The road from Kyoto: how much from transportation? Transport policies of six IEA countries

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1. SYNOPSIS

A general framework is presented for analysing both trends in carbon emissions from transport and for evaluation of national transport/CO_2 programmes.

2. ABSTRACT

This paper summarises elements of a recent IEA book, “The Road from Kyoto”, which analysed the transportation and CO_2 policies of six IEA countries. At the centre of much of the analysis is new framework, “**ASIF**”, for decomposing changes in carbon emissions into changes in transportation activity, modal shares, modal energy intensities, and carbon content of fuels. Results from previous work are brought up to date for passenger transportation. We find some slowing of the growth in emissions from passenger transport, particularly in comparison with growth in GDP.

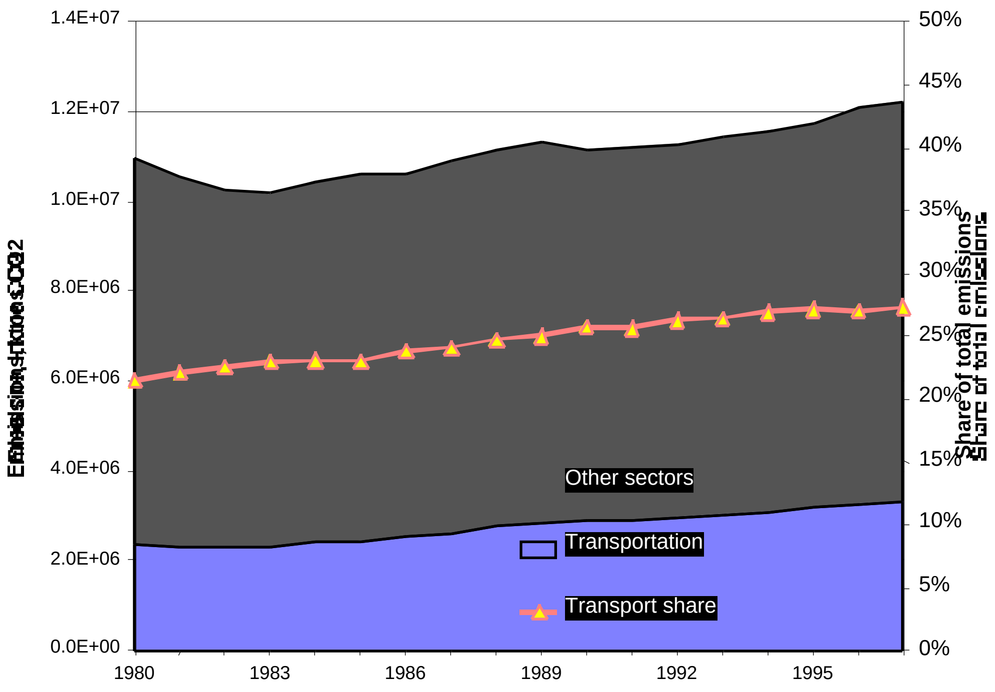
This schematic served for the case studies of six countries. We report somewhat optimistically that while neither dramatic policies nor technological surprises have stemmed growth in emissions, some countries appear to be attacking all components of CO_2 emissions with some savings in sight. The key element is the Voluntary Agreement on CO_2 emissions from new cars between EU Governments and the European automobile industry. We find that data on new car fuel economy, as well as data on test emissions from new cars suggest progress towards this goal. But unless the effort is strengthened and similar progress appears in the United States, emissions from passenger transportation will continue to grow slowly in the coming years. The Road from Kyoto will be a slow one.

3. THE CO_2 PROBLEM: THE POLICY IMPERATIVE AFTER KYOTO

Figure 1 shows the growing role of the transportation sector as a source of CO_2 emissions from energy use. This role had not gone unnoticed in the time between Kyoto and the Hague Conferences of Parties. In this update of our 1999 paper (Schipper, Lilliu, and Landwehr 1999), we highlight the key trends in transportation and carbon emissions up to the most recent years possible, trends that make restraint of those emissions so enigmatic for policy-makers. But we find signs of restraint that have appeared recently.

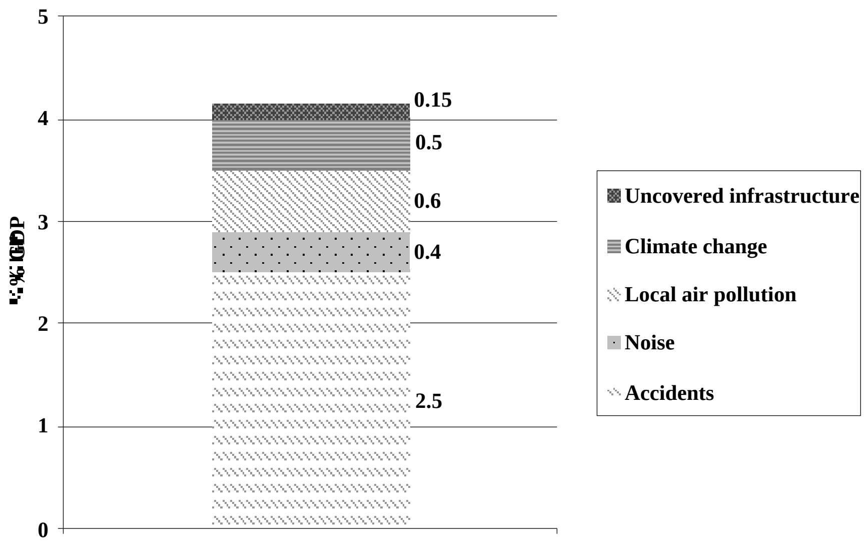
Transportation has long been associated with environmental and other problems beyond CO_2. These include safety, air, water, and noise pollution, competition for urban space, balance of payments problems and risks associated with importing oil as the main transport fuel[1]. While transportation returns a huge surplus to every economy, there are segments of transport activity where real social costs are greater than the benefits accruing to drivers or shippers. This was emphasised in a study organised by the European Conference of Ministers of Transport (ECMT 1998). That group concluded “Significant welfare gains could be realised through an adjustment of charges and taxes to provide incentives for reducing the external costs of transport”. They estimated that current welfare losses amount to “several points of GDP”. This is shown in Figure 2. Internalisation of those costs, through both direct charging and some regulations, could have a significant restraining impact on the system in the long run.

Figure 1. Carbon emissions from transport and other energy uses in OECD 1980-1997



Source: IEA

Figure 2. Estimates of externalities from transportation.



Source: ECMT

In this context, the emissions of greenhouse gases have not been ignored in major national environmental strategy documents[2]. Whatever the "real" external costs of each mode, studies suggest that the values attached to the externality for GHG emissions alone tend to be low compared to those associated with other problems. Moreover, the typical levels of carbon taxes discussed in modelling exercise, $US 10-100/tonne, are still small compared to the present levels of taxation on road fuels in Europe and Japan. This suggests that CO_2 by itself may not be "felt" as a strong stimulus for change, but that changes to deal with the other problems may affect traffic and therefore CO_2 emissions perhaps even profoundly. The other externalities in transportation may be more serious than CO_2 in the short run. These threats, whether real or perceived, stimulate constituencies to press today for or accept imposition of "solutions", by which technologies and policies could be brought to bear to reduce the problems.

4. TRENDS IN TRAVEL

Underlying factors affecting CO_2 emissions for travel and freight: a decomposition approach

A framework has been developed to isolate the importance of each factor in determining emissions **G** (Schipper and Lilliu 1999; Schipper, Lilliu and Gorham 2000). Consider that

$$\mathbf{G = \_ \ (A * S_{,} * I_{i} * F_{i,})} \qquad \mathbf{(1)}$$

where G is the greenhouse gas (carbon) emissions, A is total travel activity, S is a vector of the modal shares *i*, and I is the modal energy intensity of each mode *i*. The last term $F_{i,j}$ represents the sum of each of the fuels *j* in mode *i*, using standard IPCC coefficients to convert fuel (or electricity) used back to carbon emissions.

The modal energy intensity term itself is composed of several components (which could be repeated for each fuel):

$$\mathbf{I_{j} = E_{i} * VC_{i} * CU_{i}} \qquad \mathbf{(2)}$$

where E is technical efficiency, VC vehicle characteristics, and CU capacity utilisation for each mode *I*. Taking only E and VC yields what we call vehicle intensity, or fuel/kilometre.

Technical efficiency is the energy required to propel a vehicle of a given set of characteristics a given distance, and is affected by the motor, drive train, frictional terms (including drag), etc. For cars, car power, and technical efficiency could represent characteristics by energy use per kilometre per unit of power. Capacity utilisation would be measured as the number of people per vehicle.

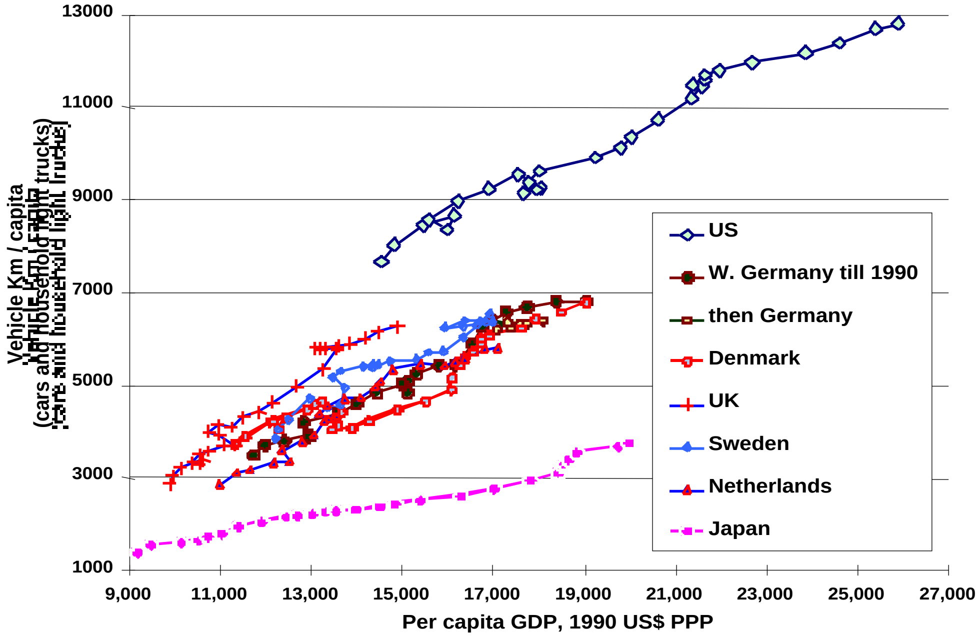
All three of these components share in determining how much energy is used to transport a person one kilometre by each mode. Driver behaviour and traffic conditions affect technical performance. And larger, more powerful vehicles often stimulate drivers to make the vehicles go faster. Capacity utilisation and indeed the selection of vehicle characteristics are important facets of behaviour and management that should not be confused with technology. Total travel and modal choice are obviously "behavioural" factors, too. The same is true for changes in power, or changes in traffic and driver behaviour, all of which affect how technology transforms energy into movement of people[3]. Thus some terms in this decomposition that are nominally "technical" – energy intensities – have important behavioural components.

Feedback between these components is important, but not major in the countries we have studied. Unquestionably lower driving costs per km, whether brought on by lower fuel prices or lower fuel intensities, encourage more driving. But the elasticities are only modest: 10% lower costs lead to somewhat more than 1% more driving in the U.S., to perhaps 2-3% more in Europe, with the average around 2- 2.5% (Schipper and Grubb 2000; Johansson and Schipper 1997). Lower costs of using cars discourage use of other modes, as can be seen by comparing relative fuel and transit costs and relative ridership in different cities in Europe.

People on the move

Travel typically accounts for 60-70% of energy use and emissions from transportation. Travel activity **A** is measured in passenger kilometres over each mode **S**i. The key component is automobile travel, and that is driven by automobile ownership. Ownership has risen with income or GDP per capita, although it is showing some saturation in the most motorised countries. Distance travelled per vehicle (vehicle-km, or v-km) is rising slowly with income. Combined, these two forces yield the dramatic coupling of kilometres driven vehicle km has been growing more slowly than GDP since 1992 after holding steady since 1960. Is this a change in a key trend that has driven CO_2 upwards?

Figure 3. Per capita car use and per capita GDP 1970-1997

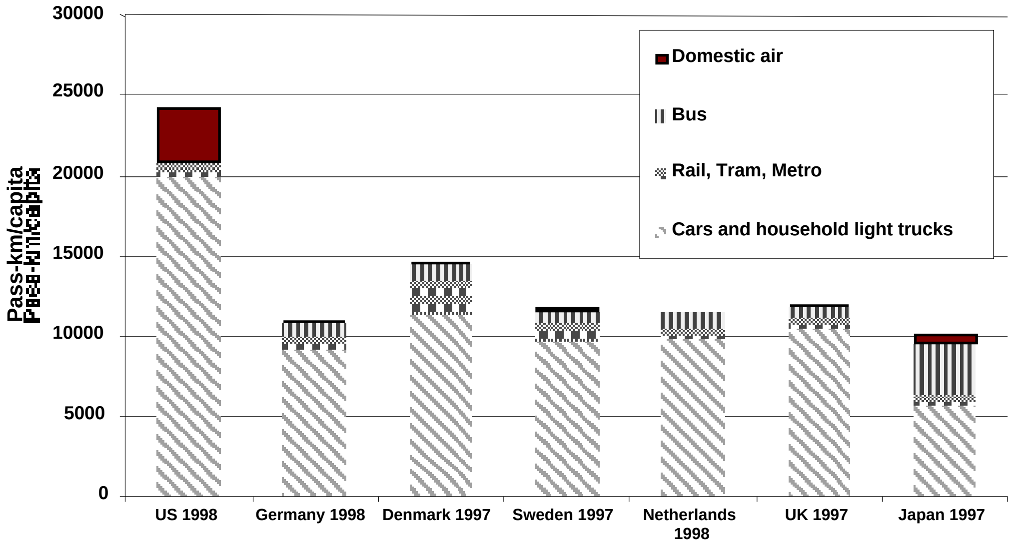


Source: LBNL and IEA

Figure 4 compares per capita motorised domestic passenger transportation in a number of countries in 1997/8, showing the dominance of the car. Total travel, as expressed by the distance travelled on all modes in passenger kilometres, is "driven" principally by car use. Note that in Figure 3, there are widely different levels of car use at a given level of GDP, suggesting that while differences in GDP/capita are important to the differences in travel in Figure 4, they do not explain all of the difference.

Car travel in this figure is rising at a less rapid rate than car use itself because the number of people in a car (load factor) has been falling, but that key value seems to be stabilising at around 1.5 people/car. Note now how the European countries in the study are bunched together. Relative to GDP, Australia and Canada (not shown), lie with the U.S., while Japan lies somewhat below Europe. If estimates of non-motorised travel were included, the totals for Denmark and the Netherlands would rise by roughly 10%, the other European countries by somewhat less, the U.S. by very little at all[4].

Figure 4. Per capita motorised travel in selected countries, 1997/8



Source: LBNL and IEA

The U.S., and to some extent Canada and Australia (not shown) have roughly similar high levels of total travel, and the same high shares of car and air travel. This suggests that geographical factors play some role in determining total travel, explaining in part why the US has such high car use at a given GDP per capita in Figure 3. By contrast, the U.K., Germany and the Netherlands are the most densely populated countries we studied, and have lower levels of travel and car dependence. Japan is even more dense (when one considers that most people live on a fraction of the total land area there), and has even lower total travel than the European countries. Economic factors are certainly important, too, as we will note later. While there are important differences among European countries, it is nevertheless interesting how the overall pattern of travel tends to reveal these three groupings as determined by geography.

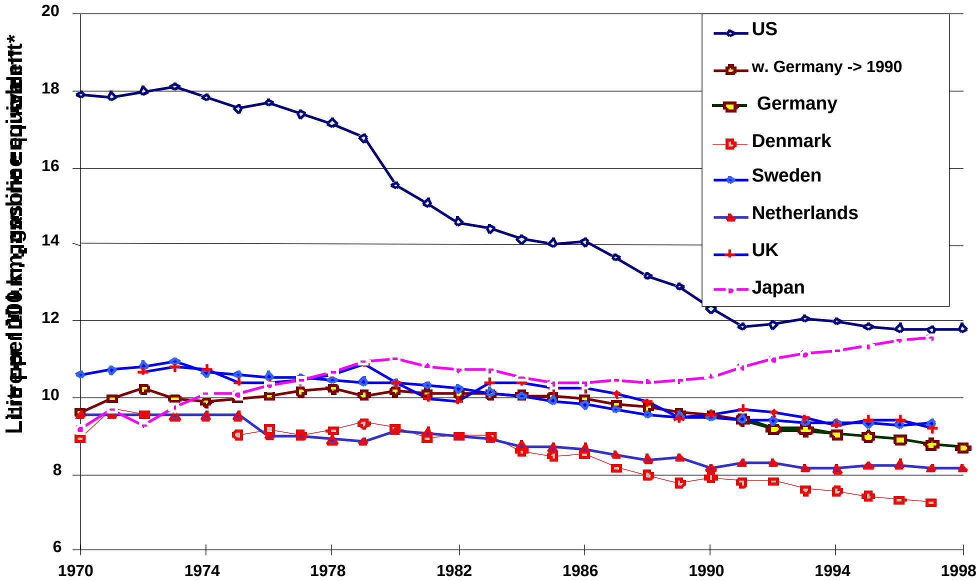
Closer examination of trends in vehicle fuel use link activity to emissions. We defined the vehicle energy intensity as energy use per vehicle kilometre, and the modal energy intensity as energy use per tonne-km or passenger-km (c.f. Eq. 1 and 2). Vehicle intensity for cars (for a given size and power) is related to the efficiency of the vehicle, while modal intensity depends also on the number of passengers or amount of freight carried. Since cars account for most of the energy use, we will focus on trends in the intensities of these key modes.

Figure 5 shows on-road vehicle fuel intensity, or fuel use per 100 km, for car fleets. Diesel and LPG are counted at their energy content. Emissions/km are very closely proportional to these trends, since the energy contents of diesel, gasoline, and LPG are close. Personal light trucks are taken into account in the U.S., as they account for nearly 30% of household vehicles[5].

Fuel intensity fell dramatically in the U.S. in the 1970s and 1980s, then stabilised. Intensity barely changed in European countries until recently, and wavered in Japan. Note that the figures for the early 1990s reflect car fleets that have been almost completely renewed since the early 1970s.

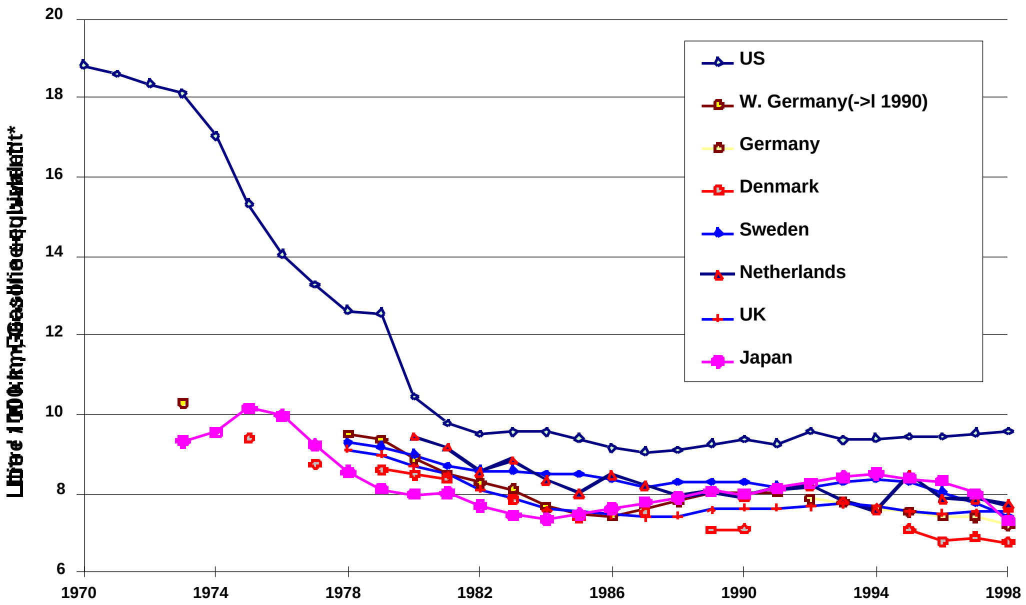
The lack of dramatic change in the vehicle intensities in many countries may be a surprise to many but has a clear explanation: Vehicle performance and weight changes have absorbed some of the savings that advances in fuel consumption technology offer, particularly since 1986 when oil prices plummeted. In the U.S., fuel intensity has been stable or rising slightly since the early 1990s as more and more urban assault vehicles are included in the stock of personal vehicles. In Japan, reduction in purchase taxes on the largest new cars after 1989, more air conditioning, and worsening traffic are all associated with the rise in fuel intensity there. In Europe, however, intensity is falling slowly. In short, most technology deployed in new cars in the late 1990s is being used to boost performance, rather than to save fuel. Again, behaviour, abetted by low fuel prices through 1998, demands more power, rather than fuel efficiency. This is important for policy, because it means opportunities to save fuel have been foregone.

Figure 5. On road fleet fuel intensity, cars and household light trucks



Source: LBNL and IEA

Figure 6. Sales weighted new-car fuel intensities

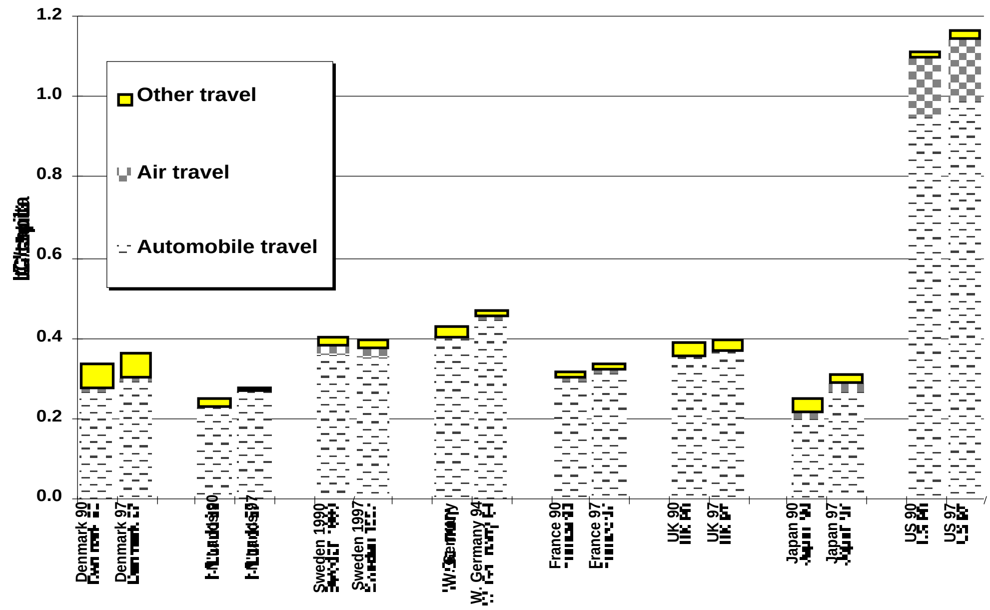


* All fuels counted at their actual energy contents and then converted back to gasoline at 31.5 mJ/litre

Changes in automobile vehicle intensity have been driven almost entirely by new car fuel economy. While the values calculated from test figures for each new car sold usually overstate actual on-road experience, they give a good indication of how fuel economy is changing. What Figure 6 shows is that fuel economy of *new* U.S. cars (and light trucks) has stagnated or even worsened, while that for cars in Europe (and Japan for the most recent year available) show improvements. Are these related to the Voluntary Agreements between car industries and governments in these two key regions? These agreements aim at a 25% reduction in test CO_2 emissions/km in Europe and roughly 21% less in Japan by 2008-2010. Note that in absolute terms, the European goals lie well below the Japanese ones, at roughly half the present US level. If these trends continue and the goals are fulfilled, they imply that by 2025 virtually all cars on the road in Europe will release roughly 20% less CO_2/km than they do today, and those in Japan roughly 16% less, given that the test values are always much better than those achieved on the road. Data collected by the ECMT from the European Manufacturers show indeed that through 1999/2000, the carbon emissions per km continue to drop (ECMT 2001, private communication).

Car (and air) travel – speed and convenience – propelled the growth in travel. Since these modes require more energy and emit more carbon per passenger-kilometre than bus or rail modes, energy use and CO_2 emissions have risen faster than total travel per capita outside of North America. Figure 7 shows these patterns (in tonnes of carbon per capita) for travel[6]. The U.S. has the highest emissions because it has both the highest level of travel (with the highest share in cars and air travel) and the highest emissions per unit of travel in cars. Japan (not shown) has low emissions principally because it has the lowest per capita travel and the largest share in rail and bus. European countries tend to cluster between these extremes, albeit more closely to Japan. Congestion in Japan – lower speeds -- may be one reason for the low values of travel relative to Europe. At first sight, then, the U.S. seems to have the most emissions to yield. Indeed, inspection of Figures 3, 4 or 5, shows that it is total distance/capita, not fuel use/distance, that distinguishes the U.S. the most from the other countries. Inspection of national travel surveys shows that the average distances for car trips in the U.S. and Europe all lie in the interval 13-15 km/trip, so it is the number of trips per capita that boosts the U.S. distance, not the length of trips. Are these differences reducible?

Figure 7. Per capita carbon emissions from travel by mode, 1990 and 1997



Source: LBNL and IEA

Decomposition of emissions from passenger transportation

We can aggregate all of the information so far for travel-related emissions. Figure 7 shows that the emissions for travel have risen slightly in every country since 1990, which was considerably higher than 1973 except in the U.S. The reasons are explained by our decomposition of emissions using Eq. 1. Consider first the 1973-1990 changes.

For passenger transportation, higher per capita travel (total **Activity**) alone increased emissions in every country, as Table 1, based on Laspeyres indices, shows for the group of aggregates. Modal shifts (**Structure**) towards more energy-intensive modes (cars, air) increases emissions by as much as 1% annually (in Japan), but in most countries this was smaller, though positive except in Denmark[7]. This growth in activity is clearly income-driven, as suggested by Figure 3[8]. Since car ownership is also income-driven, and car ownership growth lies at the root of the modal shifts, we can say that modal shifts observed at the national level are income-driven as well. And since modal shift itself moves people to more rapid modes and those then move them considerably longer distances (air, for example), we can say that higher incomes are associated with greater and more rapid travel.

Table 1. Carbon emissions from passenger transport
Average annual change of impact of each "ASIF" factor, 1973-1990, 1990-1997
Laspeyres decomposition with 1990 as the base year

1973-1990	Denmark	Sweden	France	W. Germany*	U.S.	Japan	UK
Actual emissions	1.2%	1.4%	2.5%	2.8%	0.7%	4.0%	2.4%
Carbon intensity	-0.1%	0.0%	-0.2%	0.4%	-1.2%	0.0%	-0.4%
Energy intensity	-0.3%	0.0%	-0.1%	0.5%	-1.3%	-0.4%	-0.4%
Fuel mix	0.2%	0.0%	-0.1%	-0.1%	0.0%	0.4%	0.0%
Modal structure	-0.1%	0.0%	0.1%	0.2%	0.0%	1.0%	0.2%
Total activity	1.5%	1.4%	2.5%	2.2%	1.8%	2.7%	2.5%
1990-1997							
Actual emissions	1.4%	0.3%	1.3%	2.4%	1.6%	3.3%	0.8%
Carbon intensity	-0.9%	0.2%	-0.3%	-0.3%	-0.3%	0.8%	0.2%
Energy intensity	-0.9%	0.2%	-0.4%	1.4%	-0.2%	2.2%	0.1%
Fuel mix	-0.1%	0.0%	0.1%	-1.5%	0.0%	-1.5%	0.1%
Modal structure	-0.1%	-0.1%	0.2%	0.9%	0.0%	0.8%	-1.5%
Total activity	2.5%	0.2%	1.4%	1.5%	1.9%	1.7%	0.6%

*From 1990-1997 All Germany.

Energy intensities of vehicles themselves reduced emissions in more than half the countries, but falling load factors in cars (and bus and rail in many countries) offset this restraint, leading to a net increase in energy use (and CO_2 emissions) per passenger-km in cars. Indeed, only in N. America were the emissions savings from lower modal intensities greater than 20%. Changes in Europe and Japan were small because power and weight increases offset most of the impacts of technical improvements. These factors combine to give the changes in energy intensities shown. Shifts in **Fuel mix** and utility mix (not shown separately) had almost no impact, for two reasons. First, the emissions per unit of energy released from diesel and gasoline are very close, although diesel is slightly higher[9]. Second, the role of electricity for travel (rail, trams) is so small that even the almost complete transition away from fossil fuels in some countries (Sweden) had only a very small impact on emissions from this sector. Combing the energy intensities and fuel factors yields **carbon intensities**. Thus by 1990, incomes and behavioural factors had clearly increased CO_2 emissions, even after over a decade of relatively high road fuel prices, restrained somewhat by lower carbon intensities. In the U.S. intensities fell enough to offset most of the increase in travel. In fact, per capita emissions from cars in 1990 were lower than they were in 1973.

Fuel mix has almost no effect on our results. This is in part because the mix of fuels varies so little in CO_2 content. To be sure, increased use of diesel cars should reduce intensities, which should cause that factor to decline. Some of this has occurred in Germany and the Netherlands (as well as Italy and France, not examined in detail in this study). In all these countries, however, diesel is priced lower than gasoline. This advantage is utilised by those with greater than average yearly driving distances as well as those who take advantage of the lower fuel costs to drive more (Schipper, Lilliu and Fulton 2000). Further, marketing data show that for any given car model, a diesel version tends to have 10-15% more power than its gasoline counterpart, to make up for the generally lower acceleration of a diesel engine. Thus only a small part of the potential economy of a diesel engine is actually realised as lower fuel use and CO_2 emissions in the countries where diesel cars are popular. This digression reminds us that ultimately we have to consider terms other than the modal energy intensity **I** alone in causing changes in emissions.

Since 1990, the picture of emissions is somewhat different. Except for the U.S., the rate of growth of emissions has slowed, both because of slower growth in activity and because of falling carbon intensities. Japan's higher carbon intensity is an anomaly, driven by changes in automobile fuel economy, but these appear to have reversed from 1998. In the U.S., total emissions grew faster after 1990 than before, a consequence of the stagnation of fuel economy. With recovery from recession, higher economic growth in many countries has stimulated both greater activity and slightly more rapid shift to cars and air travel. But lower automobile fuel intensities in Europe seem to be restraining emissions more than before. Thus since 1990, trends in emissions point away from their path before 1990.

Summary: more motion, more rapidly, raised emissions

Changes in the amount people travel have been the dominant cause of rising emissions. Greater car weight and power also boosted emissions (Schipper and Lilliu 1999). Technical factors, as the vehicle and modal energy intensities, led to some restraint of emissions in a few cases for cars (and trucks) but only gave a net reduction in per capita emissions (for travel) in one country. Behaviour and system optimisation factors (i.e., modal choices and utilisation, speed), clearly boosted emissions as well.

By the late 1990s, there are some signs that the coupling between these factors and ever-rising GDP may be weakening. Measures aimed at restraining CO_2 emissions from travel and freight should focus on the underlying factors driving emissions up since 1990, as these are likely the forces which policies must circumvent. But measures must also reinforce the recent trends in falling fuel intensities in Europe. In short, the challenge is not simply to reduce (or accelerate reductions in) emissions per kilometre from cars but also to restrain important trends that are raising emissions. We turn to some of those forces next.

5. THE CHALLENGES FACED: TRADITIONAL DRIVING FACTORS OF RISING INCOMES AND FUEL PRICES

Income (GDP) is an important factor driving travel activity and subsequent emissions, as suggested by Figure 3. The previous paper showed the close coupling between travel emissions/capita and GDP/capita. Only in the

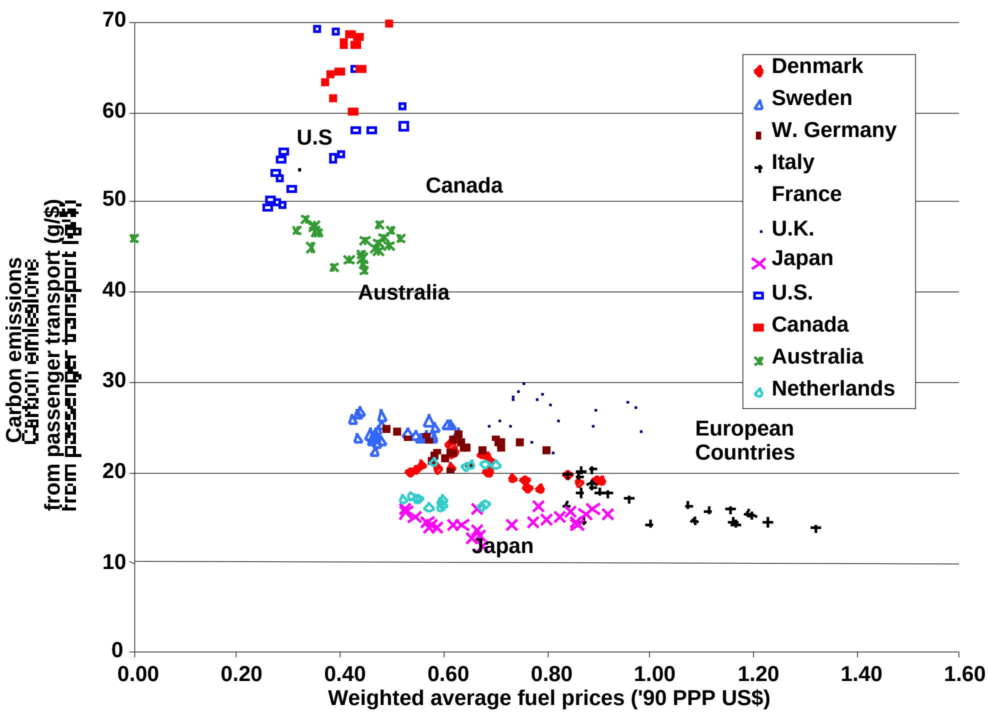
U.S. there appears to be some relenting or decoupling, both during the periods of the oil shocks and a slowing of growth after that period. There may be saturation approach in all countries, but emissions are still growing somewhat with incomes.

Fuel prices are also an important determinant of fuel consumption in the long run, as a wide range of studies has shown (reviewed in Johansson and Schipper 1997)[10]. Figure 8 gives a dramatic cross sectional picture showing how drivers in countries with the lowest prices for fuels emitted the most carbon for automobiles per unit of GDP (cf. Figures 3, 4 and 7) . But real fuel prices were only high in any given country for a relatively brief period, 1974-1977 and 1979-1986, and again in 2000, which is manifest in the rather random placing of the points for any one country. In many European countries today they barely kept up with inflation until the rise in the U.S. Dollar and OPEC price increases in 2000 brought them to the highest levels since the early 1980s (IEA 2000c). In the U.S., prices were at historic lows in 1998 but still failed to come close to their 1980s highs in 2000. With modest declines in fuel intensity in Europe and a 30% reduction in the U.S. today vis à vis 1973, the incentive to respond to costs is small both for vehicle makers and for buyers or users. What can be done to restrain the growth in emissions implied by our previous analysis?

Factors causing changes in CO_2 emission are intimately related to the nature of transportation – comfort, convenience and speed. Those factors driving distance as well as modal choice are related to individual and societal choices about housing, work and leisure location. The same is true for freight. But the cost of fuel is but a small fraction of the total cost of either travel or freight, even before the cost of the transport infrastructure is considered. And the choices noted here are deeply rooted in a transportation context. This means that these choices – today's slowly evolving transportation patterns – may be difficult to stop simply because of CO_2 concerns.

Put another way, even a stiff carbon tax would still leave the price of road fuels relatively unchanged in most countries because they are already heavily taxed. Drivers face many other costs besides those that might reflect carbon concerns. To be sure, natural limits (saturation of distance or time of travel, potential saturation of the distance physical goods are sent around) or local constraints (congestion, parking problems, local pollution) may slow or reverse some of these trends. But most national transport plans still foresee increases in personal and goods transportation with GDP without policy intervention.

Figure 8. Per capita carbon emissions from cars/personal light trucks and fuel prices



(1970-1995 For each country shown. Fuel prices weighted for gasoline, diesel, LPG)

Source: LBNL and IEA

6. THE FUTURE: THE ROAD FROM KYOTO

What could restrain CO_2 emissions in the future? In the closing section of this review, we discuss what our research suggests. Recall the ASIF formulation (Activity, Structure, Intensity, Fuel Mix) presented in the beginning. The I and F terms are strongly influenced by technology, although there are many behavioural components of I, too. A is clearly coupled to incomes, and S tends to shift towards more carbon-intensive modes as incomes grow. Governments in Europe therefore place their hopes on the multiplying effects of changes in all these components to reduce growth in emissions and eventually turn them back down.

Technology: mainly I and F

There is no doubt that technology offers enormous potential for reducing CO_2 or other emissions (and many other externalities), at modest cost, if asked to play a role (Michaelis *et al.* 1996; IEA 1999, Fulton 2000a). This was reinforced by the flurry of announcements around the time of the Kyoto conference, such as Toyota's marketing of the Prius Hybrid in Japan, and soon in the United States, with Europeans close behind. Indeed, both the Toyota Prius and Honda Insight have sold out limited production runs in Japan and the U.S. and are now on sale in Europe. Most major manufacturers have announced limited production of fuel cell cars by 2003. Thus technology is moving into the market.

One driving factor is the Voluntary Agreement on fuel economy between a government and manufacturers. For Japan a 23% reduction by 2010 for gasoline cars (15% for diesel cars by 2005) is foreseen as part of the new "Top Runners Programme" announced in December 1998. The voluntary agreements (VA) concluded between the European Union and the European Automobile Manufacturers' Association ACEA promises that new cars on average will emit 25% less carbon per kilometre by 2008 than in the mid 1990s, which as we noted earlier, seems to be seen in the emissions data for new cars. In the U.S. there is no goal, but an aggressive research programme (Partnership for a New Generation of Vehicles, or PNGV) may produce technologies that can reduce fuel use more than the current wave of large sport-utility vehicles is raising fuel consumption. Perhaps more important for the United States, major auto companies have announced voluntary fuel economy goals for sport utility vehicles and signalled their intention to put hybrid engines in many of them.

In all countries, some combination of advanced gasoline engines and advanced diesels (which offer fuel economy as low as 3-5 l/100 km), and restraint or even reversal in the growth of car power, weight and options, could make these changes a reality (IEA 2000a, 2001). The more the latter grow, the more technology has to be applied to offset their upward pull on emissions. Thus technology is fighting an uphill battle, but there are signs that the hill is getting less steep: the fact that the ratio of km driven to GDP in the U.S. is falling now as never before – although the absolute level of km travelled is still rising – may signal a saturation in car use. With air travel also growing less rapidly, relative to GDP, than in the 1980s or 1990s, this slower growth gives carbon-saving technology more time to catch up and reverse the growth in emissions .

The role of behaviour: mainly A and S

The ASIF formulation shows the influence of behaviour on total emissions. Indeed, even the brief review of trends given here makes it clear that differences in total travel per capita and modal share contributed more to overall differences in emissions per capita than differences in fuel economy. But the decomposition of trends showed that behaviour, driven principally by rising incomes, supports more travel and more reliance on carbon-intensive modes. And as Schipper and Lilliu (1999) show, car weight and power is increasing slowly but steadily in virtually every IEA country.

Carbon concerns alone are unlikely to reverse this slow trend. Changes in fuel prices alone may lead to significant changes in vehicle or fuel technology, but not large changes in travel behaviour. And the examples given immediately above make it clear that behaviour starts with the choice of the vehicle. No authority is actively telling its citizens to abandon cars or stay home. But changes in the European policy landscape motivated by the transportation concerns we sketched in the introduction may have an important impact on emissions by restraining growth in A and by pushing S somewhat back towards modes with lower carbon intensity. These changes could affect basic costs of using vehicles beyond fuel alone. How hard can these policies push? Certainly speed limit enforcement, driver training, labelling of fuel economy, and other measures could help. These kinds of measures push behaviour to use technology in a fuel-saving way, an important interaction for policy-makers to consider.

Policies to push

Our new book reviews strategies of six IEA countries. Four are based in overall transport reform, of which two (Denmark and Sweden) rest principally on the idea that each mode of transport should bear its full external social costs. In each strategy a combination of technological change (including that driven by research, development, and demonstration projects and pricing policies), higher costs for lower-emitting fuels, and application of transportation costing and regulatory measures could both improve transportation efficiency and restrain or even reduce CO_2 emissions over the next three decades. These could change both emissions per km and total km enough to make a real break in travel fuel consumption, as clearly happened in the U.S. in the 1970s and 1980s. CO_2 policies alone – or technologies aimed at CO_2 alone – may not have a great enough impact on emissions to reduce them without dramatic technological breakthroughs that appear quickly in the marketplace. But CO_2 measures implemented in transport policy measures could leave European, Japanese, and N. American transportation systems with lower total CO_2 emissions in the second or third decade of the next century than at present.

If the "sins" of transport are indeed as serious as the literature suggests, then their prompt and thoughtful treatment, together with measures designed to address CO_2, including taxation, could break the links shown in the opening figures. And if governments are really as concerned both about “sustainable transport” and CO_2 emissions as their prolific reports suggest, then the forces could be mustered for this important integration.

At the same time, each country has seen its bold plans put forth in the early 1990s shrink to a few measures related to A and S and participation in the voluntary Agreement:

- In the U.K. the regular increases in the real level of fuel taxation have been suspended.
- In the Netherlands, bold plans for better speed limit enforcement, as well as a modest tax break for reducing the cost of econometers in new cars were defeated.
- In the U.S. a well intended-scheme to require new tyres to be labelled with their energy efficiency properties was defeated.

On the other hand, the Danish government succeeded in lowering collective ground transport fares modestly in 1998 while adding a tax to air travel. They adjusted the high (circa 200%) purchase taxes on new cars to give a break to the least fuel intensive ones, such as the Volkswagen Lupo. And they introduced a shift in the yearly registration tax so it is now based on a car’s original test fuel economy, with the tax rising with test fuel intensity. Applied only to cars bought after 1998, this tax appears to be having a slight effect on the size and fuel intensity of new cars bought, according to quarterly data provided by the Danish Energy Agency. And most countries seem to be making headway changing the way trucking is taxed for both road wear and other costs, as well as in slowly revitalising parts of the rail network. Directly or indirectly, all these European authorities have discussed some kind of road pricing, but for which vehicles, and whether local and/or long-distance is unclear. The French have already introduced peak-time tolls on their autoroutes. Although no one in any country can more than guess what will be the ultimate package of measures, how fuel taxes will change, and how behaviour will change, the European governments we studied closely seem resolve to do as much as possible. The high fuel prices of the last quarter of 2000 tested this resolve in the U.K (and France), yet neither government has substantially lowered its road fuel taxes.

What can we expect?

The confrontation of CO_2 emissions from travel (and freight) in the context of overall transport reform by European countries and Japan is starting to have a small but measurable impact. These impacts are still short of what has to have occurred by 2000 if the Kyoto targets of these countries are to be met. Yet the trends we have seen in the last three years are the first encouraging signs that significant restraint in emissions from transportation can occur. Their efforts will cause measurable change, but not as much as Kyoto goals require. We summarise below what our work implies for the structure of future policies.

- CO_2 policies must be embedded in larger transport reform measures, as noted at the outset and codified now in the CO_2 plans of a number of European countries. Most of the measures designed to reform transport and make the system more effective will lead to somewhat lower levels of traffic, a modest rise in the role of collective modes, and less air pollution. These all help restrain CO_2. Within this setting, CO_2 -specific measures strike hardest and show the greatest welfare benefits as well.

- Pricing is seen in Europe as key to rearranging the various signals that affect the use of cars over other modes, the fuel economy of cars, and the choice of fuels. No one expects price reforms alone to solve problems, but few expect transport problems to solve themselves without pricing reforms. This is particularly important for the possible trade-offs among pollutants, the search for fuels with lower carbon content, and the encouragement of low-pollution vehicles.
- Technology offers enormous potential for reducing environmental problems associated with transport. But technology depends on human behaviour for acceptance and proper deployment. Proper carbon pricing is also central to both developing and deploying technology. Car companies fear large investments in fuel-saving technology or alternative propulsion without strong market support for the purchases of what they develop. Subsidies for so-called "clean" alternatives will have little effect unless the "dirty" status quo is clearly marked with taxation. Even with a dramatic breakthrough that reduces fuel consumption spectacularly, taxation reform will be necessary just to keep revenues about constant for maintaining the transport infrastructure. And while very low-consuming vehicles do not necessarily imply significant increases in vehicle use, wise governments will act to make sure that when technology leaps, signals about both CO_2 and other transportation externalities are not muted.
- There are many local policies (reviewed briefly in our book) that take direct aim at daily mobility, such as road pricing and other forms of transport demand management. Introducing such schemes is important for clearing congestion, but is often politically difficult. Similarly, there is some expectation that careful attention to land use planning and higher density development will reduce the need to travel. The positive experience with land use planning in Nordic countries and the Netherlands is hard to relate to specific declines in car use or drops in total mobility. These tools may be wise transport planning instruments to keep cities pleasant, but they remain uncertain tools for reducing CO_2 emissions unless employed in conjunction with other measures.

Present trends in motorization and mobility of goods and people in wealthy OECD countries are still raising fuel use and CO_2 emissions at nearly the rate of economic growth. Although there are some signs of saturation in the wealthiest countries, countries will have to take stronger steps towards restraint in CO_2 emissions if they want greater results in the long run. The post 1990 trends in Europe show emissions growth from travel has been slowed. Japan and the U.S. remain uncertain.

The IEA, in its most recent World Energy Outlook (IEA 2000b, see also Landwehr 2001 in this volume), has modelled the impacts of all of these policy measures on emissions in IEA countries. The modelling of a package of policies that included the voluntary agreements (with an equivalent for the U.S.), modest real fuel price increases, changes in freight pricing, etc., was seen to restrain emissions by as much as 20% over a base case by 2020. Unlike previous efforts, this modelling started from the basic ASIF equation and identified how policies and technologies could change each component over time relative to a base case. While such modelling does not prove that the various measures will work as hoped for, they do show that the package and its impact is not inconsistent with other trends.

7. WHAT IS HOLDING THINGS BACK?

What factors hinder changes in the transport system that would reduce or restrain CO_2 emissions? The price of emitting CO_2 fell through 1998 for most societies, dramatised by the oil glut of 1997/8, was a hindrance to more resolve towards restraining emissions. But recent trends in world oil markets suggest that the decline may be much more slow, if at all. The world oil glut in 1998 set off by the Asian economic collapse is probably over. Still, the U.K. policy of regular tax increases, if resumed, sends a sure signal to both motorists and manufacturers that saving fuel will become increasingly worthwhile

Working in this direction as well are shifts in the management style and goals of manufacturers. In addition to the voluntary agreements in Europe or Japan and pledges by U.S. automakers, the very fact that both the Honda and Toyota fuel-saving hybrids have sold out their (limited) production runs has encouraged virtually every manufacturer to reach for bolder fuel-saving solutions or at least use technology to offset the impact on fuel use of larger, more powerful cars.

On the other hand, incomes are rising, which makes larger cars and more car (and air) travel affordable for more people. To this must be added some resistance by political and business groups, as well as individual consumers, to policies that at least in the short run will redefine costs associated with travel. These pressures kept many proposed transport reform or carbon-saving measures from becoming law in all the countries studied. Those who know their costs will likely rise are well informed and on guard.

Still, the outlook is better than when Paper One was written. Fuel economy in Europe and Japan is improving; car companies are making strategic alliances among them selves and with fuel companies to further advance technologies; for better or worse, oil prices have strengthened after the dip of the late 1990s. Our grandchildren are already emitting sighs of relief that help may be on the way.

8. ACKNOWLEDGMENTS

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10. ENDNOTES

[1] See Kaageson, 1993; COWI, 1993; OECD, 1995; CEC, 1995a; COWI, 1995a, 1995b; Dept. of Transport, 1996; Pearce et al., 1996; Det Oekonomiske Raad, 1996, Delucchi, 1997, ECMT 1998.

[2] These are presented for six IEA countries in “The Road From Kyoto”: Paris: Int’l Energy Agency (IEA 2000a).

[3] A main case for using Laspeyres indices is their simplicity of calculations. However, note that Laspeyres indices often leave large residuals.

[4] See Schipper, Gorham, and Figueroa 1995.

[5] These figures are assembled from national data (IEA 1997a) and count the energy content of each kind of fuel, which is higher for diesel than for gasoline or LPG. Results are then converted to “gasoline equivalents” at the lower heat content of gasoline of 31.4 mJ/litre.

[6] See Schipper, 1995; Scholl, Schipper and Kiang, 1996.

[7] For Denmark the falling automobile factor led to increased emissions. We used this falling factor based on our interpretation of a number of national travel surveys. Consequently our results differ from the load factors used by Vejdirektorat, the National Road Authority.

[8] See Johansson and Schipper, 1997.

[9] We are ignoring full fuel cycle emissions, i.e., emissions associated with producing, refining, and transporting fuels.

[10] See Johansson and Schipper 1997 or Thompson, Fraser and Swaminathan 1995.