. The policy instruments proposed in the White Paper are primarily aimed at making more efficient use of the vehicle fleet by raising occupancy levels in all modes, by reducing vehicle-kilometres and by encouraging modal shift (Option C). The impact is less apparent in the passenger sector (-10%) than in the freight sector (-16%) but this balance is redressed when the changes in CO_2 emissions are viewed, where there are about 10% reductions in both sectors. The improvement in CO_2 emissions relates to expected gains in vehicle efficiency from the voluntary agreements with the car industry. It should also be noted that all these reductions are taken against the trend, not the 1998 levels. In each option for 2010 there is a substantial increase in travel and CO_2 emissions as compared with 1998 levels.

Underlying this analysis is the strong assumption that decoupling can take place without the need to restrict the mobility of people and goods. We argue that this is a high-risk strategy for the environment and energy use. If absolute levels of decoupling are to be achieved, ways need to be sought to substantially reduce passenger kilometres and

Table 2. Some of the main measures proposed by the European Transport White Paper (2001).

Theme	Examples
Passengers' rights	Changes to air passenger rights including compensation for air travel delays and denied boarding due to overbooking. Extension of passenger protection measures to other modes such as rail and water transport.
Road safety	Proposals concerning the signposting of accident blackspots, combating excessively long driving times, harmonising road transport penalties at the European level and increasing the use of new technologies in transport.
Congestion	A new programme (the Marco Polo Programme) to support intermodal initiatives and alternatives to road transport in the early stages until they become commercially viable.
Sustainable mobility	Measures to develop fair infrastructure charging, which takes into account external costs and encourages the use of the least polluting modes of transport.
Harmonised taxation	Proposals for harmonising taxes on diesel for commercial use to reduce distortions of competition in the liberalised road transport market.
Transport services	Proposals for harmonising working conditions, especially in road transport, to promote safety and improve transport service quality. Actions to encourage good practice in the provision of high quality urban transport services.
Infrastructure	Completion of 'missing links', particularly the trans-European high-speed passenger rail network and infrastructure with genuine potential for transferring goods from road to rail.
Radionavigation	Proposals for a European radionavigation system with potential applications for transport (location and measurement of vehicle speed) as well as telecommunications, medicine (telemedicine), law enforcement (electronic tagging) and agriculture (geographical information systems).

freight kilometres. In our view, the assumed increases in occupancy levels and load factors, together with voluntary agreements with industry are unlikely to be sufficient to achieve this objective on their own – they might of course help in reducing the relative levels of transport intensity.

From the perspective of decoupling transport growth and economic growth, the picture is bleak. As traffic growth is substantially higher that GDP growth, this means that some 'flip process' is required. Forecasts suggest that this will take place (Table 4) but there seems to be a technical flaw in the argument. As the SACTRA report points out, there is a clear reasoning why transport intensity should decrease over time as the traffic forecasts are driven by growth in car ownership, not by distance travelled per vehicle (SACTRA 1999, p295). Car ownership forecasts in turn are determined by income, which itself is assumed to be linked to GDP growth (assumed to rise by 3% per annum). The relationship between car ownership and income is assumed to lead to eventual saturation. These three factors together mean that intensity will decline in the future. The SACTRA report concludes that the difference between 'periods of increasing and reducing intensity will be indications of the maturity of the car ownership growth curve rather than the success or otherwise of policies intended to influence traffic growth' (SACTRA, 1999 p296).

Within European policy documents, however, there are still high expectations that decoupling economic growth and transport growth is possible. Income growth is clearly very important in determining traffic levels as well as transport prices. Both the European transport White Paper and the SACTRA report are optimistic that decoupling can be achieved, particularly if prices are set at marginal social cost levels, although there is little evidence of success of such changes in achieving shifts in transport prices. According to

Table 3. Summary of transport policy options for the EU between 1998 and 2010 in the 2001 European Transport White Paper.

	1998	Trend 2010	Option A 2010	Option B 2010	Option C 2010
Passenger:					
Passenger km (billions)	4 772	5 929	5 929	5 929	5 929
Vehicle km (billions)	2 250	2 767	2 518	2 516	2 470
CO_2 (million tonnes)	518.6	593.1	551.9	539.1	523.8
Freight:					
Tonne km (billions) [7]	2 870	3 971	3 971	3 971	3 971
Vehicle km (billions)	316	472.8	430	430	397
CO_2 (million tonnes)	300.9	445.4	408.5	405.1	378.6
Total:					
Vehicle km (billions)	2 566	3 240	2 948	2 946	2 867
CO_2 (million tonnes)	819.5	1 038.5	960.4	944.2	902.4

Based on CEC (2001a) Table 3 [Annex].

Table 4. Expected changes in transport intensity in the EU between 1998 and 2010.

	1998	2010	Change
GDP (billion Euro)	8 000	11 400	+43%
Passenger-kilometres	4 772	5 929	+24%
Tonne-kilometres [7]	2 870	3 971	+38%
Transport Intensity:			
Passenger (GDP/pass-km)	1.676	1.923	+15%
Freight (GDP/freight-km)	2.787	2.871	+3%
Passenger and freight (GDP/nmm)	2.425	2.531	+4%

Based on CEC (2001a).

a recent ECMT report, one of the reasons why it has not been possible to introduce a fair system of road pricing in the past is because mobility is seen as a fundamental right and it is therefore extremely difficult for politicians to persuade the populations of democratic countries to accept the idea of fair pricing, particularly with regard to private car use (ECMT, 2001). This suggests that a broader set of options, not just in the transport sector, should be investigated to help achieve decoupling. These are likely to be complementary to pricing policies and more politically acceptable.

Decoupling Strategies

Travel can be broken down into three component parts: (i) *volume* (of passengers or goods), (ii) *distance* and (iii) *efficiency* of transport. The first two components are usually combined to give measures of performance (i.e. passenger-kilometres or tonne-kilometres), but the third element is equally important and it relates to factors such as mode, travel time, resource use and occupancy or load factor. If we are to achieve absolute reductions in transport intensity, then there are a variety of approaches to achieve this. The three components of travel (distance, volume and efficiency) are now used to assess the impacts of various decoupling strategies as outlined above. In addition to the conventional transport policies, there are at least four others that need to be considered – information and communications technology (ICT), land use planning policies, macro-economic policies, and those relating to dematerialisation and organisational change. Clearly, different policies involve different time horizons and involve different levels of decision-making. In addition, technological developments (e.g. fuel technology or vehicle design) may help to reduce transport energy consumption through efficiency improvements, although there is less evidence that transport has become more efficient through technology over recent decades (see for example van den Brink and van Wee, 2001).

INFORMATION, COMMUNICATIONS AND TECHNOLOGY (ICT)

The use of the internet and other communication technologies has made electronic commerce (e-commerce) the fastest growing sector of most western economies. For many people, the home has become a viable site to conduct certain activities that previously were not possible. In addition, recent developments in ICT have redefined opportunities to conduct business and schedule activities while travelling or at locations away from the home or workplace. The evidence of its impacts of transport has been the subject of much debate, whether it substitutes, stimulates or modifies travel. It is likely to have all three effects, but in different ways according to the particular circumstances.

LAND USE PLANNING POLICIES

These policies are also reasonably well known and consist of the arguments about density of development, the location of development, mixed use development and critical thresholds necessary to support the full range of services and facilities, and even employment. Strategies relating to parking policies can be included here or in transport policies. The main aims of these policies are to reduce trip lengths, increase the use of public transport, improved load factors (and occupancy levels), and encourage trip chaining (see Stead and Marshall 2001 for a review of the literature concerning the impacts of land use patterns on travel).

MACRO-ECONOMIC POLICIES

These policies are normally designed to make users aware of the full costs of their transport, principally through raising prices. This can be achieved through marginal cost pricing, but also through energy or carbon taxes, landfill taxes and vehicle taxes (including fuel taxes), all of which have impacts on transport. Taxes and direct charging mechanisms have some advantages over regulation, such as achieving a certain level of pollution reduction at a lower cost when abatement costs differ across polluters or are costly for authorities to measure. However, a tax base that is well linked to external costs is often hard to find. In these circumstances, regulatory policies such as fitting cars with catalytic converters may be a more effective and less administratively costly tool than taxes. Transport has always been seen by governments to provide a major source of taxation revenues, contributing between 10 and 15% of all exchequer revenues. It is viewed as a sector that is relatively price-inelastic and there are always good reasons for raising transport taxes. Indeed, this has been one of the main arguments used by the motoring lobbies to urge governments to reinvest more of the 'transport' taxes in transport. Governments have strongly resisted the notion of hypothecation and want to maintain maximum flexibility in expenditure patterns. Nevertheless, there is an increasing desire within governments to switch taxation from production (labour taxes) to consumption (environmental taxes) in a revenue neutral manner. Such a change might lead to a double dividend by improving both the environment and the efficiency of the tax system (Ekins, 1999). Green or ecological tax reform has thus come to mean a systematic shift of the tax burden away from labour and, perhaps, capital, and onto the use of environmental resources. The case is mainly based on environmental arguments concerning the use of resources and the pollution created. It is essentially a macro-economic means to internalise the externalities caused by transport. However, the levels of taxation on consumption have been established rather arbitrarily and not related directly (or indirectly) to the resources used or the pollution created.

TRANSPORT POLICIES

These policies are again well known and relate to road charging, priority to high occupancy vehicles and public transport, and limitations on the use of vehicles in particular locations or at particular times (parking policy, access restrictions and car free zones for example). A comprehensive discussion of these options is presented elsewhere by Banister and Marshall (2000) under three headings of organisational and operational measures, infrastructure interventions and financial measures.

DEMATERIALISATION AND ORGANISATIONAL POLICIES

Dematerialisation is the achievement of a maintained or improved product or service, whilst also achieving reduced use of material and energy. It concerns production and distribution processes as well as services, both directly and indirectly. Many issues concerning dematerialisation can have repercussions for transport demand. For example, changes in production processes may reduce the use of raw materials and therefore transport volume. New distribution processes could shorten supply chains and transport demand. Changes in product specifications (such as lighter or smaller products) could lower the weight or volume of goods (and raw materials) that need to be transported. Although dematerialisation policies and actions are not explicitly being pursued in Europe, there are currently a number of implicit policies and actions in place in some EU countries that contribute to dematerialisation. These include policies and actions on packaging reduction, recycling, energy saving and waste minimisation. Organisational policies relate to the individual firms responding to new production methods and innovation, but also more generally to transport opportunities. The processes of consultation and involvement need to involve all key actors in that debate and discussion. All actors should be seen to "buy into" the decoupling strategy and see where they can make a contribution. Much recent progress has been made in pushing the issue of transport to the top of the public and political agendas, and in explaining the nature of the problems including the need for various forms of demand management. Decoupling allows further progress to be made if its rationale and outcomes can be successfully communicated to decision makers at all levels so that barriers to effective action and outcomes can be achieved.

Table 5 summarises some of the policy measures that can be used to achieve an absolute reduction in transport intensity and help to decouple transport growth from economic growth. It is structured under the three components of travel, namely volume, distance and efficiency.

Conclusions

Increases in transport growth have closely followed increases in economic growth over recent decades but this is no reason for the trend to continue. Decoupling transport growth and economic growth would result in increased economic efficiency, less use of non-renewable resources and less pollution and waste. In this paper we have sketched out the nature and scale of the problem, together with a list of the individual measures that can be used to reduce transport intensity. We have strongly argued for reductions in the absolute levels of transport intensity and not relative levels, as the expected growth in the economy would mean more transport. We are not looking for economic growth to be higher than transport growth – this has already been achieved in the USA, but not in Europe (see Gilbert and Nadeau, 2002). What we are looking for is economic growth with a *reduction* in transport requirements.

The volume of manufactured goods is clearly falling, which should lower the number of tonne-kilometres. In addition, the share of physical goods in GDP is falling compared with that of services, which should help to reduce the link between economic growth and transport. In practice, however, the volume of just-in-time transport movements has increased in order to offset reduced stock inventories and, at the same time, average trip distances have increased as a result of the specialisation of firms and globalisation of the economy, both of which are liable to increase the volume of transport (ECMT 2001). In addition, social factors are hindering decoupling. For example, household size is decreasing, with the consequences of increasing the number of dwellings required to accommodate the population and reducing the opportunities for householders to share transport, and this is often matched by increases in the consumption patterns of consumer durables (such as cars, home computers and various other household items).

Tackling transport demand does not just require transport policies. Decisions in many other sectors affect the demand for transport and these other sectors need to be addressed as well if decoupling is to occur (see also Stead and Banister, 2001). Changes in society and the economy can have some potentially significant effects on decoupling. Shifts in products and production processes, for example, can give rise to opportunities for dematerialisation and consequently for decoupling. Changes in technology may also have some significant effects on travel demand in terms of both passenger and freight transport (see for example Golob and Regan, 2001) and hence on decoupling. There is also the possibility of 'leapfrogging' where countries can jump technologies to take advantage of the newer and cheaper infrastructure. This is particularly true of satellite technology that is now available. There are a number of ways in which decoupling may occur but what has not yet been established is the relative potential for each to contribute to decoupling: more research is needed here.

In addition to the issues raised in this paper, there is the question over the limitations of GDP as a measure of economic activity. This relationship should not be limited to a simple ratio of transport growth to GDP growth, as this will inevitably demonstrate a decoupling effect, both in terms of

Table 5. Examples of Impacts of Decoupling Strategies.

Strategy	Examples	Impacts on transport *volume* (journeys)		Impacts on transport *distance*		Impacts on transport *efficiency* (mode, occupancy, loading, etc)	
		Passenger	Freight	Passenger	Freight	Passenger	Freight
Information and Communication Technology (ICT)	Navigation systems			+ opportunities for identifying shorter routes	+ opportunities for identifying shorter routes	+ could be used for car sharing	+ new opportunities for load matching
	Tele-services and activities	+ replacement of journeys through ICT applications (video-conferencing, home-banking, tele-medicine, etc)	+ reduction of certain goods normally carried by post through electronic transactions (e.g. documents by email)	- global communication can increase international business travel and therefore distance - new opportunities for longer distance recreation (last-minute) travel	- global communication can increase international trade and therefore distance		
	Real-time travel information (public transport countdown systems, motorway signing)			- less direct routes to avoid congestion/ delays	- less direct routes to avoid congestion/ delays		
	Other ICT developments	+ reduction of work journeys as a result of opportunities for working at home					

\+ Indicates a positive (favourable) effect on decoupling

\- Indicates a negative (adverse) effect on decoupling

Table 5. Examples of Impacts of Decoupling Strategies [continued].

Strategy	Examples	Impacts on transport *volume* (journeys)		Impacts on transport *distance*		Impacts on transport *efficiency* (mode, occupancy, loading, etc)	
		Passenger	Freight	Passenger	Freight	Passenger	Freight
Land use planning policies	Density			+ lowers travel distance		+ conducive to green transport modes (walking and cycling)	
	Parking supply			+/- alternative destinations (sign dependent on destination)		+ disincentive to car use	
	Location policy					+ public transport accessible locations may stimulate public transport use	
	Local services and facilities			+ lowers travel distance	- possibly more points in the distribution chain	+ conducive to green transport modes (walking and cycling)	
Macro-economic policies	Energy/carbon tax	+ incentive to rationalise journeys (e.g. trip chaining)	+ incentive to rationalise distribution	+ incentive to minimise travel distance		+ incentive to increase occupancy and use less energy intensive modes	+ incentive to increase load factors
	Landfill tax		+ incentive to reduce waste volumes				
	Vehicle and road tax						+ incentive to increase load factors

\+ Indicates a positive (favourable) effect on decoupling

\- Indicates a negative (adverse) effect on decoupling

Table 5. Examples of Impacts of Decoupling Strategies [continued].

Strategy	Examples	Impacts on transport *volume* (journeys)		Impacts on transport *distance*		Impacts on transport *efficiency* (mode, occupancy, loading, etc)	
		Passenger	Freight	Passenger	Freight	Passenger	Freight
Transport-related	Road pricing	+ incentive to rationalise journeys (e.g. trip chaining)	+ incentive to rationalise distribution	- travel to more distant locations to avoid road pricing		+ incentive to use different modes	+ incentive to use different modes
	High occupancy vehicle priority					+ incentive to share journeys	
	Public transport priority	- may increase travel distance				+/- incentive to use public transport (sign dependant on the mode used before)	
	Roadspace capacity			+ shorter (non-motorised) journeys +/- alternative destinations (sign dependant on new destination)	- less direct routes to avoid areas where capacity is lower		+ incentive to improve loading
Dematerialisation	Waste/packaging/ recycling regulations		+ less waste transport + more transport of recycled materials				
	Production processes		+ new production processes can reduce the transport of raw materials				
	New products		+ smaller products can reduce transport volumes + longer-lasting, more durable products can reduce transport volumes				

\+ Indicates a positive (favourable) effect on decoupling

\- Indicates a negative (adverse) effect on decoupling

forecasts and assumptions used and in terms of actual change (Stead, 2001; Banister and Stead, 2002).

The main conclusions to this paper are that transport policy and analysis has a major new challenge, namely the means by which transport growth can be decoupled absolutely from economic growth. Some of the options and opportunities have been outlined here, and it is clear that there are no clear directions forward, except to suggest that elements from all five strategies need to be included as the scale and complexity of the issues are vast. It needs the involvement of all actors from all levels of decision making to accept the challenge so that effective combinations of strategies can be adopted in particular situations to address the key problems identified. In addition to the involvement of all actors, it is essential that they accepted the need for change and a reorganisation of the way in which business and everyday activities are carried out. Our cautiously optimistic conclusion is that it is possible to achieve an absolute decoupling of transport growth from economic growth, but that we are still a long way from actually giving ourselves a chance to achieve it as much of the thinking is still constrained through fairly narrow professional and institutional perspectives.

Notes

1. The net mass movement of people and goods is calculated using a method similar to Peake (1994): by dividing total passenger-kilometres by 11.11 (on the assumption that people with luggage weigh 90 kilogrammes on average) and adding this figure to the total volume of freight moved (in tonne-kilometres). Note that the assumption about average weight per passenger here is substantially different to that used by Peake (1994), who assumed an average weight of 50 kilogrammes, which seems quite a low estimate.
2. The calculation of gross mass movement of people and goods is similar to the calculation of net mass movement but also includes the mass of the vehicles used to carry the people and goods and the movements of empty vehicles.
3. Only 6 countries were part of the European Community in 1970 but for comparison purposes, the data for 1970 and 1995 relate to the 15 countries that are currently members of the European Union.
4. GDP averages for 1970 and 2000 exclude Germany.
5. The freight transport figures in Table 1 include intra-European sea transport.
6. The 'other' category includes energy consumed for agricultural, commercial, public service and residential purposes.
7. Unlike Table 1, the freight transport figures in Tables 3 and 4 do not include intra-European sea transport.

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