Reducing Transport Intensity

David Banister* and Dominic Stead**
*University College London
London
United Kingdom
E-mail: d.banister@ucl.ac.uk

**OTB Research Institute
Delft University of Technology
Delft
The Netherlands

EJTIR, **2**, no. 3/4 (2002), pp.161-178

Received: First presented at STELLA FG4 workshop 3&4 May 2002
Accepted: February 2003

In this paper, transport intensity concerns the economic or energy efficiency of transport. The focus of the paper is the measurement and use of indicators of transport intensity. Most research has concentrated on the volume and distance measures, which show continuous increases over time, normally at a rate that is higher than the growth in Gross Domestic Product (GDP). It is argued that an additional element needs to be included, namely transport efficiency, which relates to modes, technologies, organisational structures, the use of resources and prices. The measurement of GDP also needs to be extended. Measures of economic and transport energy efficiency are applied to EU countries and contrasted with similar measures for the USA and Canada. The empirical evidence is then placed in the wider context of globalisation and economic change, and the case for real decoupling is made for both the freight and passenger sectors.

1. Introduction

Historically, there has been a close relationship between the growth in freight and passenger transport and economic growth, at least as measured by Gross Domestic Product (GDP). The question raised here is related to the underlying rationale for this statistical relationship and whether the relationship will (or should) continue into the future. Our conclusion in this paper is that there is no reason why transport growth needs to follow economic growth. Indeed, there are strong efficiency and environmental arguments for breaking the link. What is required are policies that contribute to reducing the transport intensity of activities whilst at the same time maintaining economic growth – this is the decoupling argument.

Travel can be broken down into three component parts: *volume*, *distance* and *efficiency*. 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 as it relates to modes, travel time and price, the use of resources, technology and organisational factors. For example, in the freight sector, efficiency can be increased through the use of logistics, flat organisational structures and new forms of handling. Such measures can increase efficiency, and reduce the volumes and distances travelled. However, they can also work to increase the volumes/distances travelled. The latter needs to be avoided if decoupling is to occur.

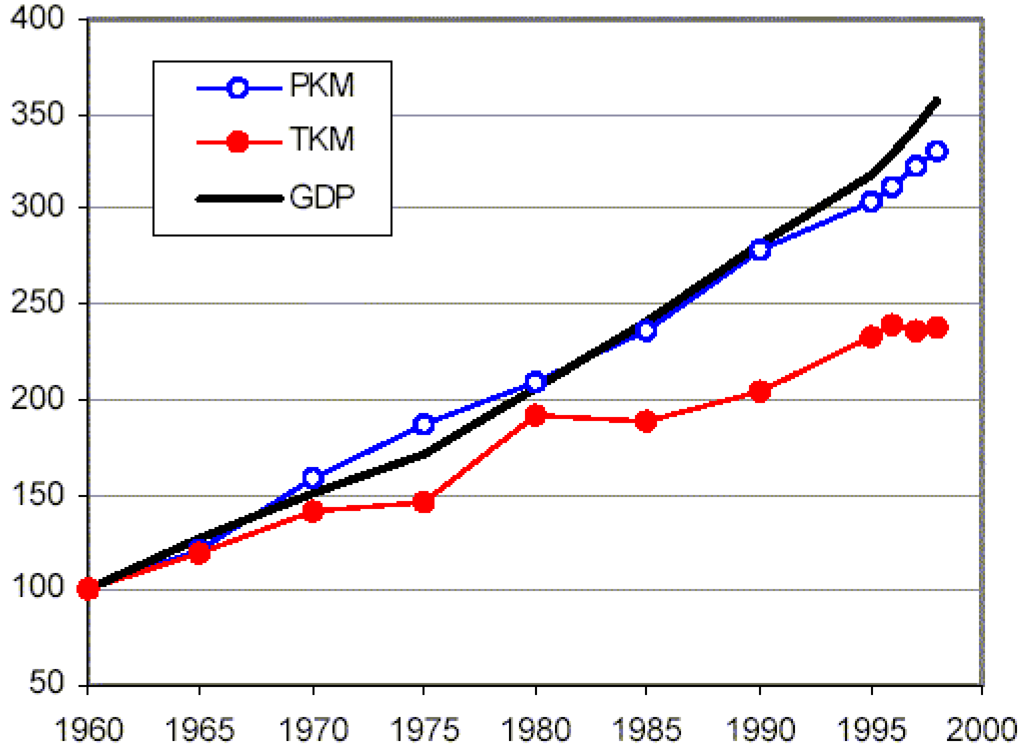
The rest of this paper is divided into five main parts. In the first part we present some of the available evidence on transport intensity as it relates to GDP from the US and the EU. Apart from helping to understand what has happened over the recent past, the evidence helps illustrate the key elements in the relationships between transport growth and economic activity. Of particular importance here are the measures of transport intensity used, GDP and the implicit assumptions built into the forecasts. The second part of the paper explores some alternative ways in which transport intensity can be measured, principally through common measures of mass movement and the addition of the efficiency element to measures of transport intensity. Alternative approaches to the use of GDP are also addressed, but here quality of data is a limiting factor. In the third part of the paper we focus on some qualitative data concerning transport intensity within European countries (as opposed to the EU as a whole outlined in the second part of the paper). We broaden the discussion in the fourth part of the paper to explore changes that are already taking place at a more detailed level in individual countries and in the economy more generally, which both have important implications for the intensity of transport. We present our conclusions in the fifth and final part of the paper.

2. Transport Intensity – Definitions and Relationships

Two distinct types of measures of transport intensity are commonly used: (i) measures of transport *energy efficiency* (TEC) and (ii) measures of transport-related *economic efficiency* (relative to transport volumes). The first category of measures is defined according to energy consumption as a ratio of passenger movements, freight movements or a combination of both (using the concepts of *net mass movement* and *gross mass movement*, discussed in more detail by Peake, 1994 and Stead, 2001). Authors such as Scholl et al (1996) and Michaelis and Davidson (1996) use this type of measure when referring to transport intensity. The second category of transport intensity measures are defined according to economic activity as a ratio of passenger movements, freight movements or a combination of both (again using the concepts of net mass movement and gross mass movement). SACTRA (1999) use this type of measure when referring to transport intensity. One of the commonly used and most widely available measures of economic activity, GDP, provides a way of comparing economic activity in different countries. However, it is recognised that this measure has a number of limitations when considering issues of welfare or sustainability (see Section 3).

The concepts of decoupling and transport intensity are perhaps of more concern in Europe than in North America (Gilbert and Nadeau, 2002). In a narrow sense, decoupling is arguably already taking place in the US freight sector: the tonne-kilometres carried have increased at a rate substantially below the growth in GDP (Figure 1). This trend is both true for the last forty years (since 1960) and for the more recent past (since 1985). A comparison between the US and the EU is informative, as there seems to be a convergence between the curves for passenger-kilometres per unit of GDP. This convergence is despite substantial differences between the two continents in terms of car ownership levels (EU = 532 vehicles per 1000 population in 1999; US = 800 vehicles per 1000 population in 1999) and in terms on land area (EU = 3.24 million km^2; US = 9.36 million km^2). The clear difference between the freight curves indicates the longer distances travelled in the US, but even here there is a narrowing of the gap. This may relate to space but also to economic restructuring that is taking place in both economies. At one level these comparisons suggest that the EU should be more concerned about decoupling than the US, partly because the EU levels of transport intensity are as high as those in the US for passenger travel but also because both the passenger and freight curves are rising in the EU.

There are some striking differences between the recent trends in passenger and freight transport and economic activity in the EU and the US (Tables 1 and 2). Between 1985 and 1998, there were similar increases in passenger-kilometres travelled in the EU and the US (45% and 40% respectively) but different increases in freight transport (54% and 26% respectively). GDP grew at a faster rate in the US than in the EU during this period (49% in the US and 35% in the EU). Gilbert and Nadeau (2002) suggest that declining transport intensities in the US and rising levels in the EU may result from the stage of economic development as transport intensity may at first rise with increasing real GDP and then fall. They further examine this proposition through plotting the transport intensity (passenger-kilometres per unit GDP) for 61 urban regions with populations over one million against GDP per capita. According to their research, '*a uniform decline in passenger transport intensity with increases in GDP for urban regions in developing and developed countries, other than those in North America and Australia*' (Gilbert and Nadeau, 2002). In the US and Australia, transport intensity is much greater than in urban regions with comparable GDP and the values do not decline with increasing regional GDP. Gilbert and Nadeau's conclusion is that GDP differences do not explain the differences in transport intensity at the regional level, and that the structural development of the economy may help explain the differences.



Source: Gilbert and Nadeau (2002: Figure 4).
Note: GDP has been adjusted for Purchasing Power Parity (PPP)

Figure 1 Transport Intensities in the US and the EU between 1985 and 1998

Table 1. Trends in Passenger, Freight and Economic Activity in the EU and the US between 1985 and 1998

	1985	1998	Increase
US Passenger-kilometres (billions)	4,920	6,870	40%
EU Passenger-kilometres (billions)	3,316	4,808	45%
Ratio US/EU	1.48	1.43	
US Freight-kilometres (billions)	4,305	5,417	26%
EU Freight-kilometres (billions)	1,859	2,863	54%
Ratio US/EU	2.32	1.89	
US GDP (billions of 1996 US$)	5,717	8,509	49%
EU GDP (billions of 1996 US$, PPP)	4,369	5,899	35%
Ratio US/EU	1.31	1.44	

Source: Gilbert and Nadeau (2002, Table 1).

Table 2. US and EU Comparative Statistics for 1998

	US	EU	Difference
Population (million)	270	375	US -28%
Passenger-kilometres per capita	24,445	12,825	US +91%
Tonne-kilometres per capita	20,060	7,635	US +163%
GDP per capita (adjusted for PPP in 1996 US$)	$31,515	$15,730	US +100%

Source: Based on Gilbert and Nadeau (2002).

The recent EU White Paper on Transport Policy identifies decoupling as a key issue (CEC, 2001a). However, it is really only a secondary objective of the document, in contrast to the European Commission's Sustainable Development Strategy, in which decoupling transport growth and economic growth is the top headline objective for transport (CEC 2001b). The White Paper recognises that transport energy consumption is increasing and that 28% of CO2 emissions are now transport related (CEC, 2001a: p10). In 1990, 739 million tonnes of CO2 were released from the transport sector, rising to 900 million tonnes in 2000. Further substantial increases are expected in the next decade (1113 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 optimistic and three types of policy options are described (p11 and annex) to reduce transport emissions. 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 recommendations of the White Paper build on Option C where the market share for the individual modes returns to the 1998 levels in 2010 as a result of the measures set out in the document. 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). A summary of the main measures proposed by the White Paper is presented in Table 3.

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 4, 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), whilst trends in passenger-kilometres and tonne-kilometres increase by 24% and 38% respectively (Table 5). 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, transport intensity will of course fall.

Table 3. Summary of the main measures proposed by the 2001 European Transport White Paper

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).

Table 4. The Base, Trend and Three Options for Transport in the EU (1998-2010)

	1998	Trend 2010	Option A 2010	Option B 2010	Option C 2010
Passenger:					
Passenger km (billions)	4772	5929	5929	5929	5929
Vehicle km (billions)	2250	2767	2518	2516	2470
CO_2 (million tonnes)	518.6	593.1	551.9	539.1	523.8
Freight:					
Freight km (billions)	2870	3971	3971	3971	3971
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)	2566	3240	2948	2946	2867
CO_2 (million tonnes)	819.5	1038.5	960.4	944.2	902.4

Based on CEC (2001a: Table 3 of the Annex).

Table 5. Expected Changes in Transport Intensity in the EU between 1998 and 2010

EU	1998	2010	Change
GDP (€ billion)	8,000	11,400	+43%
Passenger-kilometres	4,772	5,929	+24%
Tonne-kilometres	2,870	3,971	+38%
Transport Intensity:			
Passenger (pass-km/GDP)	0.5965	0.5198	-13%
Freight (freight-km/GDP)	0.3888	0.3481	-10%

Based on CEC (2001a).

Of more interest in the EU policy options is the 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.

Table 6. Differences in GDP Growth and Traffic Growth in Great Britain between 1965 and 2025

	1965-1975	1975-1985	1985-1995	Forecast 1995-2025
Car passenger-kilometres	Declining positive: +1.6% to 0.2%. Car traffic growth > GDP growth.	Constant variable: +0.4%. Car traffic growth > GDP growth.	Constant variable: +0.5%. Car traffic growth > GDP growth.	Constant negative: -0.1%. Car traffic growth < GDP growth.
HGV tonne-kilometres	Variable negative: -0.4% to –0.1%. HGV traffic growth < GDP growth.	Variable negative: -0.3% to –0.1%. HGV traffic growth < GDP growth.	Variable positive: +0.1% to +0.5%. HGV traffic growth > GDP growth.	Increasing negative: 0.0% to –0.3%. HGV traffic growth < GDP growth.
LGV tonne-kilometres	Variable: -0.4% to +0.2%. LGV traffic growth < GDP growth.	Volatile.	Volatile positive: +0.2% to +1.0% LGV traffic growth > GDP growth.	No Forecast.

Based on evidence cited in SACTRA (1999).
Notes:
1. Positive means that traffic growth is higher than GDP growth and negative means that traffic growth is less than GDP growth
2. HGV = heavy goods vehicles > 3.5 tonnes gross unladen weight
3. LGV = light goods vehicle < 3.5 tonnes gross unladen weight

The influential Standing Advisory Committee on Trunk Road Assessment (SACTRA) report, which was primarily concerned with understanding the link between transport and the economy in the UK, also examined transport intensity. It reported a strong positive correlation between GDP growth and traffic growth, with the intensity of car and light goods vehicle traffic (LGVs) increasing but that of Heavy Goods Vehicles (HGVs) decreasing. These changes were plotted as 5-year moving averages of the percentage difference between GDP change and traffic change: the main conclusions from this analysis are summarised in Table 6.

There is considerable variability between modes and at different points of time, both in terms of size and direction of the difference. However, recent evidence (between 1985 and 1995) shows that all types of traffic (car, HGV and LGV) have grown at a faster rate than GDP. For car traffic, this pattern can be traced back much further. It is not just in the UK that this is occurring. The SACTRA report also reviewed similar evidence on car and freight traffic (1970-1994) from France, Sweden, the Netherlands and Italy. In all cases, car traffic growth was substantially higher than GDP growth. The case for freight transport is on the other hand less clear. There were also substantial differences between the national figures, and within individual countries over time, suggesting that different factors were influencing the relationship between traffic growth and GDP growth. From the perspective of reducing the transport intensity of the economy, the picture is bleak. As traffic growth is substantially higher that GDP growth, this means that some 'flip process' is required to get the traffic growth curve below the GDP curve. Forecasts suggest that this will take place (Table 5) but there seems to be a flaw in the argument here. 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). The implications of this are potentially profound:

1. The intensity of car traffic should fall with time as the elasticity of traffic with respect to income falls. However, this has not yet happened. Transport intensity grows when the elasticity of traffic with respect to income is greater than one and declines when the elasticity is less than one. The cross sectional evidence suggests that there are substantial differences in car use, which are not related to either car ownership or income (SACTRA, 1999: p297). This intriguing statement is not developed further in the report.
2. There is circularity in the use of this approach to the measurement of transport intensity as car ownership, income and GDP are closely related in forecasting travel demand. GDP growth is often assumed given and this determines income growth and car ownership growth, which in turn are used to forecast increases in traffic. Such a close relationship means that it is difficult to unravel what is causing change. It seems that car use must be separated from car ownership and that other factors (such as pricing, regulation and technology) should all be influences in the use of the car.
3. GDP may also be too limiting a variable if the intention is to reduce transport intensity. Other measures of the economy could be used (Section 3).

More generally, there are other important implications:

More generally, there are other important implications:

- Income may become less important than other factors in driving the growth in travel. Car ownership is now relatively cheap compared with income levels and it is not a real constraint. In some cases, however, car use has become more expensive over time (in the UK for example) as the costs of fuel and tax/insurance have all risen at a substantially higher rate than the cost of ownership (Table 7).[1] A clearer understanding is required for the motivations of car use apart from the costs. This could be a fruitful area of research in different national settings.
- The figures used throughout reflect national travel patterns, not the growth in the longer distance and international travel markets. These two sectors are both growing substantially and further increases are expected in the future. They cannot be ignored and raise the additional question whether GDP measured on a national basis is appropriate for international travel changes.
- As noted above, the car traffic figures (and those for LGV) are above the GDP levels, so the transport intensity is increasing. However, there are still expectations (apart from the logic of the SACTRA saturation argument noted above) that there will be a reversal. Income growth is clearly very important in determining traffic levels but other policy interventions (such as price, speed and quality of transport) must also have a key role to play in curbing traffic growth. In the past, these interventions do not seem to have been particularly successful in achieving that aim, yet both the EU and SACTRA are optimistic that this can be achieved, particularly if prices are set at marginal social cost levels.
- The presentation of the data can be misleading in that transport intensity can decrease (if GDP growth is greater than traffic growth) even if traffic growth is increasing. From the perspective of sustainable development, this is not desirable. Sustainable development requires a net reduction in the environmental impact of transport as measured by emissions and the use of non-renewable resources. The headline figures from the new US statement that 'an aggressive strategy to cut greenhouse gas intensity by 18% over the next ten years' oversimplifies the challenge (The Economist, 2002: p49). There is no reduction in emissions even proposed in this statement, only the levels of emissions per unit of economic output: it is merely a continuation of the established pattern of change in the US (Gilbert and Nadeau, 2002).

Table 7. The Costs of Travel in the UK

Costs of Travel	% change 1989-1999
Retail Price Index	+43
Car	+53
Purchase	+16
Fuel	+93
Maintenance	+74
Tax and insurance	+85
Bus	+65
Rail	+72

Source: Banister (2002)

[1] Between 1989 and 1999, the cost of public transport (bus and rail) in the UK increased at a faster rate than the costs of car travel.

3. Alternative Measures of Transport Intensity

In reviewing alternative measures for presenting transport intensity and decoupling, it seems that further fundamental thinking is required. In his research on the similarities between the energy sector and the transport sector, Peake (1994) made two important contributions. One was to place passenger and freight movement on a common basis (tonne-kilometre equivalent – *tkme*) by developing the concept of mass movement. This means that each passenger is given a gross weight (made up of their own weight and their luggage), so that passenger-kilometres can be converted to tonne-kilometres. The second was to develop the notions of gross mass movement (GMM) to capture all transport movements in the economy and net mass movement (NMM) to capture the useful elements of activity. From these aggregate measures, indicators of gross transport intensity (GTI) and net transport intensity (NTI) can be obtained through linking them to GDP change. The GMM/GDP ratio is a proxy for transport efficiency (Peake, 1994: p69), and NMM/GDP is a measure of 'useful' transport activity. Peake found that the NMM/GMM ratio was falling over time (1952-1992) in the UK and that the mass productivity of transport was declining by some 20%. On the other hand, NTI was constant over time (0.7 tkme per £1 of GDP), whilst GTI was increasing, particularly after 1973, from 2.6 tkme per unit GDP in 1973 to 3.1 tkme per unit GDP in 1992 – an increase of 19%.

Peake concludes that transport intensity is becoming less sustainable, and that 77% of mass movement in 1992 was due to the incidental movement of carriers, rather than the real movement of people and freight (Peake, 1994: p73). In all of this analysis, the freight sector dominated, as it accounted for 86% of the NMM, and the huge increase in the unladen weight of HGVs (a 4-fold increase 1952-1992) added to this dominance. The 'average weight' of the passenger was set at 50 kilogrammes seems rather low, although a doubling of this figure this would probably not affect the results significantly. Peake also found measurement and data problems that may have limited the accuracy of his results, but his work does begin to include efficiency variables in the analysis of transport intensity.

This thinking has been further developed by the current authors (Banister et al, 2000; Stead, 2001) and by others (e.g. Scholl et al, 1996; Schipper and Marie-Lilliu, 1999). Measures of transport energy efficiency have been developed that enhance the traditional measures of transport intensity. They can also be used to address the issue of emissions and the use of resources. In this way it is possible not only to view the transport implications but also the environmental impacts of adopting particular policy packages. In addition, primary energy consumption can be converted into emissions levels for the key pollutants (including CO_2) through analysis of the carbon content of the different fuels used. As transport is almost entirely sourced from oil, this is relatively simple to calculate, even over a ten year period where alternative fuels might be increasingly used (Hoogma et al, 2002). This approach is similar to the development of the ASIF equation by Schipper and Marie-Lilliu (1999) in which emissions are related to the total travel activity, the energy efficiency and the fuel type for each mode. Most of the components related to transport and the environment are encapsulated in this simple equation and the impacts of the different policy alternatives can be tested, together with their feedback components. As Schipper (2001) states, '*the key purpose of ASIF identity is to show policy makers how the components of transport and emissions fit together, and make sure that the potential – and actual – impacts of their actions on each component are noted… It helps remind analysts of some of the linkages*'.

A further issue in measuring transport intensity is the usefulness of GDP as the most appropriate measure of economic activity. GDP provides a way of comparing economic activity in different countries but has a number of limitations when considering issues of welfare or sustainability, since the calculation of GDP includes spending on actions such as pollution clean-up and medical treatment for road accident victims (for more detail, refer to Anderson, 1991; Jackson and Marks, 1994; Cobb et al, 1999). In addition, GDP does not take account of unpaid household production (such as caring, preparing meals, education and housework), even though this supplies services to the economy. There are also a number of other problems with using GDP to measure and compare economic activity, each of which make long-term analysis of GDP trends difficult:

1. GDP figures do not show how economic activity is distributed across society (the Genuine Progress Indicator attempts address this – see below)
2. Exchange rate fluctuations and cost of living differences in different countries make comparisons of GDP trends between countries problematic
3. GDP does not take account of unpaid activities, including many household activities (such as caring, preparing meals, education and housework), even though these are services to the economy

Hanley et al (1999) identify a number of alternative measures of economic activity such as Net National Product, genuine savings, net primary productivity, the Index of Sustainable Economic Welfare (ISEW) and the Genuine Progress Indicator (GPI). For example, the GPI corrects some of the anomalies in the formulation of GDP and shows that in the US, GPI rose by 23% per capita (between 1950 and 1998) as compared with the 164% increase in GDP. Apart from addressing some of the limitations of the GDP measure, GPI explicitly includes income inequality and people's perceptions of progress (or lack of it). The team producing it (Cobb et al, 1999) also claim that the focus on GDP encourages short term benefits rather than longer term costs in terms of debt and loss of resources. Stead (2001) compares trends in transport efficiency in the UK between 1975 and 1990 relative to both GDP and ISEW and shows that there is a big difference between the two.

4. Empirical Evidence from EU Countries

A substantial amount of empirical evidence has already been cited at the aggregate level (Section 2). Here the focus is more on the variations within EU countries and how these have changed over time. We present data for individual EU countries on transport energy efficiency and transport economic efficiency by passenger-kilometre, tonne-kilometre and Net Mass Movement.

Transport intensity trends across individual European countries show a substantial amount of diversity from the trends for Europe as a whole (Stead, 2001). Most of the 15 EU countries have experienced quite individual trends in transport intensity between 1970 and 1995 (Table 7) and few common patterns in transport intensity trends between 1970 and 1995 are obvious. SACTRA (1999) observe that '*traffic intensity, however measured, shows very considerable variation from country to country*'. Some indicators of transport intensity used here (such as transport energy consumption per passenger-kilometre or GDP per tonne-kilometre) show improvements in the majority of EU Member States between 1970 and 1995, whilst other indicators (such as transport energy consumption per tonne-kilometre or GDP per unit of transport energy consumption) show worsening trends in transport intensity in most EU countries.

Table 8. Summary of Transport Intensity Trends in Europe, 1970-1995

	Transport Energy Efficiency:			**Transport Economic Efficiency:**			
	TEC/ pass-km	**TEC/ tonne-km**	**TEC/ net mass movement**	**GDP/ pass-km**	**GDP/ tonne-km**	**GDP/ net mass movement**	**GDP/ TEC**
Austria	▲	=	=	▼	=	=	=
Belgium	=	▼	=	=	▼	▼	▼
Denmark	▲	▲	▲	▼	▼	▼	=
Finland	=	▼	▼	=	▲	▲	=
France	=	▼	▼	▼	▲	▲	▼
Germany	=	▼	▼	n.a.	n.a.	n.a.	n.a.
Greece	▲	▼	▼	▼	=	▼	▼
Ireland	▲	▼	▼	=	▲	▲	▲
Italy	▲	▲	▲	▼	▼	▼	▼
Luxembourg	▼	▼	▼	▲	▲	▲	▼
Netherlands	=	▼	▼	▼	▲	▲	▼
Portugal	▲	▼	▼	▼	▲	=	▼
Spain	▼	=	=	▼	▼	▼	▼
Sweden	▲	▼	=	▼	=	=	=
UK	=	▼	▼	=	=	=	=
EU	=	▼	▼	▼	=	=	▼

Source: Stead (2001).

Notes:
▲ denotes an improvement in transport intensity of more than 10 per cent between 1970 and 1995[2]
= denotes no large increase or decrease in transport intensity (less than 10 per cent change between 1970 and 1995)
▼ denotes a deterioration in transport intensity of more than 10 per cent between 1970 and 1995[3]
GDP Gross Domestic Product
TEC Transport Energy Consumption

The trends in the seven measures of transport intensity for each country often do not follow the same direction – some indicators suggest that transport intensity is increasing whilst others suggest the reverse. No country in the EU can claim substantial improvements in transport intensity between 1970 and 1995 across all seven indicators. On the other hand, no country in the EU experienced substantial reductions in transport intensity between 1970 and

2. An improvement in transport intensity means either:
a. a decrease in the energy efficiency value (i.e. less energy used per unit of transport movement or per unit of transport energy consumption); or
b. an increase in the economic efficiency value (i.e. more economic activity per unit of transport movement or per unit of transport energy consumption).

3. A deterioration in transport intensity means either:
a. an increase in the energy efficiency value (i.e. more energy used per unit of transport movement or per unit of transport energy consumption); or
b. a decrease in the economic efficiency value (i.e. less economic activity per unit of transport movement or per unit of transport energy consumption).

1995 across all seven indicators. There is a certain amount of evidence for the decoupling of economic activity and transport volumes between 1970 and 1995 in some countries (such as Finland and Ireland) although transport energy efficiency decreased over the same period in these countries, according to at least some indicators. On the other hand, measures of economic efficiency suggest some evidence of worsening trends in countries such as Belgium, Denmark and Spain. Only Italy experienced an improvement in *transport energy efficiency* according to the three indicators. Luxembourg was the only country to experience a decline in *transport energy efficiency* according to the three indicators used here. Across Europe as a whole, the indicators tend to suggest that transport intensity became less efficient between 1970 and 1995. This corresponds with Peake's observation that transport intensity has become less and less efficient over the last 40 years (Peake, 1994).

Table 9. Summary of Transport Intensity Measures in Europe relative to the EU average (1995 figures)

	Transport Energy Efficiency:			**Transport Economic Efficiency:**			
	TEC/ pass-km	**TEC/ tonne-km**	**TEC/ net mass movement**	**GDP/ pass-km**	**GDP/ tonne-km**	**GDP/ net mass movement**	**GDP/ TEC**
Austria	=	▲	▲	▲	=	▼	▲
Belgium	▲	▼	▼	▲	▼	▼	=
Denmark	=	▼	▼	▲	▲	▲	▲
Finland	=	▲	▲	▲	▼	▼	▲
France	=	▼	▲	=	▲	=	▲
Germany	=	▲	▲	n.a.	n.a.	n.a.	n.a.
Greece	=	▼	▼	▼	=	▼	▼
Ireland	▲	▼	▼	▼	▲	▲	=
Italy	▲	=	▲	=	=	▼	▲
Luxembourg	▼	▼	▼	▲	▲	▲	▼
Netherlands	=	=	▲	▲	=	▼	▲
Portugal	▲	▼	=	▼	=	▼	▼
Spain	▼	▲	▲	=	▼	▼	▼
Sweden	=	▲	▲	▲	=	▼	▲
UK	=	▼	▲	=	▲	▼	▼

Source: Stead (2001).

Notes:

▲ denotes lower transport intensity than the European average by more than 10 per cent[4]
= denotes similar efficiency to the European average (within 10 per cent of the European average)
▼ denotes higher transport intensity than the European average by over 10 per cent[5]
GDP Gross Domestic Product
TEC Transport Energy Consumption

Comparing the most recent measures of transport intensity (1995 values) with the European average, few common patterns are obvious here either (Table 9). For many countries, some

[4] Lower transport intensity means either:
a. less energy used per unit of transport movement or per unit of transport energy consumption; or
b. more economic activity per unit of transport movement or per unit of transport energy consumption.

[5]. Higher transport intensity means either:
a. more energy used per unit of transport movement or per unit of transport energy consumption; or
b. less economic activity per unit of transport movement or per unit of transport energy consumption.

indicators suggest that transport intensity is more efficient whilst others suggest the reverse. No country in the EU can claim to be substantially more efficient than the EU average across all seven indicators of transport intensity but no country is less efficient than the EU average across all seven indicators. This corresponds with SACTRA's observation that '*there is* no overwhelming evidence that 'efficient' countries are consistently marked by high, low, increasing or decreasing levels of transport intensity' (SACTRA, 1999: p304).

The conclusion from this analysis is variability both over time (between 1970 and 1995) and at a single point in time (1995). Different EU countries have followed different paths and are at different stages in terms of economic and social development. The measures of transport intensity for individual countries are dependent on economic trends as well as travel trends and overall transport demand (influenced by topography, geography, size, land use characteristics, socio-economic factors, transport infrastructure and so on). This variability of transport intensity indicators across European Member States also reflects the crudeness of the measures used and the limitations of the available data. The variability is an issue, which has been noted elsewhere (such as SACTRA 1999). Some forecasts assume that transport intensity will reduce over time (even though past trends show continuous increases in transport intensity), believing that vehicle saturation may lead to improvements in transport intensity (see for example SACTRA, 1999).

The economic structure of individual countries and their geography also influence the variability of transport intensity indicators across European Member States. Countries such as Belgium or the Netherlands contain a number of large freight distribution companies with operations across Europe, which perform transport functions for neighbouring countries. It is therefore unsurprising that freight transport movement per capita is higher in these countries than the European average. It is likely that some of the freight movements counted for countries such as Belgium or the Netherlands neither originate from, nor are destined for, that country but are in transit to/from other countries (and, as such, these figures do not perfectly represent the transport intensity of a country). In countries that have experienced very marked economic growth (such as Ireland, Luxembourg and Portugal), indicators of transport intensity have often changed substantially, although not always in the same direction.

5. Changes in Society and the Economy

Much of the material presented here relates to changes in a series of transport intensity indicators over time, or at one point in time. There are other changes taking place within economies that are likely to have an impact on efficiency dimension of travel, perhaps reducing or increasing transport intensity. Included here are dematerialisation, new production processes (e.g. flexible specialisation), customer driven networks and globalisation. These will all influence transport intensity in the freight sector and some of the important ideas are briefly outlined here.

Dematerialisation can make a more fundamental impact on transport intensity. However, although the material intensity of products may decrease, material consumption can still increase as the economy grows and demand expands. According to one estimate, dematerialisation could result in a 15-20 percent reduction in freight volumes in the period between 1995-2020 (Schleicher-Tappeser et al, 1998). Further reductions could be achieved through raising the durability of products so that they last longer but here there is a trade off between lasting quality and the need to take advantage of technological innovations.

Another significant impact on transport intensity might be made as a result of a move from global to 'glocal'[6] production. Traditional arguments strongly favour concentration of production to take advantage of agglomeration economies. However, the development of flexible specialisation has created a new 'complementarity' between global networks and regional production for regional markets in which products are locally sourced (see for example Piore and Sabel, 1984). Production units are small-scale so that the new lean production methods can be introduced. For example, in the state of Baden-Wurttemberg in south Germany, most suppliers of the Mercedes car manufacturing plant are based in and around Stuttgart. Many components are sourced within a radius of 100 kilometres from the plant and are ordered virtually to the hour (Schleicher-Tappeser et al, 1998). Local production networks provide the opportunity for short travel distances and a reduction in freight traffic. However, such just-in-time sourcing can of course also mean more journeys. The potential reduction in freight traffic through the use of regional markets, regional production, and the reduction in international flow of goods (that have been produced for local markets) could amount to between 20-30 per cent over a period of 25 years (Schleicher-Tappeser et al, 1998).

There is substantial potential for decoupling in the freight sector as a result of new forms of production. The economy of scale arguments, together with economies related to specialisation and the comparative cost advantages of producing large quantities for large markets, are now being questioned. Customer-driven requirements mean that products are now tailored to individual specifications so that smaller scale production for regional markets become possible, provided that the knowledge and skills are available.

However, there is still a long way to go as global cultures and internationalisation have been instrumental in producing similar values, tastes and lifestyles, with the consequent loss of community and locality. Similarly, most changes in policy have tended to encourage greater internationalisation through trade liberalisation, market based strategies, subsidies to farmers and other groups, deregulation in transport, privatisation, and even markets for environmental and consumer protection. Boundaries are no longer drawn to coincide with national frontiers, but they are much wider, and any true investigation of transport intensity should recognise this. This is in part related to the 'leakage' issue, as the environmental costs may well be incurred in a different location (or country or even continent) to where consumption takes place. The most optimistic view is that in the freight sector, transport demand could remain constant over the next 20 years (to 2020), with the strong implementation of decoupling strategies.

In the passenger sector, the opportunities for stabilisation in demand seem harder to envisage, particularly within the context of increased affluence and leisure time. Decoupling must again be seen as a combination of strategies to reduce the volume of traffic, the distance travelled and measures to increase efficiency, but at the same time maintaining economic growth. The decoupling arguments follow the same structure as in the freight sector with dematerialisation of travel through less travel or travel by more efficient modes, and through establishing local travel patterns through the reorganisation of the production and consumption patterns based on local and regional networks (Banister et al, 2000).

---

[6]. Glocal refers to a combination of global and local, where production is still controlled by large multinational companies, but produced locally for local markets under franchising and other arrangements.

6. Conclusions and Recommendations

In the context of this paper, the important conclusion is, even if there has in the past been a link between transport use and economic growth, there is no reason why this link should continue. In order to reduce transport intensity, policy should be focused on maintaining levels of economic growth broadly defined, but at the same time reducing levels of transport growth. This relationship should perhaps 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 forecasts and assumptions used and in terms of actual change. There should be a much greater level of research on the nature of the measures to be used – primary energy consumption and carbon emissions are two possibilities for the key transport indicators – and whether GDP is the most appropriate or only measure available to reflect the real changes that are taking place in the economy.

The presentation of targets and indicators is also important. From an environmental perspective, transport and/or energy consumption/emissions need to be reduced relative to economic growth not only in a relative sense but also in absolute terms. The Kyoto Protocol makes a commitment to absolute levels of reduction, but most of the debate is about relative change. As a corollary to this, it is probably easier in the transport sector to achieve an absolute reduction in energy and emissions, rather than an absolute reduction in transport volume. This requires measures that combine transport change with environmental factors such as energy consumption and pollution emissions. It is also clear that 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 the 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.

Acknowledgement

An earlier version of this paper was presented at the STELLA focus Group 4 meeting in Helsinki in May 2002. We are grateful to the participants in that seminar for their very useful comments on the draft.

References

Anderson, V. (1991). *Alternative Economic Indicators.* Routledge, London.

Banister, D. (2002). *Transport Planning*, Second Edition. Spon, London.

Banister, D., Stead, D., Steen, P., Akerman, J., Dreborg, K., Nijkamp, P. and Schleicher-Tappeser, R. (2000). *European Transport Policy and Sustainable Development*. Spon, London.

Cobb, C., Goodman, G.S. and Wackernagel, M. (1999). *Why Bigger Isn't Better: The Genuine Progress Indicator* -- 1999 Update. Redefining Progress, San Francisco [http://www.rprogress.org/publications/glance.html].

Commission of the European Communities (2001a). *European Transport Policy for 2020: Time to Decide [COM(2001)370].* Office for Official Publications of the European Communities, Luxembourg [http://www.europa.eu.int/comm/energy_transport/en/lb_en.html].

Commission of the European Communities (2001b). *A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development. Communication of the European Commission [COM(2001)264].* Office for Official Publications of the European Communities, Luxembourg [http://www.europa.eu.int/comm/environment/eussd/index.htm].

Ehrlich, P.R. and Holdren, J.P. (1971). Impact of population growth. *Science* 171 pp.1212-1217.

Gilbert, R. and Nadeau, K. (2002). *Decoupling economic growth and transport demand: A requirement for sustainability.* Paper presented at the Conference on Transportation and Economic Development, Transportation Research Board, Portland Oregon, May 2002.

Golob, T.F. and Regan, A.C. (2001). Impacts of information technology on personal travel and commercial vehicle operations: research challenges and opportunities. *Transportation Research Part C* 9(2) 87-121.

Hanley, N.; Moffat, I.; Faichney, R. and Wilson, M. (1999) Measuring Sustainability: A Time Series of Alternative Indicators for Scotland. *Ecological Economics* 28(1) pp.55-73.

Hoogma, R., Kemp, R., Schot, J. and Truffler, B. (2002). *Experimenting for Sustainable Transport: The approach of Strategic Niche Management*. Spon, London.

Jackson, T. and Marks, N. (1994). *Measuring Sustainable Economic Welfare – A Pilot Index: 1950-1990.* Stockholm Environment Institute, Stockholm.

Michaelis, L. and Davidson, O. (1996). GHG Mitigation in the Transport Sector. *Energy Policy* 24(10/11) pp.969-984.

Peake, S. (1994). *Transport in Transition*. Earthscan, London.

Piore, M.J. and Sabel, C. (1984). *The Second Industrial Divide: Possibilities for Prosperity.* Basic Books, New York.

Schipper, L. (2001). *Sustainable Transport in the 21st Century.* Background Paper to the Shell Foundation Sustainable Energy Programme. The Shell Foundation, London [http://www.shellfoundation.org/resources/library/sep/transport.html].

Schipper, L and Marie-Lilliu, C. (1999). *Transportation and CO2 Emissions: Flexing the Link – A Path for the World Bank.* Environmental Department Paper No. 69. World Bank, Washington [http://www.worldbank.org/cleanair/global/publications/transport_pubs.htm].

Schipper, L., Figueroa, M.J., Price, L. and Espey, M. (1993). Mind the gap: the vicious circle of measuring automobile fuel use. *Energy Policy* 21(12) pp.1173-1190.

Schleicher-Tappeser, R., Hey, C. and Steen, P. (1998). Policy approaches for decoupling freight transport from economic growth. *Proceedings of the Eighth World Conference on Transport Research,* Antwerp, July 1998 [http://www.eures.de/de/download.htm].

Scholl, L. Schipper, L. and Kiang, N. (1996). CO_2 Emissions from Passenger Transport – A Comparison of International Trends from 1973 to 1992. *Energy Policy* 24(1) pp.17-30.

Standing Advisory Committee on Trunk Road Assessment – SACTRA (1999). *Transport and the Economy.* The Stationery Office, London [http://www.roads.dft.gov.uk/roadnetwork/sactra/report99/index.htm].

Stead, D. (2001). Transport Intensity in Europe – Indicators and Trends. *Transport Policy* 8(1) pp.29-46.

Stead, D. and Banister, D. (2001). Influencing Mobility outside Transport Policy. *Innovation* 14(4) pp.315-330.

The Economist (2002). Blowing Smoke. *The Economist,* 14 February 2002, p.49 [http://www.economist.com/world/na/displayStory.cfm?story_id=989298].